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DETERMINATION OF THE REYNOLDS NUMBER AND INTENSITY OF VORTEX FORMATION WHEN EXPANSION AND CONSTRICTION OF FLUID FLOW

Abstract: *The intensity fields of vortex formation and the range of the Reynolds numbers were calculated by the computer simulation during water movement at different velocities in the diffuser/confuser and at certain distances before and after the hydraulic resistance in the pipeline. It is determined that transition of the laminar regime to the turbulent regime of water movement in the pipeline after the confuser and the diffuser occurs at velocity of 2 and 3 m/s, respectively. Intensity of vortex formation does not change with increasing flow velocity of fluid in the confuser. Flow expansion leads to an increase in intensity of vortex formation with increasing flow velocity of fluid.*

Key words: *the diffuser, the confuser, vortex formation, the Reynolds number, water, flow velocity.*
Language: *English*

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Introduction

Movement of working fluid in the general purpose pipelines is carried out at velocity of up to 4 m/s. Higher fluid flow velocities cause vibrations in the pipeline. The hydraulic resistances (the diffusers and the confusers) are placed in the pipeline to reduce or increase flow velocity of fluid [1-4]. The flow characteristics of some fluids in the pipelines with the local hydraulic resistances were investigated in the number of the scientific works. In the works [5-9], initial and calculated flow velocities of water and industrial oil in the pipeline with sudden and smooth expansions and constrictions were compared. It is determined that pressure drop before the profile inlet part of the confuser and after the conical outlet part of the diffuser will depend proportionally on non-uniformity of velocities of upper and lower fluid flows. These results were obtained in the conditions of fluids flow with single initial velocity. Description of fluid flow with combination of the hydraulic resistances is given in the work [10].

Water has low viscosity. Vortices are formed that cause vibrations in the pipelines with the hydraulic resistances during water movement. Occurrence of vibrations of the pipeline is successfully predicted by mathematical modeling when changing flow velocity of fluid.

Materials and methods

The purpose of the study was to determine effect of fluid flow velocity in the pipeline with the diffuser and the confuser on intensity of vortex formation and the value of the Reynolds number for predicting the fluid flow regime. Fragments of the two-dimensional models of the pipeline with the diffuser and the confuser were built for modeling. The angle of the expanding and constricting parts of the pipeline was adopted 18 degrees. Water at the temperature of 293.15 K was taken as fluid moving through the pipeline. Initial velocity of water flow in the pipelines models with the diffuser and the confuser was 0.5, 1, 2 and 3 m/s. The boundary condition for walls of all pipelines models is no slip.

