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Devices of engineering communication in pneumatic in the wiev of energy saving

Zsolt Bartus, Zoltán Kummer

Abstract

The purpose of this paper is to aid in providing a better understanding of the fundamentals and principles of pneumatics devices of engineering communication, usually referred to as fluid power, and their related devices. A knowledge of pneumatics has become more important with the growing number of applications of pneumatic equipment in our expanding economy. To work with pneumatic energy is not a cheap way of solution but it is indispensable to use nowdays and it will be the same in the future. We will apply pneumatic systems in the field of industry, agriculture etc. so it is our main and further task to look for energy-saving solutions. The applied principles and practical features of pneumatics are discussed in detail. The installation, operation, and maintenance of pneumatic devices are covered thoroughly. This paper proves that we can find device which can offer an appropriate solution in the field of reduction of air consumption. The laboratory tests approve that with an inside-controlled valve we can adjust the pressure stepless which will be the most favourable for the cylinder in both directions in the view of energy-saving. In addition to this the laboratory tests were able to show us the operation features of pneumatically controlled linear engine. In this way we were able to see that the inside-controlled valve had a favourable influence on the whole of the operation of pneumatically controlled linear engine.

Key words: Pneumatic cylinder, Pneumatic energy, Energy-saving, Inside-controlled valve, Operation feature, Power loss

Introduction

Nowadays the demand is increasing for both energy-saving technologies and products. Of course it is the same in the pneumatic technology; we can say even more because the pneumatic actuation is very expensive.

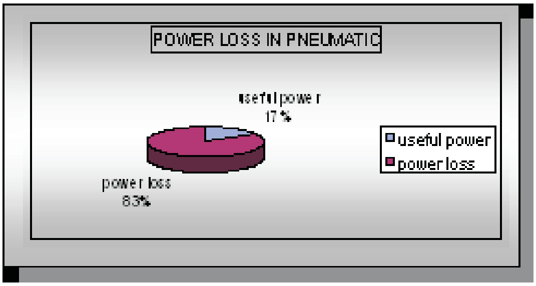

Figure 1: The energy conversion efficiency of pneumatic actuation

Verification this assertion we have to examine the energy conversion efficiency of pneumatic actuation. According to Fig.1. the energy conversion efficiency of pneumatic actuation is **17%**. To this we have to analyse of the process of the energy conversion. See over the composition of the energy conversion efficiency of pneumatic actuation. We can determine the $\mathbf{P}_{in}$ witch is the performance led into the compressor by the law of thermodinamic. The performance of pressed air coming out of the compressor is $\mathbf{P}_{v1}$ less. The pneumatic performance of airflow keeps decreasing $\mathbf{P}_{v2}$ because of leaking during the flow. In the cylinder which is the energy utilizer $\mathbf{P}_{v3}$ expended energy will appear. We can see these in fig. 2. clearly described.

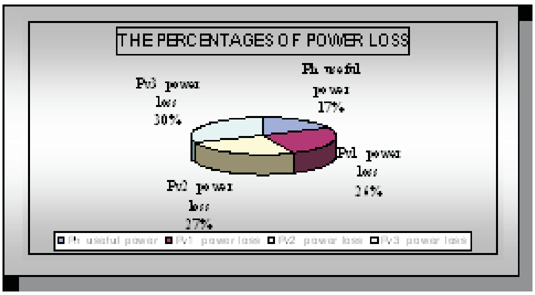

Figure 2: The percentages of power loss

Analyse the percentage of components of energy drop. The $\mathbf{P}_{v1}$ energy drop is the result of:

- warming due to air compressing
- friction loss because of moving elements of the apparatus

Consider $\mathbf{P}_{in} = 100\%$:

$$\mathbf{P}_{v1} = \mathbf{P}_{m1} + \mathbf{P}_{s1} \quad (1)$$

$$\mathbf{P}_{v1} = 18\% + 8\% = 26\%$$

where:

- $\mathbf{P}_{m1} = 18\%$ because of warming
- $\mathbf{P}_{s1} = 8\%$ friction loss

We can see these in fig. 3. clearly described.

