THEORETICAL ANALYSIS OF THE PRESSURE GAIN COEFFICIENT 
OF A SPECIAL WALL – ATTACHEMENT DEVICE

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Abstract: The paper presents the theoretical study regarding the pressure gain coefficient variation of the wall - attachment device. The examined bistable element is a special device with an incompressible fluid as supply jet and compressible fluid as command jet. In the technical literature no information was give regarding this problem.

Key words: bistable element, pressure gain coefficient, supply jet, command jet

1. INTRODUCTION

The special fluidic device discrete action, theoretically studied in this paper, has a geometrical structure inspired by an amplifier design for supersonic compressible fluids, studied by F. Bavagnoli, an Italian [1]. This power amplifier is represented through the fluidic device of the symmetrical bistable element type, basing on the principle of jet attachment to solid walls – the Coanda effect. Its particularity stands in the fact that it uses a liquid supply jet and air control jets [2].

The paper presents the theoretical analysis, based on the Mathcad application, of the way in which the pressure retrieved on the two branches [2], [3].

2. DEFINING OF THE PRESSURE GAIN COEFFICIENT

Taking into account the electropneumatic analogy, admitting a stationary model of the system, formed of impedances proper to each subsystem, the relation of the performances can be established, depending on the geometrical and functional parameters of the system.
For a symmetrical system, the power jet of \([Q_a, p_a]\) parameters is totally received on a receiving canal. The recovery in flow and pressure is established by taking into account only the resistance effect of the impedances suitable to supply spout \(Z_a\), exhaustion \(Z_e\), receiving canal \(Z_r\) and charge \(Z_s\) \([2]\). Applying Kirchhoff’s law I and law II for the knot and the two loops of the circuitry equivalent to the stationary model of the system, the gain coefficient in flow \(C_{rq}\) is obtained:

\[
C_{rq} = \frac{Q_r}{Q_a} = \frac{Z_{es}}{Z_{es} + Z_r + Z_s}
\]

or:

\[
C_{rq} = \frac{1}{1 + \frac{Z_r}{Z_{es}} + \frac{Z_s}{Z_{es}}} \quad \Leftrightarrow \quad C_{rq} = \frac{1}{1 + \frac{R_r}{R_{es}} + \frac{R_s}{R_{es}}}
\]

and also the pressure gain coefficient \(C_{rp}\):

\[
C_{rp} = \frac{p_r}{p_a} = \frac{1}{1 + \frac{R_{es}}{R_a} + \frac{R_{es}}{R_s} + \frac{R_a}{R_s}}
\]

In the relations (2) and (3) we can observe the fact that the recovery in pressure and flow is sub-unitary. If we take into account the flow rate drove by the power jet, it is possible for the flow recovery to out run the unity.

\[\text{Fig. 1 Determination of } b_r\]

### 3. THE THEORETICAL STUDY CONCERNING THE VARIATION OF THE PRESSURE COEFFICIENT

The theoretical characteristic of exit: \(Q_e = f(p_e, Z_s)\) is an important characteristic for this fluid system. For a given geometry of the interaction room \((\alpha, l_s, D)\) results a certain pressure when getting out \(p_{eb}\), if impedance \(Z_s = \infty\) (the exhaust port is blocked). Admitting a square- low of the exit impedance \([2]\) the following relation can be written:

\[
p_r = p_{eb} - \rho \left(\frac{u_r^2}{2}\right); \quad p_r = p_{rb} - \frac{\rho}{2} \left(\frac{Q_r}{A_o}\right)^2 = p_{rb} - \frac{\rho}{2} \left(\frac{Q_r}{b_r h}\right)^2
\]

For the given geometry in figure 1, the breadth of the exhaust port, \(b_r\), can be easily established applying geometrical relations in the right- angled triangles formed.

In \(\Delta OMS\) this relation can be written:

\[
tgO\overline{SM} = \frac{D + \frac{b_a}{2}}{l_s}
\]
From Δ MSN results:

\[
b_r = \overline{MS} \sin \left( \alpha + \arctg \left( \frac{D + \frac{b_a}{2}}{l_s} \right) \right) \quad \text{și} \quad \overline{MS} = \sqrt{\frac{l_s^2 + \left( D + \frac{b_a}{2} \right)^2}{2}}.
\]

Consequently:

\[
b_r = \left[ l_s^2 + \left( D + \frac{b_a}{2} \right)^2 \right]^{\frac{1}{2}} \sin \left( \alpha + \arctg \left( \frac{D + \frac{b_a}{2}}{l_s} \right) \right)
\]

being introduced in relation (5) gives in the general case:

\[
p_r = p_{rb} - \frac{p}{2} \frac{Q_a^2}{h^2} \cdot \frac{1}{\left[ \frac{l_s^2 + \left( D + \frac{b_a}{2} \right)^2}{2} \right]^{\frac{1}{2}} \sin^2 \left( \alpha + \arctg \left( \frac{D + \frac{b_a}{2}}{l_s} \right) \right)}
\]

With the help of relation (6), using Mathcad application, the pressure gain coefficient variation was represented graphically, depending on different geometrical parameters pertaining to the fluid element (fig.2a, b, c, d).

4. CONCLUSIONS.

In figures 2a, c, d. the increase of the pressure gain coefficient \(C_{rp}\) can be observed, together with the increasing of the power spout breadth. Also, analysing the variation curves obtained on theoretical way, the following conclusions can be inferred:

- From figure 2a we can notice that the ratio \(p_r/p_a\) (the pressure gain coefficient) diminishes with the increase of the wall angle of skew. For the same value of the angle \(\alpha\), the pressure gain coefficient is bigger at bigger breadths of the jet and diminishes in the same time with decrease of the power spout breadth.

- On the other hand, the pressure gain coefficient diminishes with the increase of distance \(D\), as we can see in figure 2b.

- For the same value of the ratio \(D/b_a\), the pressure gain coefficient decreases with the increase of the wall angle of skew.

- Figures 2c and d highlight the fact that the pressure gain coefficient diminishes with the increase of the distance the splitter is placed at. Also a decrease of its values can be observed in the same time with the increase of the wall angle.
Fig. 2 Variation of the pressure gain coefficient

REFERENCES

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