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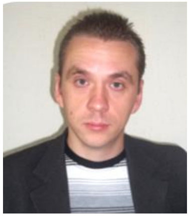

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SECTION 7. Mechanics and machine construction.

THE MOTION OF THE FLUID IN THE VOLUTE OF A CENTRIFUGAL PUMP

Abstract*: The article is presented the results of computer calculation of hydrodynamic characteristics of fluid flow in the volute of a centrifugal pump.*
Key words*: a volute, a velocity, a turbulent fluid flow, pressure.*
Language*: English*
Citation: Chemezov DA (2016) THE MOTION OF THE FLUID IN THE VOLUTE OF A CENTRIFUGAL PUMP. ISJ Theoretical & Applied Science, 04 (36): 37-39.
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Introduction

The character of fluid flow in a centrifugal pump depends on the configuration and dimensions of chamber hydraulic machine [1, 2]. The chamber of the centrifugal pump is made in a spiral shape, the axial cross section of the channel increases from the wedge to the diffuser [3]. The velocity of flow and current pressure of the fluid in each section of the volute of a centrifugal pump will be different. Respectively there is a pressure difference on the inlet and outlet of the volute, resulting to the decrease of productivity of the centrifugal pump.

The calculation and subsequent analysis of changes in hydrodynamic characteristics of fluid flow in the volute will allow to determine the loss of pressure in a centrifugal pump.

Materials and methods

The preparatory stage of the computer simulation of the motion of the fluid in the volute of a centrifugal pump was carried out in modules of program *Ansys Workbench*.

In module *Vista Centrifugal Pump Design* was performed calculation of geometrical and technological parameters of the impeller and the volute of a centrifugal pump [4]. Generation and partitioning into finite elements (asymmetrical mesh on 225178 elements with a standard deviation of 0.125) of the three-dimensional model of the volute of a centrifugal pump were implemented in the module *Mesh* [5].

Operating conditions		**Geometry**	
Rotational speed	1450 rpm	Casing rotation angle	14 deg
Volume flow rate	280 m^3/hr	Section type	Elliptical/ circular
Density (water)	1000 kg/m^3	Inlet width	82.5 mm
Head rise	20 m	Base circle radius	150.7 mm
Inlet flow angle	90 deg	Cutwater clearance	14.8 mm
Merid velocity ratio	1.1	Cutwater thickness	5.7 mm
Diffuser		Diameter	200 mm
		Length	247.5 mm
		Exit area	17620 mm^2
		Exit hydraulic diameter	149.8 mm
		Cone angle	7.0 deg

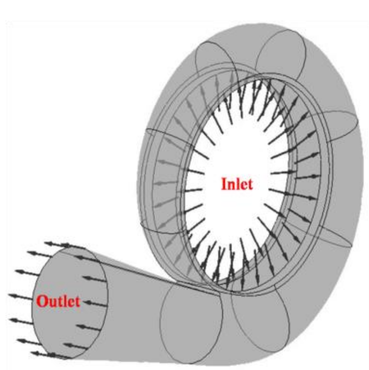

Figure 1 – Operating conditions and geometric dimensions of the 3D model of the volute of a centrifugal pump.

Operating conditions and geometric dimensions of the 3D model of the volute of a centrifugal pump are presented in Fig. 1.

The number of the sections of the volute of a centrifugal pump – 9. Outer radius of the first section amounted to 150.7 mm, the second section – 167.6 mm, the third section – 186.2 mm, the fourth section – 202.4 mm, the fifth section – 215.7 mm, the sixth section 227.6 mm, the seventh section – 238.7 mm, the eighth section – 249.0 mm, the ninth section – 260.4 mm.

Calculation and processing of results was made out in the module *CFX* [6]. The type of analysis – steady state. The reference pressure value of 1 atm, heat transfer model – isothermal, turbulence model – k-epsilon was set [7]. The velocity of the fluid flow at the inlet amounted to 13.02 m/s at a temperature 25°C.

Results and discussion

In Fig. 2 the calculated contours of the turbulence kinetic energy, the turbulence eddy frequency, the velocities of flow and total pressure of the fluid in the volute of a centrifugal pump are presented.

