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SOME ESTIMATES FOR BISINGULAR INTEGRAL WITH LOCALLY SUMMABLE DENSITY

Abstract: *It is obtained a Zigmund type estimate for the bisingular integral in the space of Summation functions. It is constructed an invariant functional space based on the inequality.*

Key words: *bisingular integral operator, Zigmund type estimate, invariant space.*
Language: *Russian*
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НЕКОТОРЫЕ ОЦЕНКИ ДЛЯ БИСИНГУЛЯРНОГО ИНТЕГРАЛА С ЛОКАЛЬНО СУММИРУЕМЫХ ПЛОТНОСТЬЮ

Аннотация: *Получены оценки типа оценки Зигмунда для бисингулярного интеграла. На основе полученных оценок строится класс функций инвариантного относительно бисингулярного оператора.*

Ключевые слова: *бисингулярный интеграл, оценка Зигмунда, инвариантное пространство.*

Введение

Классическая теорема об ограниченности сингулярного оператора с ядром Гильберта в пространстве $L_p\ (p > 1)$

$$\left\|\tilde{f}\right\|_{L_p[-\pi,\pi]} \le A_p \|f\|_{L_p[-\pi,\pi]}\ ,$$

где $\tilde{f}(x) = \frac{1}{2\pi}\int_{-\pi}^{\pi} f(s) ctg\frac{s-x}{2} ds$, а A_p –постоянная зависящая лишь от p была доказано Н. Н. Лузиным [7] при $p = 2$и М. Риссом [17] при $p > 1$.

В дальнейшем этот результат был перенесен в ряде работ для довольно широких классов жордановых спрямляемых кривых . Подробная предистория этого вопроса имеется в работе [11] см., кроме того , А. П. Кальдерон [13],[14] и [12].

Для изучения особого интеграла

$$\tilde{u}(x) = \int_a^b \frac{u(s)}{s-x} ds\ ,\ x \in (a,b)$$

$(-\infty < a < b < +\infty)$ с суммируемых плотностью в работе [5],[11] для функции $u \in L_p^{loc}(a,b)$ – множества функций, суммируемых в $p-$ой степени на любом внутренним отрезке в интервале (a,b), была введены характеристики

$$\Omega_p(u,\xi,\eta) = \left(\int_{a+\xi}^{b-\eta} |u(x)|^p dx\right)^{\frac{1}{p}} \quad \xi,\eta > 0\ ,$$
$$\xi + \eta \le b - a = l,$$

$$\omega_p(u,\delta,\xi,\eta) = \sup_{0<h\le\delta}\left(\int_{a+\xi}^{b-\eta-h} |u(x+h) - u(x)|^p dx\right)^{\frac{1}{p}},$$
$$\xi + \eta + h \le l, \delta > 0$$

и при $1 <$p$< +\infty$ доказана оценки , $(\Omega_p(\tilde{u}), \omega_p(\tilde{u}))$,через $(\Omega_p(u),\ \omega_p(u))$.

В предельном случае при $p = \infty$ и $u \in C_{[a,b]}$ эти результаты были получены в [1], [8] ,было показано, что оценки [2] в определенном смысле

неулучшаемы. В [10] с помощью теоремы М.Рисса об ограниченном действии оператора $\tilde{u}$ в пространстве $L_p(a,b)$, утачнена результаты, полученные в [1], [3].

Одной из первых работ, посвященных повторному особому интегралу с ядром Гильберта $(Bf)(x_1,x_2)=g(x_1,x_2)=\frac{1}{4\pi^2}\int_{-\pi}^{\pi}\int_{-\pi}^{\pi}f(x+t,y+\tau)ctg\frac{t}{2}ctg\frac{\tau}{2}dtd\tau$,
была работа Л. Чезари [15]. Он доказал, что если $f\in H^2_{(\delta_1^\alpha,\delta_2^\alpha)}$ то

$$g\in H^2_{(\delta_1^\alpha|ln\delta_1|,\delta_2^\alpha|ln\delta_2|)}$$

Следуя Л.Чезари, Е.Жак [6] в своей работе также показал, что класс функций $H^2_{(\delta_1^\alpha,\delta_2^\alpha)}$ не инвариантен относительно оператора B. В этай же работе доказано, что классы функций $H^{\alpha,\beta}=\{f\in C_{[-\pi,\pi]^2}:\omega_f(\delta_1,\delta_2)=O(\delta_1^\alpha\delta_2^\beta),\omega_f^1(\delta_1)=O(\delta_1^\alpha),\omega_f^2(\delta_2)=O(\delta_2^\beta),0<\alpha,\beta<1\}$
инвариантны относительно оператора B.

Основная часть.

Рассмотрим бисингулярный интеграл вида

$$\tilde{u}(x_1,x_2)=\int_{a_1}^{b_1}\int_{a_2}^{b_2}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2,$$

где функция $u\in L_p^{loc}(\Delta),\Delta=(a_1,b_1)\times(a_2,b_2)$, $p>1$.

Для $u\in L_p^{loc}(\Delta)$ введем характеристику

$$\Omega_p(u,\xi_1,\eta_1\xi_2,\eta_2)=\left(\int_{a_1+\xi_1}^{b_1-\eta_1}\int_{a_2+\xi_2}^{b_2-\eta_2}|u(x_1,x_2)|^pdx_1dx_2\right)^{\frac{1}{p}},$$

где $\xi_i,\eta_i>0,\ \xi_i+\eta_i\le b_i-a_i=l_i,\ i=1,2.$

Теорема 1. Пусть функция $u\in L_p^{loc}(\Delta)$. Тогда при сходимости соответствующих интегралов справедливо неравенство:

$$\Omega_p(\tilde{u},\xi_1,\eta_1,\xi_2,\eta_2)\le C_pK(\Omega_p)\text{ , где}$$

$$K(\Omega_p)\le C_p\Big[\frac{1}{(\xi_1\xi_2)^{\frac{1}{q}}}\int_0^{\frac{\xi_1}{2}}\int_0^{\frac{\xi_2}{2}}\frac{\Omega_p\left(u,t_1,\frac{l_1}{2},t_2\frac{l_2}{2}\right)}{(t_1t_2)^{\frac{1}{p}}}dt_1dt_2+$$

$$\frac{1}{(\xi_1\eta_2)^{\frac{1}{q}}}\int_0^{\frac{\xi_1}{2}}\int_0^{\frac{\eta_2}{2}}\frac{\Omega_p\left(u,t_1\frac{l_1}{2},\frac{l_2}{2},t_2\right)}{(t_1t_2)^{\frac{1}{p}}}dt_1dt_2+\frac{1}{(\eta_1\xi_2)^{\frac{1}{q}}}\int_0^{\frac{\eta_1}{2}}\int_0^{\frac{\xi_2}{2}}\frac{\Omega_p\left(u,\frac{l_1}{2},t_1,t_2,\frac{l_2}{2}\right)}{(t_1t_2)^{\frac{1}{p}}}dt_1dt_2$$

$$+\frac{1}{(\eta_1\eta_2)^{\frac{1}{q}}}\int_0^{\frac{\eta_1}{2}}\int_0^{\frac{\eta_2}{2}}\frac{\Omega_p\left(u,\frac{l_1}{2},t_1,\frac{l_2}{2},t_2\right)}{(t_1t_2)^{\frac{1}{p}}}dt_1dt_2$$

$$+\frac{1}{\xi_1^{\frac{1}{q}}}\int_0^{\frac{\xi_1}{2}}\frac{\Omega_p(u,t_1,\frac{l_1}{2},\frac{\xi_2}{2},\frac{\eta_2}{2})}{t_1^{\frac{1}{p}}}dt_1+\frac{1}{\xi_2^{\frac{1}{q}}}\int_0^{\frac{\xi_2}{2}}\frac{\Omega_p(u,\frac{\xi_1}{2},\frac{\eta_1}{2},t_2\frac{l_2}{2})}{t_2^{\frac{1}{p}}}dt_2+$$

$$\frac{1}{\eta_1^{\frac{1}{q}}}\int_0^{\frac{\eta_1}{2}}\frac{\Omega_p(u,\frac{l_1}{2},t_1,\frac{\xi_2}{2},\frac{\eta_2}{2})}{t_1^{\frac{1}{p}}}dt_1+\frac{1}{\eta_2^{\frac{1}{q}}}\int_0^{\frac{\eta_2}{2}}\frac{\Omega_p(u,\frac{\xi_1}{2},\frac{\eta_1}{2},\frac{l_2}{2},t_2)}{t_2^{\frac{1}{p}}}dt_2+\Omega_p(u,\frac{\xi_1}{2},\frac{\eta_1}{2},\frac{\xi_2}{2},\frac{\eta_2}{2})\Big].$$

Доказательство.

Прежде всего докажем, что $u\in L_1(\Delta)$.

Пусть $\xi_i\le\frac{l_i}{2}(i=1,2)$ имеем

$$\int_{a_1}^{a_1+\xi_1}\int_{a_2}^{a_2+\xi_2}|u(s_1,s_2)|\,ds_1ds_2=4\int_0^{\xi_1}\int_0^{\xi_2}|u(s_1+a_1,s_2+a_2)|\,ds_1ds_2\frac{1}{s_1^2s_2^2}\int_0^{s_1}\int_0^{s_2}t_1t_2dt_1dt_2$$

$$\le\int_0^{s_1}\int_0^{s_2}t_1t_2dt_1dt_2\int_{t_1}^{\xi_1}\int_{t_2}^{\xi_2}\frac{|u(s_1+a_1,s_2+a_2)|}{s_1^2s_2^2}dt_1dt_2.$$

Учитывая, что $u \in L_p^{loc}(\Delta)$, применим во внутреннем интеграле неравенство Гельдера и получим

$$\int_{a_1}^{a_1+\xi_1}\int_{a_2}^{a_2+\xi_2} |u(s_1,s_2)|\,ds_1ds_2 \le 4\int_0^{\xi_1}\int_0^{\xi_2} \frac{\Omega_p(u,t_1\frac{l_1}{2},t_2,\frac{l_2}{2})}{t_1^{\frac{1}{p}}t_2^{\frac{1}{p}}}dt_1dt_2$$

Аналогично, при $\xi_i,\eta_i \le \left(0,\frac{l_i}{2}\right](i=1,2)$ имеем

$$\int_{b_1-\eta_1}^{b_1}\int_{b_2-\eta_2}^{b_2} |u(s_1,s_2)|\,ds_1ds_2 \le 4\int_0^{\eta_1}\int_0^{\eta_2} \frac{\Omega_p(u,\frac{l_1}{2},t_1,\frac{l_2}{2},t_2)}{t_1^{\frac{1}{p}}t_2^{\frac{1}{p}}}dt_1dt_2$$

$$\int_{a_1}^{a_1+\xi_1}\int_{b_2-\eta_2}^{b_2} |u(s_1,s_2)|\,ds_1ds_2 \le 4\int_0^{\xi_1}\int_0^{\eta_2} \frac{\Omega_p\left(u,t_1\frac{l_1}{2},\frac{l_2}{2},t_2\right)}{t_1^{\frac{1}{p}}t_2^{\frac{1}{p}}}dt_1dt_2$$

$$\int_{a_1}^{a_1+\xi_1}\int_{a_2+\xi_2}^{b_2-\eta_2} |u(s_1,s_2)|\,ds_1ds_2 = \int_0^{\xi_1}\int_{a_2+\xi_2}^{b_2-\eta_2} |u(s_1+a_1,s_2)|ds_1ds_2 =$$

$$= 2\int_0^{\xi_1}\int_{a_2+\xi_2}^{b_2-\eta_2} |u(s_1+a_1,s_2)|ds_1ds_2\frac{1}{s_1^2}\int_0^{s_1} t_1dt_1 =$$

$$= 2\int_0^{\xi_1} t_1dt_1\int_{t_1}^{\xi_1}\int_{a_2+\xi_2}^{b_2-\eta_2} \frac{|u(s_1+a_1,s_2)|}{s_1^2}ds_1ds_2 \le$$

$$2\int_0^{\xi_1} t_1dt_1\left(\int_{t_1}^{\xi_1}\int_{a_2+\xi_2}^{b_2-\eta_2} |u(s_1+a_1,s_2)|^p ds_1ds_2\right)^{\frac{1}{p}}\left(\int_{t_1}^{\xi_1}\int_{a_2+\xi_2}^{b_2-\eta_2}\frac{1}{s_1^{2q}}ds_1ds_2\right)^{\frac{1}{q}} \le$$

$$\le 2l_2\int_0^{\xi_1}\frac{dt_1}{t_1^{\frac{1}{p}}}\left(\int_{t_1}^{\xi_1}\int_{a_2+\xi_2}^{b_2-\eta_2} |u(s_1+a_1,s_2)|^p ds_1ds_2\right)^{\frac{1}{p}} \le 2l_2\int_0^{\xi_1}\frac{dt_1}{t_1^{\frac{1}{p}}}\left(\int_{a_1+t_1}^{a_1+\xi_1}\int_{a_2+\xi_2}^{b_2-\eta_2} |u(s_1,s_2)|^p ds_1ds_2\right)^{\frac{1}{p}} \le$$

$$\le 2l_2\int_0^{\xi_1}\frac{dt_1}{t_1^{\frac{1}{p}}}\left(\int_{a_1+t_1}^{b_1-\frac{l_1}{2}}\int_{a_2+\xi_2}^{b_2-\eta_2} |u(s_1,s_2)|^p ds_1ds_2\right)^{\frac{1}{p}} = 2l_2\int_0^{\xi_1}\frac{\Omega_p(u,t_1,\frac{l_1}{2},\xi_2,\eta_2)}{t_1^{\frac{1}{p}}}dt_1,$$

$$\int_{a_1+\xi_1}^{b_1-\eta_1}\int_{a_2}^{a_2+\xi_2} |u(s_1,s_2)|\,ds_1ds_2 \le 2l_1\int_0^{\xi_1}\frac{\Omega_p(u,t_1,\frac{l_1}{2},\xi_2,\eta_2)}{t_1^{\frac{1}{p}}}dt_1,$$

$$\int_{b_1-\eta_1}^{b_1}\int_{a_2}^{a_2+\xi_2} |u(s_1,s_2)|\,ds_1ds_2 \le 4\int_0^{\eta_1}\int_0^{\xi_2} \frac{\Omega_p\left(u,\frac{l_1}{2},t_1t_2,\frac{l_2}{2}\right)}{t_1^{\frac{1}{p}}t_2^{\frac{1}{p}}}dt_1dt_2,$$

$$\int_{b_1-\eta_1}^{b_1}\int_{a_2+\xi_2}^{b_2-\eta_2}|u(s_1,s_2)|\,ds_1ds_2 \le 2l_2\int_0^{\eta_1}\frac{\Omega_p(u,\frac{l_1}{2},t_1\xi_2,\eta_2)}{t_1^{\frac{1}{p}}}dt_1,$$

$$\int_{a_1+\xi_1}^{b_1-\eta_1}\int_{b_2-\eta_2}^{b_2}|u(s_1,s_2)|\,ds_1ds_2 \le 2l_1\int_0^{\eta_2}\frac{\Omega_p(u,\xi_1,\eta_1\frac{l_1}{2},t_2)}{t_2^{\frac{1}{p}}}dt_2,$$

$$\int_{a_1+\xi_1}^{b_1-\eta_1}\int_{a_2+\xi_2}^{b_2-\eta_2}|u(s_1,s_2)|\,ds_1ds_2 \le 4l_1l_2\Omega(u,\xi_1,\eta_1,\xi_2,\eta_2)$$

Из последних неравенств при $\xi_i=\eta_i=\frac{l_i}{2}$, $i=1,2$ вытекает, что $u\in L_1(\Delta)$, откуда следует, что $\tilde{u}$ существует почти везде.

Далее, для почти всех $x_i\in[a_i+\xi_1,b_2-\eta_2]$ $(i=1,2)$ имеет место равенство

$$\tilde{u}(x_1,x_2)=\int_{a_1}^{b_1}\int_{a_2}^{b_2}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2 =$$

$$=\int_{a_1}^{a_1+\frac{\xi_1}{2}}\int_{a_2}^{a_2+\frac{\xi_2}{2}}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2+\int_{a_1}^{a_1+\frac{\xi_1}{2}}\int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2+$$

$$\int_{a_1}^{a_1+\frac{\xi_1}{2}}\int_{b_2-\frac{\eta_2}{2}}^{b_2}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2+\int_{a_1+\frac{\xi_1}{2}}^{b_1-\frac{\eta_1}{2}}\int_{a_2}^{a_2+\frac{\xi_2}{2}}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2+$$

$$\int_{a_1+\frac{\xi_1}{2}}^{b_1-\frac{\eta_1}{2}}\int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2+\int_{a_1+\frac{\xi_1}{2}}^{b_1-\frac{\eta_1}{2}}\int_{b_2-\frac{\eta_2}{2}}^{b_2}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2+$$

$$\int_{b_1-\frac{\eta_1}{2}}^{b_1}\int_{a_2}^{a_2+\frac{\xi_2}{2}}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2+\int_{b_1-\frac{\eta_1}{2}}^{b_1}\int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2+$$

$$\int_{b_1-\frac{\eta_1}{2}}^{b_1}\int_{b_2-\frac{\eta_2}{2}}^{b_2}\frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)}ds_1ds_2=\sum_{k=1}^{9}I_k(x_1,x_2).$$

Следовательно,

$$\Omega_p(\tilde{u},\xi_1,\eta_1,\xi_2,\eta_2)\le\Big(\int_{a_1+\xi_1}^{b_1-\eta_1}\int_{a_2+\xi_2}^{b_2-\eta_2}\Big|\sum_{k=1}^{9}I_k(x_1,x_2)\Big|^p\,dx_1dx_2\Big)^{\frac{1}{p}}\le\sum_{k=1}^{9}\Big(\int_{a_1+\xi_1}^{b_1-\eta_1}\int_{a_2+\xi_2}^{b_2-\eta_2}|I_k(x_1,x_2)|^p dx_1dx_2\Big)^{\frac{1}{p}}=\sum_{k=1}^{9}I_k$$

Оценивая слагаемые по норме $L_p(\bar{\Delta})$ $\bar{\Delta}=[a_1+\xi_1,b_1-\eta_1]\times[a_2+\xi_2,b_2-\eta_2]$ $i=1,2$ аналогично предыдущему, получим

$$|I_1|_{L_p(\bar{\Delta})} = \Big(\int_{a_1+\xi_1}^{b_1-\eta_1} \int_{a_2+\xi_2}^{b_2-\eta_2} \left| \int_{a_1}^{a_1+\frac{\xi_1}{2}} \int_{a_2}^{a_2+\frac{\xi_2}{2}} \frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)} ds_1 ds_2 \right|^p dx_1 dx_2 \Big)^{\frac{1}{p}} \leq$$

$$\leq 16 \frac{1}{(p-1)^{\frac{2}{p}}} \frac{1}{\xi_1^{\frac{1}{q}} \xi_2^{\frac{2}{q}}} \int_0^{\frac{\xi_1}{2}} \int_0^{\frac{\xi_2}{2}} \frac{\Omega_p\left(u, t_1, \frac{l_1}{2}, t_2, \frac{l_2}{2}\right)}{(t_1 t_2)^{\frac{1}{p}}} dt_1 dt_2,$$

$$|I_3|_{L_p(\bar{\Delta})} = \Big(\int_{a_1+\xi_1}^{b_1-\eta_1} \int_{a_2+\xi_2}^{b_2-\eta_2} \left| \int_{a_1}^{a_1+\frac{\xi_1}{2}} \int_{b_2-\frac{\eta_2}{2}}^{b_2} \frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)} ds_1 ds_2 \right|^p dx_1 dx_2 \Big)^{\frac{1}{p}} \leq$$

$$\leq 16 \frac{1}{(p-1)^{\frac{2}{p}}} \frac{1}{\xi_1^{\frac{1}{q}} \eta_2^{\frac{2}{q}}} \int_0^{\frac{\xi_1}{2}} \int_0^{\frac{\eta_2}{2}} \frac{\Omega_p\left(u, t_1, \frac{l_1}{2}, \frac{l_2}{2}, t_2\right)}{(t_1 t_2)^{\frac{1}{p}}} dt_1 dt_2,$$

$$|I_7|_{L_p(\bar{\Delta})} = \Big(\int_{a_1+\xi_1}^{b_1-\eta_1} \int_{a_2+\xi_2}^{b_2-\eta_2} \left| \int_{b_1-\eta_1}^{b_1} \int_{a_2}^{a_2+\frac{\xi_2}{2}} \frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)} ds_1 ds_2 \right|^p dx_1 dx_2 \Big)^{\frac{1}{p}} \leq$$

$$\leq 16 \frac{1}{(p-1)^{\frac{2}{p}}} \frac{1}{\eta_1^{\frac{1}{q}} \xi_2^{\frac{1}{q}}} \int_0^{\frac{\eta_1}{2}} \int_0^{\frac{\xi_2}{2}} \frac{\Omega_p\left(u, \frac{l_1}{2}, t_1, t_2 \frac{l_2}{2}\right)}{(t_1 t_2)^{\frac{1}{p}}} dt_1 dt_2,$$

В силу теоремы М.Рисса [17]

$$|I_2|_{L_p(\bar{\Delta})} = \Big(\int_{a_1+\xi_1}^{b_1-\eta_1} \int_{a_2+\xi_2}^{b_2-\eta_2} \left| \int_{a_1}^{a_1+\frac{\xi_1}{2}} \int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}} \frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)} ds_1 ds_2 \right|^p dx_1 dx_2 \Big)^{\frac{1}{p}} \leq$$

$$\leq 4 \frac{1}{(p-1)^{\frac{1}{p}}} \frac{1}{\xi_1^{\frac{1}{q}}} \Big(\int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}} \left| \int_{a_1}^{a_1+\frac{\xi_1}{2}} A(s_1,s_2)\, ds_1 \right|^p dx_2 \Big)^{\frac{1}{p}} \leq$$

$$4 \frac{1}{(p-1)^{\frac{1}{p}}} \frac{1}{\xi_1^{\frac{1}{q}}} \int_{a_1}^{a_1+\frac{\xi_1}{2}} \Big(\int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}} |A(s_1,x_2)|^p dx_2 \Big)^{\frac{1}{p}} ds_1 \leq \leq A_p \frac{1}{\xi_1^{\frac{1}{q}}} \int_{a_1}^{a_1+\frac{\xi_1}{2}} \left(\int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}} |u(s_1,s_2)|^p ds_2 \right)^{\frac{1}{p}} dx_1$$

$$= A_p \frac{1}{\xi_1^{\frac{1}{q}}} \int_{a_1}^{a_1+\frac{\xi_1}{2}} A(s_1) ds_1 \leq A_p \frac{1}{\xi_1^{\frac{1}{q}}} \int_0^{\frac{\xi_1}{2}} \frac{1}{t_1^{\frac{1}{q}}} \left(\int_{a_1+t_1}^{b_1-\frac{\eta_1}{2}} |A(s_1)|^p ds_1 \right)^{\frac{1}{p}} dt_1$$

$$= A_p \frac{1}{\xi_1^{\frac{1}{q}}} \int_0^{\frac{\xi_1}{2}} \frac{1}{t_1^{\frac{1}{q}}} \left(\int_{a_1+t_1}^{b_1-\frac{l_1}{2}} \int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}} |u(s_1,s_2)|^p ds_1 ds_2 \right)^{\frac{1}{p}} dt_1 = A_p \frac{1}{\xi_1^{\frac{1}{q}}} \int_0^{\frac{\xi_1}{2}} \frac{\Omega_p(u, t_1 \frac{l_1}{2}, \frac{\xi_2}{2}, \frac{\eta_2}{2})}{t_1^{\frac{1}{p}}} dt_1$$

Аналогично оценивается I_4, I_6, I_8, I_9. Теперь оценим I_5 в норме $L_p(\bar{\Delta})$. В силу теоремы [16], имеем

$$|I_5|_{L_p(\tilde{\Delta})} = \Big(\int_{a_1+\xi_1}^{b_1-\eta_1} \int_{a_2+\xi_2}^{b_2-\eta_2} \Big| \int_{a_1}^{b_1-\frac{\eta_1}{2}} \int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}} \frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)} ds_1 ds_2 \Big|^p dx_1 dx_2 \Big)^{\frac{1}{p}} \leq$$

$$\leq \Big(\int_{a_1+\frac{\xi_1}{2}}^{b_1-\frac{\eta_1}{2}} \int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}} \Big| \int_{a_1}^{b_1-\frac{\eta_1}{2}} \int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}} \frac{u(s_1,s_2)}{(s_1-x_1)(s_2-x_2)} ds_1 ds_2 \Big|^p dx_1 dx_2 \Big)^{\frac{1}{p}} \leq$$

$$\leq A_p \Big(\int_{a_1+\frac{\xi_1}{2}}^{b_1-\frac{\eta_1}{2}} \int_{a_2+\frac{\xi_2}{2}}^{b_2-\frac{\eta_2}{2}} |u(s_1,s_2)|^p ds_1 ds_2 \Big)^{\frac{1}{p}} = A_p \Omega_p\Big(u, \frac{\xi_1}{2}, \frac{\eta_1}{2}, \frac{\xi_2}{2}, \frac{\eta_2}{2}\Big)$$

где постоянная A_p независит от $\xi_i, \eta_i (i = 1,2)$. Теорема доказана.

Для стандартной схемы построим новые инвариантные пространства для оператора $\tilde{u}$.

Обозначим через G класс положительных функций $\varphi(\xi_1, \eta_1, \xi_2, \eta_2)$ определенных при $0 < \xi_i, \eta_i,\ \xi_i + \eta_i \leq l_i, i = 1,2; \varphi(\xi_1, \eta_1, \xi_2, \eta_2)$ почти убывает по $\xi_i, \eta_i\ (i = 1,2)$,

$$\varphi(\xi_1, \eta_1, \xi_2, \eta_2) = \varphi\Big(\xi_1, \frac{l_1}{2}, \xi_2, \frac{l_2}{2}, \eta_2\Big) + \varphi\Big(\frac{l_1}{2}, \eta_1, \xi_2, \frac{l_2}{2}\Big) + \varphi\Big(\xi_1, \frac{l_1}{2}, \frac{l_2}{2}, \eta_2\Big) + \varphi\Big(\frac{l_1}{2}, \eta_1, \frac{l_1}{2}, \eta_2\Big).$$

Пусть $\varphi \in G$. Введем Z_φ^p −множество измеримых на Δ функций таких, что $\Omega_p(\mathrm{u}, \xi_1, \eta_1, \xi_2, \eta_2) = 0\big(\varphi(\xi_1, \eta_1, \xi_2, \eta_2)\big)$. Нетрудно проверить, что множество Z_φ^p в норме

$$\|u\|_{Z_\varphi^p} = \sup_{\substack{\xi_i, \eta_i \\ i=1,2}} \frac{\Omega_p(u, \xi_1, \eta_1, \xi_2, \eta_2)}{\varphi(\xi_1, \eta_1, \xi_2, \eta_2)}$$

является банаховым пространством.

Теорема 2. Пусть $\varphi \in G$ и сходятся интегралы

$$\int_0^{\xi_1} \int_0^{\xi_2} \frac{\varphi\left(t_1, \frac{l_1}{2}, t_2, \frac{l_2}{2}\right)}{(t_1 t_2)^{\frac{1}{p}}} d\, t_1 dt_2, \int_0^{\xi_1} \int_0^{\eta_2} \frac{\varphi\left(t_1, \frac{l_1}{2}, \frac{l_2}{2}, t_2\right)}{(t_1 t_2)^{\frac{1}{p}}} dt_1 dt_2$$

$$\int_0^{\eta_1} \int_0^{\xi_2} \frac{\varphi\left(\frac{l_1}{2}, t_1, t_2, \frac{l_2}{2}\right)}{(t_1 t_2)^{\frac{1}{p}}} d\, t_1 dt_2, \int_0^{\eta_1} \int_0^{\eta_2} \frac{\varphi\left(\frac{l_1}{2}, t_1, \frac{l_2}{2}, t_2\right)}{(t_1 t_2)^{\frac{1}{p}}} dt_1 dt_2$$

Тогда $\tilde{u}: Z_\varphi^p \to Z_{K(\varphi)}^p$, если же $K(\varphi) = 0(\varphi(\xi_1, \eta_1, \xi_2, \eta_2))$ то $\tilde{u}: Z_\varphi^p \to Z_\varphi^p$ и ограничен.

Введем пространства $J_p(\psi_1, \psi_2, \psi_3, \psi_4)$. Пусть $\psi_i > 0$ п. в. и $\psi_i \in L_1(\Delta_1), \Delta_1[0, l_1, 0, l_2]\ i = \overline{1,4}$. Обозначим

$J_p(\psi_1, \psi_2, \psi_3, \psi_4) = \{u =$ изм:

$$K_1 = \int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \Omega_p^p\Big(u, \xi_1, \frac{l_1}{2} \xi_2, \frac{l_2}{2}\Big) \psi_1(\xi_1, \xi_2) d\xi_1 d\xi_2 < +\infty,$$

$$K_2 = \int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \Omega_p^p\Big(u, \frac{l_1}{2}, \xi_1, \xi_2, \frac{l_2}{2}\Big) \psi_2(\xi_1, \xi_2) d\xi_1 d\xi_2 < +\infty,$$

$$K_3 = \int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \Omega_p^p\left(u, \xi_1, \frac{l_1}{2}, \frac{l_2}{2}, \xi_2\right) \psi_3(\xi_1, \xi_2) d\xi_1 d\xi_2 < +\infty,$$

$$K_4 = \int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \Omega_p^p\left(u, \frac{l_1}{2}, \xi_1, \frac{l_2}{2}, \xi_2\right) \psi_4(\xi_1, \xi_2) d\xi_1 d\xi_2 < +\infty\}.$$

В норме $\|u\|_{J_p(\psi_1,\psi_2,\psi_3,\psi_4)} = \max_i\{K_i^{\frac{1}{p}}, i = \overline{1,4}\}$, $\left\{J_p, \|.\|_{j_p}\right\} - B -$ пространство.

Теорема 3. Пусть $\psi_i \in L_1(\Delta_1)$ и почти везде на Δ_1 $\psi_i > 0$ и функция

$x_1 x_2 (x_1 x_2 \psi_i(x_1, x_2))^{\frac{-q}{p}}$ почти возрастает, кроме того

$$\int_0^{x_1} \int_0^{x_2} \frac{dt_1 dt_2}{(t_1 t_2 \psi_i(t_1, t_2))^{\frac{q}{p}}} = O\left(\frac{x_1 x_2}{(x_1 x_2 \psi_i(x_1, x_2))^{\frac{q}{p}}}\right),$$

$$i = \overline{1,4}, \qquad \frac{1}{p} + \frac{1}{q} = 1, p > 1,$$

тогда $\|\tilde{u}\|_{j_p} \leq const \|u\|_{j_p}$, где постоянная не зависит от $\boldsymbol{u}$.

