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HEAD LOSSES IN CONICAL DIFFUSERS AT LOW REYNOLDS NUMBERS

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ABSTRACT

In various devices of hydraulic drive and hydraulic automation systems, elements with a conical flow path are used - conical confusers and diffusers.The cross-sectional dimensions of such elements are typically relatively small, and the fluid (mineral oil) moving through them has a high viscosity. Therefore, despite the relatively high fluid flow velocity, the Reynolds Re numbers in conical elements can be low.

It is known that at low Reynolds numbers, the work done by frictional forces takes on a predominant role compared to the kinetic energy of the flow. In this regard, it is found that the hydraulic coefficients (friction and local resistance coefficients) included in the Darcy and Weisbach head loss formulas are significantly dependent on the number Re.

In general, the local pressure loss h_j for any type of resistance, regardless of the mode of movement, is determined by the Weisbach formula:

$$h_j = \varsigma_j \frac{\vartheta^2}{2g} \qquad (1)$$

Where ϑ is the average velocity in the pipeline cross-section with local resistance; ς_j - is the local resistance coefficient.

When a liquid moves with low Reynolds numbers, the value of ς_j - depends both on the shape of the flow path of the resistance and on the Re_d number:

$$\mathrm{Re}_d = \frac{\vartheta d}{\nu}, \qquad (2)$$

where d is the diameter of the pipeline in the section of local resistance; is the kinematic coefficient of viscosity of the liquid.

The type of dependence of ς_j as a function of the Re_d number and the form of local resistance is established, as a rule, based on the data of experimental sequences. An analysis of some literary sources [1-8] concerning the problems of hydraulic resistance shows that the issue of calculating pressure losses in the case of fluid movement with small Re numbers has been studied comparatively little even for the most common types of local resistance - such as sharp expansion and contraction of pipes.

Research by V. N. Karev [3] on determining pressure losses in the case of a sharp expansion of a pipe showed that with laminar flow, the local resistance coefficient $\varsigma_{p.p}$ depends significantly on Re_d and in the range of Reynolds numbers from 1 to 9, $\varsigma_{p.p}$ depends only on the Re_d number and is determined by the formula:

$$\varsigma_{p.p} = \frac{26}{\mathrm{Re}_d} \qquad (3)$$

In the intermediate zone of Reynolds numbers (9<Re<3500) the coefficient $\varsigma_{p.p}$:

It depends both on the number Re_d and on the ratio of areas $\frac{\omega_1}{\omega_2}$; for $\mathrm{Re}_d > 3500$ the coefficient $\varsigma_{p.p}$ is a function of only the ratio $\frac{\omega_1}{\omega_2}$.

A. D. Altshul [2], based on available experimental data and individual theoretical studies, proposes to determine the coefficients of local resistance when moving through a diaphragm, as well as for a number of other cases of local resistance at $\mathrm{Re}_d < 10$, using the formula:

$$\varsigma = \frac{A}{\mathrm{Re}_d} \qquad (4)$$

where the value of the coefficient A depends on the geometry of the local resistance:

$$A = \frac{25{,}2}{n^{\frac{3}{2}}} \qquad (5)$$

where $n = \frac{w}{w_0}$ is the flow compression ratio; w - is the cross-sectional area of the pipe; w_0 - is the cross-sectional area of the diaphragm opening.

A large number of works have been devoted to the motion of incompressible and compressible fluids in conical diffusers at high speeds corresponding to the turbulent regime, and this problem can be considered to be basically solved. The pressure losses in the diffuser during turbulent flow are determined using the Weisbach formula (1). The drag coefficient $\varsigma_{диф.}$ is taken from reference literature.

Sometimes, friction losses along the length of the diffuser are conditionally distinguished from the total losses in the diffuser, i.e., the local pressure loss in the diffuser is determined in a section of length equal to zero.

