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THE ANALYSIS OF DETERMINING CIRCULATION PARAMETERS OF WATER-WATER INJECTORS

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ABSTRACT
Using injectors has a special importance on transportation and mixture of fluids, with various temperature and density, without using the moving parts. As a moving force is used the working fluid, hereby applying the hydraulic laws, makes capable sucking injected fluid, or avoids using physical pump. One of the main and important characteristic is that it doesn't require motor run to set the water flow, which means is very efficient on power consumption as one of the main parameters for the actual living time.

The special characteristic of all injectors is determination of circulation parameters of fluid on the basis of mathematical tool, respectively on the equations which describes the dynamic of fluids and on the results of experimental work.

Key words: Injector, pressure drop, injection coeffitient

1. INTRODUCTION

Basic equations for determining injectors, comes from the equation of exchanging impulses, respectively from the equation of change of motion amount in the mixing room. Figure 1, where of it results,

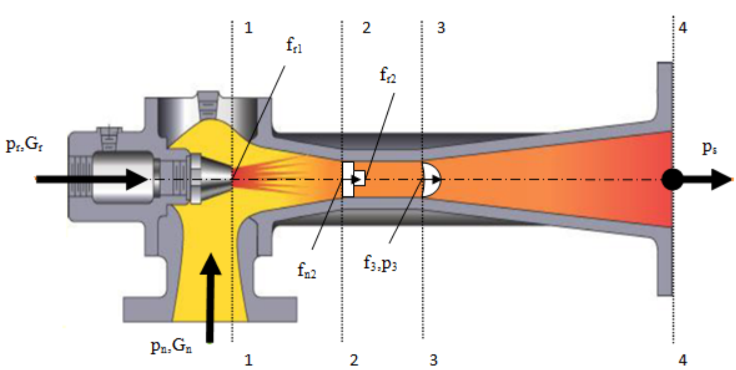

Figure 1. Functional schema of injector

$$\varphi_2(G_r \cdot W_{r1} + G_n \cdot W_{n2}) - (G_n + G_r) \cdot W_3 = \\ = (p_3 - p_{n2}) \cdot f_{n2} + (p_3 - p_{r1}) \cdot f_{r1} = p_3 \cdot f_3 - p_{n2} \cdot f_{n2} - p_{r1} \cdot f_{r1} \quad (1)$$

Where: p_{r1}, p_{n1}, p_3 – are water pressure before nozzle, the injected water in intersection (2-2) and mixed water in intersection (3-3)

G_r, G_n - amount of flowing water before nozzle and injected water into the entering room.

W_{r1}, W_{n1}, W_3 –Velocity of working water, velocity of injected water in the intersection (2-2) and velocity of mixed water in the intersection (3-3).

f_{r1}, f – Surface of transform intersection on the outlet of nozzle and cylindrical intersection of mixing room.

$f_{n2}=f_3-f_{r1}$ – transform intersection of injected flux on the inlet of cylindrical intersection of mixing room.

φ_1, φ_2, φ_3, φ_4 - velocity coefficient of nozzle, mixing cylindrical room, nozzle and inlet part of mixing room.

Where:

$\Delta p_s=p_s-p_n$ - pressure drop realized from injector,

$\Delta p_r=p_r-p_n$ - pressure drop over the disposition of the relevant working pressure,

$u = \frac{G_n}{G_r}$ - injection coefficient.

Final equation form (1), is:

$$\frac{\Delta p_s}{\Delta p_r} = \varphi_1^2 \cdot \frac{f_{r1}}{f_3}\left[2\varphi_2 + \left(2\varphi_2 - \frac{1}{\varphi_4^2}\right)\frac{v_n}{v_r} \cdot \frac{f_{r1}}{f_{n2}} \cdot u - \left(2 - \varphi_3^2\right)\frac{v_s}{v_r}\frac{f_{r1}}{f_3}(1+u)^2\right] \quad (2)$$

For the good constructed parts and well mounted, it can be taken: *φ_1= 98 %, φ_2 = 97,5 %, φ_3 = 90 % , φ_4 = 92,5 % .*

From equation (2) can be seen that for a given value of the coefficient of injection (u), the pressure drop in injector is proportional to the decline of the working fluid pressure. In the same way we can conclude that the ratio $\Delta p_s/\Delta p_r$ depends from the report of transform intersection f_3/f_{r1}, velocity coefficients in main parts of injector *(φ_1, φ_2, φ_3, φ_4)*, injection coefficient *(u),* and is independent from the absolute size of disposition pressure of working fluid Δp_r.

2. EXPERIMENTAL MEASUREMENTS

Measurements are made in a private property with location in Gjakova, where injector switching is made with PVC pipes with dimensions DN15, as it's seen on the figure 2 with proper parts.

