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CONTRIBUTIONS REGARDING THE DESIGN OF A GEOMETRICAL STRUCTURE AT A SPECIAL FLUIDIC DEVICE

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ABSTRACT
This paper presents the theoretical researches regarding the geometrical structure analysis at the wall - attachment device. The examined monostable element is a special device with an incompressible fluid as supply jet and compressible fluid as command jet. The obtained results were used to realize a model of this type of special fluid device tested experimentally.

KEY WORDS: *monostable fluidic element, supply jet, command jet, attachment distance, wall angle.*

1. INRODUCTION

The sensitive flows at amplifications, meaning the fluid flow which changes flow direction, velocity profile and nature of flow, with the help of the secondary or lateral jets, they are mostly used in automatics.

Many investigations and researches performed in the fluid field proved that the achievement of the amplification effect at the fluidic devices it is similar with the electronic magnification (electronic valves, transistors).

The actual orientation of the researches in this field of study, aims to achieve fluidic elements and systems with a minimal energy consumption, a great speed of response, high reliability, safety in operation, a higher level of compatibility with the conventional automation systems, a lower price and many other performances that justify their usage.

So, a command jet, with a lower energy level, is able to modulate, in a large band of frequency, a supply jet with a high energy level.

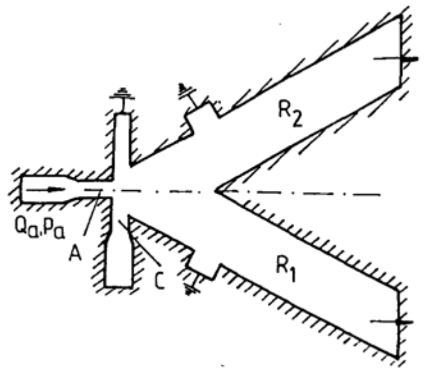

Fig 1

Monostable fluidic amplifier [4]

The bistable and monostable fluidic element, which is a special case of the bistable fluidic device, are two types of fluidic amplifiers, basing in their work, on the principle of jet attachment to solid walls – the Coanda Effect.

At the exit of the supply nozzle, the power jet meets an auspicious geometrical structure for his attachment to the solid wall. So, in the corresponding receiving canal (R_2) it obtains a pressure signal and a flow signal. Their values are established by the supply pressure (p_a) level and by the geometrical structure. In subtend receiving canal (R_1) the achieve flow is null. We achieve the first stable state. Than, we apply a command jet in the control nozzle, which determine the switch of the power jet in subtend receiving canal (R_1) [4], [5].

The power jet returns in the receiving canal (R_2) if the geometrical structure is asymmetrical (fig. 1) and the command jet disappears. We obtain again the initial stable state. The monostable fluidic device is a decision element.

2 CONTRIBUTIONS REGARDING THE DESIGN OF THE SOME IMPORTANTS GEOMETRIC PARAMETERS AT THE MONOSTABLE FLUID DEVICE

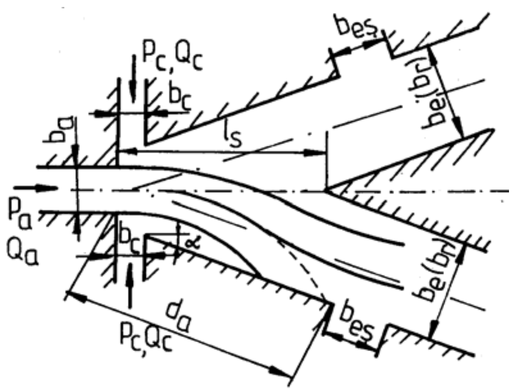

Fig. 2

Geometrical structure of the bistable fluidic amplifier [3]

In the design activity of the fluidic systems and their manufacturing they are very much problems because don't exist a standardization of the geometrical and functional parameters.

The main criterions used to the optimal design of the request to achieve a great recovery in pressure and flow. Also, we pursue a stable working of the monostable fluidic element even we have many accidental disturbances.

Basing on the theoretical study regarding the work of the fluidic amplifier in the stationary regime, presented in [3], [4] was obtained some values of the geometric parameters of the power canal, command canal and receiving canal. The other geometric parameters respect the corresponding values of the bistable fluidic element, which it used as model [2] (fig. 2).

2.1 THE CALCULUS OF THE WALL ANGLE AT THE MONOSTABLE FLUIDIC ELEMENT

Nomenclature:

- M_a [kg/m^3] – weight flow rate of the power jet;
- M_c [kg/m^3] - weight flow rate of the command jet;
- V_a [m/s] – speed of the power jet;
- V_c [m/s] – speed of the command jet;
- S_a [m^2] - section of the supply nozzle;
- S_c [m^2] - section of the command nozzle;
- h [mm] – deep of the monostable fluidic element;
- b_a [mm] – breadth of the supply nozzle;
- b_c [mm] - breadth of the command nozzle;

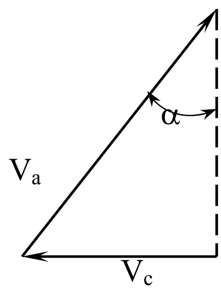

Fig. 3

Calculus geometrical elements

Was used the low of conservation of momentum [1]. There results:

$$V_c = \frac{M_c . V_c}{M_c + M_a} \tag{1}$$

$$V_a = \frac{M_a . V_a}{M_c + M_a} \tag{2}$$

In figure 3 the relation between V_a and V_c can be expressed that:

$$tg\alpha = \frac{V_c}{V_a} \tag{3}$$

The weight flow rate is $M=\rho SV$. So, was obtained $MV= \rho SV^2$.