Доказательство. Воспользовавшись теоремой 1, получим

$$\int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \Omega_p^p\left(\tilde{u}, \xi_1, \frac{l_1}{2} \xi_2, \frac{l_2}{2}\right) \psi_1(\xi_1, \xi_2) d\xi_1 d\xi_2 \leq const \int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \psi_1(\xi_1, \xi_2) (K(\Omega_p))^p d\xi_1 d\xi_2$$

Оценим

$$J = \int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \frac{\psi_1(\xi_1, \xi_2)}{(\xi_1 \xi_2)^{\frac{p}{q}}} d\xi_1 d\xi_2 \left(\int_0^{\xi_1} \int_0^{\xi_2} \frac{\Omega_p\left(u, t_1, \frac{l_1}{2}, t_2 \frac{l_2}{2}\right)}{(t_1 t_2)^{\frac{1}{p}}} dt_1 dt_2\right)^p =$$

$$\int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \frac{\psi_1(\xi_1, \xi_2)}{(\xi_1 \xi_2)^{p-1}} d\xi_1 d\xi_2 \left(\int_0^{\xi_1} \int_0^{\xi_2} \Omega_p\left(u, t_1, \frac{l_1}{2}, t_2, \frac{l_2}{2}\right) \psi_1^{\frac{1}{p}}(t_1, t_2) (t_1 t_2 \psi_1(t_1, t_2))^{\frac{-1}{p}} dt_1 dt_2\right)^p$$

По условию теоремы

$$\int_0^{x_1} \int_0^{x_2} \frac{dt_1 dt_2}{(t_1 t_2 \psi_i(t_1, t_2))^{\frac{q}{p}}} = O\left(\frac{x_1 x_2}{(x_1 x_2 \psi_i(x_1, x_2))^{\frac{q}{p}}}\right),$$

отсюда по лемме [4] существует $\alpha \in (0,1)$ что функция

$$\frac{(t_1 t_2)^{1-\alpha}}{(t_1 t_2 \psi_i(t_1, t_2))^{\frac{q}{p}}}$$

почти возрастает по t_1, t_2. Кроме того, зафиксируем r' такой, что

$$(1-\alpha)\frac{1}{q} < \frac{1}{r'} < \frac{1}{q}$$

и пусть $\frac{1}{r} + \frac{1}{r'} = 1$. Очевидно, что $p > r$. Применяя во внутреннем интеграле неравенства Гельдера и учитывая предыдущее, получим

$$J \leq \int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \frac{\psi_1(\xi_1, \xi_2)}{(\xi_1 \xi_2)^{p-1}} d\xi_1 d\xi_2 \left(\int_0^{\xi_1} \int_0^{\xi_2} (\Omega_p(u, t_1, \frac{l_1}{2}, t_2, \frac{l_2}{2}) \psi_1^{\frac{1}{p}}(t_1, t_2))^r dt_1 dt_2\right)^{\frac{p}{r}}$$

$$\frac{(\xi_1 \xi_2)^{(1-\alpha)\frac{p}{q}}}{\xi_1 \xi_2 \psi_1(\xi_1, \xi_2)} \left(\int_0^{\xi_1} \int_0^{\xi_2} (t_1 t_2)^{-(1-\alpha)\frac{r'}{q}} dt_1 dt_2\right)^{\frac{p}{r'}} =$$

$$= C \int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \left(\frac{1}{(\xi_1 \xi_2)^{p-1}} \int_0^{\xi_1} \int_0^{\xi_2} (\Omega_p(u, t_1, \frac{l_1}{2}, t_2, \frac{l_2}{2}) \psi_1^{\frac{1}{p}}(t_1, t_2))^r dt_1 dt_2\right)^{\frac{p}{r}} d\xi_1 d\xi_2$$

Далее, $\frac{p}{r} > 1$ следовательно, в силу неравенства Харди-Литтльвуда [9]

$$J \leq C \int_0^{\frac{l_1}{2}} \int_0^{\frac{l_2}{2}} \Omega_p^p \left(u, t_2, \frac{l_2}{2}, t_2, \frac{l_2}{2}\right) \psi_1(t_1, t_2) dt_1 dt_2.$$

Остальные слагаемые оцениваются аналогично.

Методом последовательных приближений доказана разрешимость нелинейного бисингулярного интегрального уравнения

$$u(x_1, x_2) = \lambda \int_0^{b_1} \int_0^{b_2} \frac{f(s_1, s_2, u(s_1, s_2))}{(s_1 - x_1)(s_2 - x_2)} ds_1 ds_2$$

в Z_φ, где функция $f(s_1, s_2, u)$ определена на $(a_1, b_1) \times (a_2, b_2) \times (-\infty, +\infty)$ и λ-действительный параметр.

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MOTIVATION PROCESS OF LEARNING IN ENGLISH THROUGH THE GAMES

Abstract: *The article is devoted to the study of the motivation features of students studying in institutions, universities, reviewing business and role-playing games to increase motivation and interest in learning the English language. Inspiration is the principle main impetus in human conduct and movement, in the very procedure of molding the future expert; intentions are a portable framework that can be affected.*

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Introduction

"Motivation is the main driving force in human behavior and activity, in the very process of shaping the future professional; motives are a mobile system that can be influenced" [1].

One of the most effective methods of increasing educational motivation is the introduction of non-traditional technologies in the learning process. Teachers of a foreign language, along with traditional types of classes, apply gaming technologies everywhere. The use of game forms in foreign language lessons in high school is widely described in the scientific literature. In essence, the students of a secondary vocational educational institution (technical school or college) are the same schoolchildren, at the age of 15-17 they could sit at a school desk if they did not choose the path to obtaining a professional education.

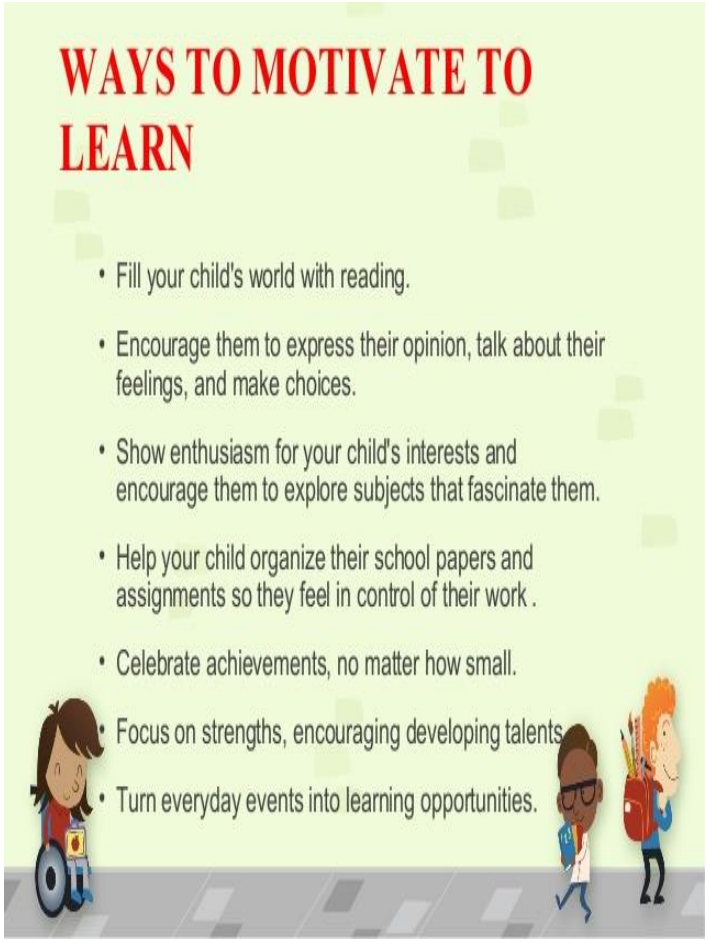
Picture 1.

At the same time, the ways of motivating school and university students with all their similarities have fundamental differences. At primary and secondary school age, children are easily motivated by a reward and evaluation system, since they are characterized by a desire to please parents, like teachers, and compete with classmates (to be the first). Finally, the upcoming final exams - the Unified State Examination and the Unified State Examination, on which a lot depends on the important role in motivation. Given these behavioral peculiarities of schoolchildren, teachers of a foreign language use game technologies to a greater extent for an unconventional form of presentation of grammatical material than to increase educational motivation. In the game, students learn language material more easily and decide to demonstrate their speech skills. For school children, the use of active outdoor games is offered in foreign language lessons.

I. RESEARCH METHODOLOGY

Students have a completely different picture: they no longer have a desire to please their parents, they are more indifferent to each other's academic successes, they also no longer have a fear of exams, since they have enough of a minimum mark in the Foreign Language discipline. At this age, teens have other interests that are supported in their "micro-society", in their environment. And in the absence of a ubiquitous fashion for learning foreign languages, especially in provincial areas, the most effective ways to increase motivation are interest and confidence that a foreign language will come in handy in the future, at least when traveling. These motivational components are easy to implement in the game. But only the nature of the games should correspond to the age characteristics of students of secondary educational institutions. Games like “find an object” or “guess an animal” among students will no longer be successful: they are “children's” games, and they are aimed at studying the “boring”, in their opinion, grammar. They are more interested in games as an element of entertainment and pleasure. And the task of the teacher is to offer them a game that will be both entertaining and cognitive. “Since the true source of a person’s motivation is in himself, it is necessary that he himself wants to do something and do this is. Therefore, the main motive for teaching is the internal motive power. Eastern wisdom says: "And one person can lead a horse to a watering-place, but even a hundred will not be able to make her drink water" ... So the student can be forced to sit in the classroom, but it is impossible to forcibly teach something and develop his abilities. A horse drinks water when he wants to drink, and a student learns when he wants to learn. A student will want and will study himself only when this lesson will be interesting and attractive to him” [3].

Most teachers use games that are educational in nature, their goal is to submit or consolidate language material. Particularly noteworthy are the games used by teachers for current or intermediate control. In such games, there is no pronounced educational sense. The teacher can easily do without them and test the students' knowledge with the help of a test or control, saving his time and effort. But just such games are very attractive from the point of view of increasing educational motivation. After all, not only the level of preparation and knowledge of the language plays a role here, but also ingenuity, speed of thinking, ability to work in a team.



Picture 2.

Here the spirit of useful rivalry and competition is successfully included, students forget that the teacher is testing their knowledge. And subconsciously, the whole period until the next game, they will be interested in foreign language lessons, of course, with the correct setting of goals and objectives by the teacher. To control the assimilation of language material, elements of business games are used to immerse students in a specially created situation and the need to implement language communication skills. For example, self-creation of dialogue between groups or teams of students on various topics: “In a restaurant”, “On an airplane”, “Acquaintance” etc. The conducted studies of ways and means of increasing educational motivation show that students encourage the holding of games in the classroom on the subject of "Foreign Language", are active and initiative. “Students see the most attractive side of the group form of training in the possibility of joint activities and communication in the classroom. This allows you to establish business and personal contacts, to ensure a certain group status. However, it is possible to become a desirable partner in joint activities only with a responsible attitude to learning. Thus, the desire to realize the motives of communication puts them before they need to engage in educational work. This, in turn, leads to the formation of educational motives, which in the future can occupy a dominant position in the motivational sphere of the individual” [2]. Activities such as business games implement the concept of learning in collaboration and are based on “modeling social interaction in the study group during classes or outside school hours. Students distribute their responsibilities for the implementation of the project and, in the process of solving real problem tasks, form interaction skills, learn to work in a team” [4].

II. ANALAYTICAL RESULTS & DISCUSSIONS

I wanted to draw attention to games not of educational or control nature, but to games aimed at bringing the teacher and students closer, to establish contact, so necessary for the successful process of learning a foreign language. The teacher must understand that his students no longer consider themselves children, they have entered adulthood, they are already acquiring a profession for this adult life. In addition, students at this age are very sensitive to manifestations of a personal attitude towards them on the part of adults, especially teachers. They consider themselves formed personalities (which they have every right to) and want to see respect for their personality. Therefore, the teacher’s step towards students, made in order to find out the circle of their

interests and preferences, will be a very important step in establishing contact between him and students and will guarantee the high efficiency of his work.

An example of such a game is the variation of one of the popular television programs among young people - the game "Where is the logic?" Several teams of students of 2–4 people take part in the game. The presenter calls on stage two teams that sit on the stage at a common table against each other. The facilitator sits at the same table in the middle (if possible, you can put separate tables for each team, and the facilitator is between the teams' tables, moving to each of the teams when announcing the question and listening to the answer). One team plays against another.

Throughout the game, teams perform various tasks and earn points. For each completed task, the team receives one point. The team that earns more points wins. The first one to answer is the team whose player presses the button the fastest. If the teams get into difficulty, they will be able to use the help promptly by contacting the host. The role of the leader is played by the teacher, in order to always be able to control the course of the game and help students out of difficult situations. After the game is completed by all teams, the total number of points is calculated and the results of the competition are announced.

Examples of tours and tasks for the game:

Step 1 "Find the general." Students are shown several pictures and teams will need to understand what unites them.

Job Option:

Answer: ***The USA***

Picture 3.

Step 2 "Formula of everything". Students see two pictures with a sign of addition between them. The team must understand ideas of two pictures and give an associative result that it turns out as a result of their addition.

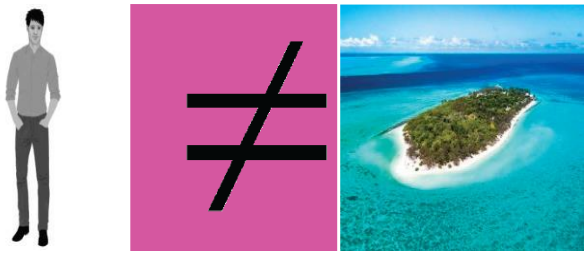
Job Option:

Answer: ***London eye***

Picture 4.

Step 3 "Guess the proverb." Students are shown several pictures and the teams will need to understand what a famous British proverb is encrypted in them.

Job Option:



*Answer: «**No man is an island**»*

Picture 5.

Step 4 "Guess the name of a literary work." At this stage, team members see the names of literary books of famous English writers encrypted in pictures.

Job Option:

*Answer: **Gulliver's Travels***

Picture 6.

The team that guessed the name gets 1 point. The team that names the author of the work receives an additional 1 point. In the process of such a game, the teacher will not only establish contact with students, but will also be able to find out the level of their activity, the circle of their interests, arouse interest in classes in them.

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In my teaching practice, this game helped me figure out the following:

1) students are interested in the theme of travel: they enthusiastically guessed tasks in which geographical names or famous sights were encrypted, while sharing their impressions or funny situations associated with these places (fortunately, the format of the game allows this, I only welcomed it);

2) students know the literary works of famous British writers, but do not know who their author is;

3) students are unacceptably little familiar with the features of British culture.

As a result of the analysis of the course of the game were formulated following conclusions:

1) Students during the game showed a noticeable revival and showed interest in future events, which means that the main goal of this event (establishing contact and increasing interest in learning a foreign language) was achieved.

2) In subsequent classes, students should be involved in tasks with elements of regional geography in order to maximize the students' interest in learning purposes.

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THE HISTORY OF THE TOPONYMS OF THE ANCIENT AND MEDIEVAL AGES

Abstract: *The article examines the toponyms of Fergana valley which are met in ancient and medieval sources. The author approached to the researches of the Russian and Uzbek specialists studied the toponyms in the Chinese chronicles, Arabian, Iranian and Sogdian sources and documents. Along with the toponyms the topoformants have also been investigated in the article.*

Key words: *toponyms, toponymy, astionym, oykonym, oronymy, hydronymy, topoformant, topoasos, etymology.*

Language: *English*

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Introduction

The names of places and the laws of naming them are studied in toponymics, one of the branches of onomastics. Being the products of the ancient times, the names of places are the part of a small history, which presents the information about the life of people. The language, religion, culture, ethics, thoughts, the mode of life of people along with farming, nature, social and political events occured in the society are collected in the place names. It is truly admitted that the main features of place names are its historicity and antiquity. The range of toponyms in our language is the products of the various times and languages. It is important to find out the period of creating and forming the place names. That is why it is necessary to render the linguistic components, words and word endings of toponyms and their meaning approaching to the social-linguistic factors of those times when the toponyms were created [1; 7, 11]. In this respect, we should note the importance of the ancient scriptures, sources and documents where the history of toponyms was cited. The profound investigations of these documents give the opportunity to make the correct inferences about the ancient variants of the geographical names, their lexical layers, nomination, etymology and other linguistic features.

In order to find out the ethnogenesis of the topoasos or topoformants the sources related to the historical toponymy of Ferghana region of Uzbekistan have been investigated. Mainly, we aimed to reveal the primary information about the socio-political life in Ferghana region, its geographical position and nature by examining the historical toponymy of the ancient and medieval sources of Central Asia.

The lack of the local written scriptures of the ancient times of our motherland makes the problem actual in order to approach to the studies of the written scriptures in other languages.

The main part

1. Toponyms in the ancient sources.

These sources included the Chinese chronicles which were directly related to the history of Ferghana state (II century B.C.-XII century A.D.) and Sogdian scriptures discovered in the mountains of Mug (VII – VIII centuries). The Chinese chronicles have a great importance by their antiquity, which had the sources

about "24 histories" [1], depicting the history of generations.

These sources were translated into Russian by N.Ya.Bichurin, N.V.Kyuner, L.S.Vasilyev, L.S.Perelomov, R.V.Vyatkin, B.S.Taskin and Yu.L.Krawl [2; 3; 4; 5; 6]; however, there are not complete translations in Uzbek language. Nevertheless, some parts of the chronicles related to Ferghana were initially translated into Uzbek language by A.Khojaev and the range of toponyms cited in the sources were given with the detailed comments [8].

According to the research of the professor A.Khojaev the toponyms in the territory of Ferghana were firstly mentioned by the "father" of the Chinese historians Sima Chyan and included in "Shiji", the first chapter of the collection of the official histories "24 histories" (104-91 B.C.). In this work, which consists of 130 chapters the records related to Feghana were placed in the 123th chapter, named as "The chronicles of Ferghana". This chapter of the book was written on the bases of the materials collected by Jan Chyan, who had been sent as ambassador to the countries of Central Asia by the emperor of Khan U-di. The horonym of Ferghana was given in this source as Dauyan "Davan".

As it was cited in Shiji, Dauyan is formed on the bases of Sogdian language and is considered the Chinese translation of Ferghana, which means: *day – great, big* and *uyan – bottom land* surrounded by mountains. Dauyan was accepted as Ferghana state [8; 358, 362]. It is pertinent to allege to some other sources of the V century A.D. as "Veyshu" and "Beyshi" that Ferghana had different names as Puoluona, Luona, in "Du Huan jingshin ji" it sounded Fahanna, in the sources of the times of Tang was named as Ninguan.

A.Khojaev explains this difference: "The historical events of "Veyshu and "Beyshi" depicted the Turkic generations. That is why the majority of the terms concerning the local place names of those countries, outside China, were written in the Chinese transcription. The toponym of Luona is the shortened variant of Puoluona, while Fahanna is the Chinese transcription of Parkona and Ferghana." [7; 127].

This situation can be seen in the names of the capitals of Ferghana state. Mainly, "Shiji", the first chapter of "24 histories" showed the capital of Ferghana as Yuan Cheng. If the components of the astionym are explained, the first hieroglyph *yuan* is the Chinese translation of Ferghana, *cheng* denotes "the city surrounded by walls". We can conclude from this source that the capital of Ferghana had the same name as Ferghana valley in the ancient times.

The matter of localization of Yuan-cheng was explored in the research of A.Anarbaev who conducted excavations in the territory of Eski Ahsikent. Basically the first Chinese chronicles "Shiji" had such information about Yuan-cheng or Feghana: "*There were not wells in the ruling city Yuan, so the drinking water was brought from flowing water outside the city" [7; 135]*. Indeed, having known about it, the Chinese closed the way of water when they were marching to Ferghana and kept the city without water for 40 days. A.Anarbaev assumed in his research when the water was brought from Kasansay within 14-15 km from the city the Chinese opened the water flowing to the capital. The plan made by the Chinese engineers was related to the city which was on the place of Eski Ahsikent [9; 11]. Moreover, in the works of at-Tabariy and Ibn Khordadbeh (VIII century) Ferghana was cited as the capital of the valley [10]. Ibn Khordadbeh wrote that in the VIII-IX centuries between Pop and Kuva there was placed Ferghana and the information about the exact distance between them was also given [11]. A.Anarbaev in his research found out that Ferghana was placed in the territory of Ahsikent [9; 14]. Generalizing all the archeological information taken from the Chinese and Arabian sources Ahsikent was called by the name of Ferghana, the same as Ferghana valley (according to the Chinese chronicles in the II century B.C.; in the Arabian chronicles it corresponds to the VIII-IX centuries). According to the numismatics materials the capital of Ferghana valley had two names – Ferghana and Ahsikat [12; 11].

However, there was different information in "Hanshu", written 170 years after "Shiji" and in the sources after the V century, mainly in "Veyshu", which gave the names of Kiveyshen (Guyshan) as the capital of Ferghana. As the historians showed the different places to the astionym Guyshan, we suppose, it will be right to share the views of A.N.Bershtam and V.V.Bartold in showing its localization in Kasan [13; 19, 14; 529]. This city was a large military-political centre of Kushan's reign in the I century of Ferghana valley and was considered the capital of Ferghana ihshids[2] in the VII-VIII centuries, then rendered the status of the capital to the other large city - Ahsikent [13; 27].

Therefore, the Chinese source "Shiji" cited the oldest cities of Ferghana Rieyshey (Ershi) and Yuan-chen. Ershi was described as the city where "the pedigree horses with bloody sweat were raised". By this reason the Chinese began their military campaign to this city in 104-101 of B.C. The scientists stated the different locations of this city, but in the latest researches Ershi was considered as Osh city [7; 15; 65, 71]. Yuychen in "Shiji" was the first city of Ferghana

[1] «24 histories» – the history of Chinese generations from the II century. The events of 3000 c.B.C.-1644 c.A.D. were depicted

[2] rulers

attacked by Chinese and as the specialists cited it was on the place of the contemporary Uzgan city.

One of the ancient documents of the toponyms of the valley is the Sogda documents found in the fortress of the mountain Mug near Panjikent in the Republic of Tadjikistan in 1932.The documents of the Mug fortress were completely issued in Russian language due to A.A.Freyman, M.N.Bogolyubov, V.A.Livshits, O.I.Smirnova in 1960 [16; 17; 18]. In 1990-1992ss the great part of the documents of Mug fortress were translated into Uzbek with comments by M.Iskhakov [19].

In particular, in the translation and the comments by V.A.Livshits the horonym Ferghana was rendered as β r γ ʾn k // β r γ ʾn ʾk – *Far (a) gāna* or *Fragāna* in ancient Sogdian in the Mug documents A-14, B-17. The scientist asserted that Feghana was cited as Pa – han – na in the Chinese sources and claimed on rejecting the comparison of that place name with Parikana by Herodotus, referring to the Sogdian documents, where β r γ ʾ n k was not reflected as Parikana [17; 85].

In the A-14 documents the astionym *K n δ – Kand//Kend* was also mentioned, which is the name of the contemporary Kanibodom (Tadjikistan, the region of Sugd). It necessary to point out that this astionym was firstly mentioned in some other sources by the Arabian travelers in X century as *Kend*, in the form of *Kandibodom* in "Baburname" and "Khabib ub siyar", while the historical works of Kokand khanate gave the present name.

A.A.Freyman defined the astionym k n δ h – Hshikat//Hishikat, written on the wood of the Mug fortress, which was mentioned in Б-2 document as the Sogdian name of Ahsikent in Ferghana. As it was written in the documents, written till the X century the wine had been brought from γ s y k n δ h, and some other sources mentioned about grape wine producing in Ferghana.

Furthermore, in the documents Б-2, Б-10, Б-13 of Sogda the village of Falgar region in the upper part of Zaravshan , named by the same name (ʾγ s y k n δ h) was mentioned. The scientists N.N.Bogolyubov and O.I.Smirnova defined the formal similarity with the main city of Ferghana Ahsikent [18; 101, 102]. Consequently, in VII-VIII centuries there were two places with the same name γ s y k n δ h, one in Sodga ihshid and the other in land of Ferghana padishah[3].

2. The toponyms of the medieval centuries

The medieval centuries included several relics of the past; in particular, the scriptures by the group of Arabian travelers Istahriy, Ibn Havkal, Mukaddasiy, Samoniy, Yokut Hamaviy and the book "Hudud ul-olam" in Tadjik language (983) by an unknown author [20; 21; 22; 23]. The general and significant feature of these sources is that that all the sources gave the complete information about the geographical place, climate, administrative division, trade and language of the population, the description of the famous cities, oronymy and hydronymy of Ferghana region as the part of Maverannahr in the IX-XI centuries.

The influence of Sogdian language is seen in the greater part of the toponyms of the medieval sources. At present the Sodgian language is the dead language related to the northern-eastern group of Iranian languages, however, its elements are preserved in the language of yagnobs of upper Zaravshan. Therefore, the majority of the specialists in this sphere (M.N.Bogolyubov, S.I.Klimchitskiy, V.A.Livshin, A.L.Khromov) consider the yagnob language as the Sogdian dialect or call it as a new Sogdian language [24; 56].

The Sogdian and Turkic people were in closest economical, cultural and political relations in the ancient times, at the beginning of the epoch. These relations had an enormous impact on both languages. Though the Turkic people in Turkic khaganate had a leading power, the official language was the Sogdian language. Moreover, this language had the status of the international language on the Great Silk Way. The toponymic materials are considered the most valuable and important sources in the study of the influence of the Sogdian language on the Uzbek language. The words and the place names which had not been changed during the centuries illustrate the relations between Uzbek and Sogdian languages [24; 57].

One can observe the topoformants *-kan // -kon // -qon // -g'on; -kand // -jand // -qand // -gand; -kat // -kot; -kana // -g'ona // -gona; -ton // -don, mitan // miton; -kas // -xas // -xos; marg'; vara, par- // far-* related to the Sogdian language, which had been used in the toponymic system of the medieval centuries.

These elements had the independent meaning in the earlier periods, but during the ages they lost their lexical meaning and turned into toponymic formants.

It will be appropriate to mention the origin of the topoformants which were used productively. The specialist in the Sogdian toponymy P.B.Luryev asserts that the productive use of the Sogdian topoformant – kand//kent is the peculiar feature in Ferghana region [25; 105]. According to the research by E.M.Mursayev the place names of Central Asia formed with the help of these units are also met in Eurasia[26; 177] with several variants –*-kant//-kend//-qand//-kan//-kat//-qat//-ket//-kanda//-ganda.*

V.I.Abaev, who conducted thorough analyses of the topoformants' etymology, stated that it was formed from the ancient Iranian language *kan, kandan* with the meaning of *"to dig"* [27; 442, 458]. I addition to it, it denoted the meanings of "gathering in groups", "gathering", "putting above" in the Iranian language.

[3] ruler, king

V.I.Abaev also asserted that the past participle forms *kata, kanta* of the verb *kan, kandan* formed from the participle forms. The words *kata, kanta, kanda* had the meaning of "hollow", "pit", "hole" in Pahlavian and Avesto language. As the Uzbek toponymist T.Nafasov writes that later *kata, kat* denoted the lexeme "house", *kanta, kanda, kant* showed the meaning of "village", "city". The people surrounded their living places with ditches, hollows, walls. That is why the primary meaning is connected with the later meaning. These places were named *kat* or *kad* in the language of those times [24; 60].

Consequently, the Sogdian kan- denoting the verb "to dig" was used with the topoformants –kant//-kend or independently. As it was written in the work "Devonu lug'otit turk" by M.Kashgariy كَنْد *кänд-kand* denoted "village" in the language of oguz, while Turkic people had the meaning of "city" [28; 233]. We have found that the variants of the formants *–гänд (gand) // кänд (kand)// - жänд (jand)// -қänд (qand) // -кенд (kend) // -кад* (*kad)* were used in the place names Hojand, Hokand, Uzgand, Kend, Astuakend, Biskend, Bukand, Navkad, Nekad; the variants *-кат (kat)// -кет (ket) in Ahsikat, Voskat, Vankent, Shikit, Ardlanket; the variants –кан(kan) // -кон (kon) // -ган (gan) // -гона (gona) formed the place names Ustikan//Ushtikan, Andukan, Miskan, Tishan, Bigan, Zarkan, Fargona, Bagaskon.*

Under the influence of Sogdian language among the toponyms of the medieval ages *вар (var)// вара (vara)* can be met, denoting "fortress", "fortified city, village", "tumulus", "the place surrounded by walls". The origin of toponyms Asbara (Isfara), Fargona, Besafar and Farogina, Voruh met in "Baburname" related to the mentioned topoformant. The Sogdian variants are met in the toponymy of Uzbekistan as *нар // фар (far), парак (parak*) in the place names Parmetan (upper village), Pandiron (high tumulus), Panji (upper place), Fankad (upper tumulus), Piron (place surrounded by walls) [1; 206-209] and the *far* denoting "surrounded by hills", "surrounded by mountains" is met in the horonym Fargona (Ferghana).

In the medieval sources besides the mentioned Sogdian formants the toponyms Tamahus// Tamahush, Bamkaus//Bamkahush, Nomankohas, Digarkard, Tishan, Marginon, Kashukas, Hirsob, Miyon Rudon, Haftdeh, Nasrobod, Vagzi, Chadgal and some others with the components *хус // хуш (hush), хас (has), хан (han), кард (kard), марг (marg), кас (kas), дех (deh), об (ob), он (on), за (za)// зи (zi), обод (obod), гал (gal) // гар* (gar) related to Iranian and Sogdian languages can be met.

Conclusion

It can be concluded that the Sogdian language greatly influenced on the toponymy of the two periods. The chronicles, documents and ancient sources in Chinese, Sogdian, Arabian and Farsi languages provided with the toponyms of the two periods. The study of the toponyms of the definite periods according to the stages of their development is significant in revealing the problems of the related fields, finding out the ethnogenesis, etymology and the lexical layers of the historical toponyms, defining their nomination from the perspectives of those times, compare the primary forms, ancient variants with the phonetic and lexical processes in the different periods and make the valid inferences, which furthers the enrichment of the sources and the development of the historical toponymy.

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DETERMINATION OF THE CUTTING FORCE OF "MULTIRISK" MATERIALS USED IN MANUFACTURING OF THE PROTECTIVE CLOTHING

Abstract: *In order to ensure adequate protection, the clothing used by workers in the work process must be designed and made of materials known to have a certain "resistance" both to the risks for which they are intended and to the factors present in the work environment. Currently, the protective characteristics of clothing used against clearly defined hazards, such as chemicals, fire, molten metal droplets, etc. are addressed in various technical specifications (standards). Also, the standards specific to protective clothing include some mechanical characteristics, such as puncture and tear resistance, without taking into consideration the cut strength of materials, although in some situations, the danger of workers coming in contact with various cutting surfaces is inevitable. Given that in certain fields (agriculture, chemical industry, food industry, etc.) the risk of cutting is ubiquitous, and the characteristics of the materials used to make clothing are defining to ensure adequate protection, the study aims to follow the cutting behavior of materials with specific uses.*

Key words: *manufacturing, clothing, specifications.*

Language: *English*

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Introduction

Regardless of of the activity which is performed, workers may be exposed to physical, mechanical, chemical dangers, actions which may cause harm as occupational disease or injury.

There are many jobs, where in addition to the predominant dangerous factors (presence of fire, heat, cold, chemicals, etc.) workers may be exposed to the risk of cutting, due to:

- handling various sharp objects (bottles, plates, containers, knives, etc.) or
- occasional contact with various sharp surfaces.

Most minor cutting incidents occur on hands and body, these being the normal parts of the human which are involved in most activities that imply risks and the cause is not using personal protective equipment (abbreviated PPE) or using an inappropriate PPE.

The obligation to provide PPE [1, p. 8] to ensure adequate protection [2, p.2] of workers has led to the development of a wide range of materials to meet specific needs. Currently, most textile manufacturers test and certify the materials they make, in relation to different standards of requirements which establish criteria and levels of performance for certain characteristics, considered defining in ensuring adequate protection.