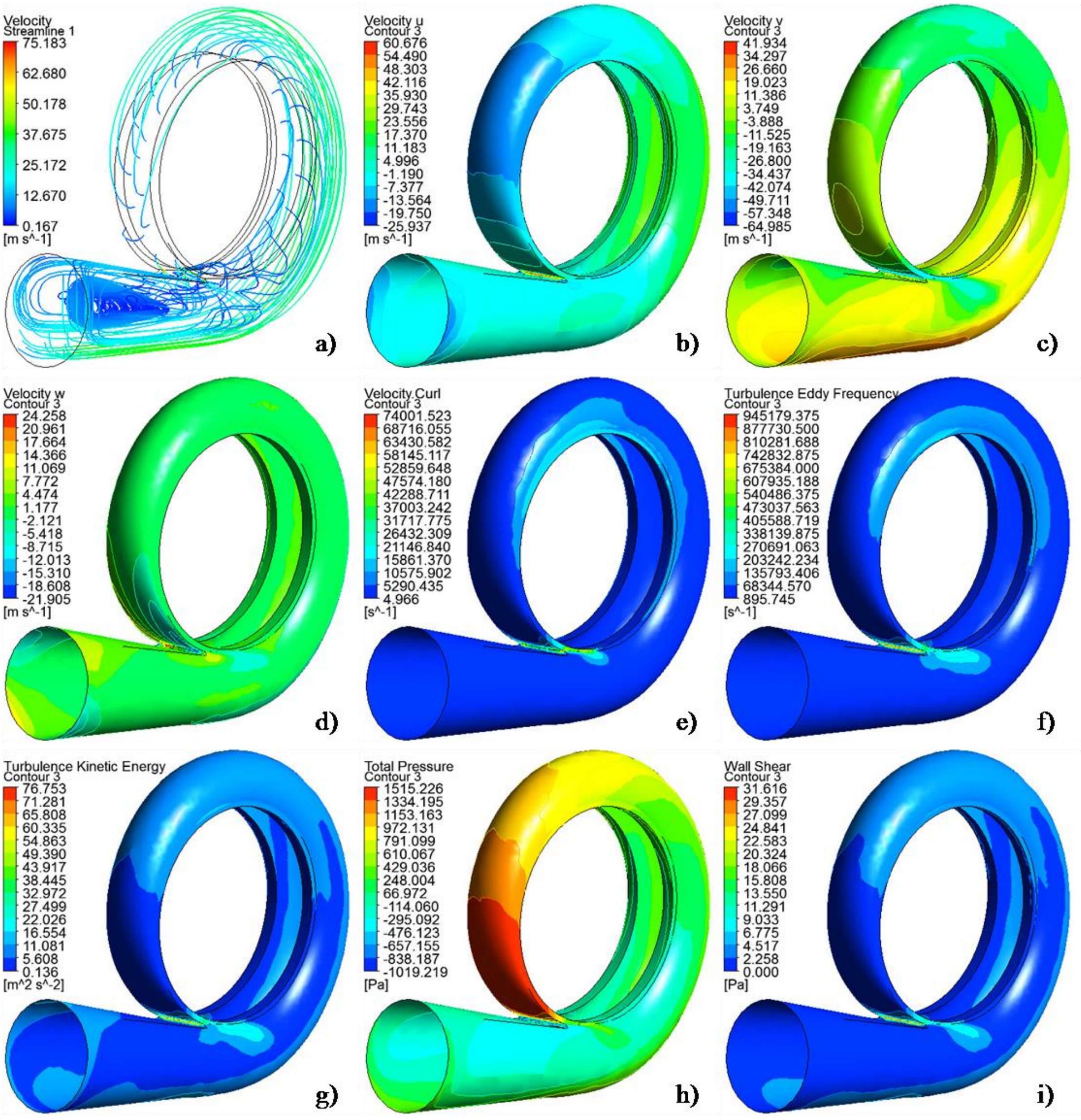

Figure 2 – The contours on the model of the volute of a centrifugal pump: a – velocity, b – velocity *u*, c – velocity *v*, d – velocity *w*, e – velocity. curl, f – turbulence eddy frequency, g – turbulence kinetic energy, h – total pressure, i – wall shear.