Then the total pressure loss in the diffuser can be represented as a sum:

$$h_{диф.} = h_{l_{диф}} + h_{расш.}, \qquad (6)$$

where $h_{l_{диф}}$ - is the friction loss along the diffuser; $h_{расш.}$ is the local pressure loss, determined over a section of length $l = 0$ conventionally called the expansion loss.
The coefficient of total pressure loss in the diffuser can therefore be represented as the sum:

$$\varsigma_{диф.} = \varsigma_{тр} + \varsigma_{расш.} \quad (7)$$

As for the calculation of conical diffusers when liquid with small Re numbers moves in them, many issues of this problem, in particular, the issue of separated flow, have not yet been covered in the literature.
A theoretical solution for the motion of fluid in a flat and conical diffuser for a given velocity profile in its initial cross-section was proposed by S. M. Targ [8]. Research into S. M. Targ's equations [8] leads to the conclusion that,

$$\mathrm{Re}\frac{\alpha}{2} < 3{,}69 \text{ (for flat diffuser)} \quad (8)$$

and

$$\mathrm{Re}\frac{\alpha}{2} < 4{,}73 \text{ (for conical diffuser)} \quad (9)$$

the pressure in the direction of flow decreases, i.e. $p_\infty < p_0$ (the fluid flow is directed in the direction of pressure drop); for values $\mathrm{Re}\frac{\alpha}{2} > 3{,}69$ for a flat diffuser and $\mathrm{Re}\frac{\alpha}{2} > 4{,}73$ for a conical diffuser, $p_\infty > p_0$ i.e. the flow in the diffuser occurs in the direction of increasing pressure. Studies of the separation phenomenon have shown that at $\mathrm{Re}\frac{\alpha}{2} < \pi^2$ for a flat diffuser and $\mathrm{Re}\frac{\alpha}{2} < 7{,}34$ for a conical diffuser, the flow will be without separation.

At values of $\mathrm{Re}\frac{\alpha}{2} > \pi^2$ for a flat diffuser and $\mathrm{Re}\frac{\alpha}{2} > 7{,}34$ for a conical diffuser, separation occurs at their walls. During separation, the fluid flow is directed toward increasing pressure.
This paper presents a study of pressure losses in conical diffusers with diameter ratios of $\frac{D}{d} = 1{,}33$ and $\frac{D}{d} = 2{,}3$. The expansion angles varied from 5 to 30° for the first diameter ratio, and from 8 to 59° for the second. The Reynolds numbers varied from 1 to 30. Colourless medical glycerin with a viscosity of $\nu \approx stokes$ (at t=20°C) was used as the working fluid. To determine pressure losses in conical diffusers at low Reynolds numbers, high experimental accuracy is required, in particular, the accuracy of measuring pressures in control sections, liquid flow rates, and its viscosity. The experimental setup also had to meet these requirements. The tank's capacity ensured the required flow rate was maintained for a relatively long period of time. Liquid was periodically pumped from the overflow tank into the pressure tank using a pump. This scheme of supplying liquid to the local resistance ensured a relatively stable temperature regime for the experiment, since it excluded significant heating of the liquid during continuous operation of the pump.