For certain sectors of activity, as a result of the use of hand knives or the handling of various cutting objects, where the risk of cutting is foreseeable, standards of requirements have been developed in which certain performance limits are imposed to

establish a certain level of protection. Thus, the standard SR EN ISO 13998: 2003 imposes for the protective clothing against cuts and blows of the hand knife with an average cutting force of at least 50 N [2, p.2], while for the protective gloves against mechanical risks, the standard EN 388: 2018 establishes 6 performance levels (A, B, C, D, E, F) classified according to cut force (2N, 5N, 10 N, 15 N, 22 N, 30 N) [4, p.7].

2. Purpose

In order to be placed on the market the protective clothing must meet, in addition to other essential health and safety requirements specific to certain risks, the following requirements in Regulation (EU) 2016/425 [5]:

- 1.3.2 on 'Light weight and solidity', which means that it must provide adequate protection against risks for which it is intended and be resistant to environmental factors under foreseeable conditions of use [5, p. 76] ;
- 3.3 on "Protection against mechanical injury", which means that the constituent materials of PPE must be chosen or designed to ensure sufficient resistance to abrasion, perforation and cutting under foreseeable conditions of use. [5, p.76; 6, p. 448]

Although the risk of cutting is pervasive in most workplaces, limited information is currently available on the cutting strength of different types of materials used to make protective clothing. The requirement in standard EN 13998 which refers to cutting strength is only considered for a high level of risk (such as that related to knife cutting), without taking into account that in certain situations, the danger of workers coming into contact with different sharp surfaces is inevitable [7, p. 107].

Thus, the study aimed to determine the cutting strength of different types of materials used to make protective clothing, in order to properly select them.

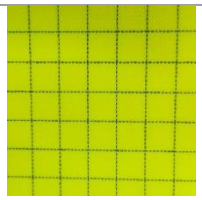
3. Criteria for selecting the test materials

To identify the elements that could influence the cutting force, were selected samples of materials frequently used in the production of chemical and "multi-risk" protective clothing , as they can be in a wide range: non-woven or woven, layered, with membranes, glued or laminated foils [8]. The criteria underlying the selection of materials used to perform the test series were the following:

- fibrous composition,
- specific mass [9, p. 17];
- thickness.

Considering the mentioned criteria, 6 types of materials were selected whose characteristics are presented in table 1.

Table 1. Characteristics of the materials selected for testing

Material code	Composition	Mass, g/m^2	Thickness, mm	Weave structure
 n	100% polypropylene laminated with polyethylene film	53	0,23	Nonwoven
 e1	98% polyester + 2% antistatic fibers + PU membrane	250	0,25	Plain 1/1
 e2	96% polyester + 4% antistatic fibers + PU membrane + knit	250	0,46	Twill 2/1

Material code	Composition	Mass, g/m^2	Thickness, mm	Weave structure
 e3	49% PPAN-fr + 42% cotton + 5% Para-aramid + 3% polyamide + 1% antistatic fibers	250	0,39	Twill 2/1
 e4	99% cotton + 1% antistatic fibers	220	0,48	Twill 2/1
 e5	65% Cotton + 33% polyester + 2% antistatic fibers	340	0,53	Twill 2/1
 e6	26% Cotton + 41% polyester + 32% modacrylic fibers + 1% antistatic fibers	330	0,80	compound bond

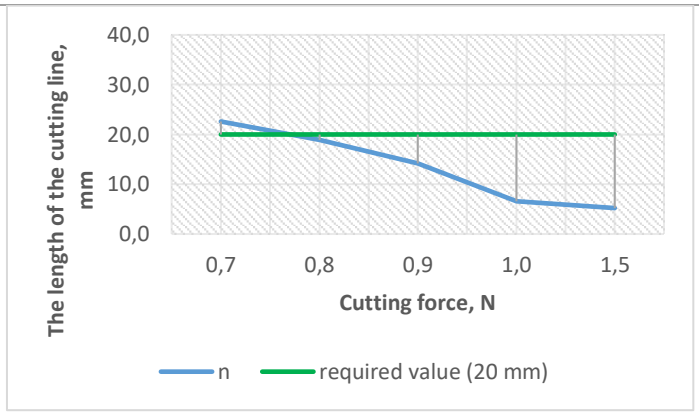
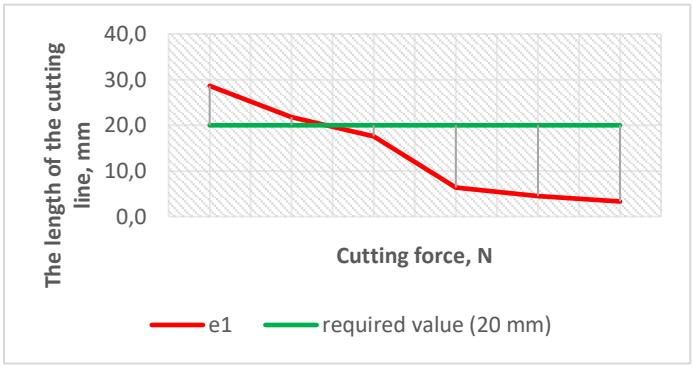
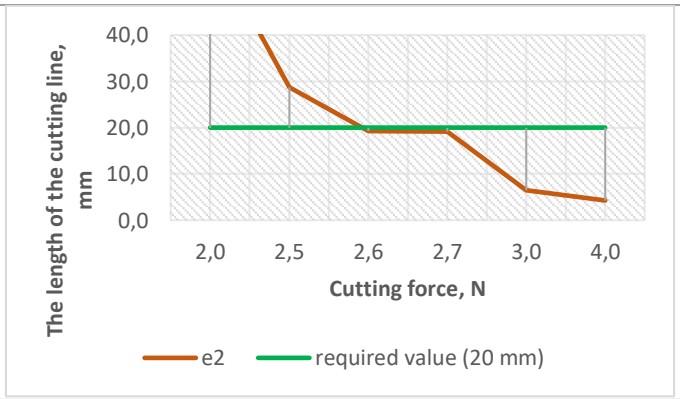
4. Tests and results

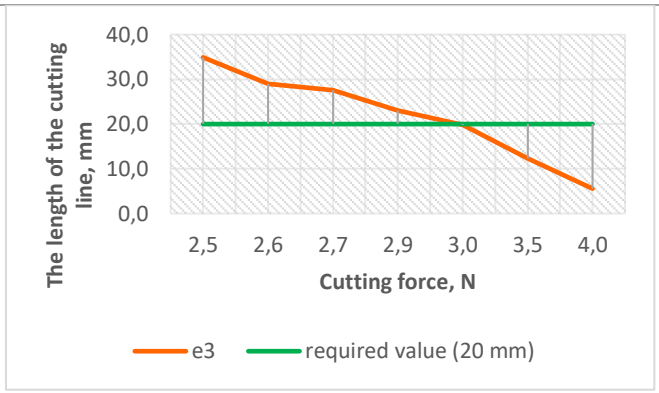
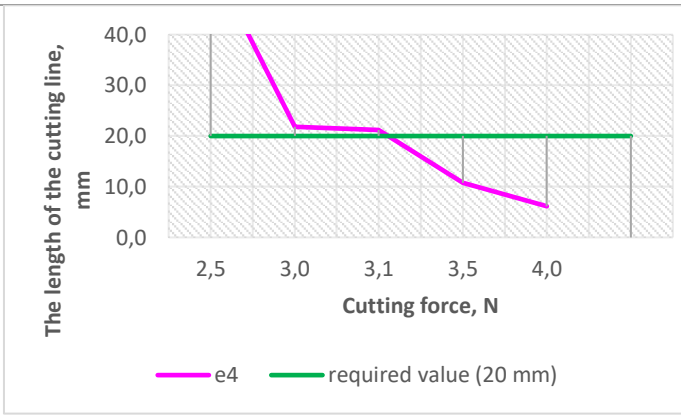
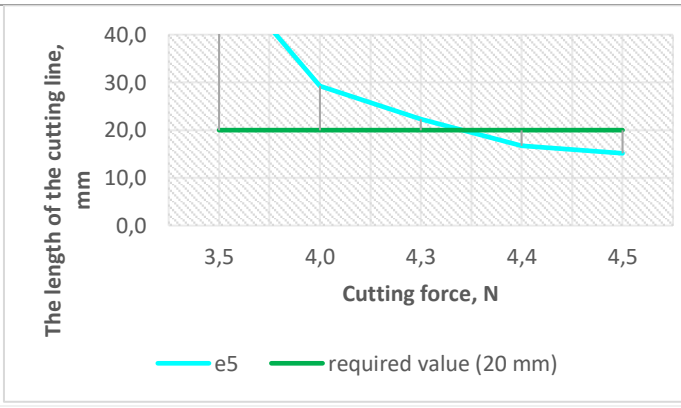
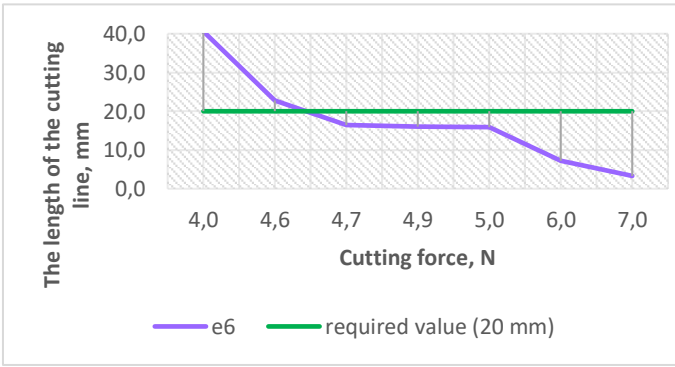
The determination of cut strength was based on compliance with the test method described in standard EN ISO 13997. In order to determine the force required to break through a material to a length of 20 mm, [10, p. 9] the specimens were taken at an angle of 45 degrees to the warp thread and were subjected to the cutting test with a stainless steel blade, on which different forces were applied (see figure 1).

Figure 1- Device for determining the cut strength

The results of the series of tests were summarized in Table 2.

Table 2. The results of the test series

Composition	Mass, g/m^2	Graph of determining the cutting force	Cutting force, N
100% polypropylene laminated with polyethylene film	53		0,77
98% polyester + 2% antistatic fibers + PU membrane	250		2,14
96% polyester + 4% antistatic fibers + PU membrane + knit	250		2,58

Composition	Mass, g/m^2	Graph of determining the cutting force	Cutting force, N
49% PPAN-fr + 42% cotton + 5% Para-aramid + 3% polyamide + 1% antistatic fibers	250		2,99
99% cotton + 1% antistatic fibers	220		3,12
65% Cotton + 33% polyester + 2% antistatic fibers	340		4,34
26% Cotton + 41% polyester + 32% modacrylic fibers + 1% antistatic fibers	330		4,64

Although it is known that the mechanical strength of the plain fabrics is higher than that of the twill fabrics, the comparative analysis of the results obtained for „e2" and „e3" specimens shows that although they have a similar composition, the cutting strength is higher in the case of the twill material.

Since the only differences between the two materials are the number of layers and the thickness, a first conclusion that can be drawn is that the cutting strength is not influenced by the type of weaving but by the thickness of the material.

Furthermore, the fact from above is also supported by the analysis of the „e5" and „e6" specimens. Even if there is often a tendency to say that a material with a higher specific mass is thicker or has a higher cutting strength, this is contradicted by comparing the results obtained for the „e5" and „e6" specimens. It should be noted that although the material from which the „e6" specimen was taken is „lighter" than the material from which the „e5" specimen was taken, in this case the cutting strength is higher. This may be the result to both the thickness, determined by the weaving mode, and the content of modacrylic fibers, which are in proportion of 1/3 of the fibrous composition.

In addition, by comparing the results obtained for the „n" and „e1" test pieces, it was observed that although the two materials have approximately equal thickness, they have different cutting forces. As expected, nonwovens have much lower cutting strength than woven materials, even if both types of material have the same chemical protection characteristics.

Overall, it can be said that the cutting strength:

- is very small in the case of nonwovens compared to woven materials;
- it is not significantly influenced by the specific mass of the material;
- it is higher in the case of thicker materials;
- it is larger if the fabric has aramid and modacrylic fibers in its composition.

By analysing the results obtained for all types of selected materials, it can be said that even if the material has been certified for a certain risk considered major, knowing the cutting strength of materials is really important for selecting appropriate protective clothing, considering the fact that each job is unique in the risks it may have.

5. Conclusions

As the characteristics of the materials used to make clothing worn by workers at work are defined to ensure adequate protection, the results of the study can be used to develop a set of guidelines for their rapid selection by PPE producers when:

- the basic risk is cutting;
- the risk, although hazardous to the worker, can significantly affect the protective characteristics of PPE against other risks that may seriously affect health.

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SEMANTIC AND ETYMOLOGICAL CLASSIFICATION OF ENGLISH AND UZBEK PHRASEOLOGICAL UNITS WITH PERSONAL NAMES

Abstract: *The article is devoted to the investigation of English and Uzbek phraseological units with proper name component. The author proposes different groups of such set expressions related to origin and semantics as well as compared the similarities and differences in both languages. Theoretical part of the article is proved by numerous examples of English and Uzbek phraseological units.*

Key words: *phraseological unit, anthroponym, historical person, historical event, semantics, prototype.*

Language: *English*

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Introduction

It is widely accepted that phraseology is closely linked to the history, culture ,traditions and literature of a nation. This connection is more evident in the phraseological units with proper names. In any cultureproper nouns, having deep roots in history, are deemed as socio-cultural sign and expresses national world of view. Proper nouns have extremely peculiar characteristics in lexico-semantic, grammar and stylistic layers of a language. Thus, thorough study of proper nouns in different linguistic contexts and speech becomes actual and important. Proper nouns (onyms) **–** (from Greekonoma- name) – words, word combinations or sentences which serve for singling out called objects among many similar kinds, individualizing and identifying the object [7, p. 171]. Actual becomes also a deep investigation of etymology and semantics of phraseological units with anthroponym component as they have been formed through a long historical period.

In this article we focus on phraseological units with anthroponym component. Anthroponyms – personal names of people: personal names, patronyms, family names, birth names, nicknames, pseudonyms, cryptonyms. [1] Anthroponyms are connected with the history of a culture, psychology of people and traditions of a nation. Superanskiy distinguishes two types of anthroponyms – individual and group (common) [7, p. 174]. Individual names of people indicate names of well-known people – personal names with individual connotation – (Shakespeare, Newton). Common personal names – personal names without individual connotation (Jack, Mary). Individual personal names are always associated with certain person and characteristics of a person are reflected by his/her name. Individual anthroponyms – *the admirable Crichton* – "incomparable Crichton", well-educated person; *according to Hoyle* – according to rules, according to plan; *Hobson's choice* – no alternative or choice at all. In phraseology, as a rule, there are individual names that are known worldwide and used in other languages: *Aflotun miya* – very knowledgeable person; *Sog' odamga Suqrotning keragi yo'q* – there is no need for Socrat for the healthy; but such individual names are not always obvious for other cultures. Group or common anthroponyms : *Lady Bountiful* – a women who engages in ostentatious acts of charity to impress others; *Dr. Jekyll and Mr. Hyde* – a person alternatively displaying good or evil personalities; *Aql Hasandir, odob Husandir* – mind is

Hasan, courtesy is Husan (Hasan and Husan are the typical names of twins).

Investigation of phraseological units with anthroponym component give grounds for considering proper nouns as preserver of cultural ideas and stereotypes, passed down from generation to generation[3, p. 4]. In the works of A.I Molotkov phraseological units with proper names are considered as a method of emotional-expressive comprehension of reality and reflection of a nation's subjective factor in the system of a language [5, p. 46].To our view, phraseological units with anthroponyms are major source of information about cultural, historical and sociolinguistic aspects of language carrier's life.

According to **the source of origin** both English and Uzbek phraseological units with anthroponym component can be divided into the following groups:

a**) phraseological units connected with the names of real historical people.** Anthroponyms are associated with famous people – distinguished political and military leaders, artists, compositors, writers and etc: *according to Cocker* – correct, certain (E. Cocker was an author of a mathematic textbook in XVII th centery) [9, p.105]; *John Hancock* – personal sign (J. Hancock was an American statesman whose sign was the first under the declarion of independance)[2,p 418]; *be in like Flynn* – seize an opportunity, be successful (Errol Flynn was an Australian-born actor and had a reputation as a notable playboy)[9,p.113]; *somewhere to the right of Genghis Khan* – holding the right wing views of extreme kind (Genghis Khan, the founder of Mongol empire is used here as a supreme example of a repressive and tyrannical ruler); *Jack Ketch* – hangman, executioner (from the name of an English hangman); *Amir Temurdan qolgan*–ancient, very old , out of date (Amir Temur was a great warrior, founder of Timur dynasty); *Xalqqa suyanib ish qilgan odamni Aflotun ham yiqita olmaydi* – a person who follows the nation can not be defeated even by Aflotun. Obviously, these people were either renowned for their remarkable achievements and admirable traits or notorious for their undesirable behavior and actions. Subsequently, the meaning of such phraseological units are closely linked to the special characters and actions of prototypes.

b) phraseological units emerged from literary sources. In both languages, literature and folklore significantly enriched the languages by giving expressive and vivid characters: *laugh like little Audrey* **–** laugh from the heart (the main character of a Shakespeare's comedy called "How do you like it?"); *a Mark Tapley* – a person who never gets depressed in any situation. (from the name of a character in Charles Dicken's novel); *a Peter Pan* – a person remaining with his childlike directness and lively imagination (from the name of a boy in J. Barrie's play); *Cordelia's gift* – soft and gentle woman voice (Cordelia, the heroine of a Shakespeare's tragedy, had such a voice); *Frankstein's monster* – a thing that becomes terrifying or destructive to its maker (the title of a novel by Mark Shelley). There are some stories that come from other languages and known worldwide and understood by majority of people in other cultures: *an Alladin's lamp* – a talisman that enables its owner to fulfill every desire; *an Alladin's cave* – a place full of valuable objects (from an Arabian Tale Nights). In Uzbek, there were found several phraseological units related to characters "Majnun" and "Layli" (main characters of Alisher Navoiy's "Layli and Majnun"): *Majnun bo'lib qolmoq* – to fall madly in love with someone ; *Laylini ko'rish uchun Majnunning ko'zi kerak* – beauty lies in lover's eyes*; Layli – har kimning mayli* – Layli is everyone's desire; "*Layli and Majnun"* is frequently used in everyday speech to refer to *"a couple who is desperately in love with each other"*; *Rustami doston bo'lmoq* – "to be epic poem", to be talked by many people for a long time. Most of these phraseological units are automatically used by native speakers as they have already become the symbols of certain human characteristics but they are unknown to people of different cultural background.

c) **phraseological units originated under the influence of certain historical events.** Certain events happened in the past had lasting impression on people and especially in English historical and social events affecting the majority undoubtedly left their traces in phraseology [10, p. 77]: *Morton's fork* – a situation in which there are two choices or alternatives whose consequences are equally unpleasant (Morton's fork was the argument used by John Morton (Archbishop of Canterbury and chief minister of Henry VII) to extract contributions to the royal treasury); *Potemkin village* – a sham or unreal thing (Count Potemkin (1739-91), a favourite of Empress Catherine II of Russia reputedly ordered a number of fake villages to be built for the empress's tour of the Crimea in 1787. We can find a plenty of such phraseological units in English, but there are few in Uzbek or they were not recorded: *Lenin o'lsa ham lelinizm tirik* – although Lenin dies, his political system is alive (V.ILenin was a Russian revolutionary politician and the head of the government when Uzbekistan was a colony of the Soviet Union).

d) **phraseological units related to religious beliefs/ in English Biblical names, mythonyms.** Religious beliefs take great place in language, especially in phraseology since religion is indispensable part of a culture: according to Islamic religion Adam was the first person in the world: *odam Atodan qolgan* – as old as the world, very old; in English there is a phraseological unit with the same meaning "*as old as Adam*". As the Bible is considered one of the ancient work of literature, it was translated into many languages and Biblical names are international: *the old Adam* – unregenerate human nature; *not to know someone from Adam* – not know

or be completely unable to recognize the person in question; *Benjamin's portion* – the largest share or portion; *the brand (or mark of Cain)* - stigma of a murderer, a sign of an evil; *raise Cain* – create trouble or commotion; *doubting Thomas* – a person who is difficult to be convinced, a sceptic. Ancient mythology include some anthroponyms too: *Achilles' heel* – a person' weak point; *Pandora's box* - a procedure that once begun generates many complicated problems; *sword of Damocles* – an imminent danger but most names in mythology are the names of gods (theonyms) and nymphs. *Qizni ko'rsa Hizir ham yo'ldan chiqadi* or *qizni ko'rsa Hizir ham dindan chiqadi* – having seen an attractive girl, even Hizir strays; *Sulaymon o'ldi, devlar qutuldi* – Suleyman died and ogres were released; *Hizir nazar solgan*– blessed, happy.

e) **phraseological units connected with common national names**. In both languages there are some personal names, surnames that are used to indicate typical people of a nation: *Brown, Jones and Robinson*– ordinary English people; the life of Riley (or Reilly) – luxurious or carefree existence (common Irish surname) ; *Tom, Dick and Harry* – used to refer to ordinary people in general; *to keep up with the Joneses* – try to maintain the same social and material standards as your friends and neighbours (Jones - British family names); *John Bull* – typical Englishman; Jack was one of the most widely used names – *every man Jack*– each and every person; in some phraseological units two names are combined to refer to a couple or friends: *Jack and Gill (or Jill)* – a young fellow and a girl; *a good Jack makes a good Gill* – if a husband is good, a wife will be good too; *Damos and Pythias* – two faithful friends. It should be noted that in Uzbek, typical names are mostly used in combination of two anthroponyms and semantically they generally mean "this or that", "all the same" or "to revenge on someone instead of another": *Eshmat ketib, Toshmat keldi* – leaving one, came another; *Alixo'ja – Xo'jaali* – it does not matter; yo Hasan, yo Husan – it is the same in both situations (Hasan and Husan are typical names of twins); *Alining o'chini Validan olmoq* – to take revenge on Vali istead of Ali.

It is interesting to note that some phraseological units may belong to two of the abovementioned groups. For instance, *all sir Garnet* – highly satisfactory (Sir Garnet Wolseley was a famous military leader and a main hero in Gilbert and Sullivan's " The Pirates of Penzanence"), *Ceaser' wife* – a person who is required to be above suspicion (G. J Caesar was well-known Roman dictator and politician and "Ceaser' wife" is connected with his decision to divorce his wife Pompeia).

Semantic classification of phraseological units with anthroponyms

Language is unique way of reflecting person's existence, products of his/her activities [8, p.5]. From a semantic point of view, phraseological units are related to human characteristics and activities [4, p.67]. Actually, phraseological units are essential source of information about person, his/her appearance, personality, intellectual and creative abilities.

In the process of investigation there were found two major semantic groups of phraseological units with anthroponyms:

1. **Phraseological units directly related to personal character, behavior and actions.**

2. Phraseological units that indicate things, situations and beverages.

1) Some phraseological units are associated with human traits, qualities, actions, physical and psychological states as well as various patterns of behavior: *peeping Tom* – extremely curious person; *Billy Bunter*–gluttonous, stout teenager, *Tom fool* – an idiot; *Jack of all trades*(*but master of none*) – a person who can do many jobs, but not specialist in any field.

These phraseological units can be divided into subgroups depending on the expression of subjective-objective marks:

a) ***positively marked phraseological units***: *admirable Crichton* – well-educated person; *a Beau Brummel* – handsome Brummel, dandy*; Johnny on the spot* – a person who is always ready to act, a reliable person; *aqli Salim* –a person who has a good judgement, a sensible person; *baloyi Azim* – talented (for everything), gifted, nimble person.

b) ***negatively marked phraseological units***: *Janus-faced* – hypocritical; *Paul Pry*–a person who pokes his/her nose into other's business, too curious person; *Lady Muck* - a haughty or socially pretentious women; *Tom o'Bedlam* – mad, insane; *Peck's Bad Boy* – a person who puts others in awkward position; *Ashir tarnov* – a very tall, awkward man; *boyagi boyagi, Boyxo'janing tayog'i* - a person who is reluctant to change (especially to positive side); *ishni qiladi Eshmat, lofni uradi Toshmat* – a person who boasts about himself while someone else does the work.

c) ***neutrally marked phraseological units*:** *Johnny Raw*–beginner, freshman, novice; a Jimmy Woodser – a person who drinks alone.

2) Some phraseological units contain anthroponyms which does not actualize its meaning and characterizes another objects, clothes, situations, beverages and event or phenomenon. *Prince Albert*(coat)–frock coat; *Jack Johnson* – heavy shell, missile; *real Mc Coy* – the authentic, genuine article; *bazmi Jamshid* – great feast, luxurious feast.

We can also distinguish two groups of such units regarding **the connection with a prototype:**

a) Some of the phraseological units referring to items have **immediate connection with the prototype**. They are closely linked to the life of certain people in history. They may be the things they created, particular style or clothes they wore, the items

they produced and etc. *Big Ben* – a clock on the building of the English parliament (Sir Benjamin Hall supervised its installation); *Joe Miller* – a joke-book, an anecdote book (from the name of an actor J. Miller who published the first anecdote-book); *Sally Lynn* – sweet bun (from the name of a confectioner); *Annie Oakley* – free ticket, free permit for the theatre (A. Oakley was a famous American actress).

b) Some phraseological units **have no or already lost connection with the anthroponyms** in their structure. In most cases, such units have common national names in their structure: *little Mary* – stomach; *John Collins*–a type of drink that is made of soda water, gin, lemon juice and ice; *bloody Mary* – cocktail made from vodka, tomato juice and ice; *long Tom* – a kind of fire gun.

Conclusion

It can be summarized that although originated in similar ways, English and Uzbek phraseological units which contain anthroponyms convey unique realities, historical facts, people and events belonging to each nation. We can rarely find exact synonyms of such units in other languages as they express specifics of cultural identity in each language. In most cases the meaning of such units closely associated with the origin of phraseological units. Thus, they are essential source of information about history, culture and traditions of an ethnos. Semantically phraseological units with anthroponym components are complex relating to both people and things. Containing different subjective-objective marks, such units carry implicit meaning for other nations.

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ENSURING FINANCIAL STABILITY IN THE MEDIUM-TERM SUSTAINABILITY OF THE LOCAL BUDGET IN UZBEKISTAN

Abstract: *This article analyzes the state of regulatory documents and their implementation in Uzbekistan for 2017-2021, aimed at the integrated economic development of the regions, ensuring the financial stability of local budgets, and preventing budget subordination to budgets with high budgets. Developed suggestions and recommendations to improve existing problems, based on the experience of developed foreign countries.*

Key words: *Economic development of the regions; vertical matching; horizontal matching; local budgets; financial stability of local budgets.*

Language: *English*

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Introduction

JEL Classification: H1, H2, H5.

A new stage of economic development in Uzbekistan began with the adoption of the Strategy of actions for the development of the Republic of Uzbekistan for 2017-2021. At this stage, the focus is on the integrated socio-economic development of the regions. In particular, the main goal of the strategy for the development and liberalization of the economy is to determine the goals and objectives of the State budget of the Republic of Uzbekistan, as well as budget allocations, sovereignty of the state budget and the most important budget revenues [1].

In the economic sphere, large-scale changes have been implemented, the most important step of which was the introduction of free conversion of the national currency, providing, first, the conditions for Uzbekistan to fulfill its obligations and repatriate the income of foreign partners, increase the investment attractiveness of the country.

Completely new principles and mechanisms for the formation of the State budget were introduced; measures were taken to ensure the transparency of its revenues and expenses. Measures have been taken to improve the efficiency of public asset management and the use of idle reserves aimed at increasing the budget revenue [2]. As part of this strategy, a conceptually new tax administration procedure has been introduced, with 5.5 trillion left at the disposal of local budgets. soums from overfulfillment of forecast indicators of tax collections, which is 6 times higher than in 2017 and 32 times higher than in 2016 [3].

Main part.

Our study showed that so far there is no single set of methods for assessing the financial situation of local budgets. Many economists, including scientists, publish scientific journals and international conferences, as well as an analysis of industry experts on the economics of income and expenses, their absolute variations, an analysis of comparisons of tax and non-taxable income, as well as high-budget share estimates, analysis of indicators such as share of each type of expenses in total costs.

In our opinion, given the financial development of the region, it is desirable to achieve a set of indicators representing a modern calculation of the economic activity of the region, as well as indicators reflecting economic efficiency.

This, in turn, provides that in 2019, one of the goals of economic development in Uzbekistan will be

to ensure that "further improvement of the system of efficient use of budgetary funds is a result-oriented indicator of qualitative and quantitative indicators of any program or project financed from the budget" . Financial sustainability should also cover all areas of the region, the dynamics of the formation and development of sectors, the distribution and redistribution of financial resources between sectors of the economy and entities [4].

Today, one of the most pressing socio-economic problems facing the state of Uzbekistan is the creation of an effective mechanism for state regulation of the domestic market. People's trust in the state, in its currency and long-term obligations are the main factors for the sustainable development of the economy. One of the conditions for their stable socio-economic development is to achieve a balance between revenues and expenditures of the local budget. The solution to this problem requires the formation of a sustainable budget system.

The budget system of Uzbekistan is two-tier, consisting of the republican and local budgets (covering the budget of the Republic of Karakalpakstan, the regions and the city of Tashkent, as well as the district and city budgets). The country's budget system is based on centralized budgeting, and, accordingly, there are some restrictions on local budgets in accordance with the current budget legislation. One of these limitations is the deficit of local budgets. The imbalances between revenues and expenditures of local budgets are regulated by higher budgets. In this regard, the assessment of fiscal stability is difficult.

Our study shows that local budgets identified the following issues:

– low collection of tax revenues to local budgets;

– the dependence of lower budgets on top-level budgets and the dependence of a high level of financial support on them;

– incompatibility of cost management of local budgets with their financial resources;

– allocation of fixed assets of local budgets for financing the social sphere, etc.

In general, there are two key types of budgets of varying degrees: vertical and horizontal alignment. Vertical alignment is aimed at the vertical balance of budgets. It implies a clear separation of powers and distribution of responsibility between levels of government. However, in our opinion, in order to solve the problems of ensuring budgetary balance, vertical alignment is best combined with horizontal budget alignment.

Horizontal alignment is a system of providing centralized financial assistance to authorities through the distribution of financial assistance to regions, and entities, in turn, transfer financial assistance to local budgets.

World experience on the problematic topics of scientific research indicates that the horizontal alignment method is also used in foreign countries. For example, in the US, the federal budget provides significant assistance to states in the form of targeted transfers. When distributing targeted financial assistance, formalized methods are used. Target transfers are the transfer of funds from a higher budget to a lower budget for specific purposes. In FY 2018, the federal government is expected to provide about $728 billion in federal financial assistance to state and local governments, covering a wide range of public policy areas, such as healthcare, transportation, income security, education, training, social services, community development and environmental protection[9].

Taking into account the experience of India in terms of the financial stability of the regions, financial assistance is allocated through high budget budgets, where inter-budgetary alignment is carried out by providing assistance to the regions, which combine the provision of financial resources to all states on a single basis, and to specific states with unfavorable social economic situation. In India, there are three types of central government transfers to states:

1) to provide subsidies for financing current expenses;

2) to finance public investment, including in the framework of development projects for specific states;

3) for socially significant projects.