The fluid flow in the volute of a centrifugal pump moves in the direction of rotation of the impeller. Taking into account the variable diameter of the channel and mixing of the fluid layers, in sections and diffuser of the volute is observed the turbulent regime of fluid flow. The velocity of the fluid flow varies in the range from 6 to 35 m/s.

The absolute velocity of the fluid flow *v* is equal to the sum of the circumferential velocity *u* and relative velocity *w*. [8]. On the model of the volute contours of velocities *u* and *w* have positive and negative values. Negative values are obtained when reducing the velocity of fluid flow. The circumferential velocity of the fluid flow decreases in the second and the third sections, increases in the sixth section of the volute of a centrifugal pump. In other sections the velocity *u* does not change and has a value of -7 m/s. The relative velocity of the fluid flow is constant throughout the length of the volute of a centrifugal pump. The value of the velocity *w* is 1 to 4 m/s.

Velocity.curl is a vector field from the three scalar components of this velocity $\sqrt{x^2+y^2+z^2}$. The changes of values of the velocity.curl (increase) in the spiral part of the chamber of the centrifugal pump are observed. This process is explained by a higher degree of the swirl flow of fluid in these sections.

Turbulence eddy is considered a developed turbulent fluid flow with large Reynolds number. The large and small vortices can distinguish when the turbulent regime of fluid flow. The characteristic of these vortices is the frequency of turbulent pulsations. The value of the velocity of fluid flow for a sufficiently large period of time remains constant. Turbulence eddy frequency of fluid flow increases in the area of the outer diameter of the impeller of the centrifugal pump.

The kinetic energy of turbulent flow is calculated as $Ek_{(V)}$ + $Ek_{(u')}$, where $Ek_{(V)}$ – kinetic energy of averaged fluid motion, $Ek_{(u')}$ – kinetic energy of pulsation motion of the fluid. The value of the kinetic energy of turbulent fluid flow in all sections of the volute of a centrifugal pump changes in the range from 2 to 16 m^2/s^2.

The calculated value of the total pressure is reduced in 7 times when motion of fluid from the zone of cutwater to the zone of the throat of the centrifugal pump. In the diffuser of the volute of a centrifugal pump acts vacuum pressure (negative values on the corresponding color scale).

The largest shear stress during operation of the centrifugal pump is subjected of a wall in the third, fourth and the fifth sections of the volute. Also there is stress at the inlet to the diffuser and partly on the length of the throat.

Conclusion

Turbulent motion of the fluid in the volute leads to decreasing the velocity of flow and pressure in the diffuser. The performance of a centrifugal pump decreases to 40% and the consumed power will be 19.5 kW. The coefficient of specific speed of centrifugal pump at the selected geometric dimensions and operating conditions is 0.82.

References:

1. Chemezov DA, Kovalenko NO (2014) Parametric analysis of the diffuser spiral chamber of the centrifugal pump. VIII International scientific-practical conference "Fundamental and applied researches in the modern world". Vol. 1. – Pp. 66 – 68. ISSN 2307-1354.
2. Gülich JF (2010) Centrifugal Pumps. Second edition. – Springer-Verlag Berlin Heidelberg, 2010. – 964 p. ISBN 978-3-642-12823-3.
3. (2016) Tsentrobezhny nasos. Available: http://k-a-t.ru/gidravlika/12_gidro_mashiny_3/index.shtml (Accessed: 18.04.2016).
4. (2016) Vista Software. 1D Preliminary design. Available: http://www.pcaeng.co.uk/software (Accessed: 18.04.2016).
5. (2016) Meshing Methods (ANSYS Meshing). Available: https://deust.wordpress.com/2013/04/23/meshing-methods-ansys-meshing/ (Accessed: 18.04.2016).
6. (2016) Ansys CFX. Available: http://www.docme.ru/doc/544612/ansys-cfx (Accessed: 18.04.2016).
7. (2016) K-epsilon turbulence model. Available: https://en.wikipedia.org/wiki/K-epsilon_turbulence_model (Accessed: 18.04.2016).
8. (2016) Teoreticheskie osnovy dvizheniya zhidkosti v tsentrobezhnom nasose. Available: http://www.nasosinfo.ru/node/7 (Accessed: 18.04.2016).