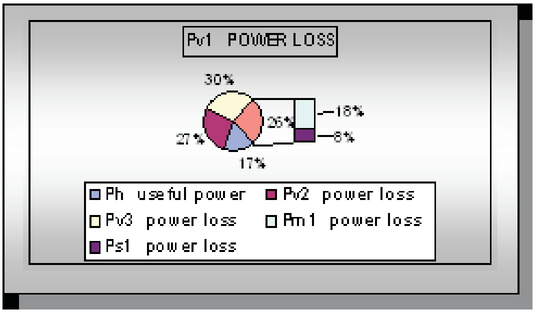

Figure 3: The percentages of energy loss of P_{v1}

The $\mathbf{P}$= 27%
The $\mathbf{P}_{v3}$ energy loss because of

- unexploited of az expansion and the back pressure
- friction loss

$$\mathbf{P}_{v3} = \mathbf{P}_{e3} + \mathbf{P}_{s3} \quad (2)$$

$$\mathbf{P}_{v3} = 27\% + 3\% = 30\%$$

where:

- $\mathbf{P}_{e3} = 27\%$ (unexploited of expansion and the back pressure)
- $\mathbf{P}_{s3} = 3\%$ friction loss

In diagram:

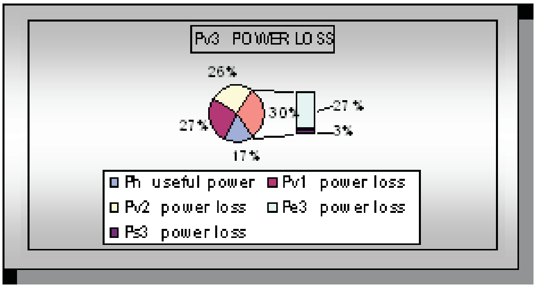

Figure 4: A P_{v3} ratio of energy loss

Total energy loss off energy conversion:

$$\mathbf{P}_{vo} = \mathbf{P}_{v1} + \mathbf{P}_{v2} + \mathbf{P}_{v3} \ldots\ldots\ldots\ldots \quad (3)$$

$$\mathbf{P}_{vo} = 83\%$$

In the view of above the efficiency of energy conversion of pneumatic:

$$\mathbf{P}_h = \mathbf{P}_{in} \text{ - } \mathbf{P}_v \ldots\ldots\ldots\ldots \quad (4)$$

$$\mathbf{P}_h = 0{,}17\% \text{ x } \mathbf{P}_{in}$$

from it:

$$\eta_o = \mathbf{P}_h \;/\; \mathbf{P}_{in} \ldots\ldots\ldots\ldots \quad (5)$$

$$\eta_o = \mathbf{0{,}17\%}$$

where:
$\mathbf{P}_h$ = useful power

$\mathbf{P}_{in}$ = input power

In the fig. 5. is demonstrated the persentages of energy loss together.

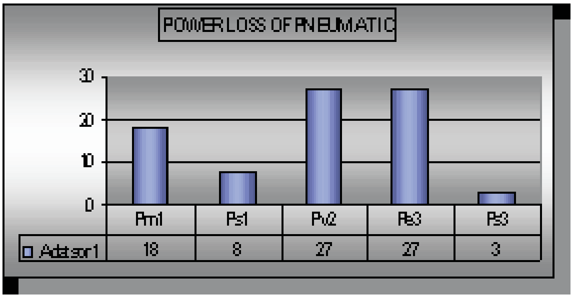

Figure 5: Comparative discripson of pneumatic energy loss

In the wiev of above mentioned it is expedient and justified to examine the operation features of pneumatically controlled linear engin in the point of energy saving.
The fig.6. showes us the pressure ratios in the pneumatically controlled linear engin on the basis of laboratory test.