The experience of Austria shows that equalization is carried out through transfers that are exclusively targeted.

Canada's fiscal equalization experience represents the implementation of annual non-earmarked grants to provinces with tax potential below standard. In Canada, the federal and provincial governments are equal partners of the federation in accordance with the constitution, and local governments do not have independent constitutional status.

The system of inter-budgetary equalization in Sweden consists in equalizing income, the purpose of which is to provide citizens with services of the same quality and at the same price throughout the state.

In Denmark, Sweden and Poland, self-government income and expenses are aligned with the state average income / expense. In Denmark, this difference is evened out on a state scale - 45% and an additional 40% to those local governments whose income after the first equalization is below 90% of the average income in the state. In Poland, only local government revenues are equalized.

Sweden has a very high level of equalization, and it reaches 95% of the average income / expense in the state. In Poland, a progressive equalization system is provided for those municipalities whose revenues range from 75% to 92% of the difference with the average incomes in the state, the subsidy is defined as

75%, those municipalities whose incomes are 40% - 75% of the average in the state, moreover, the amount of the subsidy is 80% of the difference, for the same municipalities whose incomes are below 40%, the subsidy is 90% of the difference from the average income in the state. In Germany, in turn, at the land level, the equalization system mainly aligns the differences between self-government incomes per inhabitant. The expenditure part takes into account only the population density of each land. From an analysis of the practice of EU states, it follows that the issue of the leveling level is most often solved by political means and the leveling level is greater in countries with a high level of national development and a low level of territorial differentiation.

On the issue of alignment, openness and transparency have an important place. Even in cases where the alignment is carried out by calculation according to formulas, the latter should be clear and understandable, and the data sources should be objective. In many EU countries, the amount of subsidies, the distribution mechanism or individual elements of equalization are determined in the process of forming the annual budget. In this regard, from the point of view of the development of democracy and decentralization, the role of holding consultations between the government and local governments, as well as their agreement on these issues, is very significant. In Austria, the requirement to carry out consultations on the issues of self-government finance is included in the Constitution, and in France, Greece, Portugal, Latvia, Lithuania and Poland - in the law or in another legal act, in Denmark, Finland and Slovakia - in the general agreement. In Latvia, the rules arising from the law provide for annual negotiations between the government and local governments, which are recorded and submitted to the parliament (diet) together with the draft annual budget law. An independent commission has been set up in Sweden to work out a methodology for distributing subsidies. However, in Hungary and Romania, the amount of the subsidy fund and the distribution method changes each year and is determined within the framework of the preparation of a certain budget, almost without consultation with self-government associations [4].

Thus, solving the problems of budgetary balance is the most important task. The mechanism of distribution of funds should solve the problems of both vertical and horizontal balance of budgets. And each country chooses a universal mechanism for securing the local budget suitable for them.

Researchers at Junxue Jia University of China, Yongzheng Liu, researchers at Jorge Martinez-Vazquez University, researchers at Boston University Kewei Zhang studied the vertical mismatch between budgets at different levels and local fiscal rules in China. According to the results of studies, it was found that higher levels of vertical fiscal imbalance cause fiscal indiscipline by reducing the tax efforts of local authorities. According to their comments, they said that they used a unique Chinese fiscal institution transferring tax powers on local taxes and divided taxes to two separate bodies (i.e., the local tax bureau and the central tax bureau, respectively) in several ways. We show that local governments respond to vertical fiscal imbalances by reducing their tax efforts on local taxes, but do not do so for shared taxes. In addition, the non-disciplinary effect of vertical fiscal imbalance is absent for extrabudgetary revenues, reflecting the institutional fact that extrabudgetary revenues are not taken into account when determining central fiscal transfers to local governments, thus not creating incentives for local governments to respond in this area [5].

Based on the study and the results of these studies, it can be said that the balance between different levels of budgets and the revision of revenues and expenditures between governments is also important for developing countries.

In order to ensure inter-budgetary balance at the medium-term development stage in Uzbekistan, to ensure equality of income and expenses of lower budgets and to ensure continuous social payments in the regions, targeted budget transfers were introduced:

Table#1. Revenues and expenses of local budgets, and dedicated targeted social transfers [11]

Regions	2018 FY, billion soums			2019 FY, billion soums		
	Revenues	Expenditures	Targeted Social Transfers	Revenues	Expenditures	Targeted Social Transfers
Karakalpakstan	1133,3	1740,0	606,7	2683,5	2683,5	
Andijan	1290,1	2162,1	872,0	1912,7	3292,0	1379,3
Bukhara	1226,1	1458,4	232,3	2266,6	2266,6	
Jizzakh	741,7	1153,8	412,1	1106,2	1836,8	730,6
Kashkadarya	1909,9	2223,5	313,6	3493,7	3793,7	
Navoiy	860,0	999,2	139,2	1495,8	1495,8	
Namangan	1088,4	1953,7	865,3	1784,7	3096,9	1312,2
Samarkand	1637,5	2629,9	992,3	2270,9	4031,8	1760,9

Surkhandarya	1052,1	1879,9	827,8	1657,2	2872,0	1214,8
Syrdarya	535,0	806,3	271,3	736,3	1217,4	481,1
Tashkent	1692,4	2066,8	374,3	3169,0	3169,0	
Ferghana	1588,0	2621,3	1033,3	4038,0	4038,0	
Khorazm	892,6	1411,7	519,1	1232,2	2116,4	884,2
Tashkent city	2378,9	2378,9	-	3236,2	3236,2	
Total:	**18026,0**	**25485,5**	**7459,3**	**31083,0**	**38846,1**	**7763,1**

According to table 1, targeted social transfers, which are introduced from 2018, will be directed to the local budgets of all regions except Tashkent, 7459.3 billion soums, in 2019, 7763.1 billion soums will be directed to the following areas: Andijan, Jizzakh, Namangan, Samarkand, Surkhandarya, Syr Darya and Khorezm.

In fulfilling the tasks set in the medium-term development strategy of Uzbekistan, the goals are set to ensure sustainable financing of the integrated development of territories based on the radical strengthening of the revenue base and decentralization of local budgets, further improving inter-budget relations, strengthening the financial independence of local government bodies and increasing their responsibility for the implementation of specific targeted measures to expand the tax potential by promoting the development of small business and private entrepreneurship, creating new jobs and providing employment, accelerated development of engineering and communications, road transport and social infrastructure.

In the medium term, we reviewed the legal documents adopted by the government to ensure the financial sustainability of local budgets. We want to draw your attention to the analysis of the results of the state budget (see Tab.№2).

Table#2. Execution of local budget revenues [11]

Regions	**Approved plan**	**Completed plan**	**Execution**	**Difference**	
				(+), (-)	**%**
Karakalpakstan	1 133 300	1 356 951	2 376 379	1 243 079	210
Andijan	1 290 100	1 290 100	1 708 991	418 891	132
Bukhara	1 226 062	1 190 462	1 383 035	156 973	113
Jizzakh	741 712	758 712	948 320	206 608	128
Kashkadarya	1 909 920	1 909 920	2 341 111	431 191	123
Navoiy	859 994	859 994	1 217 136	357 142	142
Namangan	1 088 412	1 113 412	1 360 012	271 600	125
Samarkand	1 637 531	1 637 531	1 970 792	333 262	120
Surkhandarya	1 052 140	1 052 140	1 378 313	326 173	131
Syrdarya	535 000	593 708	812 180	277 180	152
Tashkent	1 692 422	1 760 422	1 949 310	256 888	115
Ferghana	1 587 979	1 587 979	1 833 042	245 063	115
Khorazm	892 558	892 558	1 106 259	213 701	124
Tashkent city	2 378 949	2 433 949	2 796 470	417 521	118
Total:	**18 026 080**	**18 437 839**	**23 181 352**	**5 155 271**	**129**

According to Table 2, the execution of local budget revenues as a whole in 2018 was executed by 129% or more, by 5 155 271 million soums. Also, in the Republic of Karakalpakstan, the plan was implemented by 210% or 1,243,079 million soums. In Syrdarya region, the plan was completed by 152% or 277 1810 million soums, in Andijan region - by 132% or 418 891 million soums, in Surkhandarya region - by 131% or 326 173 million soums. Leaving local budgets to overfulfillment of the plan for excessive income served them as a motivation to fulfill more than the given plan.

Таблица №3. Execution of local budget expenditures [11]

Regions	Approved plan	Completed plan	Execution	Difference	
				(+), (-)	%
Karakalpakstan	1 740 024	2 135 546	2 681 604	546 058	126
Andijan	2 162 072	2 657 945	2 925 060	267 115	110
Bukhara	1 458 388	1 920 554	2 186 636	266 082	114
Jizzakh	1 153 801	1 586 273	1 848 688	262 415	117
Kashkadarya	2 223 505	2 734 293	2 994 856	260 564	110
Navoiy	999 156	1 267 397	1 571 354	303 957	124
Namangan	1 953 729	2 420 416	2 602 011	181 595	108
Samarkand	2 629 867	3 279 156	3 500 236	221 080	107
Surkhandarya	1 879 906	2 330 232	2 590 652	260 419	111
Syrdarya	806 300	1 088 649	1 184 635	95 986	109
Tashkent	2 066 765	2 720 452	3 023 202	302 750	111
Ferghana	2 621 266	3 133 769	3 314 895	181 126	106
Khorazm	1 411 694	1 718 646	1 835 838	117 192	107
Tashkent city	2 378 949	3 057 170	3 770 427	713 257	123
Total	**25 485 423**	**32 050 498**	**36 030 094**	**3 979 596**	**112**

From table 3 above it can be seen that the expenses on local budgets were met with overfulfillment of 112% or 3,979,596 million soums. In general, it should be noted that the excess plan revenues were spent on improving the socio-economic development of the region. This served to ensure the comprehensive socio-economic development of these territories.

Conclusion

As a result of this research article, the following conclusions were drawn:

First, at the new stage of independent development of Uzbekistan, special attention is paid to the financial independence of local budgets. In our opinion, in the future it would be expedient to reconsider the powers of local budgets on revenues and expenditures;

Secondly, during the current economic reforms, incentives and fines of local authorities, in particular the heads of financial and tax authorities, have led to additional sources of income in local budgets;

Thirdly, the country's economy is gradually moving to a market economy, therefore, in order to ensure the financial independence of local budgets, it is necessary to introduce market mechanisms;

Fourth, the decentralization of regions, in particular the revision of revenues and expenditures of government with inter-budgetary balances, contributes to an increase in the financial burden of local authorities;

The last, it is desirable to establish interstate budgetary relations in Uzbekistan, based on such aspects as accounting for powers on income and expenses, budgetary independence of regions, and ensure financial independence of regions.

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NUMERICAL STUDY OF THE PROPAGATION OF ONE-DIMENSIONAL SURFACE WAVES IN SEDIMENTARY ROCK LAYERS

Abstract: *The propagation of surface waves in the layers of fluidized material caused by a pressure wave source has been studied. A method for the numerical calculation of this problem in a one-dimensional formulation is presented and the dynamics of hydroimpact waves is investigated.*

Key words: *surface wave, hydroimpact wave, vibration fluidization, sedimentary layer, plasticity, pressure waves.*

Language: *Russian*

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ЧИСЛЕННОЕ ИССЛЕДОВАНИЕ РАСПРОСТРАНЕНИЯ ОДНОМЕРНЫХ ПОВЕРХНОСТНЫХ ВОЛН В СЛОЯХ ОСАДОЧНЫХ ПОРОД

Аннотация: *Изучена распространения поверхностных волн в слоях ожиженного материала, вызванных от источника волн давления. Приведена методика численного расчета данной задачи в одномерной постановке и исследована динамика гидроударных волн.*

Ключевые слова: *поверхностная волна, гидроударная волна, виброожижение, осадочный слой, пластичность, волны давления.*

Введение

Известно, что при сильных землетрясениях береговая полоса может подниматься очень сильно (например, до 15 метров). Такое поднятие связано с возникновением в морских осадочных породах волн, похожих на цунами [7,15]. В случае воды, такие цунами возвращаются в океан обратно. В случае волны в осадочных породах, если амплитуда волны велика, эти волны фиксируются на берегу океана, что и приводит к их поднятию. При этом даже относительно слабая сейсмическая волна, может усиливаться во много раз из-за изменения толщины осадочного слоя и резонансного эффекта. Такой же эффект имеется и в долинах Средней Азии, где сейсмические волны на краях долин могут усиливаться. В частности, они усиливаются на краях долин, где толщина слоя земли, по которому волна распространяется, уменьшается. В результате сейсмическая энергия аккумулируется и земля начинает сильно колебаться [6,14,15].

В работах [6,7] автор построил новую теорию распространения нелинейных поверхностных волн. Теория строится на том факте, что во время землетрясений (во время первых сейсмических колебаний) некоторые поверхностные слои осадочных пород переходят в почти жидкое состояние, т.е. теряют сдвиговую прочность (рис.1). Под действием вертикальных вибраций в слое осадков возникают (растут) газовые полости (дефекты). Чем больше полостей, тем меньше сдвиговая прочность. Этот эффект известен как виброожижение (рис.2). Учет таких эффектов в расчетах требуют более оптимального проектирования важных сооружений и объектов в сейсмических зонах.

Грубо говоря, после вибраций частички почвы начинают так слабо контактировать друг с другом, что слабо работают на сдвиг, однако сжатие (давление) они передают достаточно хорошо. Используя подобные идеи, автор работ [4-10] построил теорию распространения поверхностных волн в слоях ожиженного материала.

Пусть слой осадков ограничен снизу с недеформируемым слоем (например, гранит) и ее толщина уменьшается с приближением на край долины. Изучим распространение поверхностных волн в долине, вызванных от землетрясения, падением обломков скал и метеоритов, резким изменением метеорологических факторов, взрывами подводных и подземных вулканов и атомных бомб и т.п. Эту задачу можно разделить на три типа подзадачи: а) вдали от края слоя амплитуда волны не велика и после прохождения волны поверхность слоя возвращается в исходное состояние; б) вблизи края осадочного слоя ее толщина начинает уменьшаться, амплитуда волны увеличивается, трение о дно увеличивается. Этот момент, видимо, соответствует началу опрокидывания волны (возникновению скачки на фронте волны). Начинает проявляться сильно трение о дно. В результате передний фронт замедляется, однако задний фронт продолжает двигаться. Волна сжимается, при этом количество пор на поверхности волны уменьшается и материал слоя переходит из ожиженного в упругое (твердое) состояние. Далее это слабо деформируемое тело (волна) движется по поверхности, испытывая трение о недеформируемый слой; в) при выходе волны на поверхность недеформируемого слоя ожидается большое значение трения, в результате чего волна может тормозиться и быстро остановиться. Если амплитуда достаточно велика, то поверхность не вернется в исходное состояние. Имеет место пластическая деформация и изменение формы волны.

Рис.1. Виброожижение в жидкости

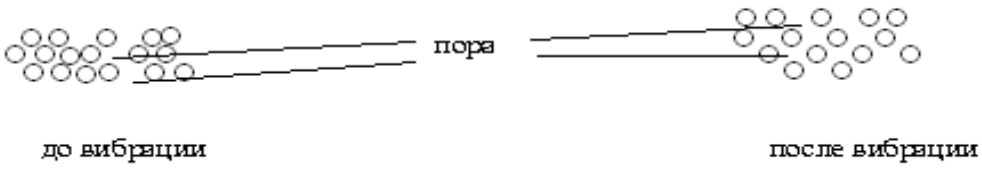

Рис.2. Виброожижение в почве при вертикальных вибрациях.

Если энергия волны большая, то может возникнуть явления, напоминающие цунами. При этом волна осадочных пород может выкатиться на недеформируемый слой и там только остановится.

В работе [6] все эти три подзадачи рассмотрены, в приближенном виде: наиболее полно решены задачи: а); для задач б) и в) сформулированы основные уравнения; качественно показано, как можно учесть пластичность и трение о дно. В этом случае можно предполагать случай малых пластических деформаций и использовать эти уравнения. Их надо только дополнить соотношениями для пластичности, следуя методику М.Уилкинса [9,12,16]. В [4,5,8-10,12] описаны методика решения некоторых конкретных задач. Все вопросы, связанные с поведением волны, при стремлении толщины осадков к нулю являются очень сложными. Там имеется сингулярность, усугубляемая нелинейностью. Поэтому предполагается, что материал волны переходит в упругое состояние (теряет ожиженность) до того, как волна достигает точки, где толщина осадков равна нулю. Как только материал волны стал упругим, далее волна движется как недеформируемое тело, выкатывается на берег и далее останавливается из-за трения на нижнем основании.

Постановка задачи.

На основе этой методики можно: исследовать, как меняется форма поверхности земли (осадочных пород) в месте, где толщина осадков начинает меняться (задача б); оценить, как далеко волна осадочных пород выйдет на недеформируемый слой (задача в). Эти задачи могут быть рассмотрены как одномерные в следующей постановке:

Уравнения движения:

$$\frac{\partial^2 u}{\partial t^2}=-\frac{1}{\rho}\frac{\partial P}{\partial x}+\frac{4G_*}{3\rho}\frac{\partial^2 u}{\partial x^2}-\left(\frac{2G_*}{3\rho}+\frac{g}{n+1}\right)\frac{\partial \eta}{\partial x}+X+X_*+\frac{1}{\rho}X^P. \qquad (1)$$

Здесь

$$X_*=\frac{\tau_{31}}{\rho h}-\frac{g}{n+1}\left(\frac{\partial \eta}{\partial x}\right)^+-g\left(\frac{\partial \eta}{\partial x}\right)^-;\ X^P=\frac{\partial s_{11}}{\partial x}+\frac{\partial P}{\partial x};\ \tau_{31}=const*\frac{\partial^3 u}{\partial t\partial x^2};\ h=-\left[1+\left(\frac{\partial u}{\partial x}\right)^{-1}\right]\eta;$$

$$G_*=\nu(1-a_s\phi_0);\ \ b=\lambda(1-\phi_0)+\phi_0 P_0^{-1};\ \ a_s^2=\frac{G_*}{\rho_0};\ \ P_0=P_a+\frac{1}{2}g_0\rho_0 h_0;\ \ g=g_0+g_d; \qquad (2)$$

$$\frac{\partial^2 P}{\partial x^2}=-\frac{1}{b}\frac{\partial^2}{\partial x^2}\left(\frac{\partial u}{\partial x}+\frac{\eta}{h}\right);\ \ \frac{\partial^2 \eta}{\partial x^2}=-\left[g\rho_0\frac{2n+1}{n+1}+\frac{4G_*}{3h}+\frac{1}{bh}\right]^{-1}\left[g\rho_0\frac{\partial^2 h}{\partial x^2}+\left(\frac{1}{b}-\frac{2G_*}{3}\right)\frac{\partial^3 u}{\partial x^3}\right]; \qquad (3)$$

X - массовые силы; h_0 - начальная толщина слоя; P_0 - начальное (статическое) давление в смеси; P_a - атмосферное давление; ρ_0 - начальная плотность смеси; ϕ_0 - начальная средняя пористость смеси; g_0 - ускорение свободного падения; G - модуль сдвига; α_s - экспериментально определяемые постоянные; u - поперечное перемещение точек слоя по осевой координате x; τ_{31} - параметр учета трения о дно; η - параметр учета вязкости среды; P, ρ, h - текущее давление, плотность и толщина среды.

Состояние пористости слоя проверяются следующим образом: если $\phi_0 \to 0$, то среда близка к упругому телу; если $\phi_0 \to 1$, то среда близка к газу; если $\alpha_s\phi_0 \to 1$, то материал превращается в более жидкое состояние (или пузырьковая кавитация); если $0<\alpha_s\phi_0<1$, то материал находится между твердым и жидким состояниями и $G=\nu(1-\alpha_s\phi_0)$.

Условие пластичности для твердой части среды проверяется по алгоритму М.Уилкинса [9,16]:

$$s_{11}^2+2s_{13}^2-\frac{2}{3}\sigma_T^2=J, \qquad (4)$$

где

$$s_{11}=\frac{G}{3}\left(\frac{\partial^2 u}{\partial x^2}-2\frac{\partial u}{\partial x}\right);\ \ s_{13}=-\left(\frac{z}{h}\right)^n\frac{\partial \eta}{\partial x},$$

$$(n=1,\ |z|\le h). \qquad (5)$$

Если $J>0$ то

$$s_{11}^{\circ}=s_{11}\frac{\sqrt{2/3}\sigma_T}{\sqrt{s_{11}^2+2s_{13}^2}};\ \ s_{13}^{\circ}=s_{13}\frac{\sqrt{2/3}\sigma_T}{\sqrt{s_{11}^2+2s_{13}^2}}. \qquad (6)$$

и переопределяем компоненты тензора девиаторов s_{11}, s_{13} напряжений.

Алгоритм решения задачи.

Последовательность решения задачи следующая [8-10, 12]: задается начальные данные при t = 0 (результаты задачи а) являются начальным условием данной задачи); конечный край жестко закреплен, а в другом крае задаются массовые силы X, которые приводят к образованию возмущений в среде, например, $g_d = \delta \cos \varpi t$ [4]; уравнения (1) решается методом конечных разностей по явной или неявной схеме; по формулам (2) расчет ведется сквозным счетом для m+1 –го временного слоя; по формулам (3) расчет ведется по неявной схеме для m+1 –го временного слоя (применяется метод прогонки); проверяется состояние пористости среды; если среда более твердая, то проверяется условие пластичности (4) с учетом (5), если «да», то вычисление по (6).

Расчеты осуществляли для осадочного слоя ($\alpha_s \phi_0$ = 0.05) толщиной h=5 м и для воды. Плотность заряда принимали 1650 кг/м^3, скорость детонации - 7655 м/с, начальное давление - 12 ГПа. При численных расчетах из среды и воды выделили одномерную область, границы которой в некотором конечном промежутке времени не влияют на параметры исследуемых процессов. Динамика данной газогидроупругопластической системы изучены на основе вышеуказанных уравнений. Чтобы сократить машинное время вычислений, в расчетах использовали неравномерную сетку. Шаг по времени, обеспечивающей устойчивость вычислений, рассчитывали по условию Куранта. Рассмотрим результаты расчета, при которых варьировали расстояние между газовым объемом и слоем: d = 120; 160; 200, 240 h.

Результаты численных расчетов.

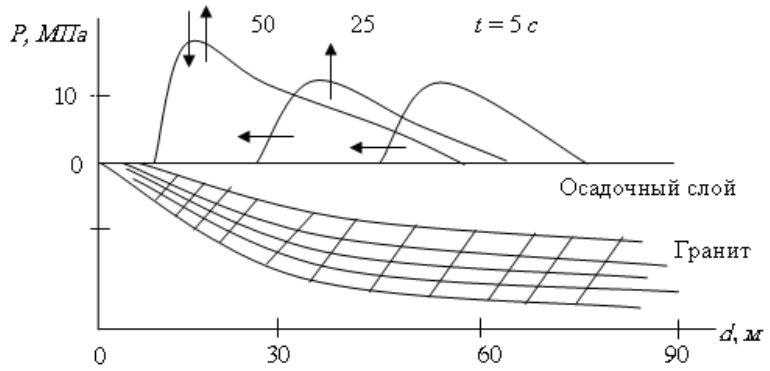

Рис.3. Распространения волн давления по поверхности слоя.

Сначала исследуем динамику гидроударных волн. Построенные эпюры изменения давления подводной волны во времени в точке подхода волны давления в слой рассчитанные для различных расстояний газового объема от слоя показали, что уменьшение пиковых значений давления ударной волны с удалением источника возмущений происходит по экспоненциальному закону (рис.3). Поскольку при расчетах печать результатов осуществляли через шаг по времени 5τ, приведенные кривые в первую очередь описывают качественную картину давления. Другая особенность проблемы связана с изменением волны давления по глубине расчетной области: увеличение амплитуды давления происходит по экспоненциальному закону (рис.4).

Установлено, что гидроударную волну можно качественно представить в виде плоской волны

$$P = P_0 e^{\beta(ct+z)}\left(1 - e^{\alpha(ct+z)}\right),$$

где P_0 , α , β - амплитуда, скорость роста и последующий спад давления в волне; c – скорость волны давления в жидкости; $\alpha = -1/L_1$; $\beta = -1/(L - L_1)$; L – длина волны; L_1 - расстояние до пикового значения.

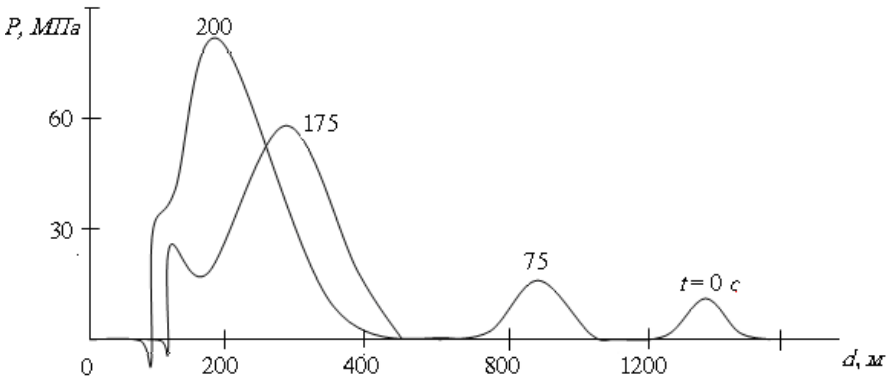

Рис.4. Профили волны давления на поверхности осадочного слоя.

Выводы.

Таким образом, изучена распространения волн давления в осадочном слое, приведена численная методика решения одномерной задачи гидроупругости (основные уравнения, алгоритм расчета, численные результаты) для расчета динамики материала, теряющего упругое состояние (в твердом теле – упругопластическое деформирование, в жидкости – пузырьковая кавитация) и представлена качественная картина распространения гидроударных плоских волн в слоях ожиженного материала. Проблемы прочности эксплуатируемых современных конструкций и сооружений ставят перед исследователями задачи автоматизации процесса решения физически и геометрически нелинейных задач механики деформируемого твердого тела. В горных зонах Средней Азии часто наблюдаются резкие изменения сейсмологических и метеорологических факторов. Это в свою очередь приводит к изменению прочностных свойств слоя земли, например, пористости и других емкостно-фильтрационных характеристик среды. Для оценки этих явлений требуется анализировать изменение толщины и резонансного эффекта в процессе колебания осадочного слоя земли. Поэтому результаты данной работы могут быть интересными и полезными при проектировании сооружений и строительных объектов в сейсмических зонах [11,13,17-20].

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APPLICATION OF APPROXIMATE METHODS FOR SOLVING HIGHER ORDER FREDHOLM INTEGRO-DIFFERENTIAL EQUATIONS

Abstract: *The main aim of the present paper is to implement the Adomian decomposition method and variational iteration methods for to an approximation and exact solution the higher order integro-differential equation Fredholm. Implementation of these methods demonstrates the useful-ness in finding exact solution for linear and nonlinear problems. Comparison is made between the exact solutions and the results of approximate methods in order to verify the accuracy of the results, revealing the fact that these methods are very effective and simple.*

Key words: *Fredholm integro-differential equation, Adomian decomposition method, variational iteration method, approximate and exact solution.*

Language: *English*

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Introduction

The recent years have seen significant development in the use of various methods for the numerical, approximate and analytic solution of the linear and nonlinear integro-differential equation. Over the last decades several analytical/approximate methods have been developed to solve linear and nonlinear integro-differential equations. Some of these techniques include variational iteration method [2-5, 9, 11, 16-20], homotopy perturbation method (HPM) [1, 2, 6-8, 10, 12, 14, 16, 18, 19], Adomian decomposition method (ADM) [13, 14, 16-19, homotopy analysis method (HAM) [16-19] etc. [16-19]. Linear and Nonlinear phenomena play an important role in varios fields of science and engineering, such as chemical kinetics, fluid dynamics, engineering problems and biological models. Most models of real life problems are still

very difficult to solve. There-fore, approximate-analytical solutions such as homotopy perturbation method, Adomian decomposition method, variational iteration method etc were introduced [11, 14, 15, 18, 19]. These methods is the most effective and convenient ones for both linear and nonlinear equations. The aim of the present paper is to implement the Adomian decomposition method and variational iteration methods for to an approximation and exact solution the Fredholm integro-differential equation.

Formulation of the problem.

The aim of the present paper is to implement the Adomian decomposition method and variational iteration methods for to an approximation and exact solution the Fredholm integro-differential equation.

The mathematical formulations of many physical phenomena result into integro-differential equations. The standard *i*th order Fredholm integro-differential equation is of the form

$$y^{(i)}(x) = f(x) + \int_a^b K(x,s)F(y^{(i)}(s))ds, \quad (1)$$

where $y^{(i)}(x) = \frac{d^i y}{dx^i}$: $y^{(i)}(x)$ indicates the *i*-th order derivative of $y(x)$; $y(0), y'(0), ..., y^{(i-1)}(0)$ are the initial conditions; F – is a nonlinear function, $K(x, s)$ is the kernel and $f(x)$ is a function of x; $y(x)$ and $f(x)$ are real and can be differentiated any number of times for $x \in [a, b]$ [14, 15].

Problem solving techniques.

Basic idea of Adomian decomposition method.

We usually represent the solution $y(x)$ a general nonlinear equation in the following form $Ly(x) + Ry(x) + Ny(x) = f(x)$, were L, R – a linear operator, N - a nonlinear operator, $f(r)$ – a known analytic function. Invers operator L with $L^{-1} = \int_0^x (\cdot)dx$. Equation can be written as $y(x) = L^{-1}[f(x)] - L^{-1}[Ry(x)] - L^{-1}[Ny(x)]$. The decomposition method represents the solution of equation as the following infinite series $y(x) = \sum_{n=0}^{\infty} y_n(x)$. The nonlinear operator $Ny = g(y)$ is decomposed as $Ny = \sum_{n=0}^{\infty} A_n(x)$. Where A_n are Adomian polynomial which are defined as, $A_n = \frac{1}{n!}\frac{d^n}{d\xi^n} g\left[\sum_{m=0}^{\infty} \xi^m y_m(x)\right]_{\xi=0}$, $n = 0,1,2,\ldots$.

Therefore, we have $y = \sum_{n=0}^{\infty} y_n(x) = L^{-1}(f) - L^{-1}\left(\sum_{n=0}^{\infty} y_n(x)\right) - L^{-1}\left(\sum_{n=0}^{\infty} A_n(x)\right)$. Consequently, it can be written as, $y_0 = L^{-1}(f)$,

$y_1 = L^{-1}(R(y_0)) - L^{-1}(A_0)$,

$y_2 = -L^{-1}(R(y_1)) - L^{-1}(A_1)$,....

Consequently the solution of (1) in a series form follows immediately by using $y(x) = \sum_{n=0}^{\infty} y_n(x)$. As indicated earlier, the series obtained may yield the exact solution in a closed form, or a truncated $\sum_{n=1}^{m} y_n(x)$ series may be used if a numerical approximation is desired.

Basic idea of variational iteration method.

The correction functional for the integro-differential equation (1) is

$$y_{n+1}(x) = y_n(x) + \int_0^x \lambda(\xi)\left[y^{(i)}(\xi) - f(\xi) + \int_a^b K(\xi,s)y(s)ds\right]d\xi. \quad (2)$$

As presented before, the variational iteration method is used by applying two essential steps. It is required first to determine the Lagrange multiplier $\lambda(\xi)$ that can be identified optimally via integration by parts and by using a restricted variation. Having $\lambda(\xi)$ determined, an iteration formula, without restricted variation, should be used for the determination of the successive approximations $y_{n+1}(x)$, $n \geq 0$ of the solution $y(x)$. The zeroth approximation y_0 can be any selective function. However, using the given initial values $y(0), y'(0), \ldots$ are preferably used for the selective zeroth approximation y_0 as will be seen later. Consequently, the solution is given by $y(x) = \lim_{n\to\infty} y_n(x)$.

