INELASTIC FLOWS

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Mestchersky's force in inelastic flows of the liquid is described.
Овсянников В.М. В статье вычисляются силы Мещерского в неупругих течениях жидкости.

We know about absolutely an inelastic collision of two solid bodies. Such motions exist for continuos environment. The mechanical energy is not constant for such flows. We know about two different inelastic flows. We can speak about inelastic flows with decrease of the mechanical energy and about inelastic flows with increase of the mechanical energy. In such flows acts Mestchersky's force to elementary volume of the environment.

We shall speak about decelerated flow of fluid. We have elementary volume AB of the liquid. The first stage of the motion. A liquid segment AB moves along axis x in position A_1B_1 as hard body (see fig. 1a, 1b). The second stage. There is the deformation A_1B_1 to A_1B (see fig. 1b, 1c). Such the point B is nonmovable. The length of a segment AB equal to Δx. The length of a segment A_1B equal to $(\Delta x)/k$, $(k>1)$.

Let's enter coordinate χ. $\chi = 0$ for point A_1. A segment A_1B we shall divide into elementary segments by point

$$\chi_n=(\Delta x)/k^n \qquad (n=0,1,2,...)$$

(see fig. 1d). On the second stage each point χ_n will be displaised to point χ_{n+1} during time Δt. The velocity of the removel at the compressive deformation we shall calculate as

$$u_n=(\chi_{n-1}-\chi_{n+1})/(2(\Delta t))=((k-1/k)k^{-n})(\Delta x)/(2(\Delta t)), \qquad (n=0,1,2,...)$$

The speed of the deformation of the point B_1 is equal to

$$u_0=(\chi_{-1}-\chi_1)/(2(\Delta t))=(k-1/k)(\Delta x)/(2(\Delta t)),\ \chi_{-1}=(\Delta x)k \qquad (1)$$

Such

$$u_n/u_0=k^{-n}$$

It is the move of the segment AB with an extreme large compressive deformation.

On a segment AB acts Mestchersky's force at the stage of the deformation (see fig 1b, 1c). Each of the elementary segment, will produce the contribution to Mestchersky's force

$$F_{M(n)}=u_n(\Delta m)_n/(\Delta t)$$

Here Δm_k mass, removed by deformation move during Δt near to a point χ_n. The cross-section of the fluid segment is $(\Delta y)(\Delta z)$.

The volume is

$$(1/2)(\chi_{n-1} - \chi_{n+1})(\Delta y)(\Delta z).$$

The mass is

$$(1/2)\rho(\Delta x)(k-1/k)k^{-n}(\Delta y)(\Delta z).$$

Here ρ is density. The contribution of Mestchersky's force to a pressure drop

$$\Delta p_{M(n)}=F_{M(n)}/((\Delta y)(\Delta z))=\rho(k-1/k)k^{-n}(\Delta x)/(2(\Delta t))=\rho u_n^2$$

The contribution of all segments to a pressure drop is equal to

$$\Delta p_M=\Sigma_n \rho u_n^2=\rho u_0^2\Sigma_n(u_n/u_0)^2=\rho u_0^2\Sigma_n 1/(k^2)_n,\ (n=0,1,2,...)$$

Thus

$$\Delta p_M=\rho u_0^2 k^2/(k^2-1)$$

At the first stage of the decelerated motion of the segment AB (see fig. 1a, 1b) is necessary during time Δt to enclose a force F calculated by mechanics of a solid

$$m(u_0-0)=F(\Delta t)$$

Here m is mass

$$m=\rho(\Delta x)(\Delta y)(\Delta z)$$

Also we shall receive for force come per unit of the cross-section of the flow

$$\Delta p=F/((\Delta y)(\Delta z))=\rho u_0(\Delta x)/(\Delta t)=\rho((\Delta x)^2/(2(\Delta t)^2)(k^2-1)/k$$

From the equation (1) is discovered, that

$$(\Delta x)/(\Delta t)=u_0 2k/(k^2-1)$$

Then

$$\Delta p=(\rho/2)((k^2-1)/k)((\Delta x)/(\Delta t)^2=$$
$$=(\rho/2)((k^2-1)/k)u_0^2 4k^2/(k^2-1)^2=\rho u_0^2 2k/(k^2-1)$$

Also

$$(\Delta p_M)=(\Delta p)=k/2$$

$$(\Delta p_M)/(\Delta p) \to 0.5 \text{ if } k \to 1$$

Such for decelerated flow

$$(\Delta p_M)=0.5(\Delta p)$$

For accelerated flow

$$(\Delta p_M)=-0.5(\Delta p)$$

Difference form of the equation of the motion for inelastic flow is

$$\rho u\, \Delta u/\Delta x= -[\Delta p/\Delta x \pm (1/2)\Delta p/\Delta x]$$

Here p is the pressure, ρ is the density, u is velocity, x is coordinate. The absolutely inelastic flows arise in the stream of the gases with chemical reactions. Early inelastic properties were discovered in the experiments with the flows of the liquids with negative and positive acceleration.

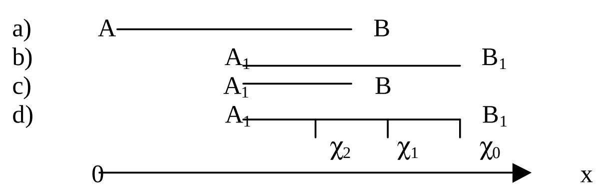

Fig. 1

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