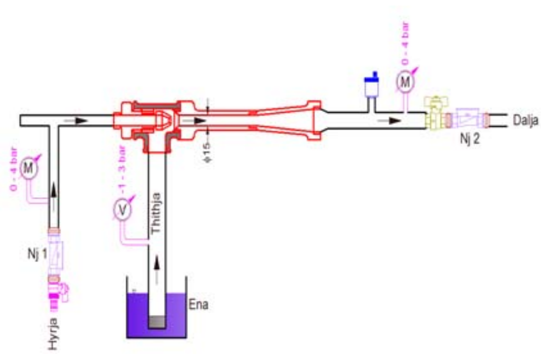

Figure 2. Functional schema of switching the injector

Figure 3. Injector with two meters

3. CALCULATION AND MEASUREMENTS RESULTS

3.1. Injector with one meter

The pressure drop in nozzle is calculated based on the equation:

$$\Delta pr_1 = \frac{(Gr_1)^2 \cdot v_{r1}}{2 \cdot (fr_1)^2 \cdot \varphi_1^2} = 133.5\,kPa \tag{3}$$

Pressure drop between the atmospheric pressure p_{at} and vacuum metric pressure p_v

$$\Delta p_s = p_{at} - p_v = 1 - 0.87 = 0.13\ bar = 13kPa$$

Injection coefficient $$u = \frac{G_n}{G_r} = 1.8667 \tag{4}$$

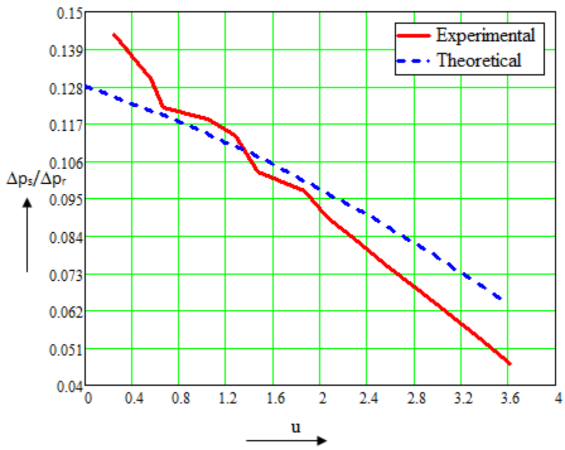

Figure 5. Pressure drop in dependence from the injection coefficient for measurements with one meter

3.2. Injector with two water meter

Pressure drop in nozzle is calculated based on equation:

$$\Delta pr_1 = \frac{(Gr_1)^2 \cdot v_{r1}}{2 \cdot (fr_1)^2 \cdot \varphi_1^2} = 166.2kPa \tag{5}$$

For the reason that meter is set after the nozzle, the pressure p_2 is not atmospheric pressure but is greater for local loses in the meter, which can be calculate as below.

$$\Delta p = \xi \cdot \frac{\rho \cdot w^2}{2} = \xi \cdot \frac{\rho \cdot 16 \cdot G_2^2}{\rho^2 \cdot \pi^2 \cdot d^4} = \xi \cdot \frac{8 \cdot G_2^2}{\rho \cdot \pi^2 \cdot d^4} \tag{6}$$

For the local resistance of meter $\xi = 7.5$; d=15 mm; G_2=0.2975 kg/m^3 the pressure drop will be:

$$\Delta p = \xi \cdot \frac{8 \cdot G_2^2}{\rho \cdot \pi^2 \cdot d^4} = 0.10618\ bar \tag{7}$$

Absolute pressure after the nozzle is p_{ap}=1 + Δp = 1.10618 bar.

Pressure drop between full pressure p_{ap} and vacuum metric pressure p_v is:

$$\Delta p_s = p_{ap} - p_v = 1.10618 - 0.91 = 0.19618\ bar = 19.618\ kPa$$

Injection coefficient : $$u = \frac{G_n}{G_r} = 0.34163 \tag{8}$$

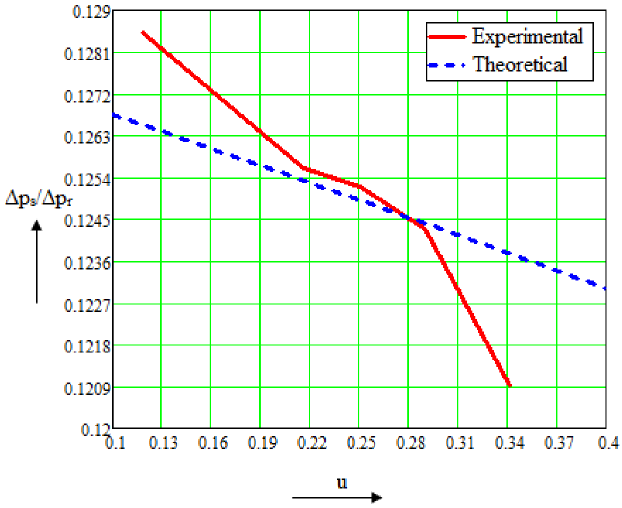

Figure 6. Pressure drop depending from injection coefficient for measurement with two meters

4. CONCLUSION

Based on the equation (2) can be noticed that given injection coefficient (u), pressure drop in injectors is made in proportional manner with pressure drop of working fluid.

Experimenting with one meter, where results are presented on figure 5, it can be noticed that injection coefficient is greater for the same values of pressure drop report than experimenting with two meters figure 6. The reason of pressure dropping is that second meter causes the considerable pressure drop. From that is mention above we can conclude, with pressure drop in secondary system, the injection decreases. Therefore this system is preferred for pressure drop, smaller than 15 kPa.

Comparing measurements (on thermic substation) in [2] and measurements in this paper (in private house) it can be seen that the position of setting the nozzle in mixing room, has an important role on injection coefficient.

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