In the following examples, we will illustrate the usefulness and effectiveness of the proposed techniques.

Illustrative Examples.

The following are examples that demonstrate the effectiveness of the methods.

Example 1. Consider third- order Fredholm integro-differential equation [14, 15]

$$y'''(x) = 1 - e + e^x + \int_0^1 y(s)ds,$$

with initial conditions $y(0) = y'(0) = y''(0) = 1$, the exact solution is $y(x) = e^x$.

Application of Adomian decomposition method.

Using $y(x)=\sum_{n=0}^{\infty} y_n(x)$ and the recurrence relation we obtained: we start by setting the zeroth component $y_0'''(x)=1-e+e^x$, so that the first component is obtained by $y_1'''(x)=\int_0^1 y_0(s)ds$;

$y_2'''(x)=\int_0^1 y_1(s)ds$; … . Applying the three-fold integral operator L^{-1} defined by, $L^{-1}(\cdot)=\int\int\int(\cdot)dxdxdx$, and using the given initial condition we obtain

$$y(x)=\frac{1-e}{6}x^3+e^x+\frac{1}{6}x^3\int_0^1 y(s)ds.$$

Hence, taking into account the boundary conditions, we have

$$y_0(x)=\frac{1-e}{(3!)^1 4^0}x^3+e^x;$$

$$y_1(x)=-\frac{23(1-e)}{(3!)^2 4^1}x^3;$$

$$y_2(x)=-\frac{23(1-e)}{(3!)^3 4^2}x^3;\ldots.$$

This gives the solution in the series form $y(x)=\sum_{n=0}^{\infty} y_n(x)=e^x+(1-e)x^3\sum_{n=0}^{\infty}\frac{1}{(3!)^{n+1}4^n}=e^x$.

Application of variational iteration method.

Making $y_{n+1}(x)$ stationary with respect to $y_n(x)$, we can identify the Lagrange multiplier, which reads $\lambda=-(s-x)^2/2$. So we can construct a variational iteration form for (2) in the form:

$$y_{n+1}(x)=y_n(x)-\int_0^x\frac{(s-x)^2}{2}\left[y_n'''(s)+\cos s-s-s\int_0^{\pi/2}y''(p)dp\right]ds.$$

We start by setting the zeroth component

$$y_0(x)=y(0)+xy'(0)+\frac{x^2}{2}y''(0)=1+x+\frac{x^2}{2}.$$

That will lead to the following successive approximations:

$$y_1(x)=e^x+\left(\frac{4}{9}-\frac{e}{6}\right)x^3;$$

$$y_2(x)=e^x+\left(\frac{1}{54}-\frac{e}{144}\right)x^3;$$

$$y_3(x)=e^x+\left(\frac{1}{1296}-\frac{e}{3456}\right)x^3;\ \ldots.$$

If $y_1(x)=e^x+\left(\frac{4}{9}-\frac{e}{6}\right)x^3\approx e^x$, then

$y_2(x)=e^x$; $y_3(x)=e^x$; … .

So we obtain the following approximate solution $y(x)=\lim_{n\to\infty}y_n(x)=e^x$, which is the exact solution of the problem: $y(x)=e^x$.

Example 2. Consider third- order Fredholm integro-differential equation [14, 15]

$$y'''(x)=-\cos x+x+\int_0^{\pi/2}xy''(s)ds,$$

with initial conditions $y(0)=0,\ y'(0)=1,\ y''(0)=0$, the exact solution is $y(x)=\sin x$.

Application of Adomian decomposition method.

Using $y(x)=\sum_{n=0}^{\infty} y_n(x)$ and the recurrence relation we obtained: we start by setting the zeroth component $y_0'''(x)=-\cos x+x$, so that the first component is obtained by $y_1'''(x)=x\int_0^{\pi/2}y_0''(s)ds$;

$y_2'''(x)=x\int_0^{\pi/2}y_1''(s)ds$; … . Applying the three-fold integral operator L^{-1} defined by, $L^{-1}(\cdot)=\int\int\int(\cdot)dxdxdx$, and using the given initial condition we obtain

$$y(x)=\sin x+\frac{x^4}{4!}+\frac{x^4}{4!}\int_0^{\pi/2}y''(s)ds.$$

Hence, taking into account the boundary conditions, we have

$$y_0(x)=\sin x+\frac{x^4}{4!};\quad y_1(x)=-\frac{1}{24}x^4+\frac{1}{1152}x^4\pi^3;\quad y_2(x)=-\frac{1}{1152}x^4\pi^3+\frac{1}{55296}x^4\pi^6;\ \ldots.$$

This gives the solution in the series form

$$y(x)=\sum_{n=0}^{\infty}y_n(x)=\sin x+\frac{1}{24}x^4-\frac{1}{24}x^4+\frac{1}{1152}x^4\pi^3-\frac{1}{1152}x^4\pi^3+\frac{1}{55296}x^4\pi^6-\ldots=\sin x.$$

Application of variational iteration method.

Making $y_{n+1}(x)$ stationary with respect to $y_n(x)$, we can identify the Lagrange multiplier, which reads $\lambda=-(s-x)^2/2$. So we can construct a variational iteration form for (2) in the form:

$$y_{n+1}(x)=y_n(x)-\int_0^x\frac{(s-x)^2}{2}\left[y_n'''(s)+\cos s-s-s\int_0^{\pi/2}y''(p)dp\right]ds.$$

We start by setting the zeroth component

$$y_0(x)=y(0)+xy'(0)+\frac{x^2}{2}y''(0)=x.$$

That will lead to the following successive approximations:

$$y_1(x)=\sin x+\frac{1}{24}x^4\approx\sin x;\quad y_2(x)=\sin x;$$

$$y_3(x)=\sin x;\ \ldots.$$

So we obtain the following approximate solution $y(x)=\lim_{n\to\infty}y_n(x)=\sin x$, which is the exact solution of the problem: $y(x)=\sin x$.

Example 3. Consider the third-order linear integro-differential equation [14, 15]

$$y'''(x)=\sin(x)-x-\int_0^{\pi/2}xsy'(s)ds,$$

with initial conditions $y(0)=1,\ y'(0)=0,\ y''(0)=-1$; the exact solution is $y(x)=\cos(x)$.

Application of Adomian decomposition method.

Using $y(x)=\sum_{n=0}^{\infty}y_n(x)$ and the recurrence relation we obtained: we start by setting the zeroth component $y_0'''(x)=\sin x-x$, so that the first component is obtained by $y_1'''(x)=-x\int_0^{\pi/2}sy_0'(s)ds$;

$y_2'''(x)=-x\int_0^{\pi/2}sy_1'(s)ds$; … . Applying the three-fold integral operator L^{-1} defined by, $L^{-1}(\cdot)=\int\int\int(\cdot)dxdxdx$, and using the given initial condition we obtain

$$y(x)=\cos x-\frac{x^4}{4!}-\frac{x^4}{4!}\int_0^{\pi/2}sy'(s)ds.$$

Hence, taking into account the boundary conditions, we have

$$y_0(x)=\cos x-\frac{x^4}{4!};$$

$$y_1(x)=\frac{1}{24}x^4+\frac{1}{23040}x^4\pi^5;$$

$$y_2(x)=-\frac{1}{23040}x^4\pi^5-\frac{1}{22118400}x^4\pi^{10};$$

$$y_3(x)=\frac{1}{22118400}x^4\pi^{10}+\frac{1}{21233664000}x^4\pi^{15};$$

…. .

This gives the solution in the series form

$$y(x)=\sum_{n=0}^{\infty}y_n(x)=\cos x-\frac{1}{24}x^4+\frac{1}{24}x^4+\frac{1}{23040}x^4\pi^5-$$

$$-\frac{1}{23040}x^4\pi^5-\frac{1}{22118400}x^4\pi^{10}+\ldots=\cos x.$$

Application of variational iteration method.

Making $y_{n+1}(x)$ stationary with respect to $y_n(x)$, we can identify the Lagrange multiplier, which reads $\lambda = -(s-x)^2/2$. So we can construct a variational iteration form for (2) in the form:

$$y_{n+1}(x) = y_n(x) - \int_0^x \frac{(s-x)^2}{2}\left[y_n'''(s) - \sin s + s + s\int_0^{\pi/2} py'(p)dp \right] ds.$$

We start by setting the zeroth component

$$y_0(x) = y(0) + xy'(0) + \frac{x^2}{2}y''(0) = 1 - \frac{x^2}{2}.$$

That will lead to the following successive approximations:

$$y_1(x) = \cos x - \frac{1}{24}x^4 + \frac{1}{576}\pi^3 x^4 \approx \cos x;$$

$$y_2(x) = \cos x;\ \ y_3(x) = \cos x;\ \ \ldots .$$

So we obtain the following approximate solution $y(x) = \lim_{n\to\infty} y_n(x) = \cos x$, which is the exact solution of the problem: $y(x) = \cos x$.

Example 4. Consider fourth- order Fredholm integro-differential equation [14, 15]

$$y^{(4)}(x) = \frac{1}{4} + (1 - 2\ln 2)x - \frac{6}{(1+x)^4} + \int_0^1 (x-s)y(s)ds,$$

with initial conditions $y(0) = 0,\ y'(0) = 1,\ y''(0) = -1,\ y'''(0) = 2$; the exact solution is $y(x) = \ln(1+x)$.

Application of Adomian decomposition method.

Using $y(x) = \sum_{n=0}^{\infty} y_n(x)$ and the recurrence relation we obtained: we start by setting the zeroth component

$y_0^{(4)}(x) = \frac{1}{4} + (1 - 2\ln 2)x - \frac{6}{(1+x)^4}$, so that the first component is obtained by

$$y_1^{(4)}(x) = \int_0^1 (x-s)y_0(s)ds;$$

$$y_2^{(4)}(x) = \int_0^1 (x-s)y_1(s)ds;\ \ldots .$$

Applying the three-fold integral operator L^{-1} defined by, $L^{-1}(\cdot) = \int\int\int(\cdot)dxdxdx$, and using the given initial condition we obtain

$$y(x) = \frac{1}{4\cdot 4!}x^4 + \frac{1}{5!}(1 - 2\ln 2)x^5 + \ln(1+x) + \frac{x^5}{5!}\int_0^1 y(s)ds - \frac{x^4}{4!}\int_0^1 sy(s)ds.$$

Hence, taking into account the boundary conditions, we have

$$y_0(x) = \frac{1}{96}x^4 + \frac{1}{120}(1 - 2\ln 2)x^5 + \ln(1+x);$$

$$y_1(x) = \left(\frac{1}{10080}\ln 2 - \frac{5099}{483840}\right)x^4 + \left(\frac{719}{43200}\ln 2 - \frac{287}{34560}\right)x^5;$$

$$y_2(x) = -\left(\frac{181}{181440}\ln 2 - \frac{8543}{69672960}\right)x^4 + \left(\frac{5096}{217728000}\ln 2 - \frac{12671}{435456000}\right)x^5;\ \ldots .$$

This gives the solution in the series form

$$y(x) = \sum_{n=0}^{\infty} y_n(x) = \ln(1+x) + \alpha_n x^4 + \beta_n x^5 = \ln(1+x),\ \lim_{n\to\infty}\alpha_n = 0,\ \lim_{n\to\infty}\beta_n = 0.$$

After the fourth iteration, the maximum absolute error is less than 10^{-12}, but the maximum absolute error decreases with increasing iteration.

Application of variational iteration method.

Making $y_{n+1}(x)$ stationary with respect to $y_n(x)$, we can identify the Lagrange multiplier, which reads $\lambda = (s-x)^3/6$. So we can construct a variational iteration form for (2) in the form:

$$y_{n+1}(x) = y_n(x) + \int_0^x \frac{(s-x)^3}{6}\left[y_4^{(4)}(s) - \frac{1}{4} - (1-2\ln 2)s + \frac{6}{(1+s)^4} + \int_0^1 (s-p)y(p)dp \right] ds.$$

We start by setting the zeroth component

$$y_0(x) = y(0) + xy'(0) + \frac{x^2}{2!}y''(0) + \frac{x^3}{3!}y'''(0) = x - \frac{x^2}{2} + \frac{x^3}{3}.$$

That will lead to the following successive approximations:

$$y_1(x) = \ln(1+x) - 0.001041666667x^4 + 0.00025310255x^5;$$

$$y_2(x) = \ln(1+x) + 0.000005727233x^4 - 0.00000138458x^5;$$

$$y_3(x) = \ln(1+x) - 3.15295\cdot 10^{-8}x^4 + 7.62234\cdot 10^{-9}x^5; \ \ldots.$$

So we obtain the following approximate solution $y(x) = \lim_{n\to\infty} y_n(x) = \ln(1+x)$, which is the exact solution of the problem: $y(x) = \ln(1+x)$.

Conclusion.

This results shows a comparative study between variational iteration method and Adomian decomposition method of solving Fredholm integro-differential equations. The main advantage of these methods are the fact that they provide its user with an analytical approximation, in many cases an exact solution in rapidly convergent sequence with elegantly computed terms. Also these methods handle linear and non-linear equations in a straightforward manner. These methods provide an effective and efficient way of solving a wide range of linear and nonlinear integro-differential equations. Illustrative examples are given to demonstrate the validity, accuracy and correctness of the proposed methods. The error between the approximate solution and exact solution decreases when the degree of approximation increases.

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APPLICATION OF APPROXIMATE METHODS FOR SOLVING HIGHER ORDER VOLTERA INTEGRO-DIFFERENTIAL EQUATIONS

Abstract: *The main aim of the present paper is to implement the homotopy perturbation method, Adomian decomposition method and variational iteration method for to an approximation and exact solution the higher order integro-differential equation Voltera. Implementation of these methods demonstrates the usefulness in finding exact solution for linear and nonlinear problems. Comparison is made between the exact solutions and the results of approximate methods in order to verify the accuracy of the results, revealing the fact that these methods are very effective and simple.*

Key words: *Voltera integro-differential equation, homotopy perturbation method, Adomian decomposition method, variational iteration method, approximate and exact solution.*

Language: *English*

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Introduction

Integro-differential equations have been studied in many works of researchers and scientists. Such equations can be found in applications to physics, mechanics, biology, and technology. A new perturbation method called Homotopy perturbation method (HPM) was proposed in [8-11] by He in 1997, and a systematical description was given in 2000 which is in fact, a coupling of the traditional perturbation method and Homotopy in topology. This new method was further developed and improved by He and applied to various linear and nonlinear problems. Below we consider only classical integro-differential equations. Voltera integro-differential equations arise in the mathematical modeling of various scientific phenomena. Nonlinear phenomena, which appear in many applications in scientific fields, such as fluid dynamics, solid state physics, plasma

physics, mathematical biology and chemical kinetics, can be modeled by partial differential equations and by integral equations as well. This paper shows a comparative study between three traditional methods for analytic treatments of Voltera integro-differential equations. Homotopy perturbation method, Adomian decomposition method and variational iteration method, well-addressed in [1-17] has a constructive attraction that provides the exact and approximate solutions by computing only a few iterations. Homotopy perturbation method, Variational iteration method, Adomian decomposition method have been applied to analyze the behavior of the solution of Voltera integro-differential equations. Finally, a comparative study has been made among these methods.

Formulation of the problem.

The aim of the present paper is to implement the homotopy perturbation method, Adomian decomposition method and variational iteration methods for to an approximation and exact solution the Volterra integro-differential equation.

The mathematical formulations of many physical phenomena result into integro-differential equations. The standard *i*-th order Volterra integro-differential equation is of the form

$$y^{(i)}(x) = f(x) + \int_0^x K(x,s), F(y^{(i-1)}(s))ds,$$
$$0 < x < b \qquad (1)$$

where $y^{(i)}(x) = \frac{d^i y}{dx^i}$: $y^{(i)}(x)$ indicates the *i*-th order derivative of $y(x)$; $y(0), y'(0), ..., y^{(i-1)}(0)$ are the initial conditions; F – is a nonlinear function, $K(x, s)$ is the kernel and $f(x)$ is a function of x; $y(x)$ and $f(x)$ are real and can be differentiated any number of times for $x \in [0, b]$ [8-11, 14-16].

Problem solving techniques.

Basic idea of homotopy perturbation method.

Perturbation method is based on assuming a small parameter. The majority of nonlinear problems, especially those having strong nonlinearity, have no small parameters at all and the approximate solutions obtained by the perturbation methods, in most cases, are valid only for small values of the small parameter. Generally, the perturbation solutions are uniformly valid as long as a scientific system parameter is small. However, we cannot rely fully on the approximations, because there is no criterion on which the small parameter should exists. Thus, it is essential to check the validity of the approximations numerically and/or experimentally.

Consider the nonlinear differential equation,

$$L(y)+N(y)=f(r),\ r\in\Omega. \qquad (2)$$

With boundary conditions, $B\left(y, \frac{\partial y}{\partial n}\right),\ r \in \Gamma$,

were L – a linear operator, N - a nonlinear operator, $f(r)$ – a known analytic function, B – a boundary operator, Γ – the boundary of the domain Ω. By Homotopy perturbation technique [He,1999] define a Homotopy $u(r,p)$: Ω x $[0,1] \to R$ this satisfies

$$H(u,p) = (1-p)[L(u) - L(y_0)] + p[L(u) - N(u) - f(r)] = 0 \quad \text{or} \qquad (3)$$
$$H(u,p) = L(u) - L(y_0) + pL(y_0) + p[N(u) - f(r)] = 0. \qquad (4)$$

Where, $r \in \Omega$, $p \in [0,1]$ is an embedding parameter and y_0 is an initial approximation, which satisfies the boundary conditions. Clearly

$$H(u,0) = L(u) - L(y_0) = 0, \quad H(u,1) = L(u) + N(u) - f(r) = 0.$$

As p changes from 0 to 1. Then $u(r,p)$ changes from $y_0(r)$ to $y(r)$. This is called a deformation and $L(u) - L(y_0)$, $L(u) + N(u) - f(r)$ are said to be Homotopy in topology. According to the HPM, the embedding parameter p can be used as a small parameter and assume that the solution of equation (3) and (4) can be expressed as a power series p, that is $u = u_0 + pu_1 + p^2u_2 + \dots$. For $p = 1$, the approximate solution of equation (2) therefore, can be expressed as $u = \lim_{p\to 1} u = u_0 + u_1 + u_2 + \dots$. The series is convergent in most cases and the convergence rate of the series depends on the nonlinear operator.

Basic idea of Adomian decomposition method.

We usually represent the solution $y(x)$ a general nonlinear equation in the following form $Ly(x) + Ry(x) + Ny(x) = f(x)$. Invers operator L with $L^{-1} = \int_0^x (\cdot)dx$.

Equation can be written as $y(x) = L^{-1}[f(x)] - L^{-1}[Ry(x)] - L^{-1}[Ny(x)]$. The decomposition method represents the solution of equation as the following infinite series

$y(x) = \sum_{n=0}^{\infty} y_n(x)$. The nonlinear operator $Ny = g(y)$ is decomposed as $Ny = \sum_{n=0}^{\infty} A_n(x)$. Where A_n are Adomian polynomial which are defined as, $A_n = \frac{1}{n!}\frac{d^n}{d\xi^n} N\left[\sum_{m=0}^{\infty} \xi^m y_m(x)\right]_{\xi=0}$, $n = 0,1,2,\ldots$.

Therefore, we have

$$y = \sum_{n=0}^{\infty} y_n(x) = L^{-1}(f) - L^{-1}\left(\sum_{n=0}^{\infty} y_n(x)\right) - L^{-1}\left(\sum_{n=0}^{\infty} A_n(x)\right).$$

Consequently, it can be written as,

$$y_0 = L^{-1}(f),\ y_1 = -L^{-1}(R(y_0)) - L^{-1}(A_0),\ y_2 = -L^{-1}(R(y_1)) - L^{-1}(A_1),\ldots.$$

Consequently the solution of (1) in a series form follows immediately by using $y(x) = \sum_{n=0}^{\infty} y_n(x)$. As indicated earlier, the series obtained may yield the exact solution in a closed form, or a truncated $\sum_{n=1}^{m} y_n(x)$ series may be used if a numerical approximation is desired.

Basic idea of variational iteration method.

We illustrate the basic concept of variational iteration method, we consider the following general nonlinear differential equation given in the form

$$Ly(x) + Ny(x) = f(x),$$

where L is a linear operator, N is a nonlinear operator, and $f(x)$ is a known analytical function. We can construct a correction functional according to the variational method as:

$$y_{n+1}(x) = y_n(x) + \int_0^x \lambda\left[Ly_n(s) + N\tilde{y}_n(s) - f(s)\right]ds, \qquad (5)$$

where λ is a general Lagrange multiplier, which can be identified optimally via the variational theory, the subscript n denotes the nth approximation, and $\tilde{y}_n$ un is considered as a restricted variation, namely $\delta\tilde{y}_n = 0$. The exact solution is thus given by $y(x) = \lim_{n\to\infty} y_n(x)$ [14, 15].

In the following examples, we will illustrate the usefulness and effectiveness of the proposed techniques.

Illustrative Examples.

The following are examples that demonstrate the effectiveness of the methods.

Example 1. Consider third-order Voltera integro-differential equation [14, 15]

$$y'''(x) = 2y(x) + 1 + x - \frac{x^2}{2} - \int_0^x y(s)ds,$$

with initial conditions $y(0) = 0,\ y'(0) = 0,\ y''(0) = 1,$; the exact solution is $y(x) = -1 - x + e^x$.

Application of homotopy perturbation method.

A Homotopy can be readily constructed as follows

$$H(u, p) = u_n'''(x) - 2u_n(x) - 1 - x + \frac{x^2}{2} + \int_0^x u_n(s)ds = 0. \qquad (6)$$

Substituting $u = u_0 + pu_1 + p^2u_2 + \ldots$ into (6) and rearranging the resulting equation based on power of p-terms, one has

p^0: $u_0'''(x) - 1 - x + \frac{x^2}{2} = 0$;

p^1: $u_1'''(x) - 2u_0(x) + \int_0^x u_0(s)ds = 0$;

p^2: $u_2'''(x) - 2u_1(x) + \int_0^x u_1(s)ds = 0\ldots$

With the following conditions $u_n(0)=0,\ u_n'(0)=0,\ u_n''(0)=1,\ n=0,1,2,\ldots$.

With the effective initial approximation solution can be written as follows

$$u_0(x)=\frac{1}{2}x^2+\frac{1}{6}x^3+\frac{1}{24}x^4-\frac{1}{120}x^5;$$

$$u_1(x)=\frac{1}{60}x^5+\frac{1}{720}x^6+\frac{1}{5040}x^7-\frac{1}{13440}x^8+\frac{1}{362880}x^9;$$

$$u_2(x)=\frac{1}{10080}x^8+\frac{1}{362880}x^{10}-\frac{1}{5702400}x^{11}+\frac{1}{95800320}x^{12}-\frac{1}{6227020800}x^{13};\ldots.$$

After the fourth iteration, the absolute error is less than 10^{-10}. In the same manner, the rest of components were obtained using the Maple package

$$y(x)=\lim_{p\to 1}u=u_0+u_1+u_2+\ldots=$$

$$-1-x+\sum_{n=0}^{\infty}\frac{1}{n!}x^n=-1-x+e^x.$$

Application of Adomian decomposition method.

Using $y(x)=\sum_{n=0}^{\infty}y_n(x)$ and the recurrence relation we obtained: we start by setting the zeroth component $y_0'''(x)=1+x-\frac{x^2}{2}$, so that the first component is obtained by

$$y_1'''(x)=2y_0(x)-\int_0^x y_0(s)ds;$$

$$y_2'''(x)=2y_1(x)-\int_0^x y_1(s)ds;\ldots.$$

Applying the three-fold integral operator L^{-1} defined by, $L^{-1}(\cdot)=\int\int\int(\cdot)dxdxdx$.

Hence, taking into account the boundary conditions, we have

$$y_0(x)=\frac{1}{2}x^2+\frac{1}{6}x^3-\frac{1}{24}x^4;\quad y_1(x)=\frac{1}{12}x^4+\frac{1}{120}x^5-\frac{1}{240}x^6+\frac{1}{5040}x^7;$$

$$y_2(x)=\frac{1}{180}x^6-\frac{1}{5760}x^8+\frac{1}{72576}x^9-\frac{1}{3628800}x^{10};\ldots.$$

This gives the solution in the series form

$$y(x)=\sum_{n=0}^{\infty}y_n(x)=-1-x+\sum_{n=0}^{\infty}\frac{1}{n!}x^n=-1-x+e^x.$$

Application of variational iteration method.

Making $y_{n+1}(x)$ stationary with respect to $y_n(x)$, we can identify the Lagrange multiplier, which reads $\lambda=-(s-x)^2/2$. So we can construct a variational iteration form for (5) in the form:

$$y_{n+1}(x)=y_n(x)-\int_0^x\frac{(s-x)^2}{2}\left[y_n'''(s)-2y_n(s)-1-s+\frac{s^2}{2}+\int_0^s y(p)dp\right]ds.$$

We start by setting the zeroth component

$$y_0(x)=y(0)+xy'(0)+\frac{x^2}{2}y''(0)=\frac{x^2}{2}.$$

That will lead to the following successive approximations:

$$y_1(x)=\frac{1}{2}x^2+\frac{1}{6}x^3+\frac{1}{24}x^4+\frac{1}{120}x^5-\frac{1}{720}x^6;$$

$$y_2(x)=\frac{1}{2}x^2+\frac{1}{6}x^3+\frac{1}{24}x^4+\frac{1}{120}x^5+\frac{1}{720}x^6+\frac{1}{5040}x^7+\frac{1}{40320}x^8+\ldots;\ldots.$$

After the fourth iteration, the maximum absolute error is less than 10^{-11}, but the maximum absolute error decreases with increasing iteration.

So we obtain the following approximate solution $y_n(x) = -1 - x + \sum_{n=0}^{\infty} \frac{1}{n!} x^n$, which is the exact solution of the problem: $y(x) = -1 - x + e^x$.

Example 2. In the following example, we consider linear boundary value problem for the integro-differential equation [14, 15]

$$y''(x) = -\cos x + \frac{1}{4}\sin 2x + \frac{1}{2}x + \int_0^x y^2(s)ds,$$

with initial conditions $y(0) = 1,\ y'(0) = 0$; the exact solution is $y(x) = \cos x$.

Application of homotopy perturbation method.

A Homotopy can be readily constructed as follows

$$H(u, p) = u''(x) = -\cos x + p\left(\frac{1}{4}\sin 2x + \frac{1}{2}x\right) + p\int_0^x u^2(s)ds = 0. \quad (7)$$

Substituting $u = u_0 + pu_1 + p^2u_2 + \ldots$ into (7) and rearranging the resulting equation based on power of p-terms, one has

$$p^0:\ y_0''(x) = -\cos x;$$

$$p^1:\ y_1''(x) = \frac{1}{4}\sin 2x + \frac{1}{2}x - \int_0^x y_0^2(s)ds;$$

$$p^2:\ y_2''(x) = -\int_0^x 2y_0(s)y_1(s)ds;$$

$$p^3:\ y_3''(x) = -\int_0^x (2y_0(s)y_2(s) + y_1^2(s))ds;$$

$$p^4:\ y_4''(x) = -\int_0^x (2y_0(s)y_3(s) + 2y_1(s)y_2(s))ds;\ \ldots.$$

Applying the three-fold integral operator L^{-1} defined by, $L^{-1}(\cdot) = \int_0^x\int_0^x (\cdot)dxdx$.

Hence, taking into account the boundary conditions, we have $y_0(x) = \cos x;\ y_1(x) = 0;$ $y_2(x) = 0; \ldots$.

This gives the solution in the series form $y(x) = \sum_{n=0}^{\infty} y_n(x) = \cos x$.

Application of Adomian decomposition method.

Using $y(x) = \sum_{n=0}^{\infty} y_n(x)$ and the recurrence relation we obtained: we start by setting the zeroth component $y_0''(x) = -\cos x + \frac{1}{4}\sin 2x + \frac{1}{2}x$, so that the first component is obtained by $y_n''(x) = \int_0^x \left(\sum_{n=0}^{\infty} A_n(s)\right)ds,\ n \geq 1$. Applying the three-fold integral operator L^{-1} defined by, $L^{-1}(\cdot) = \int_0^x\int_0^x (\cdot)dxdx$. Hence, taking into account the boundary conditions, we have

$$y_0(x) = -1 + \frac{1}{8}x + \frac{1}{12}x^3 + \cos x - \frac{1}{16}\sin 2x;$$

$$y_2(x) = -\frac{15899}{1728} - \frac{15329}{8192}x + \frac{35}{96}x^2 + \frac{769}{3072}x^3 - \frac{1}{96}x^4 + \frac{1}{3840}x^5 - \frac{1}{720}x^6 + \frac{1}{10080}x^7 +$$
$$+ \frac{1}{72576}x^9 + 2\sin x + \frac{147}{16}\cos x - \frac{71}{1024}\sin 2x + \frac{1}{64}\cos 2x - \frac{1}{432}\cos 3x + \frac{1}{32768}\sin 4x \ ; \ \ldots .$$
$$+ \frac{23}{4}x\sin x + \frac{5}{512}x\cos 2x + \ldots .$$

This gives the solution in the series form $y(x) = \sum_{n=0}^{\infty} y_n(x) = \cos x$.

Application of variational iteration method.

Making $y_{n+1}(x)$ stationary with respect to $y_n(x)$, we can identify the Lagrange multiplier, which reads $\lambda = (s-x)^3/6$. So we can construct a variational iteration form for (5) in the form:

$$y_{n+1}(x) = y_n(x) + \int_0^x (s-x)\left[y_n''(s) + \cos s - \frac{1}{4}\sin 2s - \frac{1}{2}s + \int_0^s y^2(p)dp \right] ds .$$

We start by setting the zeroth component $y_0(x) = y(0) + xy'(0) = 1$.

That will lead to the following successive approximations:

$$y_1(x) = 1 - \frac{1}{2}x^2 + \frac{1}{24}x^4 - \frac{1}{60}x^5 - \frac{1}{720}x^6 + \frac{1}{630}x^7 + \frac{1}{40320}x^8 + \ldots ;$$
$$y_2(x) = 1 - \frac{1}{2}x^2 + \frac{1}{24}x^4 - \frac{1}{720}x^6 + \frac{1}{8064}x^8 - \ldots .;$$
$$y_3(x) = 1 - \frac{1}{2!}x^2 + \frac{1}{4!}x^4 - \frac{1}{6!}x^6 + \frac{1}{8!}x^8 - \ldots$$

After the fourth iteration, the maximum absolute error is less than 10^{-10}, but the maximum absolute error decreases with increasing iteration.

So we obtain the following approximate solution $y_n(x) = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n)!}x^{2n}$, which is the exact solution of the problem: $y(x) = \lim_{n\to\infty} y_n(x) = \cos x$.

Conclusion.

