EFFICIENCY ANALYSIS OF THE LIQUID CONTROLLER WITH A RING VALVE

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***Abstract**: This paperwork studies the efficiency of the liquid controllers with a ring valve analysing the liquid running through the controller, the variation of the pressure and its speed for various forms of the ring valve controller.*

Keywords: controller with a ring valve, flowing, energy lines, pressure decline, speed

1.Introduction. Hydraulic contacts (flowing spaces between the mobile and fixed pieces of the devices)

Multiple hydraulic contact, actually, characterises the liquid controllers (with a ring or a hinged valve) used in the actuation or self regulating hydraulic systems. Unlike the singular contact, in this case, there interfere, in an unique functionality, simultaneous flows in a contact assembly, connected between them in serial and/or in parallel way. In order to determine the interested relation $Q = f(x, \Delta p)$, where $\Delta p = p_i - p_m$ (and p_m is the pressure drop in the actuation hydraulic engine), there must be considered not only the possible leaks from the contact (the controller) that connects the pump and the engine entrance, but also all contacts that modify themselves unitively (with the same variation of the x opening) with the mentioned contact, which are higher or lower from it. Practically known situations are multiple, they depend on the following main factors: type of the power supply (with a constant pressure or a constant flow), type of the controller (with a valve – with 1, 2, 4 active edges – or with help switch), type of the actuation engine (differential or undefferential gear), type of valve (with a positive, null or negative cover, symmetrical or asymmetrical).

Uneven characteristic ecuation of the controllers with negative cover fed at a constant pressure can be expressed in the general form:

$$Q_m = c_1 c_2 \left[\sqrt{c_4 - c_5 p_m} - \sqrt{c_4 + c_5 p_m}\right] \mp c_1 c_3 x_m \left[\sqrt{c_4 - c_5 p_m} + \sqrt{c_4 + c_5 p_m}\right] = f_1(p_m) \mp x_m f_2(p_m) \quad (1)$$

where: x_o *[cm]* represents valve's negative cover;

D [cm] represents the valve's diameter for the active edge.

The relation (1) expressed for the four active edge valve fed with a constant pressure p_i (according to the data from the following table) can be resumed to the formula (2):

No. of active edges	c_1	c_2	c_3	c_4	c_5
4	$c_d \pi D \sqrt{1/\rho}\sqrt{p_i}$	x_o	1	1	$1/p_i$
2	$c_d \pi D \sqrt{2/\rho}\, x_o \sqrt{p_i}$	1	$1/x_o$	1	$2/p_i$
1	$c_d \pi D \sqrt{1/\rho}\, x_o \sqrt{p_i}$	1	$1/x_o$	1	$2/p_i$

$$Q = (1 \mp x)\sqrt{\frac{1-p}{2}} - (1 \pm x)\sqrt{\frac{1+p}{2}} \quad (2)$$

Where one must remember that the variables are expressed non-adimensionally

$$p = \frac{p_m}{p_i} \quad ; \quad Q = \frac{1}{c_d \pi D \sqrt{2/\rho}\, x_0} \cdot \frac{Q_m}{\sqrt{p_i}} \quad ; \quad x = \frac{x_m}{x_0}$$

For the four active edges valve, fed with a constant flow Q_i, the unliniar characteristic eqution is as follows:

$$Q = \frac{-(1+x^2) \pm \sqrt{(1+x^2)^2 \mp 4[\pm x - (x^2-1)^2]p}}{\pm 2x} \quad (3)$$

Where one must remember that the variables are expressed in an nondimensionalised form:

$$Q = \frac{Q_m}{Q_i} \quad ; \quad p = (c_d \pi D \sqrt{2/\rho}\, x_0)^2 \cdot \frac{p_m}{Q_i^2} \quad ; \quad x = \frac{x_m}{x_0}$$

