CALCULATION OF CAVITY FLOWS IN AN AXISYMMETRIC CHANNEL

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Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, Vol. 10, No. 4, pp. 118–119, 1969

The results are presented of a calculation of cavity flow in an axisymmetric channel with an annular obstacle. The problem was suggested to the author by G. B. Tsvetnov.

The problem is solved by the method published in [1, 2].

We take the ring shown in Fig. 1 as the cavitating obstacle. The form of the sides which are not parallel to the stream is not essential for the method.

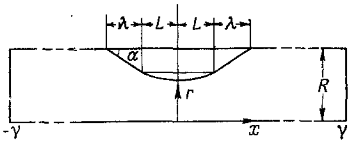


Fig. 1

In the x, r coordinate system the equation for the function $z(x,\psi)$ has the form

$$z_\psi{}^2 z_{xx} - 2z_x z_\psi z_{x\psi} + \{4(R^2 - z) + z_x{}^2\} z_{\psi\psi} = 0 \qquad (z(x, \psi) = r^2(x, \psi)) \tag{1.1}$$

where R is the channel radius.

The flow velocity is expressed by

$$V = \frac{1}{z_\psi}\left(\frac{4(R^2 - z) + z_x{}^2}{R^2 - z}\right)^{1/2} \tag{1.2}$$

The boundary conditions at the contour are as in [2]: $V^2 = \sigma + 1$ at the free surface; $z = W_k^2(x)$, $k = 1, 2$ at the obstacle walls which are not parallel to the flow, where $W_k$ are the equations of these walls; $z = 2\psi$ on the remaining segments of the region boundary, where the variable $\psi$ is connected with the stream function $\psi'$ by the formula

$$\psi = {}^1/_2 R^2 - \psi'$$

Account for the cavitation parameter ahead of each free boundary correction is made using the formula

$$\sigma^s = \frac{1}{(R^2 - z^s_{k+1,\,0})(z^2_\psi)^s_{k+1,\,0}}\left[4(R^2 - z^s_{k+1,\,0}) + \left(\frac{z_{k,0} - z_{k-1,0}}{h_k}\right)^2\right] - 1 \tag{1.3}$$

where the derivative $z_\psi$ is calculated using three points as in [2]. Formula (1.3) provides smooth joining of the free surface with the cavitator.

The calculations were made for the following values of the problem parameters (Fig. 1):

$$\alpha = 30°, \quad \lambda = 1, \quad L = 1{,}5, \quad R = 2$$

The table shows the results of calculations for axisymmetric and plane channels. Figure 2 shows the free surface and the velocity profile for the axisymmetric channel as solid curves and the same relations for the plane channel by the dashed curves.

REFERENCES

1. B. G. Kuznetsov, V. N. Shepelenko, and N. N. Yanenko, "Calculation of cavity form in gravity field with account for surface tension," Izv. SO AN SSSR, Ser. tekhn. n., no. 13, issue 3, 1967.

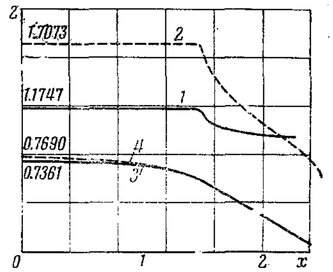


Fig. 2

Table

| $x$ | Axisymmetric case | | Plane case | |
|---|---|---|---|---|
| | $r$ | $V$ | $r$ | $V$ |
| 0.000 | 0.7361 | 1.1747 | 0.7690 | 1.7073 |
| 0.272 | 0.7337 | 1.1747 | 0.7651 | 1.7073 |
| 0.518 | 0.7269 | 1.1747 | 0.7545 | 1.7073 |
| 0.736 | 0.7162 | 1.1747 | 0.7382 | 1.7073 |
| 0.927 | 0.7018 | 1.1747 | 0.7173 | 1.7073 |
| 1.090 | 0.6841 | 1.1747 | 0.6928 | 1.7073 |
| 1.227 | 0.6635 | 1.1747 | 0.6662 | 1.7073 |
| 1.336 | 0.6409 | 1.1747 | 0.6393 | 1.7073 |
| 1.418 | 0.6179 | 1.1747 | 0.6142 | 1.7073 |
| 1.472 | 0.5970 | 1.1747 | 0.5930 | 1.7073 |
| 1.500 | 0.5773 | 1.1070 | 0.5773 | 1.6391 |
| 1.722 | 0.4490 | 1.0168 | 0.4490 | 1.2806 |
| 1.916 | 0.3367 | 0.9787 | 0.3367 | 1.1222 |
| 2.083 | 0.2405 | 0.9607 | 0.2405 | 1.0057 |
| 2.222 | 0.1603 | 0.9534 | 0.1603 | 0.9066 |
| 2.333 | 0.0962 | 0.9529 | 0.0962 | 0.8184 |
| 2.416 | 0.0481 | 0.9565 | 0.0481 | 0.7425 |
| 2.472 | 0.0160 | 0.9622 | 0.0160 | 0.6855 |
| 2.500 | 0.0000 | 0.9669 | 0.0000 | 0.5697 |
| 2.642 | | 0.9808 | | 0.7239 |
| 2.928 | | 0.9910 | | 0.8632 |
| 3.357 | | 0.9965 | | 0.9402 |
| 3.928 | | 0.9988 | | 0.9772 |
| 4.642 | | 0.9997 | | 0.9926 |
| 5.500 | | 0.9999 | | 0.9980 |
| 6.500 | | 0.9999 | | 0.9995 |
| 7.642 | | 0.9999 | | 0.9999 |
| | $\sigma = 0.3800$ | | $\sigma = 1.9151$ | |

2. V. N. Shepelenko, "Calculation of cavity flows," PMTF [Journal of Applied Mechanics and Technical Physics], vol. 9, no. 5, 1968.

24 February 1969

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