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THE INFLUENCE OF THE FRICTION IN THE LONG PIPE

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ABSTRACT
In this paper we propose to analyses the alternative flow in the circuit including one capacity, one inertia and the one resistance, except the consideration of the capacity and inertia distributed of the liquid in the pipes. By the transmission to the long distance are necessary to allowance by the effect of the capacity and the inertia of the liquid himself.
Keywords: sonic pressure sonic flow, friction capacity .

1. THE INFLUENCE OF THE SONIC FLOW BY THE FRICTION IN THE LONG PIPE

If are C_f, L_S, C_p and C_S the friction, inertia, perditance and the capacity by the long unity of the flow mass into the long pipe and if we considered a portion of this *dx*. If are $\vec{p}_{a\,max}$ and $\vec{Q}_{a\,max}$ the vectors values of the sonic pressure and the sonic flow, we can determinates this by the method grapho-analytical.

If $d\vec{p}_{a\,max}$ are the sonic pressure that produce the movement of the mass of the liquid in the portion *dx* and $d\vec{Q}_{a\,max}$ the difference of the flow to the extremity of the portion *dx* (produces by the C_S and C_p), we have:

a) The sonic pressure need to win the supplementary resistance forces create by the necessity the make in the movement the mass of the liquid in the pipe, also for the win the friction, this we can experimented by the relation (1);

b) The loss of the flow, (determinate by the perditance coefficient C_p) and the volume of the „loss” fluid to bring about the compression of this determinate by the sonic capacity C_S), we can quantize by relation (2).

$$d\vec{p}_{a\,max} = \vec{Q}_{a\,max} \cdot C_f \cdot dx + j \cdot \omega \cdot \vec{Q}_{a\,max} \cdot L_S \cdot dx \qquad (1)$$

$$d\vec{Q}_{a\,max} = \vec{p}_{a\,max} \cdot C_p \cdot dx + j \cdot \omega \cdot \vec{p}_{a\,max} \cdot C_S \cdot dx \tag{2}$$

so:

$$\frac{d\vec{p}_{a\,max}}{dx} = C_f \cdot \vec{Q}_{a\,max} + j \cdot \omega \cdot L_S \cdot \vec{Q}_{a\,max} \tag{3}$$

$$\frac{d\vec{Q}_{a\,max}}{dx} = C_p \cdot \vec{p}_{a\,max} + j \cdot \omega \cdot C_S \cdot \vec{p}_{a\,max} \tag{4}$$

If we noted:

$$\vec{L}_S = L_S - j \cdot \frac{C_f}{\omega} \tag{5}$$

$$\vec{C}_S = C_S - j \cdot \frac{C_p}{\omega} \tag{6}$$

If we calculated by multiply the relation (5) by $\vec{Q}_{a\,max}$ and the relation (6) by $\vec{p}_{a\,max}$, we give the common multiple by $C_f \cdot \vec{Q}_{a\,max}$ and $C_p \cdot \vec{p}_{a\,max}$, result:

$$\vec{L}_S \cdot \vec{Q}_{a\,max} = L_S \cdot \vec{Q}_{a\,max} - j \cdot \frac{C_f}{\omega} \cdot \vec{Q}_{a\,max}$$

or:

$$\frac{j}{\omega} \cdot C_f \cdot \vec{Q}_{a\,max} = L_S \cdot \vec{Q}_{a\,max} - \vec{L}_S \cdot \vec{Q}_{a\,max}$$

respective:

$$C_f \cdot \vec{Q}_{a\,max} = \frac{\omega}{j} \cdot L_S \cdot \vec{Q}_{a\,max} - \frac{\omega}{j} \cdot \vec{L}_S \cdot \vec{Q}_{a\,max}$$

Multiply the relation about $-j^2$ result:

$$C_f \cdot \vec{Q}_{a\,max} = -j \cdot \omega \cdot L_S \cdot \vec{Q}_{a\,max} + j \cdot \omega \cdot \vec{L}_S \cdot \vec{Q}_{a\,max}$$