Just as with the singular contact, in practice, it is usually necessary to present ecuation (1) or (2) at a liniar form. In order to function in a narrow field of the x opening variation. This is necessary for the mathematical pattern-making of the hydraulic systems (especially for those with self regulation) in order to analyse them dynamicly. For partial deviations of the general equation (1), according to the pre-established definitions of the transmission gains c_o, E_o, one can arriave at the replacement of the unliniar equation (1) with a liniar one:

$$\Delta Q = A c_0 \Delta x_m + \frac{A^2 c_0}{E_0} \Delta p_m \quad (4)$$

Values of the transmission gains c_o and E_o are determined by the controller's construction. As an example, we will consider controller *4/3* presented in Figure 1

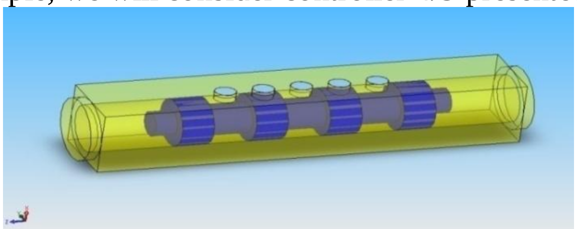


Figure 1 *Controller 4/3*

In Figure 2, there are presented the 3 shifting positions of the controller.

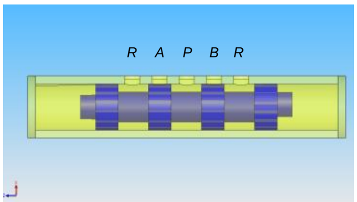


Figure 2 */ Position 1*

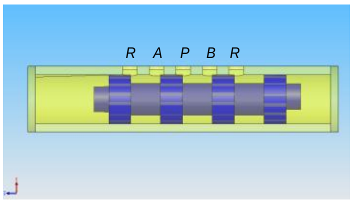


Figure 2 */ Position 2*

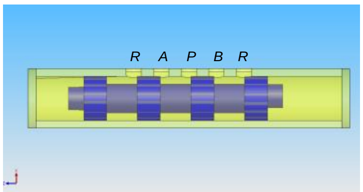
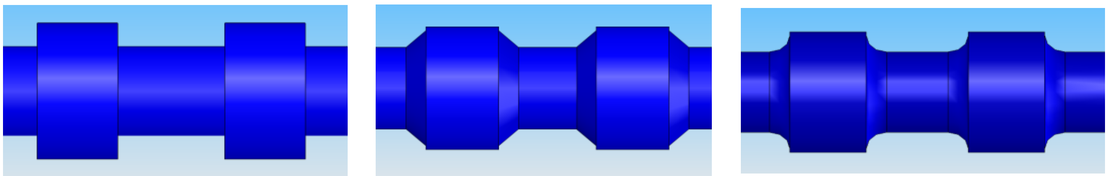


Figure 2 */ Position 3*

2.Study of pressure drop in the controller

We propose to study the pressure drop between two passing positions of the controller, for three controller contruction solutions, as follows:

- Controller with a straight edge valve, Figure 3 a);
- Controller with a slightly conoidal edge valve, Figure 3 b);
- Controller with a round edge, Figure 3 c).



a) b) c)

Figure 3 *Three controller contruction solutions*

We consider the controller in position *3*. The labour fluid will flow from pump *P* towards pipe *A* (Figure 4) with a constant rate of *4.5* m^3/h. The controller has the same size as the valve presented in Figure 5, the diameter of the feedings in which flows the liquid is of *10 mm*.