Introducing the relation (1) and (2) into (3) there results:

$$tg\alpha = \frac{\rho_c . S_c . V_c^2}{\rho_a . S_a . V_a^2}, \tag{4}$$

where:

$$S_c = h\, b_c\, ; \quad S_a = h\, b_a. \tag{5}$$

It was obtained:

$$tg\alpha = \frac{\rho_c.b_c.V_c^2}{\rho_a.b_a.V_a^2}. \tag{6}$$

But $p = \rho\frac{V^2}{2}$ is the kinetic head (dynamic pressure). From this last relation we can express:

$$V_c^2 = \frac{2p_c}{\rho_c} \quad ; \quad V_a^2 = \frac{2p_a}{\rho_a} \tag{7}$$

Introducing the relation (7) into (6) there results:

$$tg\alpha = \frac{b_c p_c}{b_a p_a}. \tag{8}$$

That is available in the case when the supply and command jets have the same physical nature. Respectively:

$$\delta' \cong \alpha = arctg\frac{\rho_c b_c p_{c1,2}}{\rho_a b_a p_a}. \tag{9}$$

That is available in the case when the monostable fluidic element works with different physical nature jets.

2.2 GEOMETRY OF THE SUPPLY NOZLE

Taking account by the technical recommendations in their manufacturing [4], [5], [7] and also by the fact that the special fluidic device, theoretically and experimentally studied, has a geometrical structure inspired by an amplifier design for supersonic compressible fluids, studied by *Bavagnoli* [2], was established few design supplementary indications.

The supply nozzle is the most important source of perturbation in the work of the fluidic amplifier. Therefore, the negative effects can be eliminated using longer power canal. $(l_a \geq 5b_a)$. So, for the experimentally model, was adopted $l_a = 20mm$, with a splay exit and 28^0 angular spread. The radius of curvature to the interaction room wall must be at the best hand ($R = 2mm$).

2.3 GEOMETRY OF THE COMMAND NOZZLE

For the achievement of a fluidic amplifier, which is commanded through the pressure power of the control jet, it is necessary an adequate input impedance. This purpose is obtained using more breadth command nozzle, which also serve to achieve a good pressure gain. Thus, the optimal condition can be written:

$$\left(\frac{b_c}{b_a}\right)_{optimal} \rightarrow maximum\,. \qquad (10)$$

It was observed that for the too broad command nozzle appears fluid dynamics effects, which can't be control. Those deteriorate, a little, the fluidic amplifier's performances [5], [7], [8], [9]. There recommends:

$$(b_c)_{optimal} = (1 \div 3) b_a\,. \qquad (11)$$

Was adopted $b_c = 1mm$.

Determination of the optimal distance between the extremity's command jet is recommended in [4],[5],[6]. There results:

$$(d_c)_{optimal} = (2{,}5 \div 3) b_a\,. \qquad (12)$$

That is recommended when we respect the condition that the supply jet isn't intercept by the command nozzle. At the monostable fluid device, one of the two command nozzle of the model which was used is cut. Was adopt $d_c = 2{,}5mm$.

2.4 GEOMETRY OF THE RECEIVING NOZZLE

Because pursue a good operating and high performances of the fluidic amplifier, meaning that is experimental possibly under 15^0 for the wall angle, this value will limited at:

$$|\alpha| \leq 15^0\,. \qquad (13)$$

For a maximum pressure gain coefficient ($K_p = maxim$), there results:

$$\frac{l_s}{b_c} \rightarrow l_s\,. \qquad (14)$$

That means the positioning of the receiving nozzle right behind the command nozzle.

Taking account by the recommendations in the used references [2], [3], [4], [5], there results:

$$l_{s\ optimal} = (8 \div 12) \cdot b_a\,. \qquad (15)$$

Was adopted l_s = 12,5mm.

The breadth of the receiving nozzle was adopted basing on the recommendations presented in [3],[4]. So, b_e=3mm.

3. CONCLUSIONS

- Relation (8) shows that the wall angle α de is pressure dependent; it is dependent on supply and command pressure, p_a and p_c.
- Experimentally was established the relation between wall angle's value (α) and supply pressure's value, which assures a good stability of the attach jet and a good work of monostable fluid element. So, was studied three fluidic elements and the supply pressure's variation domain was limited into *1,3 - 28 bar*; Consequently was chosen $2\alpha=28^0$, therefore $\alpha=14^0$.
- For a correct design of the receiving nozzle it is necessary to take account by the influence of the receiving canals shape and the influence of the wall angle concerning the performance's amplifier.
- In order to obtain higher values of pressure gain coefficient and flow rate gain coefficient, the receiving nozzles of the fluidic amplifier should be placed right behind the command nozzle.
- In order to obtain higher amplification and higher sensitivity, the receiving nozzles should be placed at a longer distance as the command canal. Therefore, the achievement of this purpose should do compromise between recovery and amplifier function.

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