This results shows a comparative study between homotopy perturbation method, variational iteration method and Adomian decomposition method of solving Voltera integro-differential equations. The main advantage of these methods are the fact that they provide its user with an analytical approximation, in many cases an exact solution in rapidly convergent sequence with elegantly computed terms. Also these methods handle linear and non-linear equations in a straightforward manner. These methods provide an effective and efficient way of solving a wide range of linear and nonlinear integro-differential equations. Illustrative examples are given to demonstrate the validity, accuracy and correctness of the proposed methods. The error between the approximate solution and exact solution decreases when the degree of approximation increases.

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MAIN SPECIES OF SPIDER MITES (ACARIFORMES: TETRANYCHIDAE) IN POME FRUIT ORCHARDS AND DEGREE OF THEIR OCCURRENCE

Abstract: *In the article, researches on the monitoring of the main species of (acariformes tetranychidae) in seed-fruit gardens and their occurrence levels were conducted. According to the research, a total of 6 types of mites were involved from the tetranychidae family of the class of ticks in the seed-fruit trees (apple, pear, quince).Of these, 3 species were identified as the most harmful and volatile species. In seed-fruit gardens, apple red mite, gray fruit mite, and common cariformes: tetranychidae have been observed to damage leaves, young branches, and fruits of trees to a high degree. It was represented by cold beating of the branches of damaged trees, shedding of leaves and the appearance of various spots on the fruit.*

Key words: *pome fruit crops, mites, Tetranychidae, species composition, systematic analysis, harmfulness, degree of occurrence.*

Language: *Russian*

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ОСНОВНЫЕ ВИДЫ ПАУТИННЫХ КЛЕЩЕЙ (ACARIFORMES: TETRANYCHIDAE) В СЕМЕЧКОВЫХ ПЛОДОВЫХ САДАХ И СТЕПЕНЬ ИХ ВСТРЕЧАЕМОСТИ

Аннотация: *В статье приведены данные по основным видам паутинных клещей (Acariformes: Tetranychidae) в семечковых плодовых садах и мониторингу их степени встречаемости. Согласно исследованиям в семечковых плодовых культурах (яблоня, груша, айва) встречаются 6 видов клещей относящиеся семейству Tetranychidae класса клещей. Из них выявлены 3 вида наиболее вредоносных и встречающихся видов. Наблюдения показывают, что в семечковых плодовых садах яблонный красный клещ, серый плодовый клещ и обыкновенный паутинный клещ наносит значительный вред листьям, молодым веткам и плодам плодовых культур. Поражённые ветки и листья деревьев опадают и появляются пятна на плодах.*

Ключевые слова: *семечковые плодовые культуры, клещи, Tetranychidae, видовой состав, систематический анализ, вредоносность, степень встречаемости.*

Введение

УДК: 632.6

В плодовых садах наносят вред несколько видов клещей. Считается, что они принадлежат главным образом к двум семействам, к первым относятся четвероперноногие клещи (Tetranychidae) и двухпарноногие клещи (Eriophyidae). Эти клещи можно увидеть в специальном увеличительной лупе в полевых условиях, в микроскопе в лабораторных условиях. Основными встречающимися клещами в плодовых садах нашей республики являются обыкновенные паутинные клещи, боярышниковые клещи и садовые клещи [5]. В садоводческих хозяйствах, было установлено, что несколько видов клещей с высокой степенью вредоносности способны наносить большой ущерб. Это серый плодовый клещ (*Bryobia redikorzevi* Rech), боярышниковый клещ (*Tetranychus viennensis* Zacher), яблоневый красный клещ (*Metatetranychus ulmi* Koch), обыкновенный паутинный клещ (*Tetranychus urticae* Koch) и другие галловые клещи. Паутинные клещи развиваются и размножаются в основном на основе паутины [6]. Паутинный клещ (*Tetranychus urticae* Koch). В Узбекистане несколько видов растительных клещей повреждают хлопчатник и другие сельскохозяйственные культуры, но наиболее опасными из них являются обыкновенные паутинные клещи. Он является растительноядным существом класса пауков (Arachnida), отряда акариформных клещей (Acariformes) [1].

Обыкновенные паутинные клещи - самые опасные вредители хлопчатника и других сельскохозяйственных культур в Средней Азии. Этот вредитель может уничтожить более половины урожая на некоторых полях. В обычные годы из-за паутинного клеща погибает 6-10% от всего валового сбора, а в отдельные годы даже на 14% [2].

Паутинный клещ считается высоким по степени опасности и вредности по сравнению с другими клещами (*Tetranychus urticae*), считается основным вредителем ландшафтных деревьев, бахчевых, технических культур и садоводства. В мире паутинные клещи были зарегистрированы в качестве основного вредителя более чем 150 видов сельскохозяйственных культур [8]. Согласно исследованиям, других ученых, клещи распространены на полях возделывания практически всех сельскохозяйственных культур земной поверхности, а фитофаги клещей считаются связанными с растениями всех стадий своего развития по отношению к другим клещам. Было установлено, что паутинные клещи причиняют вред 1200 видам культурных и других растений, а 150 видов этих растений находятся в высокой экономической опасности [7, 9, 10].

В наших садоводческих хозяйствах были проведены исследования по клещам, их биоэкологическим характеристикам и систематическому статусу, но они не были изучены глубоко. По этой причине была поставлена задача провести исследования по анализу и вредоносности клещей и их видов, с которыми мы столкнулись в садоводческих районах республики.

Материалы и методы

Исследования проводились в 2017-2019 годах в местных и интенсивных семечковых плодовых садах Ташкентской, Самаркандской и Сурхандарьинской областей. В ходе исследований были проведены многолетние наблюдения за садоводческими районами регионов, а в сезон были выявлены клещи в семечковых плодовых садах, и с них были взяты пробы. Образцы систематически анализировались в лаборатории защиты растений Ташкентского государственного аграрного университета на основе различных литературных и интернет-источников. Были определены такие показатели, как виды клещей, системный анализ и их степень встречаемости. В лабораторных исследованиях использовался термостат Memmert IPP IPP55plus, микроскоп XSZ-152 для выделения морфологических признаков. Создавались условия для развития каждого вида, а образцы хранились в чашке Петри и в пробирках ПХ 20.

Результаты исследования и их обсуждение

В ходе исследований в основном пораженные клещами участки выделялись отдельно и наблюдались в течение всего сезона. Первоначально клещи, собранные в 2017 -2018 годах, были сопоставлены между собой, и систематическая точность была введена в их виды. По этим данным, определялись клещи, наносящие вред яблоне, груше и айве которые обильны и имеют высокую степень вредоносности. По этим данным, в изученных регионах в семечковых плодовых садах встречалось 6 видов клещей. Но не все они имели высокий уровень развития и плотность населения. В семечковых плодовых садах в основном попадались паутинные клещи, относящиеся к семейству Tetranychidae. Из них встречались яблонный красный клещ - *Panonychus ulmi* Koch, 1836 (*Metatetranychus ulmi* Koch.), боярышниковый клещ - *Tetranychus viennensis* Zacher., серый плодовый клещ – *Bryobia redikorzevi* Rech., обыкновенный паутинный клещ - *Tetranychus urticae* Koch., плодовый паутинный клещ - *Schizotetranychus pruni* Oudms., Туркестанский паутинный клещ - *Tetranychus turkestani* Ug. Et Nik.

Таблица 1. Степень встречаемости и систематический анализ клещей в семечковых плодовых садах (Ташкентский, Самаркандский и Сурхандарьинские области, 2017-2018гг)

№	Виды клещей		Семейство	Степень встречаемости
На яблоне (*Malus domestica*)				
1.	Яблонный красный клещ	*Panonychus ulmi* Koch, 1836. (*Metatetranychus ulmi* Koch.)	*Tetranychidae*	+++
2.	Боярышниковый клещ	*Tetranychus viennensis* Zacher.	*Tetranychidae*	++
3.	Серый плодовый клещ	*Bryobia redikorzevi* Rech.	*Tetranychidae*	++
4.	Обыкновенный паутинный клещ	*Tetranychus urticae* Koch.	*Tetranychidae*	+++
5.	Садовый паутинный клещ	*Schizotetranychus pruni* Oudms.	*Tetranychidae*	++
6.	Туркистанский паутинный клещ	*Tetranychus turkestani* Ug. Et Nik.	*Tetranychidae*	+
На груше (*Pyrus communis* L.)				
1.	Яблонный красный клещ	*Panonychus ulmi* Koch, 1836. (*Metatetranychus ulmi* Koch.)	*Tetranychidae*	+++
2.	Боярышниковый клещ	*Tetranychus viennensis* Zacher.	*Tetranychidae*	++
3.	Серый плодовый клещ	*Bryobia redikorzevi* Rech.	*Tetranychidae*	+++
4.	Обыкновенный паутинный клещ	*Tetranychus urticae* Koch.	*Tetranychidae*	++
5.	Туркистанский паутинный клещ	*Tetranychus turkestani* Ug. Et Nik.	*Tetranychidae*	+
На айве (*Cydonia oblonga* Mill)				
1.	Яблонный красный клещ	*Panonychus ulmi* Koch, 1836. (*Metatetranychus ulmi* Koch.)	*Tetranychidae*	++
2.	Серый плодовый клещ	*Bryobia redikorzevi* Rech.	*Tetranychidae*	++
3.	Обыкновенный паутинный клещ	*Tetranychus urticae* Koch.	*Tetranychidae*	+++

Эти клещи повреждают плодовые виды деревьев, и степень их встречаемости разные, а в некоторых случаях наблюдалось сопутствующее развитие нескольких видов клещей в одном виде плодовых культур. В основном такие случаи наблюдались у яблони и груши. На сильно повреждающимися клещами плодов яблони были зарегистрированы яблонные красные клещи, обыкновенные паутинные клещи, а также клещи средней степени поражения встречались боярышниковый клещ, серый плодовый клещ. Как вид, менее распространенный, чем другие клещи, было обнаружено Туркестанский паутинный клещ. В одно время на яблоне, наряду с яблонным красным клещом, был также обнаружен серый клещ.

В период плодоношения груши умеренное количество наблюдалось у боярышниковых клещей и паутинных клещей, когда сильное поражение обнаруживалось у яблонного красного клеща и серого клеща. Туркестанский паутинный клещ встречался с очень небольшим количеством. На груше тоже состояние повреждения клещами было выше, и в основном обыкновенный паутинный клещ был обнаружен как очень вредоносный клещ. В то же время в некоторых местах наблюдалось умеренное поражение яблони красными и серыми плодовыми клещами. Помимо вышеперечисленных плодовых культур, в косточковых плодовых культурах было выявлено много случаев повреждения клещами, и в наших дальнейших исследованиях на эту тему мы прольем свет.

Выводы

В результате проведенных исследований было установлено, что в семечковых плодовых культурах (яблоня, груши, айва) зарегистрировано в общей сложности 6 видов клещей из видов, относящихся к семейству Tetranychidae. Из них 3 вида были определены как наиболее вредные и много встречающиеся виды. Из них было замечено, что яблонный красный клещ, серый плодовый клещ и обыкновенный паутинный клещ сильно повреждали листья, молодые ветви и плоды плодовых культур. Это проявлялось в опадении листьев и появлении различных пятен на плодах.

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COMMON PROBLEMS IN READING AND ITS STRATEGIES IN TEACHERS' OPINION

Abstract: *This article shares some ideas and research of the problems of reading as well as strategies to skip these problems.*

Key words: *storytelling, comprehension, reading, enhancing, vocabulary.*

Language: *English*

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Introduction

Reading is the base of effective communication. So improper grammar can likewise affect the meaning and clarity of an intended message or speech. Proper reading makes your content more readable and in turn more interesting.

Storytelling and reading are literacy practices that have the potential to bridge both home and school literacy practices. Agosto (2016) clearly distinguishes between "storytelling" and "story reading", exploring both the literacy-related benefits to a purely oral story, and the potential physical barrier a book may pose. In reality, not all teachers will feel perfectly confident telling a story completely freely, and many classrooms may explore a compromise.

Lotherington (2008) explore three separate case studies of multiliterate story-telling, giving other practitioners a broad overview of possibilities in the classroom. One example involved one story ("Three Little Pigs") which was then told by several children in their various home languages, often involving parents in the preparation of the story. Another case used role play and technology to re-create an Aesop's fable in multiple languages. A third example created a multilingual storyboard, based on the story of Little Red Hen, forming a visual, multilingual representation of languages and cultures present in the classroom. Lotherington point out how important it is to have a visual representation of classroom languages present, and embedded in curriculum development, going beyond the basics of having greetings or "welcome" in multiple languages in the classroom.

During my working procedure with students I investigated that multiple reading and storytelling can show their effect not only in the sphere of enhancing visual representation of students but also gives a big opportunity to enlarge their speech and phonetic problems , especially in those students who have some defects in the speech . The fluency was noticed in their pronunciation step by step after more practicing storytelling in reading classes.

According to the results of the study, classroom teachers state that students with reading/comprehension difficulties are having problems in understanding and interpreting the questions and directives as regards the text, making reading errors (adding, omitting, changing letters, pauses) and their language skills in Turkish and grammar problems affect all other courses negatively. It is also claimed that students are not interested in courses. It is found out that a majority of classroom teachers do not use any special strategy while working with students having these difficulties, but frequently felt the need to benefit from the experiences of special education teachers. In addition, different opinions were declared on "co-teaching" performed by special education teacher and classroom teachers in the same classroom. Based on the research findings, it is

believed that although there are some positive opinions, classroom teachers are not ready to provide education in cooperation with special education teachers in the same classroom environment.

However Meredith Cicerchia (a teaching affiliate at the University of Nottingham education consultant and a freelance writer) numerates the followings as problems in reading:

Issues with decoding when children are able to put sounds to letters in order to sound out written language. It is common for beginner readers to struggle when they meet new or unfamiliar terms, but typically decoding becomes easier with phonics.

Poor comprehension is the next issue that is going on in reading, from letter and word recognition to understanding meaning at the, sentence and paragraph level. When a beginner reader encounters vocabulary they do not know or recognize due to inaccurate decoding, they are likely to skip ahead. The more blanks in a line of a text the harder it is to make meaning and the more cognitively challenging and frustrating the reading tasks become. However here I have to mention that reading also requires being able to pay attention to narrative. Students especially at high schools need to identify gist, main ideas and specific details even make inferences about what they are reading.

The third issue which she counts is speed; there may be an underlying problem, such as slow procession. Reading is cognitively demanding task and holding so much information in the mind while continuing to process text can exhaust children with slow processing. Strategy instruction may help but it is important that these students be allowed extra time to complete tasks that require extensive reading.

In this cases there are reading strategies that can help students their prior knowledge of a topic and take guesses about what they are about to read by analyzing pictures and titles or skimming a text to assess the main idea.

You can also create mind maps as a pre-reading activity or put a few questions on the board and have the students start by discussing them in order to prepare for the reading.

The next strategy is building vocabulary the more words a student knows the easier it will be to recognize them in reading. Teaching vocabulary is also helpful for spelling skills. Teacher can provide glossary alongside a text or pre –teach key terms before the reading begins. As learning words in context provides additional depth in meaning, of course teachers might also consider providing instruction in contextual guessing.

Dr .Erica is a reading specialist, educational therapist and a author of multisensory and mindful educational materials, she suggests some solutions for reading disabilities:

Black text on a white background can be visually uncomfortable for many children, as the contrast can make the letters appear to move or vibrate. If this is the case, then you can make color overlays. You can cut out your own overlays by using transparent, colorful report covers or pocket folders. I like to use a paper cutter and slice them into strips that can be used as bookmarks too. As another option, you can purchase glasses with color-tinted lenses. The most popular colors are blue and yellow.

Similarly, if changing the background color is helpful when reading, these students will probably benefit from changing the background when typing. On a Mac computer using MS Word, this can be completed by selecting the Format drop down menu and then choosing background. Here other background colors can be selected. Please note that the background will not be impacted when printing documents. On a PC this can be done by choosing Page Layout and then Page Color.

Play search games with words and letters that are confusing. For instance, if a young learner mixes up the letters b and d, provide a magazine, newspaper, or other print out and ask them to circle all the letter b's. They do not have to read the text. They will just be scanning for the letter or word. If you ask them to look across one line at a time, then you will also help them to improve tracking skills.

Locate some jokes on the internet or in a book. Review each joke and discuss what makes it amusing. Talk about words that have double meanings, and make a list of as many words that you can think of that have multiple meanings. Lastly, suggest that the learner makes his or her own joke book.

If spelling is a problem, go through the student's notebooks and handouts to uncover commonly misspelled words. Place each word on a single page, and have fun inventing memory strategies that will help the student recall the correct spelling. For example, if a student is having difficulty with the word "what," he or she may notice that the word "what" has the word "hat" in it. Then, they may draw hats on the page and then write down the question, "What hat?"

In my working procedure with students I noticed the following methods as solutions useful for reading:

Playing enjoyable internet games and watching videos that review and enhance basic phonics.

Integrating kinesthetic and tactile modalities into lessons ,usually they make them enjoyable and memorable.

Reading aloud or utilizing books on tape. While listening I usually ask students to close their eyes so that they can imagine the story in their mind as this helps learners to develop the capacity to utilize their mind's eye improves attention, reading comprehension and memory. Another alternative is to ask learners read along with the audio as a result they begins to observe whole words and phrases.

Another side of difficulties in reading is connected with some opinion and investigation of scientists of complex problems in reading. Scientists

have been investigating poor reading—also known as reading difficulty, reading impairment, reading disability, reading disorder, and developmental dyslexia (to name but a few)—for over a century. While it may take another century of research to reach a complete understanding of reading impairment, there are number of things that we have learned about reading difficulties, as well as the children who experience reading them, that provide key clues about how poor reading can be identified and treated effectively.

Poor readers display different reading behaviors

This problem, which is often called poor phonological recoding or decoding, can be detected by asking children to read novel "nonwords" such as YIT. Other poor readers have a particular difficulty with learning to read new words accurately that do not follow the regular mappings between letters and sounds, and hence must be read via memory representations of written words.

Reading behaviors have different "distal" causes

Distal causes reflect the fact that reading is a taught skill that unfolds over time and across development. It depends upon a range of more cognitive abilities, such as memory, attention, and language skills, to name but a few. Depending on children's strengths and weaknesses in these underlying abilities, and how these abilities affect learning over time, children will have different profiles of developmental, or distal, causes of their reading impairment. Stated differently, there can be different causal pathways to the same impairment of the reading system.

Translating what we know (thus far) into evidence-based practice

At first glance, what we have learned (so far) about poor readers and reading difficulties paints a picture of such complex heterogeneity that it is tempting to throw one's hands up in despair. And yet, somewhat paradoxically, it is this very heterogeneity that provides some important clues about how to maximise the efficacy of intervention for poor readers. First, the fact that poor readers vary in the nature of their reading behaviors suggests that the first step in identifying an effective intervention for a poor reader is to assess different aspects of reading (e.g., word reading accuracy, reading fluency, and reading comprehension).

Second, the fact that poor readers' reading behaviors can have different proximal causes suggests that the next step is to test them for the potential proximal causes of their poor reading behaviors. This is where cognitive models of reading are a useful roadmap, providing an explicit account of the key processes directly underpinning successful reading behavior. Again, this can be done using standardized tests that are available commercially (e.g., the Peabody Picture Vocabulary Test Fourth Edition available from Pearson)

Over the last century or so, we have learned important things about reading difficulties and the people who have them. We have learned that poor readers display different reading behaviors, that any one reading behavior has multiple proximal and distal causes, that some poor readers have concomitant problems in other areas of their cognition and emotional health, and that interventions that focus on proximal causes of poor reading behaviors may be more effective than those that focus on distal causes. This knowledge provides some clues to how we might best assist children with reading difficulties. Specifically, we need to assess poor readers for (1) a range of reading behaviors, (2) proximal causes for each poor reading behavior, and (3) co morbidities in their cognition and emotional health. It should be possible to design an individualized intervention programme that accommodates for a poor reader's co morbid cognitive or emotional problems whilst targeting the proximal causes of their poor reading behavior or behaviors. This approach, which requires the co-ordinate efforts of teachers and specialists and parents, is no mean feat. However, according to the scientific evidence thus far, this is the most effective approach we have for helping children with reading difficulties. As for teachers' view problems in reading it shows both difficulties and ways out at the same time.

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FEATURES OF THE ORGANIZATION OF AN INTEGRATED INTRODUCTORY PHONETIC COURSE OF GERMAN AS A SECOND FOREIGN LANGUAGE IN A NON-LINGUISTIC HIGHER EDUCATIONAL INSTITUTIONS

Abstract: *The article substantiates the relevance, considers the conditions and basic principles of building an integrated introductory phonetic course of the German language in the implementation of the optional discipline "German as a second foreign language" in a non-linguistic higher educational institutions. The concepts of positive transfer and interference of phonetic skills are analyzed from the position of artificial subordinative triglossia: Uzbek as a native language, English as a first language and German as a second foreign language.*

Key words: *subordinative triglossia, basic disciplines, linguodidactic processes and phenomena, German as second foreign language.*

Language: *English*

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Introduction

The leading position of English as a lingua franca in the academic and professional spheres of international communication has led to the fact that non-linguistic universities are increasingly converting German to the status of an elective, excluding it from the list of basic disciplines. At the same time, the strength of our state's ties with German-speaking countries and the developed academic partnership have an impact on the fact that the popularity of this optional discipline and the interest of students in it increases.

The study of several foreign languages in a non-linguistic university has revealed the current problems of teaching foreign languages in a bilingual, as well as in a multilingual audience. Its relevance is due to both external factors and processes mentioned above, and internal linguodidactic processes and phenomena, for example, such as subordinative triglossia (trilingualism), which occurs when learning a second foreign language (2nd FL), as a result of which the native language, the first foreign language, and 2nd FL interact and create this unique linguistic phenomenon. Triglossia is defined as "the ability of an individual to use three languages (native and two foreign)" [1].

Transfer is an important mechanism for learning a second foreign language. It is based on the generalization of principles, programs, and methods of action, knowledge, skills and abilities in the native language and an understanding of strategies for mastering a foreign language. The interaction of language systems of the native language and two foreign languages forms an artificial subordinative trilingualism. Typical characteristics of such education are: a) artificial character; b) subordinativity; C) mixed type of language proficiency. Subordinative trilingualism is characterized by an indissoluble connection of all three contacting languages [2].

In our case, we are talking about following the chain of command languages: Uzbek as a native language – English as a first language and German as second foreign language, since as practice shows, three out of four, studying German language as 2nd FL,

studied English as 1st FL and can potentially use the experience, knowledge, and skills that can be transferred to 2nd FL and greatly facilitate its study [1], since these languages belong to one language group – German. We largely share this opinion, but in this article we would like to focus our attention on the phonetic aspect of mastering German as an 2nd FL and analyze whether the knowledge of phonetic foundations and a high level of phonetic skills in English ensures the successful formation of appropriate skills in German. In this regard, the subject of our research is interlanguage interference at the phonetic level, as well as ways and means to prevent and overcome it when learning German as a second foreign language in a non-linguistic university.

An important basis for analyzing the above problem for us is the article that in modern linguodidactics, most researchers tend to believe that the influence of 1st FL on the study of 2nd FL is stronger than the influence of the native language [3, 86]. According to E. E.Shavrukova, at the appropriate level of skill formation in 1st FL, the probability of transferring them from this language increases, and the influence of the native language weakens, however, the degree of influence from 1st FL is determined by the level of proficiency of students [4]. Along with the positive transference (transportation,) English into German, for facilitating the formation of skills and development of abilities, there is, as we have noted earlier, and his interfering, the negative impact that involves all levels of language and speech and non-speech behavior. M.V.Sherbakova distinguishes four levels of migration: at the level of intellect activity, at the language level, at the level of academic skills and socio-cultural level [3, 85].

The choice of the phonetic aspect in our situation is not accidental. Many years of experience and practice of teaching German as a 2nd FL in a non-linguistic university, as well as the analysis of research on this topic [5, 9] confirm that the most stable phenomenon of interference of English into German is observed at the phonetic level, which leads to a violation of communication both from the position of reception and from the position of speech production, since deviations from the pronouncing norm of the German language arising from the action of phonetic skills, the languages formed on the basis of English or Uzbek as a native language cause certain difficulties in understanding the interlocutors, switching their attention from the content to the form. Despite the importance and significance of pronunciation training, it is impossible to disagree with the opinion of German researchers H.Dealing and W.Hirschfeld, who say that despite the great importance of correct construction of intonation patterns, as well as correct articulation of sounds for speech communication, the complex development of phonetic competence still plays a secondary role in the process of teaching a foreign language, thus testifying to the low status of a "foster child of a foreign language discipline" [6, 10]. To change the attitude to the role of pronunciation and improve the effectiveness of foreign language communication in German in general, we believe it is urgent and necessary to identify the optimal ways and means of preventing and overcoming the interfering influence of English on German and determine the methods of teaching phonetics when learning German as a 2nd FL in a non-linguistic university.

Researchers of the phonetic aspect of the language believe that any target groups can master pronunciation with a minimal accent, since only two factors must be present to achieve this goal: the presence of high motivation and the choice of an effective method of teaching phonetics [7, 60]. The fact of choosing German as an optional discipline already implies a fairly high level of motivation for students to learn German, as well as interest in mastering and improving its phonetic aspect. As for the methodology, for its optimal construction, it is extremely important to study the mechanism of spontaneous transfer in the process of switching codes, determining its regularities and related phenomena. This allows us to identify the possibilities of system transfer management in the process of mastering a second foreign language [2].

The process of learning foreign language pronunciation can be structured in different ways. Summing up the accumulated didactic and methodological experience, I.S.Krestinsky identified the following stages of cognition, assimilation and activation of phonetic skills, which are reflected in certain sections of the integral phonetic course, consisting of introductory and transitional phonetic, intonation expressiveness and verbal and phrasal accents, corrective and phonostilistic courses [7].

Of course, to achieve a high level of formation of phonetic skills, all these sections are important and necessary, but based on the organizational and regulatory conditions of teaching German as a foreign language in a higher education institution, which imply a fairly limited number of classroom hours, as a rule, the non-target value of phonetics laid down in the discipline's programs, it is, in our opinion, impractical to talk about building a complete and isolated phonetic course. An integrated introductory phonetic course (IIPC), based on special didactic and methodological principles and components, should be the most optimal way to form auditory and rhythmic-intonation skills of the German language.

As a rule, the purpose of the introductory phonetic course is the primary development of pronunciation skills and general acquaintance with the phonetic structure of a foreign language; the study of the characteristics of sounds in their contrast with the sounds of the native language, the development of skills in transcribing and intonation of texts, the ability to hear and correct phonetic errors; familiarity with the principles of pronunciation training [7]. In our

case, the basis of IIPC should be a conscious comparison of two phonetic systems and their contrastive characteristics, based on the principles of learning 2nd FL: the cognitive principle, the principle of support and comparative communication with 1st FL, as well as the principle of individualization [8]. In addition, an important feature of IIPC is its involvement in the lesson, which implies familiarization and development of phonetic phenomena, improving phonetic skills on the basis of those speech structures that are currently being studied.

The first and necessary stage of building the IIPC is the selection of its content, based on the analysis of potential deviations from the German language norm at the phonetic level, caused by the interfering influence of the native language and 1st FL and most complicating communication. To determine such phonetic phenomena, comparative analysis and language comparison are used. Comparing the phonetic systems of the studied languages allows you to predict with a high degree of probability what distinctive and similar features can cause positive and negative transfer. It is also important to determine the individual difficulties and features of articulation of sounds by students, which are caused, among other things, by the problem of stability of skills, more precisely, the inequality of stability of skills in the studied languages, which consists in the fact that of the two systems of skills that collide with each other, the one that has the greatest stability wins.

Understanding and identifying the causes of interference occurs based on several positions: the features of articulation of sounds, the meaning-distinguishing value of stress, intonation pattern and its meaning, the features of articulation of individual sounds that are absent in the native and 1st FL. Here are just some examples of the interfering influence of English on German, which we encounter most often: the pronunciation of voiced consonants at the end of a word (und, Geld, Diaolog) and words with letters and combinations of letters "w", "v", "r", "ch", "st", "sp", "ng", pronounced differently in English, incorrect stress in international words and words of Germanic origin that have common roots (stúdent-Studént, músic-Musik), difficulties often arise both with the articulation of letters that are absent in both native and 1st FL, and with their reception, auditory perception, for example, letters with umlaut, diphthong. It is also difficult for students to build intonation patterns of German sentences that differ from English and Uzbek (for example, intonation of incompleteness, interrogative intonation). The analysis of such difficulties and deviations from the language norm of the German language should form the basis of the content of the integrated introductory phonetic course.

In the process of studying 2nd FL, previously learned phonetic samples of the native language and 1st FL serve as a kind of standard or filter that exists in our minds. The student tries to arrange new knowledge in accordance with existing patterns. All similar phonetic phenomena are automatically assigned attributes that already exist in the mind [9]. Hence the occurrence of errors, both at the level of perception and articulation. By paying attention to similar and distinctive features of phonetic phenomena, their conscious identification, perception, and purposeful auditory and articulatory training, the student can reduce the influence of interference, as well as use this knowledge as a basis for positive transfer.

Based on the above, we note the fundamental components of the IIPC of the German language as 2nd FL – first, exercises that prepare for identification, recognition of new phonetic phenomena by ear (for example, to listen consciously and purposefully, to see the features of articulation of individual sounds; to distinguish intonation and related intent; recognize and select words with specified sounds, etc.) second, exercises for independent reproduction of articulation and intonation (for example, repetition of the reference pronunciation, reproductive and productive tasks with concentration on certain sounds, intonation, etc.). In the process of working on phonetics, to overcome interference from the 1st FL, differentiated exercises are important and necessary, accompanied by an explanation of the differences in articulation of matching sounds and intonation patterns [4]. The number of exercises and duration of training is determined by the characteristics of a specific target group of students.

As a rule, modern educational and methodological complexes used in the process of teaching German as a 2nd foreign language contain a certain number of exercises and tasks aimed at the formation of phonetic skills. However, a more detailed analysis from the point of view of the need for training and prevention of the interfering influence of 1st FL revealed that the selection of phonetic phenomena proposed for mastering is not based on comparing the studied languages and predicting possible difficulties, and in addition, the didactic and methodological tools for practicing phonetics are quite similar and focused mainly on imitative exercises, without taking into account the interfering influence of the native and first foreign languages, this once again confirms the relevance of the revision of the approach to teaching the phonetic side of German as a 2nd foreign language in the framework of teaching this optional discipline in a non-linguistic university.

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"PICK UP A KEY" - METHOD ESTIMATIONS OF KNOWLEDGE AND THE COMPETENCE OF THE PUPILS

Abstract: *In given clause the new test method Estimations of knowledge is offered, skill and competence of the pupils - " Pick up a key ". The given offered method, his (its) essence and meaning (importance) is in detail described during teaching on an example of subjects the Uzbek language and literature.*

Key words: *a method, estimation, knowledge, competence, method "Pick up a key".*

Language: *Russian*

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«ПОДБЕРИ КЛЮЧ» - МЕТОД ОЦЕНИВАНИЯ ЗНАНИЙ И КОМПЕТЕНЦИЙ УЧЕНИКОВ

Аннотация: *В данной статье предлагается новый тестовый метод оценивания знаний, навык и компетенций учеников – «Подбери ключ». Подробно описывается данный предлагающийся метод, его суть и значение в процессе преподавания на примере предметов узбекский язык и литература.*

Ключевые слова: *метод, оценивание, знание, компетенция, дневник-диаграмма тестовый метод «Четвертый лишний», метод «Подбери ключ».*

Введение

В системе образования каждой страны, в том числе и в системе народного образования Узбекистана используются многочисленные методы и технологии при преподавании разных предметов. Данные популярные методы преподавания в основном направлены на повышение эффективности обучения. Но, если учитывать современную ситуацию, возникшую в результате развития науки и технологии, разных средств общения, активности сетей виртуального общения, в частности сети интернет, современные ученики имеют огромные возможности получить обширную информацию по темам. В связи с этим, возникают трудности при привлечении внимания учеников к аудиторным занятиям. Значит, учителя имея прочные теоретические знания по своей специальности должны уметь применять методы, которые смогут привлечь внимание учеников к определенному предмету и к теме, то есть должны быть мастерами своей профессии, должны идти на шаг впереди от своих учеников.