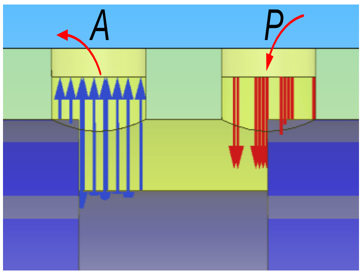


Figure 4

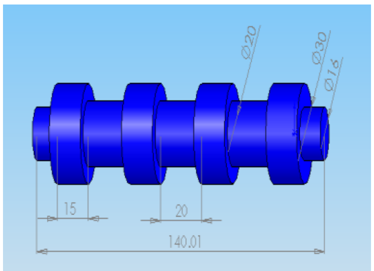


Figure 5

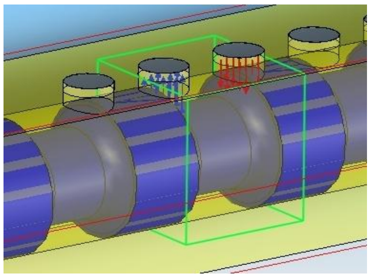
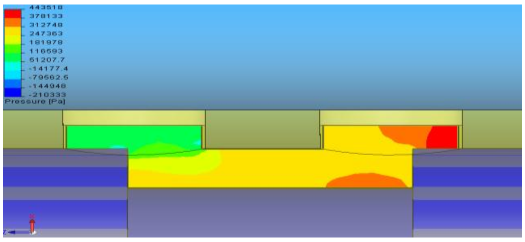


Figure 6

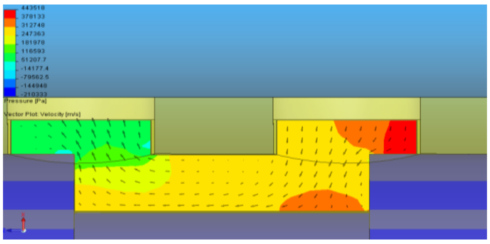
With the help of *COSMOS FloWorks* software, we analyse the flowing of the fluid through the controller above presented. The analysis field contains the internal volume where the fluid from a cube flows just like in Figure 6. The limit conditions are the following: at the entrance, through the feeder of the pump, it is introduced a fluid rate represented with red arrows in Figure 6, and at the exit, the fluid will meet a potential pressure represented with blue arrows.

A. From the model from Figure 3 a) there are the following graphical results:

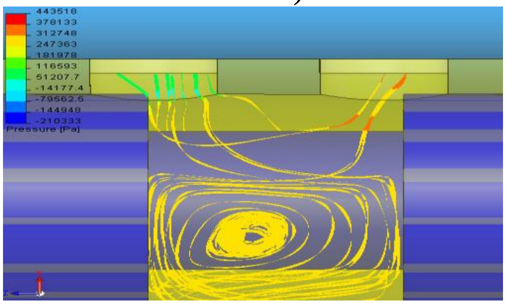
- Flowing on a section from the volume of the liquid disposed on the frontal side: Representation on the perimeter, Figure 7 a); Representation on the perimeter with the speed vectors, Figure 7 b).
- Representing fluid lines: frontal side, Figure 7 c); on the inferior side of the valve (opposite the feeders), Figure 7 d); on the superior side of the valve, Figure 7 e); In perspective, Figure 7 f);
- Variation graphics of the fluid's parameters on a curve from the interior of the controller, parallel with the valve: Variation of speed Figure 7 g); Variation of pressure Figure 7 h).



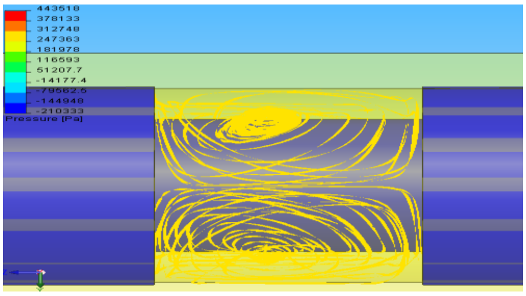
a)



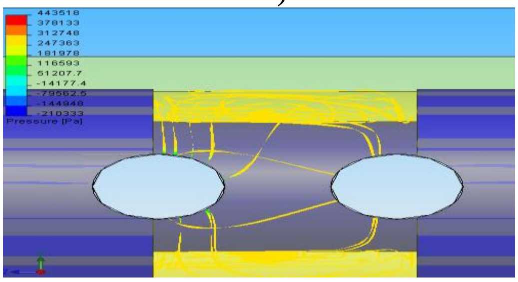
b)



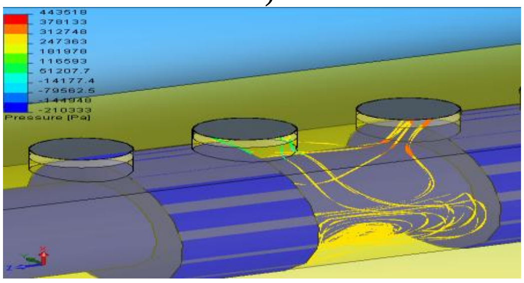
c)



d)



e)



f)