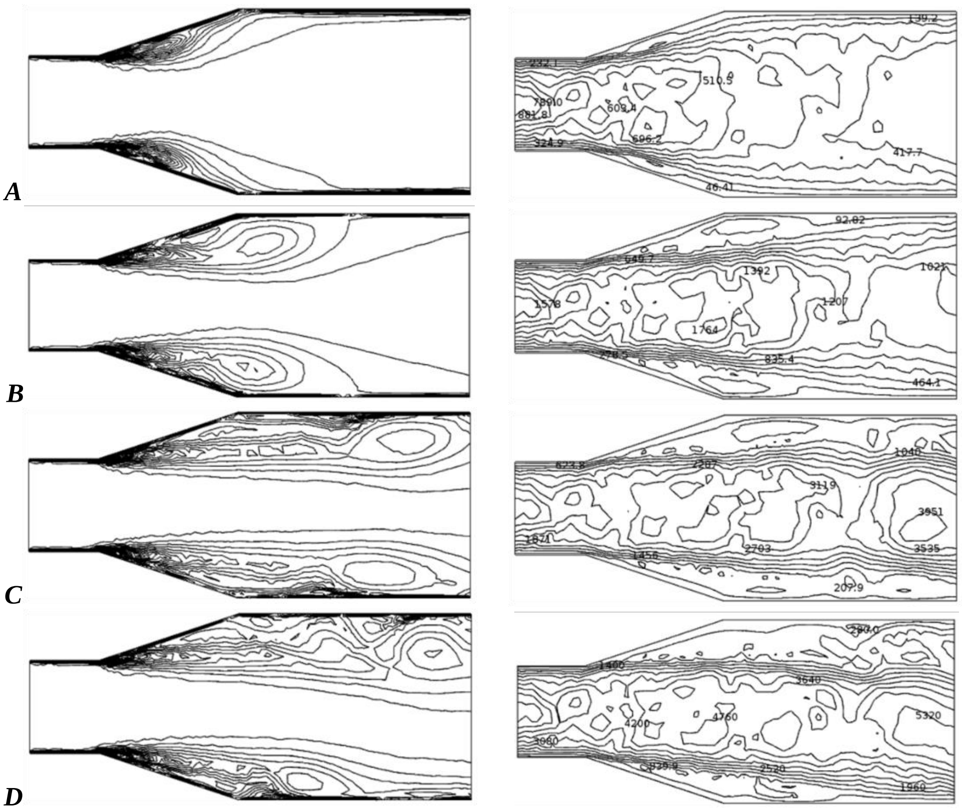

Figure 1 – The contours of intensity of vortex formation (left) and the Reynolds number (right) of water flow in the pipeline with the diffuser: *A* – initial flow velocity of 0.5 m/s; *B* – initial flow velocity of 1 m/s; *C* – initial flow velocity of 2 m/s; *D* – initial flow velocity of 3 m/s.

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	GIF (Australia) = 0.564	ESJI (KZ) = 8.997	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 5.667	OAJI (USA) = 0.350

Results and discussion

The contours describing distribution of vortex formation in flow of moving water and the numerical values of the Reynolds number were formed on the two-dimensional models of the pipelines with the diffuser and the confuser after the calculation. The contours of intensity of vortex formation and the Reynolds number of water flow in the pipeline with the diffuser and the confuser are presented in the Figs. 1 and 2.

Movement of fluid at velocity of 0.5-2 m/s through the diffuser does not change the flow core direction. Changing direction of the flow core (asymmetric vortex formation) is observed at initial water flow velocity of more than 3 m/s. Formation of vortex flows occurs in the expanding part of the pipeline. Intensity and distribution of vortex flows increase with increasing fluid flow velocity. Vortex flows are saved at certain distance after the hydraulic resistance at water flow velocity of more than 2 m/s. The calculated values of the Reynolds number indicate the flow regime of fluid in the pipeline with the diffuser:

- laminar (the Reynolds number from 46.41 to 1764) at water flow velocity of up to 1 m/s;
- transient (the Reynolds number from 207.9 to 3951) at water flow velocity of 2 m/s;
- turbulent (the Reynolds number from 280 to 5320) at water flow velocity of 3 m/s or more.

Vortex formation in the pipeline with the confuser occurs near walls. Increasing velocity of water flow does not lead to distribution of vortices in the cross section of flow. The flow regimes were determined taking into account increasing flow velocity of fluid in the confuser and the calculated values of the Reynolds number:

- laminar (the Reynolds number from 73.99 to 1406) at water flow velocity of 0.5 m/s;
- transient (the Reynolds number from 147.9 to 2810) at water flow velocity of 1 m/s;
- turbulent (the Reynolds number from 295.4 to 8413) at water flow velocity of 2 m/s or more.

