17th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2013, Istanbul, Turkey, 10-11 September 2013

# THEORETICAL CONSIDERATION ABOUT THE EFECTS OF THE FRICTIONS TO THE SONICS CIRCUIT

**Carmen Bal**
**Technical University Cluj Napoca**
**Street Daicoviciu, nr. 15, Cluj Napoca**
**Romania**

**Nicolaie Bal**
**Technical University Cluj Napoca**
**Street Daicoviciu, nr. 15, Cluj Napoca**
**Romania**

**Ioana Carmen Iuhos**
**S.C. Broker S.A Cluj Napoca**
**Street Motilor, nr. 105, Cluj Napoca**
**Romania**

**ABSTRACT**
*In this paper will make obvious the effects of the friction about the sonic flow. Will present the same variations of the and sonic pressure, sonic flow, on functions of the characteristic size, how are: the variation o the pressure with the variation of the capacity of friction, and also the variation of the length of the pipe in bearing of the diameter of this.*
**Keywords:** sonic pressure sonic flow, friction capacity

## 1. GENERAL NOTION

If have sinusoidal flow, we have the relation:

$$Q_i = C_p \cdot p_{Si|_p} \quad (1)$$

were $C_p$ is the coefficient of the perditanta, result the $p_{Si|_p}$ will be sinusoidal formed and in phases with the sonic pressure we can writing:

$$Q_{a\max} = C_p \cdot p_{a\max} \quad (2)$$

*Friction*. For the friction we have the relation:

$$p_{a\max} = C_f \cdot Q_{a\max} \quad (3)$$

is in phases with the flow, figure 1,

$R_f = C_f$, define the friction coefficient.

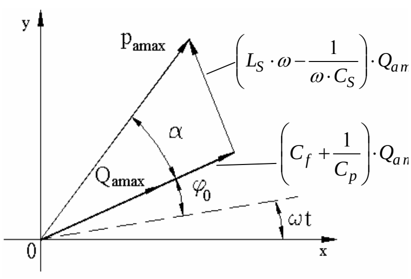



*Figure 1. The vector diagram of the sonic flow*

By the vector diagram, we observe the modulus of the $p_{a\max}$ can be:

$$p_{a\max} = Q_{a\max} \sqrt{\left(C_f + \frac{1}{C_p}\right)^2 + \left(\omega \cdot L_S - \frac{1}{\omega \cdot C_S}\right)^2} \quad (4)$$

the vector $\vec{p}_{a\,max}$, can be advanced with the $\vec{Q}_{a\,max}$ vector, with the α angle, give by relation:

$$\operatorname{tg}\alpha = \frac{\omega \cdot L_S - \dfrac{1}{\omega \cdot C_S}}{C_f + \dfrac{1}{C_p}} \qquad (5)$$

With $\alpha = 0$, we have:

$$L_S \cdot C_S \cdot \omega^2 = 1 \qquad (6)$$

This condition suit a situation of resonance between capacity and inertia.

The capacity $L_S \cdot \omega - \dfrac{1}{C_S \cdot \omega}$, are name *reactance*, have the same dimension with the friction coefficient, but are differenced to friction because the sonic pressure of the friction resistance are in phases with the revolution. Whereas the sonic pressure due to one reactance, are deferent phases with $90^0$ against the flow.

In the same mode we can see the friction coefficient $C_f$, as symbolic inertia, while *perditanta,* as symbolic capacity, for example the value of the equivalent inertia for a $C_f$ resistance, can be distinguish:

$$p_{Si_{|f}} = p_{Si_{|L}} \qquad C_f \cdot Q_{a\,max} = j \cdot \omega \cdot L_S \cdot Q_{a\,max} \qquad (7)$$

## 2. THE TEORETICAL EFFECTS OF THE FRICTION

We considered have one generator G, with the piston who produces a sonic flow into the simple line, figure 2, the course of the piston are 6 cm, the section of this are S=5cm$^2$, than the revolution are n = 955 rot/min. The capacity $C_{S1}$, are one steel cylinder with the volume V= 2000 cm$^3$. The fluid used is water that has the elasticity coefficient 20000 kg /cm2, neglected the effect of the fluid in the pipe. We want calculated the sonic pressure $p_{amax}$ and the mechanical work to make by the generator and the absorbing warming of the friction device on figure 1.