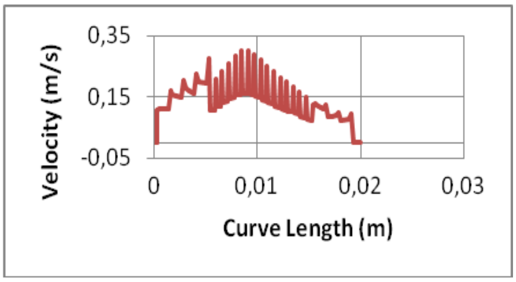


Figure 7 g) Variation of speed

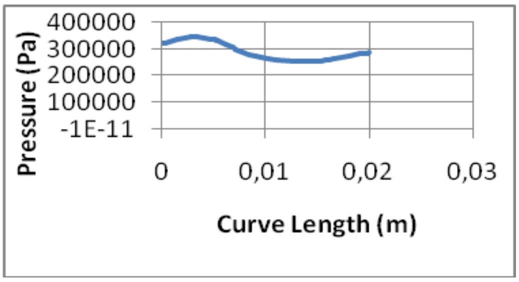
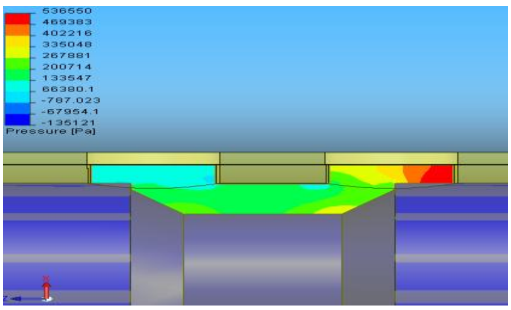
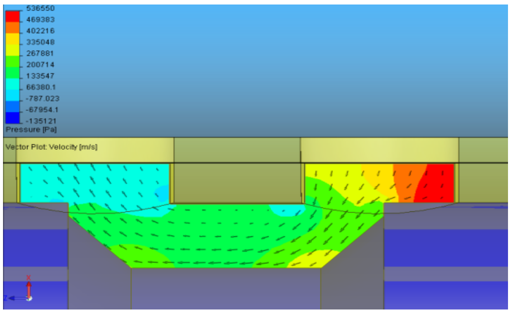


Figure 7 h) Variation of pressure

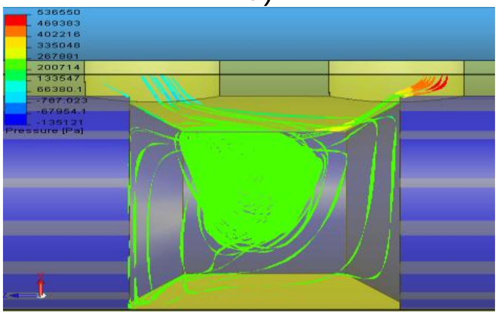
B. From the model from Figure 3 b) there are the following graphical results:

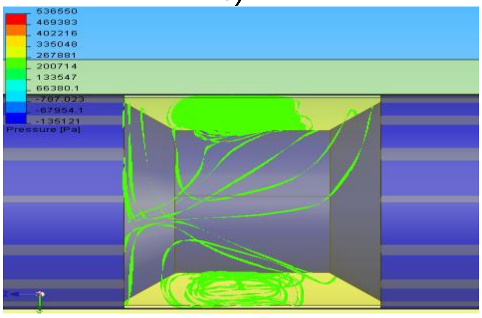
- Flowing on a section from the volume of the liquid disposed on the frontal side: Representation on the perimeter, Figure 8 a); Representation on the perimeter with the speed vectors, Figure 8 b);
- Representing fluid lines: frontal side, Figure 8 c); on the inferior side of the valve (opposite the feeders), Figure 8 d); on the superior side of the valve, Figure 8 e); In perspective, Figure 8 f);
- Variation graphics of the fluid's parameters on a curve from the interior of the controller, parallel with the valve: Variation of speed Figure 8 g); Variation of pressure Figure 8 h).