Урок – индивидуальный, творческий процесс, в котором преподаватель при опросе прошедшей темы, объяснении новый темы и при оценивании знаний, навыков и компетенций

учеников, учитывая возможности аудитории, имеет возможность применять различные методы объяснения, укрепления и оценивания.

Если иметь в виду что процесс оценивания с психологической точки зрения является важным этапам урока, так как именно поощрение, полученное учеником на предыдущем уроке, выполняет функцию мотива, привлекающего его к последующему уроку. Само по себе ожидание получения особого внимания и похвалы за выполненный труд способствует внимательному прислушиванию ученика к заданиям и эффективному получению знаний.

Оценивание знаний учеников может осуществляться индивидуально или в малых группах. Не зависимо от того какой метод оценивания применяется на уроках, по нашему мнению, необходимо обязательно подчеркивать заслуги каждого ученика: динамику повышения или снижения знаний по предмету. Для этого в начале учебного года можно предложить ученикам вести дневник-диаграмму. Эта диаграмма может быть разделена на недели, месяца, четверть, и иметь примерно следующею структуру:

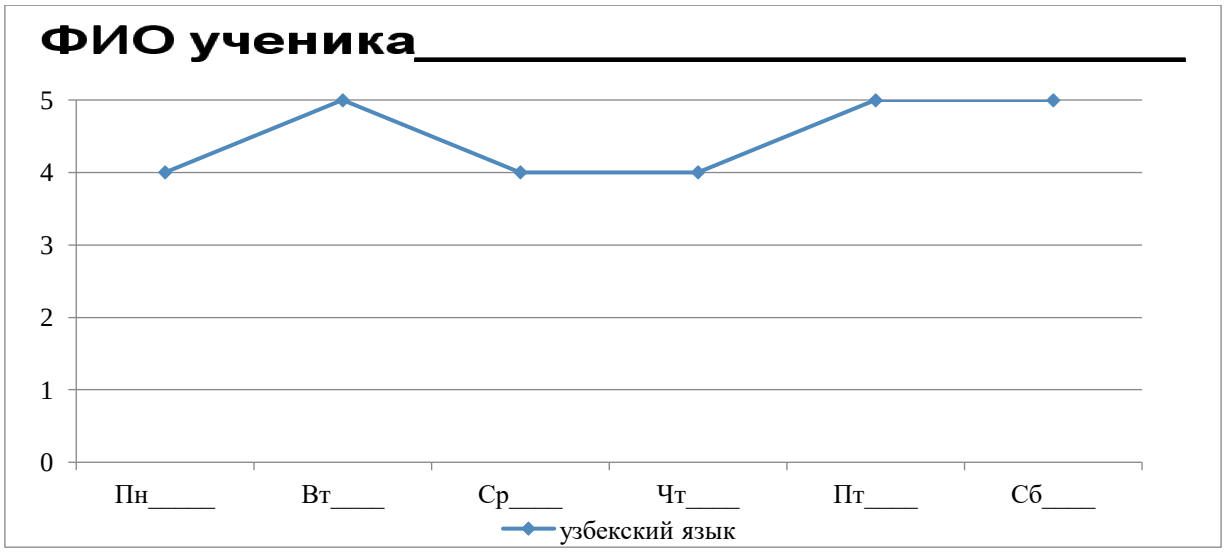

Рисунок 1.

Такую диаграмму могут применять учителя по разным предметам. Так как в ней ярко выражается динамика роста или снижения знаний учеников. Также целесообразно применение диаграммы-дневника в качестве приложения к традиционному дневнику со стороны классного руководителя и может вестись одновременно по всем предметам. Это будет иметь примерно следующий вид:

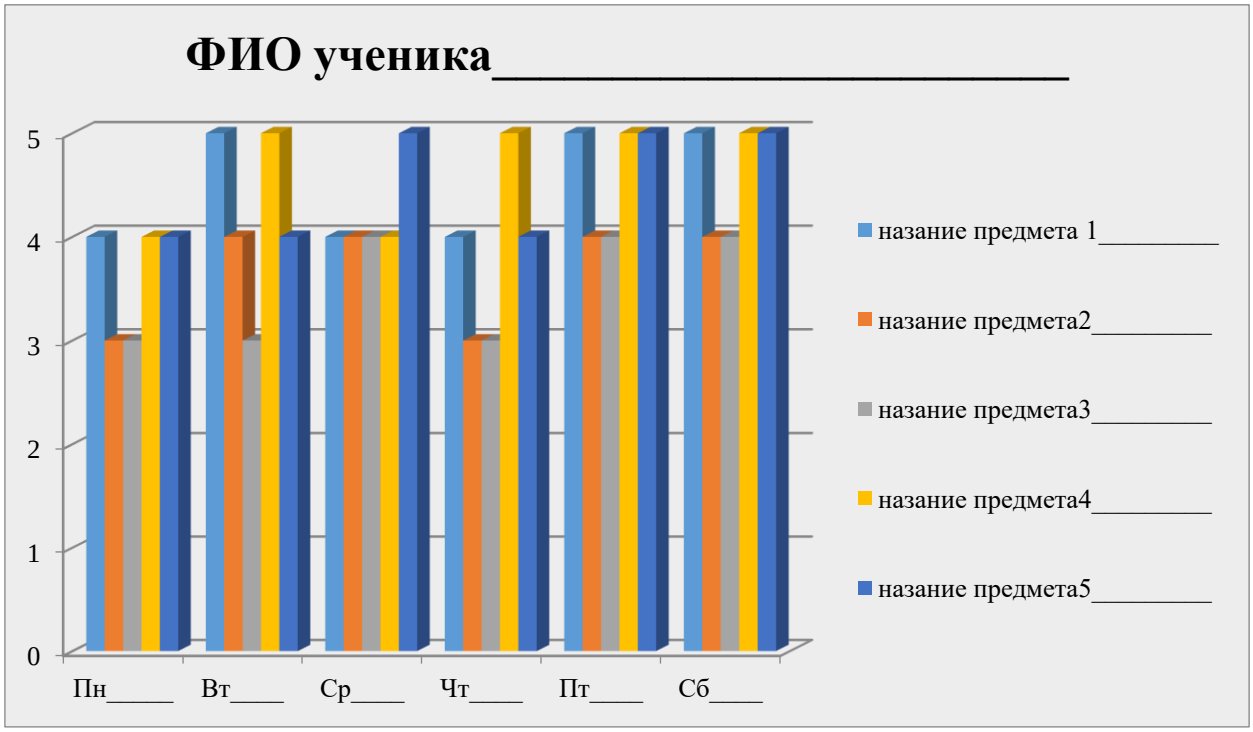

Рисунок 2.

Как было выше изложено, методы оценивания знаний учеников имеют большое значение при привлечении внимания учеников к предмету. Многочисленными методами, в том числе выше указанным методом –диаграмма-дневник и наглядностью можно привлечь учеников в активный процесс обучения. Но, как известно, основное содержание преподавания предусматривает получение учениками наибольших знаний и навыков по предметам, повышение их базовых компетенций и компетенций по предмету, которые определены в Государственном образовательном стандарте Республики Узбекистан по предметам родной язык (узбекский язык) и литература[1].

Целью нашей статьи является ознакомить преподавателей с новым тестовым методом оценивания знаний, навык и компетенций учеников – «Подбери ключ»[2].

Порядок применения метода «Подбери ключ»:

Данный метод является логическим продолжением тестового метода «Четвертый лишний». Для применения данного метода на этапах урока как: проверка домашнего задания и укрепление прошедшей темы, укрепление новой темы нужно раздать ученикам в определенном количестве (например, 10 тестовых заданий) тесты «Четвертый лишний». На этом этапе ученики выбирают в качестве ответа один из предложенных четырех вариантов, который не соответствует заданному вопросу (суждению). Даётся определенное время (в зависимости от количества и сложности тестов) для выполнения задания.

Ответы учеников могут проверяться (со стороны самого ученика, передавая ответы друг другу по часовой стрелки и тд., все это зависит от того как ведется процесс урока: разделяя на группы, в традиционном порядке и пр.) различными способами (например, презентация на экране ключей тестов). Затем, на втором этапе проведения метода ученикам раздаются вопросы и они должны подобрать ключи к этим вопросам так, чтобы ответы, которые считались лишними в тестах «Четвертый лишний», в совместимости с розданными вопросами на втором этапе, образовали обычные тесты с одним правильным ответом.

Пример по применению метода:

Данный метод впервые использован на уроке родной язык в 8 классе 116-средней школы. Ниже в качестве примера по применению предлагаемого метода приводятся вопросы, предназначенные для

[1] Ўзбекистон Республикаси қонун ҳужжатлари тўплами. 2017.Тошкент. 139-147-бет. WWW.LEX.UZ

[2] Shirinova Ye.T., Turopova M.A. Ona tili darslarni innovatsion yondashuv asosida tashkil etish// Til va adabiyot ta`limida zamonaviy axborot va pedagogik texnologiyalar. –Toshkent. 2018. 53-55-bet.

8-классов средних школ, которые созданы на основе учебника **8-sinf «Ona tili»**[3]**.**

1-этап. "To'rtinchisi ortiqcha" testi savollari (Тестовые вопросы «Четвертый лишний»):

1. **Quyidagilar ilmiy uslubda yoziladi (... пишутся в научном стиле).**
   a. Darsliklar (Учебники);
   b. Ilmiy maqolalar (Научные статьи);
   c. Ish qog'ozlari (Деловые документы);
   d. Lug'atlar (Словари).
2. **Erkin mavzudagi inshoda ... aks etadi (В повествовании на свободную тему отражаются …).**
   a. Biror asar yoki qahramonlar taqdiri tahlili (анализ судеб героев некоторых произведений);
   b. Ma`lum mavzu yuzasidan turli fanlar orqali egallangan bilimlar (Научные знания по определенной томе, усвоенные через разные предметы);
   c. O'quvchining dunyoqarashi (Мировоззрение ученика);
   d. Shaxsiy fikr-mulohazalari (Собственные мнения).
3. **Quyidagilar epigraf bo'la oladi (Следующие могут стать эпиграфом).**
   a. Mashhur hikmatli so'z (Знаменитый афоризм);
   b. Chuqur va ta`sirchan mazmun aks etgan har qanday gap (Любое предложение с глубоким, богатым смыслом);
   c. Maqol (Пословица);
   d. Ibora (Фразеологизм).
4. **Rasmiy-idoraviy uslubda quyidagi qoliplashgan so'zlar va so'z birikmalari keng qo'llaniladi (Следующие шаблонные сочетания широко используются в официально-деловом стиле).**
   a. Qaror qilindi (Принято решение);
   b. Inobatga olinsin (Принять во внимание);
   c. Tasdiqlanadi (Утверждено);
   d. Tabriklaymiz (Поздравляем).
5. **Quyidagilar ot turkumiga mansub so'zlar emas (Следующие слова не являются существительными).**
   a. Gapirmoq (Говорить);
   b. Do'tlashmoq (Дружится);
   c. O'qilgan (Прочитанный);
   d. Go'zallik (Красота).

6. Ma`lumotnoma matnida...(В тексте сведение…)

a. Bo'lib o'tgan voqea-hodisa yoki mavjud holat haqida oddiy axborot ifodalanadi (выражается простая информация о происшедшем событии или существующем состоянии);
b. Voqealar aniq bayon qilinadi (события излагаются с точностью);
c. Voqealar ijodiy ravishda bayon etiladi (события могут излагаться творчески);
d.  Tasviriy vositalardan deyarli foydalanilmaydi (почти не используются изобразительные средства).

7. Ijodiy-tavsifiy matn ko'rinishlariga ... kiradi (К видам творческо-описательного текста относятся…).

a. Ijodiy bayon (Творческое изложение);
b. Insho (Повествование);
c. Rasmiy-idoraviy uslubdagi matnlar (Тексты в официально-деловом стиле);
d. Badiiy uslubdagi matnlar (Тексты художественного стиля) .

8. Insho mazmun-mohiyatiga ko'ra quyidagi turlarga bo'linadi (По сути и содержанию повествование делятся на следующие виды):

a. Ta`limiy insholar (Образовательные повествования);
b. Adabiy mavzudagi insholar (На литературную тему);
c. Adabiy-ijodiy mavzudagi insholar (Литературно-творческие);
d. Erkin mavzudagi insholar (На свободной тему).

9. Tilshunoslikning morfologiya bo'limida ... o'rganiladi (В разделе языкознания морфология изучаются…).

a. Mustaqil so'zlar (самостоятельные части речи);
b. Yordamchi so'zlar (союзы);
c. Undov, taqlid va modal so'zlar (междометия, слова-подражания, модальные слова);
d. So'z va uning lug'aviy ma`nolari (Слово и его лексическое значение).

10. Grammatika bo'limiga xos xususiyatlar (Специфические свойства раздела грамматика):

a. 2 qismdan iborat (состоит из двух частей);
b. Tilshunoslik fanining yirik bo'limlaridan biri (является одним из крупных разделов языкознания);
c. Orfografiya sanaladi (Это раздел Орфография);
d. Morfologiya va sintaksisni o'z ichiga oladi (Состоит из морфологии и синтаксиса).

[3] M.Qodirov, H.Ne'matov, M.Abduraimova, R.Sayfullayeva. Ona tili. Umumiy o'rta ta`lim maktablarining 8-sinfi uchun darslik. Toshkent 2010.

To‘rtinchisi ortiqcha testining kaliti
(Ключ тестовых вопросов «Четвертый лишней»):

№	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
J:	C	A	B	D	D	C	C	A	D	C

Рисунок 3.

2-этап. Раздаются следующие вопросы:

1. Imlo me`yorlarini o‘rganuvchi tilshunoslik bo‘limi...(Раздел языкознания, изучающий правила правописания…)
2. Fe`l turkumiga mansub bo‘lmagan so‘zni toping (Найдите слово которое не относится к глаголу).
3. Qutlamoq so‘zining ma`nodoshi berilgan qatorni toping (Синоним слова “қутламоқ” (поздравить)).
4. Qoliplashgan so‘zlar va so‘z birikmalari keng qo‘llaniladigan matnlar … (Тексты в которых используются шаблонные слова и словасочетания это...)
5. ...ni epigraf sifatida qo‘llab bo‘lmaydi (… не возможно использовать в качестве эпиграфа).
6. Adabiy mavzudagi inshoda ... ifodalanadi (В повествовании на литературную тему отражается).
7. Inshoning didaktik maqsadiga ko`ra turlaridan biri ...dir (Один из дидактических видов повествования …).
8. Ijodiy-tavsifiy matnda ... (В творчески-описательном тексте…)
9. Nimalar rasmiy-idoraviy uslubda yoziladi (Что пишется на официально-деловом стиле)?
10. Tilshunoslikning leksikologiya bo‘limida ... o‘rganiladi (В разделе языкознания лексикология изучается…).

Ответы вопросов «Подбери ключ»:

Рисунок 4.

Данный метод можно использовать почти в процессе преподавания всех предметов, которые организуют работу на уроках посредством тестовых методов. Подчеркивая определенную сложность в применении данного тестового метода, необходимо отметить то, что этот метод эффективно можно использовать только в хорошо подготовленных группах. Для применения этого метода несколько раз нужно применять только тестовый метод «Четвертый лишний». Необходимо чтобы у учеников развились навыки по выполнению первого этапа предлагаемого метода. Убеждаясь в том что, ученики готовы к

дополнительному заданию можно использовать тестовый метод «Подбери ключ».

В качестве вывода необходимо подчеркнуть, что тестовый метод «Подбери ключ» апробирован со стороны автора данной статьи (то есть мной) в преподавании родного языка (узбекского языка) и литературы (в 116-средней школе р.Учтепа г.Ташкент) и эффективно может использоваться в процессе преподавания всех предметов для повышения и оценивания знаний, навык и компетенций учеников. Кроме этого данный метод имеет и воспитательную цель. В процессе выполнения тестов «Подбери ключ» ученики осознают, что любая вещь, которая с одной точки зрения может быть лишней, с другой позиции может быть необходимой. Надеемся предлагаемый нами метод, хотя с некоторыми преобразованиями, будет использоваться в системе образования и послужит повышению знаний молодого поколения.

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FEATURES OF EVALUATION OF EVIDENCE IN CRIMINAL PROCESS

Abstract: *This article is devoted to types of facts on crime determined in criminal prosigal law and the concepts of evaluating criminal facts analyzed by scientific and comparative-legal side. Also useful recommendations are given about improvement the concepts of evaluating criminal facts.*

Key words: *types of facts, to prove, relevance, acceptability, reliability, adequacy.*

Language: *English*

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Introduction

Today, a number of foreign countries are making significant changes to improve the norms of criminal and criminal procedure legislation, to implement advanced international standards and foreign practice in order to ensure the rights and freedoms of citizens involved in criminal proceedings.

The Basic Laws of a number of countries also stipulate that a person accused of committing a crime may not be found guilty until his or her case has been tried in a lawful and public manner. From this point of view, in order to ensure the rights and freedoms of citizens, the Criminal Procedure Code also provides that a suspect, accused or defendant shall be presumed innocent until proven guilty in accordance with the law and a court verdict that has entered into force.

International experience in criminal cases shows that the analysis of the legal framework, practical application and results of the organization of pre-trial criminal proceedings shows that there are a number of problems in this area related to procedural theory and judicial practice. In particular, finding a scientific solution to the problems associated with the norms of criminal procedure law governing the evaluation of evidence and the practice of their application remains one of the most pressing issues.

Analysis and results

The purpose of criminal procedural proof is to determine the truth, in other words, the circumstances of the case in accordance with the facts. The process of proof is regulated by law and is conducted in a certain procedural form. Criminal procedural law establishes rules for dealing with evidence. These rules include the collection, verification, and evaluation of evidence; requirements for evidence, subjects of proof, and so on.

Evaluation of evidence in criminal proceedings is the most important element of the evidentiary process. The main purpose of the evidence evaluation is to determine the facts about the circumstances that are relevant to the lawful, reasonable, and fair resolution of the case. [1]

The lexical meaning of the term "assessment" is to express an opinion about the importance and value of a person, thing or event.

Proof in the theory of criminal procedure is the activity of searching for information carriers, collecting information about the facts, their procedural consolidation, investigation and evaluation [2]. First of all, it should be noted that documentation and proof perform the same function [3] and are performed only by representatives of public authorities who have the corresponding legal rights and obligations.

As noted by legal scholars B. Mirensky, A. Asamutdinov and J. Kamalkhodjaev, "the assessment of evidence is a necessary condition for making legal and reasonable procedural decisions, the correct application of criminal law." [4]

Evaluation of evidence on crimes identified in criminal proceedings provides a basis for a procedural decision on the case. It is impossible to imagine the process of gathering, researching, drawing conclusions, and making the right procedural decision without evaluation.

The essence of the evaluation of evidence is to determine their relevance, acceptability and reliability, as well as their sufficiency to find the circumstances that are the subject of evidence in a criminal case. The legislation sets out general requirements for the evaluation of evidence, which are unique to all stages of the criminal process. [5]

It is well known that by evaluating the evidence gathered, their relevance, validity and reliability are examined. But evaluating evidence is not exactly the same as evaluating evidence. Already, the collected data is evaluated in terms of being considered evidence. Evidence shall be considered evidence if the information confirms, refutes or doubts the conclusions about the circumstances relevant to the criminal case, about the facts or things collected in the prescribed manner and in accordance with the conditions and facts provided by the rules of procedural law.

The defense counsel also has the right to collect and present evidence in a criminal case, which must be attached to the criminal case file, as well as compulsorily assessed during the pre-trial investigation, inquiry, preliminary investigation and trial. These evidences include: interviewing persons with relevant information and obtaining written explanations with their consent; may be collected by sending inquiries to government agencies and other bodies, as well as enterprises, institutions and organizations, and obtaining from them references, descriptions, explanations and other documents.

Evidence is gathered not only through the conduct of investigative and judicial proceedings, but also through the acceptance of the items and documents presented. When evaluating the submitted objects and documents as evidence, it is necessary to take into account their features, which embody the necessary features, without which the submitted objects and documents can not be used as evidence.

These features include:

1) Relevance (that is, the fact that the evidence can serve as a means of determining the circumstances relevant to the case. In other words, the relevance is the validity of the evidence in terms of content);

2) Admissibility (in any state governed by the rule of law, evidence is considered admissible only if it meets the conditions provided for in the criminal procedure legislation and is collected in the prescribed manner);

3) Reliability (evidence found to be true as a result of an investigation is considered reliable);

4) Significance (the value of the evidence is its proof power);

5) Sufficiency (if all the convincing evidence of the case, which unequivocally confirms the truth of all and each case to be proved, is collected, their total is considered sufficient to resolve the case).

Evidence for crimes identified in criminal proceedings is evaluated on the basis of scientific validity and adherence to procedural rules.

Evaluation of evidence is not only a logical operation to determine the value, acceptability, reliability and other characteristics of the evidence, but also the process of forming such conclusions. Distinguishing the evaluation of evidence as a concluding element of the proof does not fully reflect its original role in the structure of the proof process. This is because the evaluation of the evidence is done throughout the whole process of proof.

Evaluating evidence is not limited to knowing their properties, because knowing and evaluating are not the same in their content. Assessment is not only knowledge, but also an attitude towards an object in the form of an opinion about it.

Evaluation of evidence is an independent element of proof, just as gathering and verifying evidence. As a result, there is a need to differentiate between evidence verification and evaluation. In the words of another jurist, AV Rudenko, “these two elements of proof can be distinguished only by one feature: that is, the evaluation of evidence is a separate thinking ability, and the activity of examining evidence has a practical aspect in addition to thinking. The results of the evidence review will need to be evaluated. Confirmation of the content of the evidence under investigation takes place at the time of obtaining information on the circumstances that are identical to the information on the circumstances contained in the evidence under investigation. [6]

It should be noted that the law provides that the assessment of evidence by state bodies and officials responsible for criminal proceedings, other participants in criminal proceedings (public prosecutor, defense counsel, victim, defendant, etc.) is only a decision of these bodies on the relevance, acceptability and reliability of evidence. have the right to appeal against the rulings in the manner prescribed by law.

The results of the comparative legal analysis show that the criminal justice legislation of foreign countries has the following approaches to the criteria for assessing the evidence:

the first approach: a set of evidence - must be evaluated in terms of its sufficiency to resolve the case (Article 127 Part 1 of the CPC of Armenia, Article 136 Part 1 of the CPC of Turkmenistan);

second approach: all the evidence gathered must be assessed in terms of its sufficiency to resolve the criminal case (Article 88 Part 1 of the CPC of the Russian Federation, Article 88 Part 1 of the CPC of Tajikistan, Article 95 Part 1 of the CPC of Kyrgyzstan, CPC of Kazakhstan 125 - Article 1 part);

third approach: a set of evidence - to be assessed in terms of its sufficiency to complete the preliminary investigation and resolve the criminal case (Article 105, Part 1 of the Criminal Procedure Code of Belarus);

fourth approach: set of evidence - should be evaluated in terms of comparability of evidence (Article 101, Part 1 of the CPC of Moldova);

the fifth approach: all the evidence gathered in the criminal prosecution - their set should be assessed as sufficient to resolve the charge (Article 145 (1) of the CPC of Azerbaijan);

sixth approach: the set of evidence gathered is assessed in terms of its sufficiency and relevance for making a procedural decision correctly (Article 94 § 1 of the CPC of Ukraine). In most countries (Armenia, Belarus, Turkmenistan, the Russian Federation, Azerbaijan, Tajikistan, Ukraine, Kyrgyzstan, Kazakhstan), the sufficiency of evidence is defined as the criterion for assessing the set of evidence. In some countries, the comparability of evidence (Moldova) and the relevance of evidence (Ukraine) have been cited as criteria for evaluating a set of evidence. It should also be noted that in most countries (Russian Federation, Azerbaijan, Tajikistan, Kyrgyzstan, Kazakhstan) the issue under discussion is defined as an assessment of the whole set of evidence, not a set of evidence.

It appears from the analysis that it is generally accepted that the sufficiency of evidence is a criterion for evaluating a set of evidence.

Therefore, on the basis of scientific and theoretical and legal literature on criminal procedure of law enforcement agencies, as an important stage of the criminal process, the analysis of inquiries, investigative practices and available statistics, as well as the study of criminal procedure legislation of foreign countries. we found it necessary to quote our proposal.

In particular, a specialist is a person with special knowledge who is a participant in criminal proceedings. The expert's job is to assist in finding, gathering, consolidating, evaluating evidence, assisting in formulating the questions posed to the expert, and assisting the body that appointed the expert in evaluating the expert's findings. The functions of the expert and the specialist in criminal proceedings are close to each other. However, in the criminal procedural legislation of many states, the legal status of an expert is not as fully defined as that of an expert. However, it must also be acknowledged that in some cases the expert will assist the inquiry officer, investigator, prosecutor and the court in determining the accuracy of the expert opinion and the research methods used in it. Therefore, in addition to the rules governing criminal proceedings, it is advisable to include the phrase "assessment of evidence."

For example, the Expert: the presence of the inquiry officer, investigator, prosecutor, summoned by the court; to participate in investigative actions and court proceedings using scientific and technical means, special knowledge and skills to find, evaluate and strengthen evidence; to draw the attention of the inquiry officer, investigator, prosecutor and court to the circumstances relevant to the establishment of the facts of the case; give explanations on the actions taken by him; to assist the inquiry officer, investigator, procurator and the court in determining the causes of the crime, the circumstances that led to its commission and in developing measures to eliminate them; failure to disclose the materials of the inquiry and preliminary investigation without the permission of the inquiry officer, investigator, prosecutor; must follow the procedure during the investigation of the case and the trial.

Conclusions

In short, the expected results of the improvement of criminal procedure legislation are the further improvement of criminal procedure legislation, taking into account the rapid development trends of the world community, reliable protection of the rights and freedoms of citizens, public and state interests, peace and security.

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ONE-DIMENSIONAL PROBLEM OF RHEOLOGICAL LAW OF MOLECULAR AND MOLAR TRANSFER IN FLUIDS

Abstract: *The fluid flow is considered in the paper according to the rheological law of molecular and molar transfer in a flow. The obtained differential equation of the third order was solved analytically for the one-dimensional problem of fluid flow in a round pipe. The flow pattern obtained for the selected model according to the analytical solution was given.*

Key words: *fluid motion, differential equation, analytical solution.*

Language: *English*

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Introduction

The fluid flow in various canals and pipelines has been sufficiently well studied with account for molecular transfer for layered flows in the framework of the Navier-Stokes equations. Numerous publications [1, 2, 3, 4, 5, 6, 7] were devoted to the solution of this equation. However, the improvement of the methods for studying flows under various conditions made it possible to identify a number of hydrodynamic features (for example, in velocity diagram) that cannot be explained by the Navier-Stokes equations.

Assuming that the fluid is a thermodynamic system, and its source of flow is the Gibbs free energy, more general equations of fluid motion were obtained when compared to theNavier-Stokes' ones [8]. In this paper, to take into account the group transfers of molecules in the flow, the stress is taken in direct proportion to the derivative of fluid acceleration. In a concurrent consideration of the mechanisms of individual molecules and their groupstransfer using the Navier-Stokes differential equations, the terms with a third-order derivative were formed.The stationary problem of fluid flow in a flat canal was solved for this model [9] using operational calculus.

Statement of problem. Consider the fluid flow in a cylindrical tube. According to the rheological law of molecular and molar transfer in a fluid

$$\tau = \mu \frac{\partial u}{\partial n} + m_l \frac{\partial w}{\partial n}, \qquad (1)$$

or in a component form:

$$\tau = \begin{cases} \mu\left(\frac{\partial v_i}{\partial x_j} + \frac{\partial v_j}{\partial x_i}\right) + m_l\left(\frac{\partial w_i}{\partial x_j} + \frac{\partial w_j}{\partial x_i}\right) & j \neq i, \\ -p + 2\mu\frac{\partial v_i}{\partial x_i} + m_l\frac{\partial w_i}{\partial x_i} & j = i \quad (\mathrm{i, j} = 1,2,3) \end{cases} \qquad (2)$$

the system of equations of fluid motion in cylindrical coordinate systems takes the following form:

$$\begin{cases} \dfrac{\partial v_1}{\partial t} = -\dfrac{dp}{dx_1} + \mu\left(\dfrac{\partial^2 v_1}{\partial x_2^2} + \dfrac{1}{x_2}\dfrac{\partial v_1}{\partial x_2}\right) + m_l\left[\dfrac{\partial^3 v_1}{\partial t \partial x_2^2} + \dfrac{1}{x_2}\dfrac{\partial^2 v_1}{\partial t \partial x_2} + \right. \\ \left. + v_1\left(\dfrac{\partial^3 v_1}{\partial x_1 \partial x_2^2} + \dfrac{1}{x_2}\dfrac{\partial^2 v_1}{\partial x_1 \partial x_2}\right) + v_2\left(\dfrac{\partial^3 v_1}{\partial x_2^3} + \dfrac{1}{x_2}\dfrac{\partial^2 v_1}{\partial x_2^2}\right) + \dfrac{\partial v_1}{\partial x_2}\dfrac{\partial^2 v_1}{\partial x_1 \partial x_2} + \dfrac{\partial v_2}{\partial x_2}\dfrac{\partial^2 v_1}{\partial x_2^2}\right], \\ \dfrac{\partial v_1}{\partial x_1} + \dfrac{1}{x_2}\dfrac{\partial (x_2 v_2)}{\partial x_2} = 0. \end{cases} \quad (3)$$

A model one-dimensional problem is formulated.

The equations of motion under the assumptions $dp/dx_1 = N = const$, are reduced to the form:

$$v_1 = v_1(x_2, t), \quad v_2 = const,$$

$$m_l\left(\frac{\partial^3 v_1}{\partial t \partial x_2^2} + \frac{1}{x_2}\frac{\partial^2 v_1}{\partial t \partial x_2}\right) + m_l v_2\left(\frac{\partial^3 v_1}{\partial x_2^2} + \frac{1}{x_2}\frac{\partial^2 v_1}{\partial x_2^2}\right) + \mu\left(\frac{\partial^2 v_1}{\partial x_2^2} + \frac{1}{x_2}\frac{\partial v_1}{\partial x_2}\right) = N. \quad (4)$$

Equation (4) is solved under the following initial and boundary conditions

$$\left.\begin{array}{lll} v_1 = 0, \ \dfrac{\partial v_1}{\partial x_2} = 0, \ \dfrac{\partial^2 v_1}{\partial x_2^2} = 0 & t = 0, \\ \dfrac{\partial v_1}{\partial x_2} = 0, \ v_1 < \infty & x_1 = 0, \\ v_1 = 0 & x_1 = R. \end{array}\right\} \quad (5)$$

The boundary conditions of equation (4) are the cohesion conditions and axial symmetry. At initial time, the fluid in the infinitely long round pipe is at rest, and at time $t = 0$, a pressure drop dp/dx_1 occurs, that later remains constant in time.