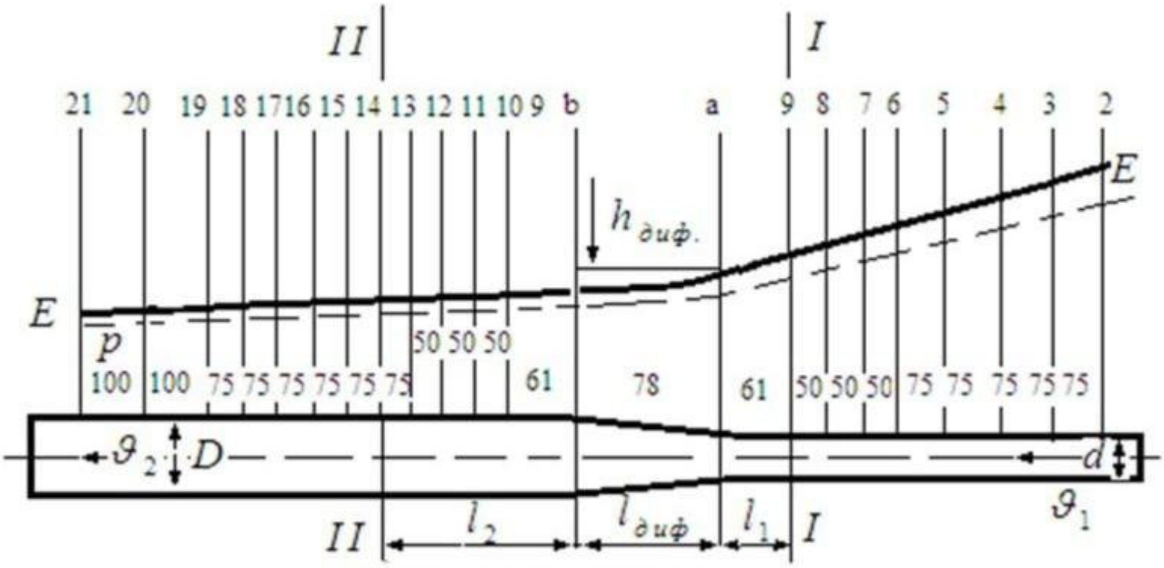

Figure 1. Diagram for determining pressure losses in a diffuser

The gravity-flow system also excluded the pulsation phenomena that accompany the supply of liquid directly from the pump, which took place in the works of V. N. Karev, N. V. Levkoeva [2] and others.

When processing the experimental data, we determined both the coefficient of total pressure losses in the diffuser $\varsigma_{диф.}$ and the coefficients of expansion losses.

The pressure losses were calculated in accordance with the Bernoulli equation, written for two control sections I-I and II – II. (Fig. 1.)

$$h_{расш.} = \frac{p_1}{\gamma} - \frac{\alpha \vartheta_1^2}{2g} - \frac{p_2}{\gamma} - \frac{\alpha \vartheta_2^2}{2g} - h_{l_1} - h_{l_{диф}} - h_{l_2} \qquad (10)$$

where $\frac{p_1}{\gamma}$ and $\frac{p_2}{\gamma}$ are readings from piezometers installed in sections I-I and II-II; and h_{l_2} is the pressure loss along the length in the sections from section I-I to the diffuser and from the diffuser to section II-II.

REFERENCES

1. Chugaev R. R. Hydraulics. L., "Energy", 1970.
2. Altshul A. D. Local hydraulic resistance during the movement of viscous fluids. Moscow, Gostoptekhizdat, 1962.
3. Karev V. N. Pressure losses during sudden expansion of pipelines. "Oil Industry", No. 11, 12, 1952.
4. Altshul A.D. Kiselev P.G. Hydraulics and aerodynamics. M.,. Sgroyizdat, 1965.
5. Idelchik I.E. Aerodynamics of flow and pressure losses in diffusers. Industrial Aerodynamics, No. 3, 1947.
6. Frenkel N.Z. Hydraulics. M.-L., Gosenergoizdat, 1956
7. Idelchik I.E. Hydraulic resistance. M.-L., Gosenergoizdat, 1954.
8. Targ S. M. Basic tasks of the theory of laminar flows. M.-L., Gostekhizdat,

9. Khudaikulov S., Begimov U. Modeling of developed cavitation in the hydrochannel of the Pachkamar reservoir. Collection of papers of the Republican Scientific and Practical Conference on Current Problems of Mathematical Modeling, Computational Mathematics and Software Engineering, October 23-24, 2020, Karshi pp. 92-95.

10. Khudaikulov S.I., Begimov U.I. Collection of materials of the republican scientific and technical conference on the topic "Modeling the equation of vibrational motion of a cavern" Problems of introducing innovative technologies into production and using renewable energy sources". Volume 1 (November 2, 2020. Jizzakh.) B430-432.

11. Жовлиев У.Т., Казаков Э., Якубов Г. "Extension Of Tubular Water Discharge Limitations With Water Flow Extinguishers" "International journal of scientific & technology research volume 8, issue 12, december 2019 issn 2277-8616 Pp-2080-2082 www.ijstr.org "(ScopusISSN 2277-8616) IF.4.850

12. Jovliev U.T., Khudaykulov S.I. Algorithm for accounting for vortex zones at the pump inlet. Bulletin of the Turin Polytechnic University in Tashkent, issue 1/2018. pp. 58-60. (05.00.00; No. 25)

13. Jovliev U.T., Mannopova H., Khudaykulov B.S. "Correlation of the zone of low or high pressure with characteristic changes in the velocity head" J: Problems of Mechanics. No. 3, Tashkent 2018 pp. 87-91. (05.00.00; No. 6)

14. Jovliyev U.T., "Vibration processes in water movement in high-pressure hydraulic structures" J. Agro Ilm No. 2, Tashkent 2019, P. 96-98.(05.00.00; No. 3)

15. U. Jovliev. "Hydraulic parameters of high-pressure flow in high-pressure structures" Scientific supplement to the Journal of Agriculture and Water Management of Uzbekistan. "AGRO-ILM" Tashkent 2019. No. 3, P. 66-67. (05.00.00; No. 3).