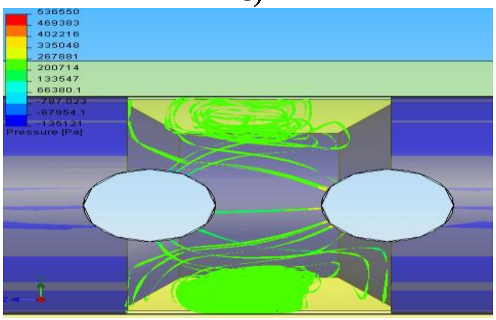


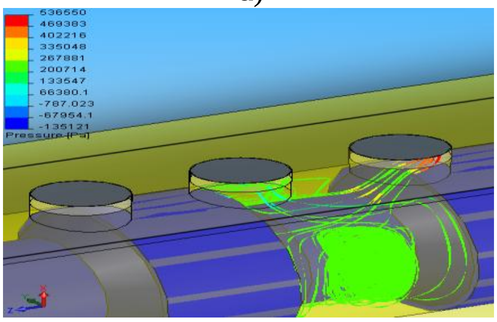
a) b)



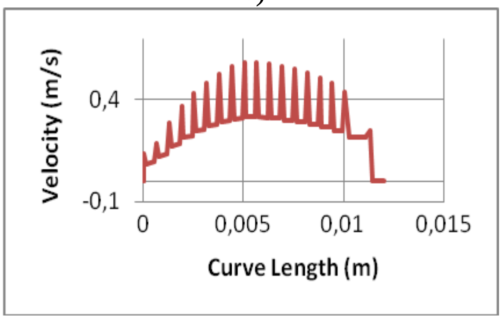


c) d)





e) f)



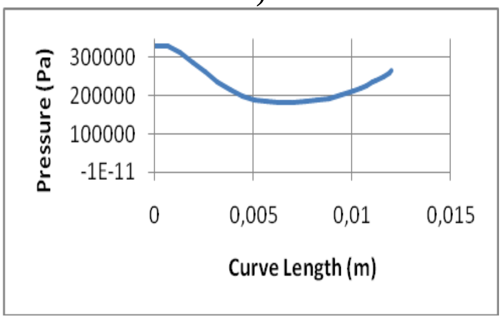
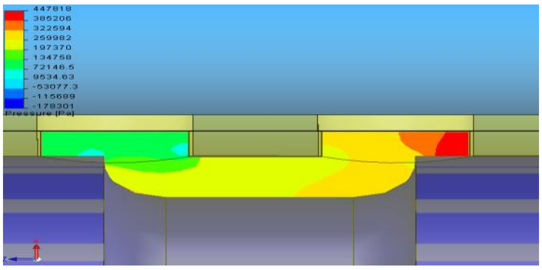


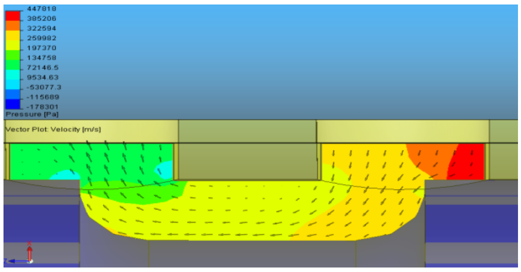
Figure 8 g) Variation of speed Figure 8 h) Variation of pressure

C. From the model from Figure 3 c) there are the following graphical results:

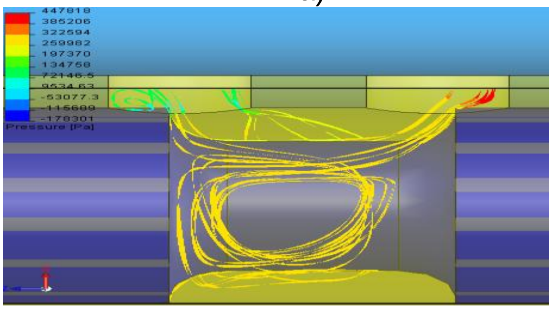
- Flowing on a section from the volume of the liquid disposed on the frontal side: Representation on the perimeter, Figure 9 a); Representation on the perimeter with the speed vectors, Figure 9 b);
- Representing fluid lines: frontal side, Figure 9 c); on the inferior side of the valve (opposite the feeders), Figure 9 d); on the superior side of the valve, Figure 9 e); In perspective, Figure 9 f);