We calculated the throb and the sonic flow:

$$\omega = 2\pi \cdot n = 2\pi \cdot \frac{955}{60} = 100 \qquad Q_{a\,max} = S \cdot 1 \cdot \omega = 3 \cdot 5 \cdot 100 = 1500 \ \text{cm}^3/\text{s} = 1{,}5\ 10^{-3}\ \text{m}^3/\text{s}.$$

Also we calculated the capacity of the steel cylinder:

$$C_S = \frac{V}{E} = \frac{5000}{20000} = 0{,}25\ \text{cm}^5/\text{kg} = 0{,}25 \cdot 10^{-11}\text{m}^5/\text{N}$$

$$C_{S1} = \frac{V_1}{E} = \frac{2000}{20000} = 0{,}1\ \text{cm}^5/\text{kg} = 0{,}1 \cdot 10^{-11}\text{m}^5/\text{N}$$

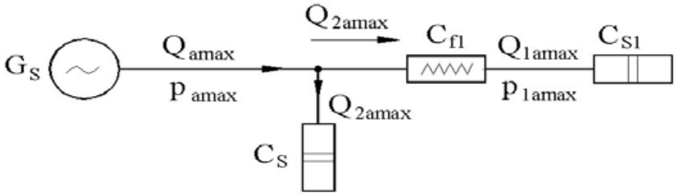



*Figure 2. The sonic circuit with one resistance*

The force in this case can be calculated with to help of relation:

$$P_{max} = \frac{Q^2_{a\,max} \cdot C_{S1}}{4 \cdot \omega \cdot C_S \cdot (C_S + C_{S1})} = \frac{(1500)^2 \cdot 0{,}1}{4 \cdot 100 \cdot 0{,}25 \cdot (0{,}25 + 0{,}1)} = 6440\,\text{kg/cm} = 0{,}85\text{CP} = 625{,}3\,\text{W}$$

In this case the sonic pressure can be calculeted with the relation:

$$p_{a\,max}=\frac{Q_{a\,max}}{\omega\cdot(C_S+C_{S1})}\cdot\sqrt{1+\frac{C_{S1}}{C_S}+\frac{1}{2}\cdot\left(\frac{C_{S1}}{C_S}\right)^2}=\frac{1500}{100\cdot(0{,}25+0{,}1)}\cdot\sqrt{1+\frac{0{,}1}{0{,}25}+\frac{1}{2}\cdot\left(\frac{0{,}1}{0{,}25}\right)^2}=52$$

$p_{a\,max} = 52$ kg/cm$^2$ = $5{,}1\cdot10^6$ Pa.

The multiplication $P=\frac{p_{a\,max}\cdot Q_{a\,max}}{2}$ gives the apparent force that is the necessary value to calculate the force parameter of the installation.

$$P=\frac{p_{a\,max}\cdot Q_{a\,max}}{2}=\frac{52\cdot1500}{2}=39000 \text{ kg·cm/s} = 5{,}1 \text{ CP}$$

the force parameter can be:

$$\cos\theta=\frac{P_{max}}{P}=\frac{0{,}85}{5{,}1}=0{,}167 \text{ were } \theta = 80^0\ 23'.$$

The numerical value of the flow $Q_{a\,max1}$ and $Q_{a\,max2}$ can be determinate. So we have:

$$\vec{Q}_{2a\,max} = \omega\cdot C_S\cdot p_{a\,max} = 100\cdot0{,}25\cdot52 = 1300 \quad \text{cm}^3/\text{s}$$

$$Q_{1a\,max}=\omega\cdot C_{S1}\cdot p_{a\,max}\cdot\sqrt{1+(\omega\cdot C_{S1}\cdot C_f=)^2}=$$

$$=100\cdot0{,}1\cdot52\cdot\sqrt{1+(100\cdot0{,}1\cdot0{,}14)^2}=302$$

$Q_{1a\,max} = 302$ cm$^3$/s.

Supposed that the friction is represented by a pipe with the interior diameter $d_i$ = 0,6 cm, his section can be:

$$S_f=\frac{\pi d_i}{4}=\frac{\pi\cdot(0{,}6)^2}{4}=0{,}282 \text{ cm}^2$$

the maximum of the speed is:

$$v=\frac{Q_{1a\,max}}{S_f}=\frac{302}{0{,}282}=1070 \text{ cm/s} = 10{,}7 \text{ m/s}$$

The efficacy speed obtained used the formula:

$$v_{ef}=\frac{v}{\sqrt{2}}=\frac{1070}{\sqrt{2}}=756 \text{ cm/s} = 7{,}56 \text{ m/s}$$

The friction coefficient can be equal with:

$$C_f=k\cdot\frac{1}{S_f\cdot10^2}\ ;\quad k=\frac{v_{ef}}{100d_i}+\frac{9}{100d_i}\cdot\sqrt{\frac{v_{ef}}{d_i}}=\frac{756}{100\cdot0{,}6}+\frac{9}{100\cdot0{,}6}\cdot\sqrt{\frac{756}{0{,}6}}=17{,}9\,.$$

Was the pipe length can be in this case:

$$l=\frac{k\cdot S_f\cdot10^6}{C_f}=\frac{0{,}14\cdot10^6\cdot0{,}282}{17{,}9}=2280 \text{ cm}=22{,}8 \text{ m}$$