To solve the posed problem, modifying (4) we obtain the equation convenient for integration

$$m_l \frac{1}{x_2}\frac{\partial}{\partial x_2}\left(x_2 \frac{\partial^2 v_1}{\partial t \partial x_2}\right) + m_l v_2 \frac{1}{x_2}\frac{\partial}{\partial x_2}\left(x_2 \frac{\partial^2 v_1}{\partial x_2^2}\right) + \mu \frac{1}{x_2}\frac{\partial}{\partial x_2}\left(x_2 \frac{\partial v_1}{\partial x_2}\right) = N. \quad (6)$$

Multiplying both sides of this equation by x_2 and integrating the obtained valuesby x_2, we have:

$$m_l x_2 \frac{\partial^2 v_1}{\partial t \partial x_2} + m_l v_2 x_2 \frac{\partial^2 v_1}{\partial x_2^2} + \mu x_2 \frac{\partial v_1}{\partial x_2} = \frac{N x_2^2}{2} + c_1. \quad (7)$$

Applying this procedure for the second time, we arrive at the equation

$$\frac{\partial v_1}{\partial x_2}+\frac{1}{x_2}\frac{\partial v_1}{\partial t}+\frac{\mu}{m_l v_2}v_1=\frac{Nx_2^2}{4m_l v_2}+\frac{c_1}{m_l v_2}\ln x_2+\frac{c_2}{m_l v_2}. \quad (8)$$

After Laplace transform with respect to *t*, the sequential equation is written in the form

$$\frac{\partial \overline{v_1}}{\partial x_2}+\left(\frac{s}{v_2}+\frac{\mu}{m_l v_2}\right)\overline{v_1}=\frac{Nx_2^2}{4sm_l v_2}+\frac{c_1\ln x_2}{sm_l v_2}+\frac{c_2}{sm_l v_2}, \quad (9)$$

wheresis the transform parameter.

The conditions for $t=0$ from (5) were taken into account in passing to the images.

The obtained inhomogeneous equation (9) was solved by the method of variation of constants. The homogeneous part of the equation has the following solution

$$\overline{v_1}=c\ e^{-bx_2},$$

where $b=\frac{s}{v_2}+\frac{\mu}{m_l v_2}$.

If to consider *c* not as an arbitrary constant, but as some function of x_2, i.e. $c=c(x_2)$, then we can choose the function $c(x_2)$ so that function (8) becomes a solution to the inhomogeneous equation (9).

To find the function $c(x_2)$, we calculate the derivative of function $\overline{v_1}=c(x_2)e^{-bx_2}$, substitute the expressions $\overline{v_1}$ and $d\overline{v_1}/dx_2$ into equation (9) and require that it be satisfied identically. Since

$$\frac{d\overline{v_1}}{dx_2}=\frac{dc(x_2)}{dx_2}e^{-bx_2}-c(x_2)be^{-bx_2}, \quad (10)$$

then equation (9) goes over to equation

$$\frac{dc(x_2)}{dx_2}e^{-bx_2}=\frac{Nx_2}{4m_l v_2 s}+\frac{c_1\ln x_2}{m_l v_2 s}+\frac{c_2}{m_l v_2 s}. \quad (11)$$

The latter is an equation with separable variables and has a general solution

$$c(x_2)=\frac{N}{4m_l v_2 s}e^{bx_2}\left(\frac{x_2^2}{b}-\frac{2x_2}{b^2}-\frac{2}{b^3}\right)+\frac{c_1}{m_l v_2 s}\left[\frac{e^{bx_2}\ln x_2}{b}-\left(\ln x_2+\sum_{n=1}^{\infty}\frac{(bx_2)^n}{n\cdot n!}\right)\right]. \quad (12)$$

Substituting the found expression $c(x_2)$ into equality (8), we obtain the sought for solution to the inhomogeneous equation (9) in the form:

$$\overline{v_1}(x_2)=\frac{N}{4sm_l v_2}\left(\frac{x_2^2}{b}-\frac{2x_2}{b^2}-\frac{2}{b^3}\right)+ \\ +\frac{c_1}{m_l v_2 s}\left[\left(\frac{1}{b}-e^{-bx_2}\right)\ln x_2-e^{-bx_2}\sum_{n=1}^{\infty}\frac{(bx_2)^n}{n\cdot n!}\right]+\frac{c_2}{m_l v_2 bs}+\frac{c_3}{m_l v_2 s}e^{-bx_2}. \quad (13)$$

To determine the integration constants c_1, c_2, c_3, we use the boundary conditions from (5). Sincefor $x_2\to\infty$ the following is appropriate

$$\frac{c_1}{m_l v_2 s}\left[\left(\frac{1}{b}-e^{-bx_2}\right)\ln x_2 - e^{-bx_2}\sum_{n=1}^{\infty}\frac{(bx_2)^n}{n\cdot n!}\right]\to\infty,$$

then from the boundedness condition of axial velocity $c_1 = 0$ is determined. From the conditionof cohesion, i.e. $\overline{v_1} = 0$, at $x_2 = R$ the following relation is obtained

$$c_2 = \frac{Nb}{4} - \left(\frac{R^2}{b} - \frac{2R}{b^2} - \frac{2}{b^3}\right) - c_3 b e^{-bR}. \quad (14)$$

The value of the constant c_3 is determined from the condition of axial symmetry, i.e. $d\overline{v_1}/d\,x_2 = 0$ at $x_2 = 0$:

$$c_3 = -\frac{N}{2b^3}.$$

Substituting the value of c_3 into (14), c_2 is determined in the final form

$$c_2 = -\frac{N}{4}\left(R^2 - \frac{2R}{b} - \frac{2}{b^2}\right) + \frac{N}{2b^2}e^{-bR}.$$

After simple modifications, we obtain an expression for the velocity in the images

$$\overline{v_1}(x_2) = \frac{N}{4m_l v_2}\left[\left(x_2^2 - R\right)\frac{v_2}{s\left(s+\mu/m_l\right)} - 2\left(x_2 - R\right)\frac{v_2^2}{s\left(s+\mu/m_l\right)^2} + 2\frac{v_2^3}{s\left(s+\mu/m_l\right)^3}\left(e^{-\left(\frac{s}{v_2}+\frac{\mu}{m_l v_2}\right)R} - e^{-\left(\frac{s}{v_2}+\frac{\mu}{m_l v_2}\right)x_2}\right)\right]. \quad (15)$$

In (15)we turn now to the original. From the table of originals and images [10] for the first two terms we have

$$\frac{1}{s\left(s+\frac{\mu}{m_l}\right)} \doteq \frac{m_l}{\mu}\left(1 - \mathrm{e}^{-\frac{\mu}{m_l}t}\right),$$

$$\frac{1}{s\left(s+\frac{\mu}{m_l}\right)^2} \doteq \left(\frac{m_l}{\mu}\right)^2\left(1 - \mathrm{e}^{-\frac{\mu}{m_l}t} - \frac{\mu}{m_l}t\mathrm{e}^{\frac{\mu}{m_l}}\right). \quad (16)$$

For the last term of equation (15) the Duhamel integral [10] is used:

$$sG(s)F(s) \doteq f(0)g(t) + \int_0^t f'(\tau)g(t-\tau)d\tau, \quad (17)$$

in this case

$$F(s) = \frac{e^{-\frac{s}{v_2}x_2}}{s^2} \doteq \begin{Bmatrix} 00 < t < \frac{x_2}{v_2} \\ t - \frac{x_2}{v_2}\, t > \frac{x_2}{v_2} \end{Bmatrix} = f(t),$$

$$G(s) = \frac{1}{\left(s+\frac{\mu}{m_l}\right)^3} \doteq \frac{t^2}{2}e^{-\frac{\mu}{m_l}t} = g(t),$$

$$f(0) = \frac{x_2}{v_2}, f'(\tau) = 1. \quad (18)$$

We substitute (18) into (17) and perform the integration. Considering the obtained formulas and (16), we have

$$v_1(t,x_2)=\frac{dp}{dx_1}\frac{1}{4\mu}\left\{\left(x_2^2-R\right)\left(1-e^{-\frac{\mu}{m_l}t}\right)-\right.$$
$$-2\left(x_2-R\right)v_2\frac{m_l}{\mu}\left(1-e^{-\frac{\mu}{m_l}t}-t\frac{\mu}{m_l}e^{-\frac{\mu}{m_l}t}\right)+$$
$$+2v_2^2e^{-\frac{\mu x_2}{m_l v_2}}\left[e^{-\frac{\mu}{m_l}t}\left(\frac{t^2}{2}+\frac{t^2}{2}\frac{\mu x_2}{m_l v_2}+t\frac{m_l}{\mu}+\frac{m_l^2}{\mu^2}\right)-\frac{m_l^2}{\mu^2}\right]- \quad (19)$$
$$\left.-2v_2^2e^{-\frac{\mu x_2}{m_l v_2}}\left[e^{-\frac{\mu}{m_l}t}\left(\frac{t^2}{2}+\frac{t^2}{2}\frac{\mu R}{m_l v_2}+t\frac{m_l}{\mu}+\frac{m_l^2}{\mu^2}\right)-\frac{m_l^2}{\mu^2}\right]\right\}.$$

Discussion of obtained solution (19). Function (19) is a general solution of equation (4) and describes the flow rate distribution in a round pipe. Here the expressions in square brackets for $t>\frac{x_2}{v_2}$ are equal to zero, and as $t\to\infty$ the expression for the stationary distribution of the fluid velocity in the pipe is:

$$v_1=\frac{dp}{dx_1}\frac{1}{4\mu}\left[\left(x_2^2-R\right)-2\left(x_2-R\right)v_2\frac{m_l}{\mu}+2v_2^2\frac{m_l^2}{\mu^2}\left(e^{-\frac{\mu R}{m_l v_2}}-e^{-\frac{\mu x_2}{m_l v_2}}\right)\right]. \quad (20)$$

In the absence of molar transfer in motion, i.e. for $m_l v_2=0$, it is possible to derive a formula from (20) for the velocity distribution of a viscous fluid in a pipe [11].

Results of computational experiments. Analysis of numerical calculations carried out for the stationary case based on the obtained analytical solution of the model problem of fluid flow in a round tubeaccording to the selected rheological law showed that a set of parameters $a_1=m_l v_2/\mu$ plays a characterizing role in the flow motion.

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Figure 1 shows the velocity profiles in dimensionless coordinates for various values of a_1.

Curve 1 corresponds to a zero valueof a_1, i.e. to the velocity distribution of viscous Newtonian fluid (the Poiseuille solution).

Curves 2-5 are obtained at valuesof $a_1=$ 0.36; 0.73; 1.45; 2.18, respectively.

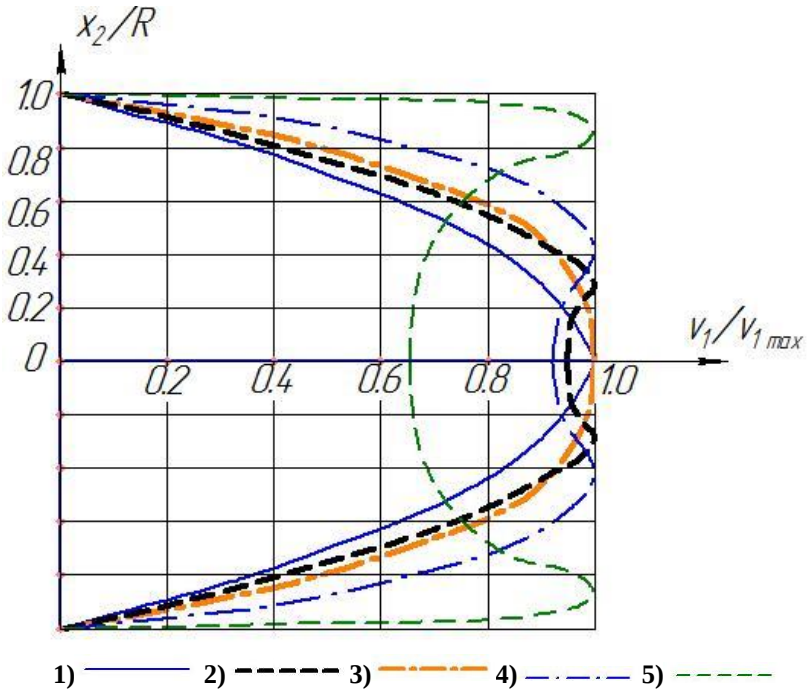

Fig. 1.Velocity distribution.

As follows from the presented velocity distribution curves, as the molar transfer coefficient of the momentum increases, the region of maximum velocities moves from the middle of the pipe to the peripheral region. Curve 2 corresponds to the fluid flow with the formation of a flow core. This nature of the flow is manifested at values of a_1 in the range from 0.01 to 0.6. Starting from $a_1 > 0,6$, the velocity along the flow axis decreases, the region of maximum velocity moves toward the wall. The decrease in velocity along the flow axis, according to the author, is associated with an increase in the molar force of internal friction.

Conclusions

Thus, the calculations based on equation (20) showed:

• the consistency of the selected rheological model for describing the distribution of flow velocity;

• the consistency of the model for determining other hydrodynamic flow parameters depending on the physicomechanical properties of fluids.

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CYLINDRICAL DISTRIBUTION OF ELECTRIC DISCHARGE IN A FLUID

Abstract: *Mathematical model of an electric discharge in a fluid is developed in the paper. Cylindrical problem was solved for the active and post-discharge stages of electric discharge in water with an explicit specification of the boundary condition for pressure on the contact surface. A transition to other variables has been made. The moving boundary in new variables corresponds to the origin of coordinates. A uniform rectangular meshwas used in numerical solution.*

Some results of computational experiments are presented.

Key words: *Electric discharge in liquid,numerical simulation, hydrodynamic parameters.*

Language: *English*

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Introduction

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Impulse energy technology is widely used in various fields of production and processing of useful materials. The brief review presented in [1] showed the advantage of the high-voltage discharge current method in production of porous materials from titanium, niobium and tantalum powders. The recycling of useful materials, such as metals and plastics, is rated as an important process in terms of conserving resources and protecting the environment. In this regard, the use of impulse energy technology [2] in the field of recycling attracts considerable attention.

Experimental studies of the phenomena occurring in droplets of various liquids under the action of nanosecond spark discharges [3] showed the need to pay attention to hydrodynamic and physicochemical phenomena in droplets. Experimental and theoretical studies concerning partial discharges in liquids [4] showed that an additional source of ionizing radiation (x-rays) should be used for the occurrence of partial discharges under these conditions.

The use of this process in fluids has its application in the processing of various materials, in stamping, crushing, in food industry [5]. Mathematical simulation of hydrodynamic processes during an electric discharge in a liquid is a way of finding the optimal parameters of this process.

From a hydrodynamic point of view, an electric discharge in a fluid is considered as a process of cavity expansion in a fluid. The cavity dynamics can be described by an analytical solution [6] or determined by numerical methods of gas dynamics problems [7, 8]. The process of fluid flow behind the cavity can be determined by the equations of hydrodynamics [9].

Experimental studies of electric discharge in a fluid to determine the hydrodynamic parameters were carried out at a considerable distance from the source. Theoretical studies also related to the areas remote from the discharge channel.

A mathematical model of electric discharge in a fluid was proposed; it determines the change in hydrodynamic parameters, both in remote areas and close to the source of discharge.

Statement of problem. Consider a cylindrical model. Let the cylindrical cavity formed in afluid as a result of the break-down of the interelectrode space expands at high velocity and sets the fluid in motion. The fluid flow is described by a system of unsteady-state equations [9] in a conservative form

$$\left.\begin{aligned}\frac{\partial(r\rho)}{\partial t}+\frac{\partial(r\rho v)}{\partial r}=0,\\ \frac{\partial(r\rho v)}{\partial t}+\frac{\partial\left[r\left(P+\rho v^2\right)\right]}{\partial r}=0,\end{aligned}\right\} \quad (1)$$

where r – is the radial coordinate, v is the flow velocity, P is the pressure, ρ is the density of the medium, t is time. The system of equations (1) is closed by the Taitequation of state of the fluid in the form

$$P=A(\rho/\rho_0)^{\chi}-B, \quad (2)$$

where

$\chi=7, A=3{,}04\cdot10^8 Pa, B=A-P_\infty, \rho_0=10^3 kg/m^3, P_\infty=1{,}04\cdot10^5 Pa$– is the hydrostatic pressure.

The initial conditions at $t = 0$ are:

$$P(0,r)=P_\infty, v(0,r)=0$$
$$a_0\le r\le r_b, \quad (3)$$

where a_0– is the initial radius of the plasma cavity or the lower boundary of fluid (≈0.1-0.15 mm),$r_в$ is the upper boundary of computational domain. These conditions correspond to the fluid at rest; the conditions imposed on the lower boundary of fluid are:

$$P(t,a)=P_a(t), v(t,a)=\frac{da}{dt}. \quad (4)$$

To solve the problem, it is necessary to know the law of expansion of the discharge channel $a(t)$ or the pressure at the channel boundary $P_a(t)$. The equation of energy balance in the channel [10] is

$$\frac{d}{dt}\frac{P_aV}{\gamma-1}+P_a\frac{dV}{dt}=\frac{dE}{dt}, \quad (5)$$

where dE/dt– is the power released in the channel, V is the channel volume, γ = 1.26 – is the effective adiabatic index.

To determine the value of $P_a$we substitute the expression for the volume $v=l\pi a^2$ in (5) and obtain:

$$a^2\frac{dP_a}{dt}+2\gamma aP_a\frac{da}{dt}=\frac{\gamma-1}{\pi l}\frac{dE}{dt}. \quad (6)$$

Taking into account the boundary condition (4), the latter takes the form:

$$a^2\frac{dP_a}{dt}+2\gamma aP_av=\frac{\gamma-1}{\pi l}\frac{dE}{dt}. \quad (7)$$

The law of energy input into the discharge channel is taken in the form [10]:

$$E(t)=(1{,}9\frac{t^2}{\tau_0^2}+1{,}3\frac{t^3}{\tau_0^3}-2{,}2\frac{t^4}{\tau_0^4})E_0, \quad (8)$$

where τ_0 is the discharge duration, E_0 is the total energy released in the channel.

Equations (1), (2) and (5) with initial (3) and boundary (4) conditions represent a closed system of equations of electric discharge in a fluid, but they cannot be solved analytically.

The solution of the problem. Numerical solution of such problems is performed in a moving mesh. Numerical calculation can be carried out in a normalized interval from 0 to 1, introducing a new coordinate system:

$$\tau=t, \eta=\frac{r-a(t)}{r_b-a(t)},$$

where the cavity boundary corresponds to zero value of the newly introduced coordinate η, and the upper boundary corresponds to η = 1.

The system of equations of fluid flow in new coordinate systems takes the form:

$$\frac{\partial\left[\rho\left(a+\eta\left(r_b-a\right)\right)\right]}{\partial\tau}-\frac{1-\eta}{r_b-a}a'\frac{\partial\left[\rho\left(a+\eta\left(r_b-a\right)\right)\right]}{\partial\eta}+\frac{1}{r_b-a}\frac{\partial}{\partial\eta}\left[\rho v\left(a+\eta\left(r_b-a\right)\right)\right]=0,$$

$$\frac{\partial\left[\rho v\left(a+\eta\left(r_b-a\right)\right)\right]}{\partial\tau}-\frac{1-\eta}{r_b-a}a'\frac{\partial\left[\rho v\left(a+\eta\left(r_b-a\right)\right)\right]}{\partial\eta}+$$

$$+\frac{1}{r_b-a}\frac{\partial}{\partial\eta}\left[\left(\eta\left(r_b-a\right)+a\right)\left(P+\rho v^2\right)\right]=P. \qquad (9)$$

The initial and boundary conditions in the newly introduced coordinates have the form:

$$P(0,\eta)=P_\infty, v(0,\eta)=0, \qquad 0\le\eta\le 1;$$

$$P(\tau,a)=P_a(\tau), v(\tau,a)=\frac{da}{dt}. \qquad (10)$$

The presented equations were nondimensionalized using scaled quantities — the density of a fluid at rest, the size of computational domain, and the velocity of sound in water. In the numerical solution, a uniform rectangular mesh $t^n=nh_t,\ n=0,1,2,...;\ \eta_m=mh_x,\ m=0,1,2,..$ was used. For the stability of the calculation, the time derivatives were approximated by the forward differences, i.e. derivatives of $\partial v/\partial t$ type at the point $\left(nh_t, mh_x\right)$ were replaced by the difference relation: according to

$$\frac{\partial v}{\partial t}=\frac{v_m^{n+1}-0,5\left(v_{m+1}^n-v_{m-1}^n\right)}{h_t}.$$

The derivatives with respect to spatial variables of $\partial v/\partial\eta$ type are approximated by central differences

$$\frac{\partial v}{\partial\eta}=\frac{v_{m+1}^n-v_{m-1}^n}{2h_x}.$$

The initial condition $v(0,\eta)=0$ involved in the problem generates a mesh initial condition $v_m^0=0$.

As a result, from the continuity equation we obtain the meshequation of density to determine the fluid density at the interior points of the computational domain,

$$\rho_m^{n+1}=\rho_{m+1}^n\frac{\left(a^n+(m+1)h_x\left(1-a^n\right)\right)}{\left(a^{n+1}+mh_x\left(1-a^{n+1}\right)\right)}\left(\frac{1}{2}\frac{1-mh_x}{1-a^n}\frac{a^{n+1}-a^n}{2h_x}-\frac{h_t v_{m+1}^n}{2h_x\left(1-a^n\right)}\right)+$$

$$+\rho_{m-1}^n\frac{\left(a^n+(m-1)h_x\left(1-a^n\right)\right)}{\left(a^{n+1}+mh_x\left(1-a^{n+1}\right)\right)}\left(\frac{1}{2}\frac{1-mh_x}{1-a^n}\frac{a^{n+1}-a^n}{2h_x}-\frac{h_t v_{m-1}^n}{2h_x\left(1-a^n\right)}\right).$$

In the same way, from the equations of momentum and energy balance in the discharge channel, the fluid rate and pressure between the cavity and the fluid boundary are determined. The value of *a* is calculated by numerical integration of the velocity *v*at $\eta=0$.

The steps in the numerical calculations were takenas $h_x=0,06; h_t=0,006$.The parameters are determined by the marching method in time.

The pressure at the cavity boundary is determined from the equation of energy balance in the discharge channel.In the same way the fluid density and velocity at $\eta=0$ are determined from the corresponding equations.

At the upper boundary of cylindrical domain, the no-fluid-loss condition was posed for the flow velocity, and the density and pressure were determined by the extrapolation method.

Results of computational experiment. The results of numerical calculations for different discharges showed that at the initial time instants the maximum values of hydrodynamic parameters are at the lower boundary. Over time, the disturbance reaches the end of computational domain. After a certain time, the disturbance moves from the end to the beginning of fluid volume. Then the pressure drops everywhere. The overall pattern of the process

is similar for all discharges.The difference lies in the parameter values and the process time. List the results obtained for one discharge. The electrical parameters of the circuit used in calculations for this discharge had the following values:*u=6 kV,l=3 cm,*τ_0 *=30 μs,E₀,=2480J, Cu²/2,=2970J, R₀ =0,89 cm.*

Figure 1 shows the changes in dimensionless fluid pressure depending on dimensionless radius for this discharge at time instants $\tau/\tau_0 = 0,3$ (1); 1,0 (2); 1,3 (3); 1,7 (4).As seen from the figure,at the beginning of the process the maximum pressure value is at the origin of calculated spatial coordinates, which corresponds to the cavity boundary and is 1.35.In the upper boundary of the calculation domain, the pressureat this time still retains its original value, which means that at time $\tau/\tau_0 = 0,3$at points close to the upper boundary the fluid is still at rest. Further, at $\eta = 0$ a decrease in pressure is observed and its value gradually grows in the upper domain.

This is noticeable on the curve at $\tau/\tau_0 = 1$ and at this time, the maximum pressure is still in the lower boundary. This means that the fluid is still receiving force from the discharge channel. At $\tau/\tau_0 = 1,3$ the maximum pressure is in the middle zone, and its value is greater at $\eta = 1$ than at $\eta = 0$. After a certain time, the disturbancemoves from the upper boundary to the lower one and this is clearly seen on the curve at $\tau/\tau_0 = 1,3$. The calculations showed that at further calculated time instants a decrease in pressure is observed in the calculation domain.

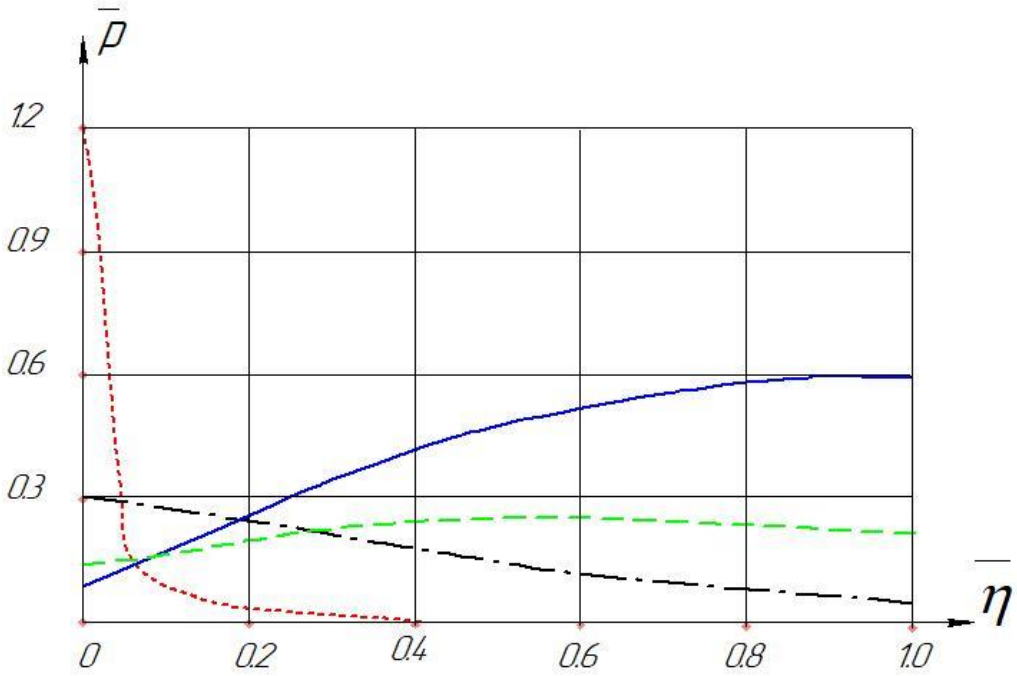

Fig. 1. Change in fluid pressure

The change in fluid velocity for this discharge is shown in Fig. 2 at four consecutive time instants: $\tau/\tau_0 = 0,3$ (1); 1,0 (2); 1,3 (3); 1,7 (4). At the first fixed point in time, the value of dimensionless velocity reaches 0.5. Then, its value decreases and a reverse flow forms, explained by the collapse of the cavity.

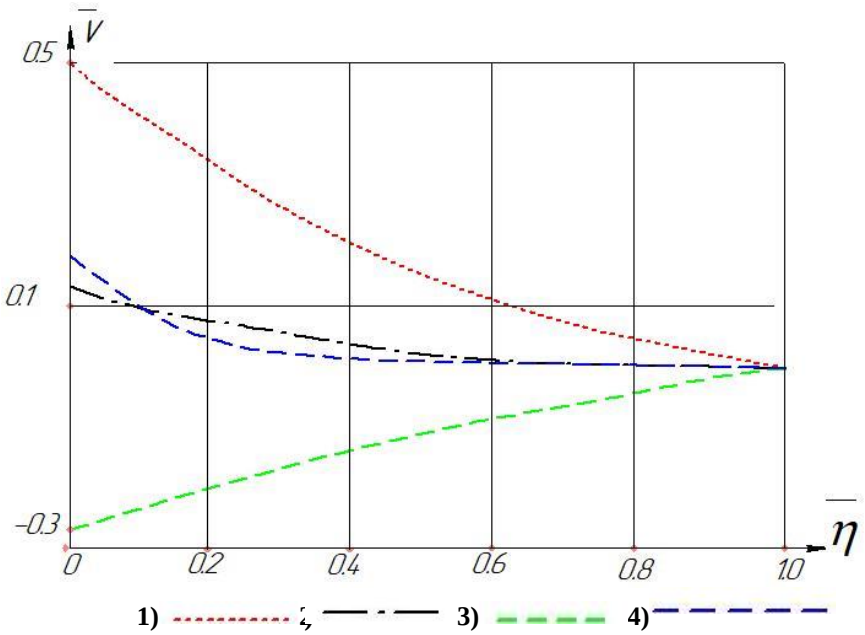

Fig. 2. Fluid velocity distribution

The change in fluid density corresponding to time instants is shown in Fig. 3. The highest density value is 1.39 and it is reached on the channel boundary at $\tau/\tau_0 = 0$. Then, the density disturbancemoves to the upper boundary of computational domain.

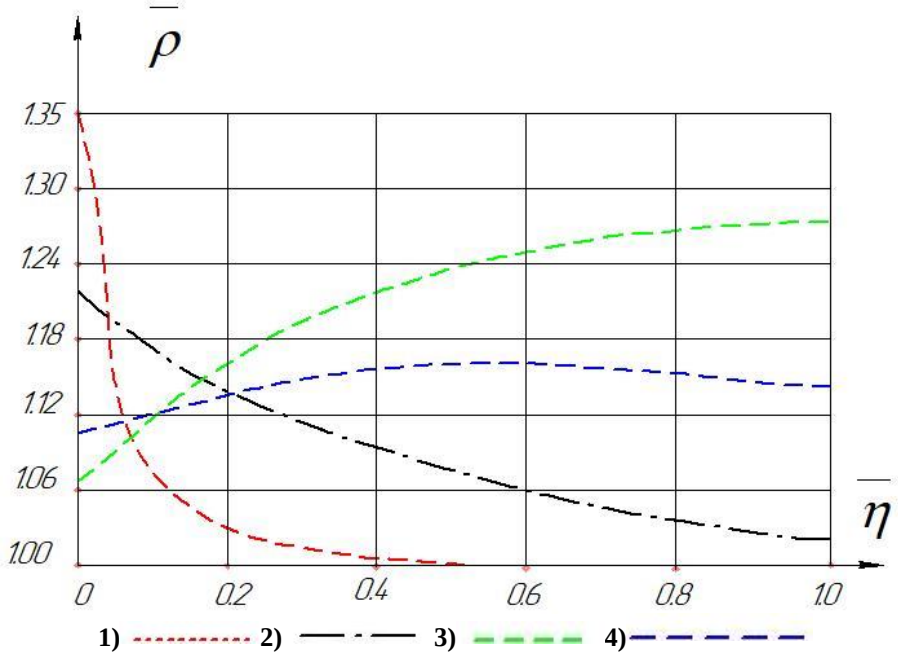

Fig. 3.Change in fluid density

The calculations on the electric discharge in the fluid for the cylindrical expansion of the channel showed that the key parameters of this process are the values of the energy supplied to the unit of the interelectrode distance and of the time of energy release. When developing various devices based on the phenomenon of electric discharge in a fluid, a mode can be chosen (varying these values), in which rational characteristics are obtained for the definedstructure.

Conclusion

Computational experiments have confirmed the correctness of the presented model by describing the ongoing physical processes of electric discharge in a fluid. The advantage of this model is the determination of hydrodynamic parameters close to the discharge source.

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