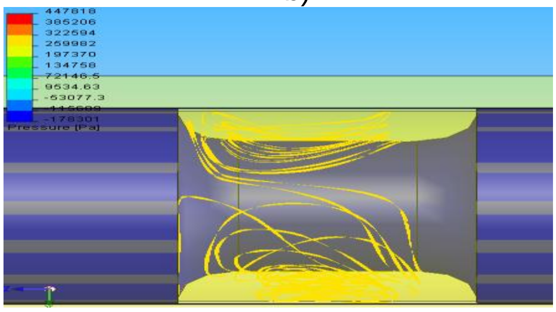
• Variation graphics of the fluid's parameters on a curve from the interior of the controller, parallel with the valve: Variation of speed Figure 9 g); Variation of pressure Figure 9 h).



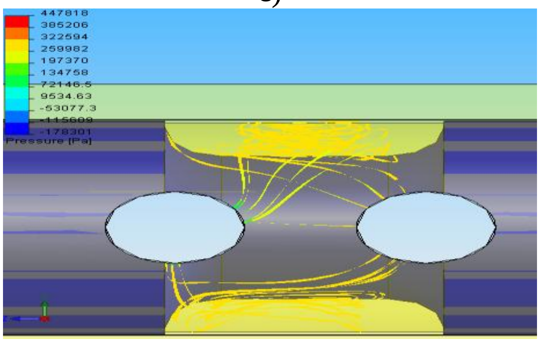


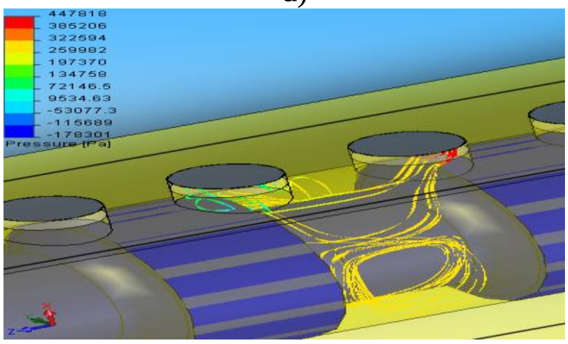
a) b)





c) d)





e) f)

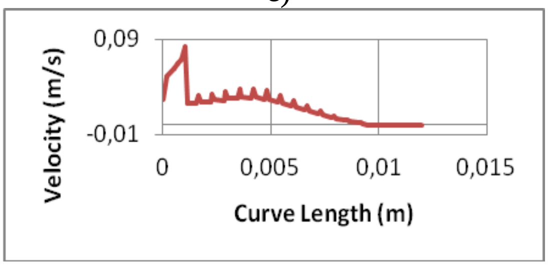


Figure 9 g) Variation of speed

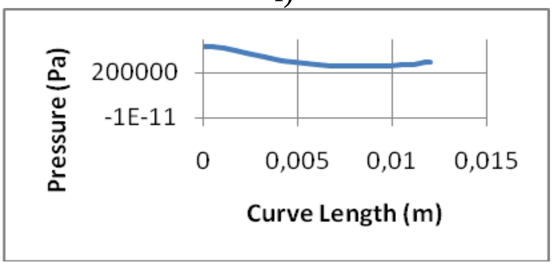


Figure 9 h) Variation of pressure

3.Conclusions

One can notice from the three sets of analyses done that there were obtained different results. The analysis aim was to determine the best construction solution from a fluid flow point of view through the hydraulic slots, feeders and contacts.

The less advantageous is the one presented in case B, in which the fluid lines are distributed uneven on the surface of the core bar between the two pistons of the hydraulic controller. This uneven distribution determines different requests upon the valve in different plans that may lead to a fast deterioration of the centering and actuation mechanisms of the controller and may lead to fluid leaks between its pistons.

4. References

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