To mention that pipe is very length to can be used in practical, than must necessary used one pipe with the lesser diameter and little length. In this situation used one pipe with the interior diameter a 3,2 cm, the surface can be:

$$S_f=\frac{\pi d_i}{4}=\frac{\pi\cdot(0{,}32)^2}{4}=0{,}08 \text{ cm}^2\ ;\qquad v=\frac{Q_{1a\,max}}{S_f}=\frac{302}{0{,}08}=3750 \text{ cm/s};\qquad v_{ef}=\frac{v}{\sqrt{2}}=\frac{3750}{\sqrt{2}}=2650$$

cm/s

$$k=\frac{v_{ef}}{100d_i}+\frac{9}{100d_i}\cdot\sqrt{\frac{v_{ef}}{d_i}}=\frac{2650}{100\cdot0{,}32}+\frac{9}{100\cdot0{,}32}\cdot\sqrt{\frac{2650}{0{,}6}}=105$$

$$l=\frac{k\cdot S_f\cdot10^6}{C_f}=\frac{0{,}14\cdot10^6\cdot0{,}08}{1`05}=107cm=1{,}07\ m$$

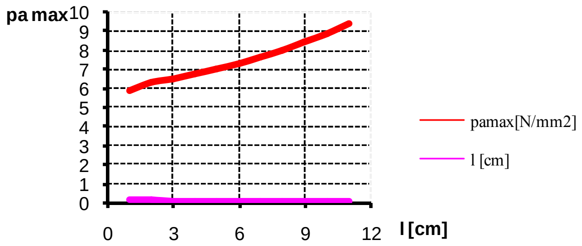
## 3. ANALITICAL OBSERVATION OF THE FRICTION EFFECTS IN THE SONIC CIRCUIT

On relation $p_{a\max} = C_f \cdot Q_{a\max}$, we can observed the caloric effect because the movement the flow in the friction pipe calculated

Iinteresting situation to be considerate is the variation of the length of the friction pipe in report with the sonic pressure created in the two tanks. (Table 1).

*Table 1.*

| $C_f$ | $p_{amax}$ [N/mm$^2$] | v [m/s] | $v_{ef}$ [m/s] | k | l [cm] | $Q_{1max}$ |
|---|---|---|---|---|---|---|
| 1,326076027 | 5,897108668 | 24,1962 | 17,1093 | 6,572481792 | 0,122691 | 1710187 |
| 1,381100901 | 6,282090081 | 28,40352 | 20,08432 | 7,932417701 | 0,099278 | 2007561 |
| 1,427558431 | 6,49340729 | 32,2879 | 22,83099 | 9,256156163 | 0,083588 | 2282109 |
| 1,479037702 | 6,727322927 | 36,74537 | 25,9829 | 10,85219903 | 0,070444 | 2597163 |
| 1,536264126 | 6,987867154 | 41,89266 | 29,62258 | 12,79295605 | 0,059368 | 2960973 |
| 1,600128034 | 7,278359199 | 47,88732 | 33,86145 | 15,17881218 | 0,049979 | 3384676 |
| 1,671844437 | 7,604293924 | 54,94219 | 38,85 | 18,15078967 | 0,041972 | 3883314 |
| 1,752713213 | 7,972121176 | 63,31285 | 44,76895 | 21,89465548 | 0,035132 | 4474953 |
| 1,844604638 | 8,390388052 | 73,36727 | 51,87849 | 26,68551968 | 0,029267 | 5185598 |
| 1,949580227 | 8,86788112 | 85,57711 | 60,51215 | 32,90789848 | 0,024238 | 6048590 |
| 2,070607782 | 9,418047417 | 100,6216 | 71,15023 | 41,14442776 | 0,019922 | 7111936 |




*Graphic 3. The variation of the sonic pressure in report by the length of the friction pipe*

We observe in this situation the length of the friction pipe is proportionally by his diameter. Also is interesting to see the influence of the effective speed in the case of the length of the pipe.

We observe in this case who the variation of the length is inverse proportionality by the effective speed of the fluid.

***In conclusion*** in pipe who have the small diameter and big displacement of the fluid, produce a big friction because the big energy created, who is demonstrate by the evolving the warm.

We observe to big values to the pressure, the length values decrease.

## 4. CONCLUSION

When the pressure is big for accomplish a better friction capacity we are need as the little length.

We can considerate also the situation when the sonic flow with to charge the tank $C_{s1}$, the influence of this to the friction capacity. The way in who can be influenced the flow into the tank on the friction.

## 5. REFERENCES

[1] Constantinescu, G., (1985), The theory of the sonicity, Bucureşti, Editura Academiei.

[2] Carmen Bal, (2007), The caloric effect in the circuits by harmonic flow, Cluj Napoca, Ed. ALMA MATER, ISBN 978-973-7898-75-3.

[3] Pop I. Ioan, Carmen Bal, Marcu Lucian ş.a., (2007), The sonicity applications. Experimental results, Iaşi, Ed. Performantica, ISBN 978-973-730-391-2.