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To the Projection of a Peristaltic Slit Pump

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Abstract

The analysis of a peristaltic pump of the slatted type is made, which in contrast to conventional pumps with the working body on the basis of elastic hose has no significant limitations on the value of the output pressure and does not pollute the transmittable fluid. Flow of an incompressible liquid in a flat gap is considered, the analytical expressions for a flow rate and a differential pressure are received. The paper also discusses design features of the motor based on piezoelectric materials as well as the modal and dynamic analyses of the proposed design are made, its concrete implementation is shown.

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Keywords: a peristaltic pump; Reynolds's equation; fluid flow; pressure; a form of fluctuations; piezoelectricity; amplitude; damping; the dynamic analysis

1. Introduction

Currently, the peristaltic pumps are widely used in technology [1], the principle of which is based waveformated motion of the working body (the hose) in which the transmittable material comes into contact only with the inner surface of the hose and not with any moving parts. These pumps have unique properties, as suitable for transportation of corrosive, abrasive and other products with solid particles and liquids sensitive to agitation, so the task of improving these pumps is up to date.

It should be noted that the intensive deterioration of the hose prevents operation of the pump in some industries, for example, in the medicine industry, as a hose material pollutes the fluid and the outlet pressure of the pump is limited to the strength properties and the elastic hose may not be enough in most applications.

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Obviously, if you replace the flexible hose of an elastic cylinder made of metal and provide waveformated motion of its surface, the working body of the pump will be almost perpetual, and the magnitude of the output pressure will be limited to only the design and operational features of the engine, which in this case must be performed on the basis of piezoelectric materials. Small amplitude of oscillations of the working surface of the piezoelectric motor (vibration motor) defines the small value of gap (gap), which is implemented waveformated motion. This imposes more strict demands on the composition and properties of the pumped liquids and makes a natural limitation on the capacity of the pump per cycle of oscillation, which, however, can be reused to compensate for a corresponding increase in operating frequency.

2. The increase in pressure and flow in a thin layer of incompressible fluid

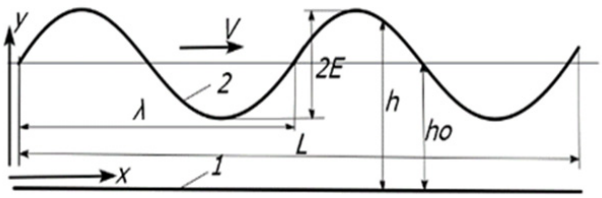

Fig.1. The gap with waveformated surface.

We consider the problem of the planar flow of viscous incompressible fluid in an incompressible thin layer of infinite width, enclosed between a flat moving surface 1 (fig.1) immobile and 2, forming a longitudinal running wave in the direction of the coordinates x. To describe the motion of the medium we apply the Reynolds equation in the form of pressure [2]:

$$\frac{\partial h_i}{\partial t} - (1/12\mu)\frac{\partial}{\partial \bar{x}}\left(h_i^3 \frac{\partial \mathcal{P}}{\partial \bar{x}}\right) = 0\,, \qquad (1)$$

where $\mathcal{P}$ is the instantaneous pressure in the layer ($\mathcal{P}_0$ – the ambient pressure).

The gap function will describe the following two expressions:

$$h_1 = h_0\left\{1 + E_0 \cos\left[\omega\left(t - \bar{x}/V\right)\right]\right\}, \qquad (2)$$

$$h_2 = h_0\left\{1 + E_0 \cos\left[\omega\left(t - \bar{x}/V\right)\right]\cos\nu t\right\}, \qquad (3)$$

in which h_0 is the mean value of gap (fig.1), $E_0 = E/h_0$ is the dimensionless amplitude of the running wave, $\omega = 2\pi\varpi$ is the circular frequency of the moving wave; ν – circular frequency normal gap fluctuations (ω<<ν), $V = \lambda\bar{\nu}$ – the velocity of the running wave, λ is the wavelength. Gap function h_1 (2) describes the process of kinematic excitation of the liquid layer waveformated motion of the running wave type, and the function h_2 (3) – layer with the fluctuations modulated by the running wave, i=1,2 (the author proposed invention the reference node with the wave of the form h_2 [3], which facilitates the task of designing).

Proceed to dimensionless parameters $P = \mathcal{P}/\mathcal{P}_0$, $H_i = h_i/h_0$, $\tau = \varpi t$, $x = \bar{x}/\lambda$, which allows to obtain the following equation for the pressure distribution:

$$\Lambda_\omega \frac{\partial H_i}{\partial \tau} = \frac{\partial}{\partial x}\left(H_i^3 \frac{\partial P}{\partial x}\right), \qquad (4)$$

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