If replace in the relation (3) we obtain:

$$\frac{d\vec{p}_{a\,max}}{dx} = -j \cdot \omega \cdot L_S \cdot \vec{Q}_{a\,max} + j \cdot \omega \cdot \vec{L}_S \cdot \vec{Q}_{a\,max} + j \cdot \omega \cdot L_S \cdot \vec{Q}_{a\,max}$$

or:

$$\frac{d\vec{p}_{a\,max}}{dx} = j \cdot \omega \cdot \vec{L}_S \cdot \vec{Q}_{a\,max} \tag{7}$$

Similar:

$$\frac{d\vec{Q}_{a\,max}}{dx} = j \cdot \omega \cdot \vec{C}_S \cdot \vec{p}_{a\,max} \tag{8}$$

To derive the equation (7) obtain:

$$\frac{d^2 \vec{p}_{a\,max}}{dx^2} = j \cdot \omega \cdot \vec{L}_S \cdot \frac{\vec{Q}_{a\,max}}{dx}$$

replace this in the relation (8) result:

$$\frac{d^2 \vec{p}_{a\,max}}{dx^2} = j^2 \cdot \omega^2 \cdot \vec{L}_S \cdot \vec{C}_S \cdot \vec{p}_{a\,max}$$

The analog, to derive the equation (8) we have:

$$\frac{d^2 \vec{Q}_{a\,max}}{dx^2} = j \cdot \omega \cdot \vec{C}_S \cdot \frac{d\vec{p}_{a\,max}}{dx} \tag{9}$$

replace this in the relation (7) result:

$$\frac{d^2 \vec{Q}_{a\,max}}{dx^2} = j \cdot \omega \cdot \vec{C}_S \cdot j \cdot \omega \cdot \vec{L}_S \cdot \vec{Q}_{a\,max}$$

$$\frac{d^2\vec{Q}_{a\,max}}{dx^2} = j^2 \cdot \omega^2 \cdot \vec{C}_S \cdot \vec{L}_S \cdot \vec{Q}_{a\,max}$$

We obtain:

$$\frac{d^2\vec{Q}_{a\,max}}{dx^2} = -\omega^2 \cdot \vec{C}_S \cdot \vec{L}_S \cdot \vec{Q}_{a\,max} \tag{10}$$

If we noted:

$$\mu = \omega \cdot \sqrt{\vec{L}_S \cdot \vec{C}_S} \tag{11}$$

obtain: $\mu^2 = \omega^2 \cdot \vec{L}_S \cdot \vec{C}_S$

or: $\omega^2 = \dfrac{\mu^2}{\vec{L}_S \cdot \vec{C}_S}$

by replace the relation tom up in the relation (9) result [3]:

$$\frac{d^2\vec{p}_{a\,max}}{dx^2} = -\frac{\mu^2}{\vec{L}_S \cdot \vec{C}_S} \cdot \vec{L}_S \cdot \vec{C}_S \cdot \vec{p}_{a\,max}$$

were:

$$\frac{d^2\vec{p}_{a\,max}}{dx^2} + \mu^2 \cdot \vec{p}_{a\,max} = 0 \tag{12}$$

Similar, we obtain also the relation:

$$\frac{d^2\vec{Q}_{a\,max}}{dx^2} + \mu^2 \cdot \vec{Q}_{a\,max} = 0 \tag{13}$$

The general solutions of these equations are:

$$\vec{p}_{a\,max} = A \cdot sin(\mu \cdot x) + B \cdot cos(\mu \cdot x) \tag{14}$$

$$\vec{Q}_{a\,max} = A_1 \cdot sin(\mu \cdot x) + B_1 \cdot cos(\mu \cdot x) \tag{15}$$

To establish the constants, we considerate the fin of the pipe from the generator, were $\vec{p}_g = p_{a\,max}$ şi $\vec{Q}_g = Q_{a\,max}$ are the sonic pressure and the sonic flow.[4]

When we have for each $x = 0, B = \vec{p}_g$ şi $B_1 = \vec{Q}_g$.