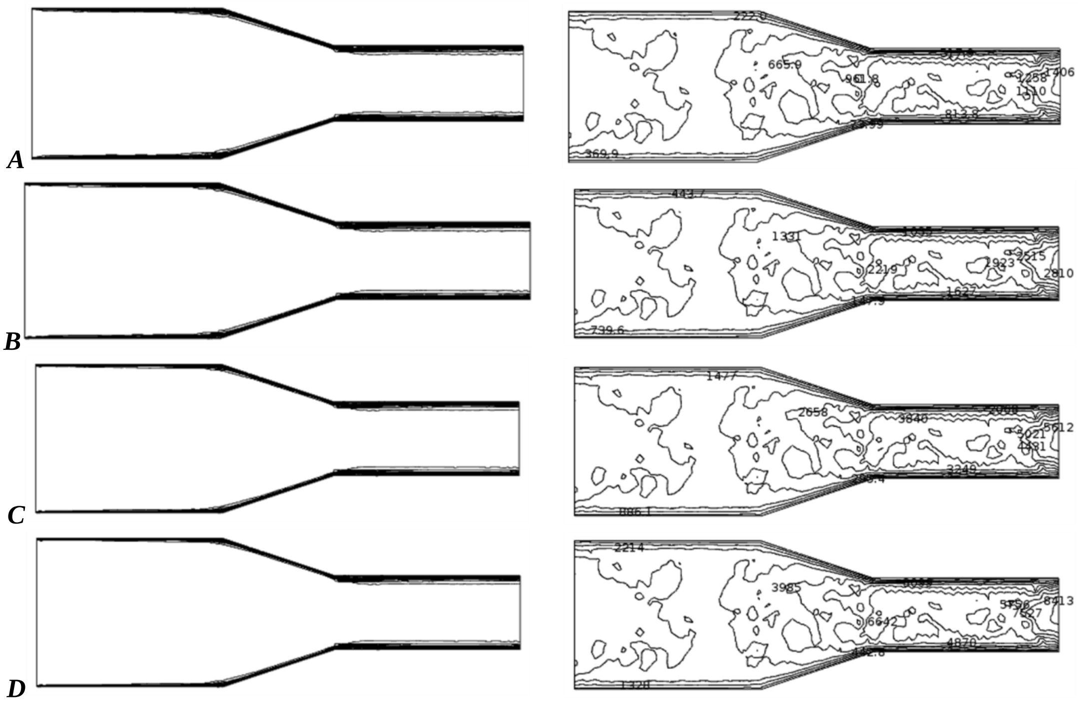

Figure 2 – The contours of intensity of vortex formation (left) and the Reynolds number (right) of water flow in the pipeline with the confuser: *A* – initial flow velocity of 0.5 m/s; *B* – initial flow velocity of 1 m/s; *C* – initial flow velocity of 2 m/s; *D* – initial flow velocity of 3 m/s.

Conclusion

Thus, based on the performed analysis of the study results, the following conclusions were made:

1. Vortex formation in the pipeline with the confuser is concentrated on walls and does not pass into the flow core of moving fluid at different velocity. Vortices are formed at the inlet to the hydraulic resistance and act at certain distance after the resistance with increasing flow velocity of fluid in the pipeline with the diffuser.

2. Vortices are formed asymmetrically and lead to a change in direction of the flow core at fluid flow velocity of 3 m/s in the pipeline with the diffuser. Thus, vibrations occur in the pipeline at given water flow velocity.

3. The laminar regime is observed at fluid flow velocity of up to 2 m/s in the pipeline with the diffuser. Same distribution of the Reynolds number contours in the pipeline with the confuser indicates the stable turbulent regime determined at water flow velocity of more than 2 m/s.

References:

1. (1991). ISO 5167-1:1991 (E) *Measurement of fluid flow by means of pressure differential devices. Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full*.
2. (1992). ISO/TR 3313:1992 (E) *Measurement of pulsating fluid flow in a pipe by means of orifice plates, nozzles or Venturi tubes*.
3. (2003). ISO 5167-3:2003 *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 3: Nozzles and Venturi nozzles (MOD)*.
4. (2003). ISO 5167-4:2003 *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 4: Venturi tubes (MOD)*.
5. Chemezov, D., et al. (2020). Comparative analysis of characteristics of water and industrial oil flows in the pipeline with the diffuser. *ISJ Theoretical & Applied Science, 10 (90)*, 368-380.
6. Chemezov, D. A., & Bayakina, A. V. (2014). Simulation modeling of water flow in the Venturi nozzle. *ISJ Theoretical & Applied Science, 07 (15)*, 25-29.
7. Chemezov, D. (2016). The character of the fluid flow in the pipelines with the local hydraulic resistances. *ISJ Theoretical & Applied Science, 12 (44)*, 62-68.
8. Durst, F., Melling, A., & Whitelaw, J. H. (1974). Low Reynolds number flow over a plane symmetric sudden expansion. *Journal of Fluid Mechanics, vol. 64, Issue 01*, 111-128.
9. Thiruvengadam, M., Armaly, B. F., & Drallmeier, J. A. (2009). Three dimensional mixed convection in plane symmetric-sudden expansion: Symmetric flow regime. *Int. Journal of Heat and Mass Transfer, 52*, 899-907.
10. Kurbangaleev, A. A. (2016). Method 3D designs of process of mixing of newtonian liquids in tubular channels of the diffuser-confuser type. *International Research Journal, Issue № 12 (54), Part 5*, 16-21.