On the equation (7) and (8) and the differentiation of relation (14) and (15) we obtain the equality:

$$\frac{d\vec{p}_{a\,max}}{dx} = j \cdot \omega \cdot \vec{L}_S \cdot \vec{Q}_{a\,max} = \mu \cdot [A \cdot cos(\mu \cdot x) - B \cdot sin(\mu \cdot x)] \tag{16}$$

$$\frac{d\vec{Q}_{a\,max}}{dx} = j \cdot \omega \cdot \vec{C}_S \cdot \vec{p}_{a\,max} = \mu \cdot [A_1 \cdot cos(\mu \cdot x) - B_1 \cdot sin(\mu \cdot x)] \tag{17}$$

so for $x = 0, -A = j \cdot \dfrac{\omega \cdot \vec{L}_S \cdot \vec{Q}_g}{\mu}$ and $-A_1 = j \cdot \dfrac{\omega \cdot \vec{C}_S \cdot \vec{p}_g}{\mu}$.

If $\vec{p}_r$ and $\vec{Q}_r$ are the values to $\vec{p}_{a\,max}$ and $\vec{Q}_{a\,max}$ to the receptor, the length of the pipe are *l*, by replace to *A* and μ in the relation (14) and (15) we obtain [2]:

$$\vec{p}_r = \vec{p}_g \cdot cos(\mu \cdot l) - j \cdot \vec{Q}_g \cdot \sqrt{\frac{\vec{L}_S}{\vec{C}_S}} \cdot sin(\mu \cdot l) \tag{18}$$

$$\vec{Q}_r = \vec{Q}_g \cdot cos(\mu \cdot l) - j \cdot \vec{p}_g \cdot \sqrt{\frac{\vec{C}_S}{\vec{L}_S}} \cdot sin(\mu \cdot l) \tag{19}$$

On the (18) and (19) we extract $\vec{p}_g$ and $\vec{Q}_g$, thus [3]:

$$\vec{p}_g = \frac{\vec{p}_r}{cos(\mu \cdot l)} + j \cdot \vec{Q}_g \cdot \sqrt{\frac{\vec{L}_S}{\vec{C}_S}} \cdot \frac{sin(\mu \cdot l)}{cos(\mu \cdot l)} \tag{20}$$

$$\vec{Q}_g = \frac{\vec{Q}_r}{cos(\mu \cdot l)} + j \cdot \vec{p}_g \cdot \sqrt{\frac{\vec{C}_S}{\vec{L}_S}} \cdot \frac{sin(\mu \cdot l)}{cos(\mu \cdot l)} \tag{21}$$

Replace the (19) in the (20) result:

$$\vec{p}_g = \vec{p}_r \cdot cos(\mu \cdot l) + j \cdot \vec{Q}_r \cdot \sqrt{\frac{\vec{L}_S}{\vec{C}_S}} \cdot sin(\mu \cdot l) \tag{22}$$

$$\vec{Q}_g = \vec{Q}_r \cdot cos(\mu \cdot l) + j \cdot \vec{p}_r \cdot \sqrt{\frac{\vec{C}_S}{\vec{L}_S}} \cdot sin(\mu \cdot l) \tag{23}$$

were:

$$\mu = \omega \cdot \sqrt{\vec{L}_S \cdot \vec{C}_S} \tag{24}$$

$$\vec{L}_S = L_S - j \cdot \frac{C_f}{\omega} \tag{25}$$

$$\vec{C}_S = C_S - j \cdot \frac{C_p}{\omega} \tag{26}$$

Conclusion: ***These formulas are simples and enough for the practical to calculus to the long pipe then haven't perditance.*** If the length of the pipe is multiply exactly of the band we have $cos(\alpha \cdot l) = 1$, $sin(\alpha \cdot l) = 0$, result [4]:

$$\frac{\omega \cdot C_S}{\alpha^2 + \beta^2} = \frac{1}{\omega \cdot L_S}$$

the general formula (23) and (24), to become:

$$\vec{p}_g = p_r \cdot ch(\beta \cdot l) + \frac{Q_r}{\omega \cdot C_S} \cdot \alpha \cdot sh(\beta \cdot l) - j \cdot \frac{Q_r}{\omega \cdot C_S} \cdot \beta \cdot sh(\beta \cdot l) \tag{27}$$

$$\vec{Q}_g = Q_r \cdot ch(\beta \cdot l) + \frac{p_r}{\omega \cdot L_S} \cdot \alpha \cdot sh(\beta \cdot l) + j \cdot \frac{p_r}{\omega \cdot L_S} \cdot \beta \cdot sh(\beta \cdot l) \tag{28}$$

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