Operation features of pneumatically controlled linear engin

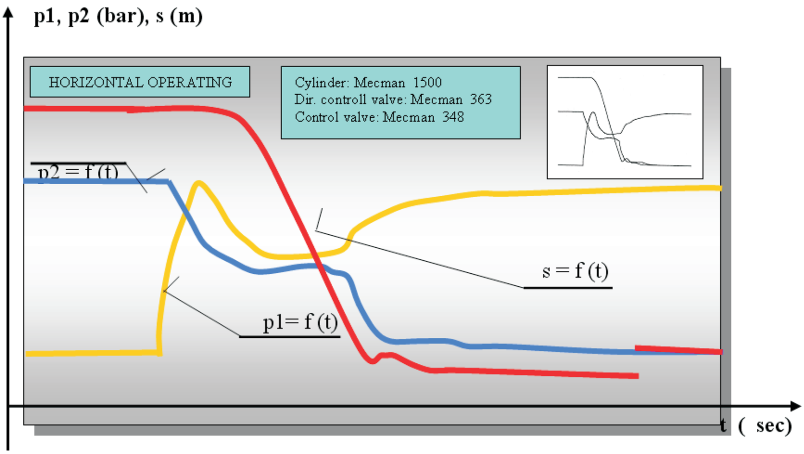

Figure 6: The pressure ratios in the pneumatically controlled linear engin

The fig.6. showes us clearly the changes of value of pressures in cylinder chambers. In this case the direction of pistol is „plus". It comes up in the process of the examination of the diagram that it isn't justified to operate the cylinder at the pressure of 6,3 bar in the direction „minus" If the cylinders do usefull work for us in the direction „plus" only as it occur often, it is expedient to operate the cylinders under 6,3 bar in the direction „minus".

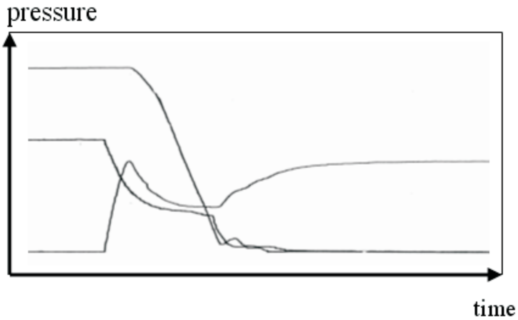

Figure 7: The result of laboratory test of cylinder operatid with the inside-controlled valve

The role of this valve is to prevent of developing of 6,3 bar. It is justified to do laboratory test with the inside-controlled valve. (See fig.7.)
As we can see in the fig.8. by the help of inside-controlled valve the pressure in the „minus" chamber of the cylinder will be less then 6,3 bar. In this case we can operate our cylinders in energy-saving form because it is obvious that the used quantity of air will be less in this case.

We can see in the fig.8. that the cylinder cycle can be divided into phases as well.

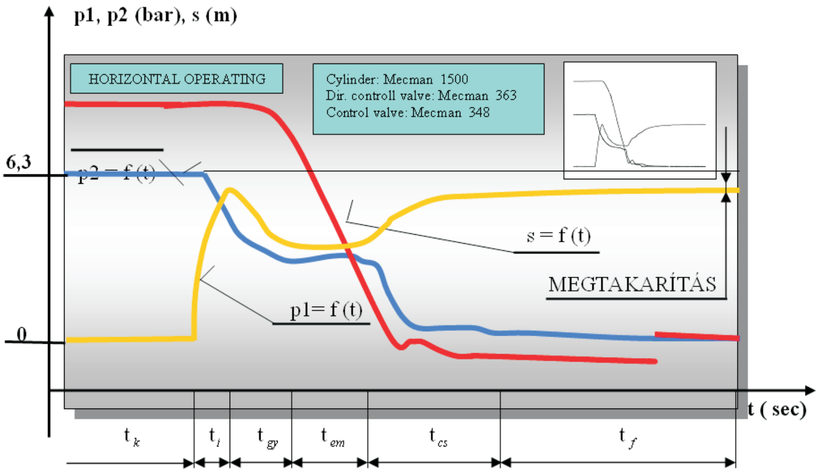

Figure 8: The zones of cylinder with the inside-controlled valve

- **starting zone**

The starting zone is characterized by $\mathbf{t}_i$ switching time.
The $\mathbf{t}_i$ starting time depends on:

- geometry of pneumatic cylinder
- both type and size of loading
- set of speed controll valves, in fact on the desired speed

At the switching of directional control valve in the „minus" chamber the pressure of $\mathbf{p}_2$ will be generally as high as $\mathbf{p}_{2i}$ the nominal working pressure fast. In the chamber of plus the $\mathbf{p}_1$ pressure is gradually decreasing, in the first place because of conductivity of restriction choke. The $\mathbf{p}_1$ and $\mathbf{p}_2$ pressures act on both side of the piston. When the pressure difference is sufficiently large to overcome start friction of the cylinder and eny external load, the cylinder starts. We can state that in the starting zone in the case of unloaded and at the nearly the same input and output conductivity, the decrease of $\mathbf{p}_1$ far less than the growth of $\mathbf{p}_2$. The reason for this is that the volume of the chambers of the cylinder not the same. So generally the starting time is determined by the change in time of $\mathbf{p}_1$. We can see the percentages of the claim to time of zone in the fig.9.

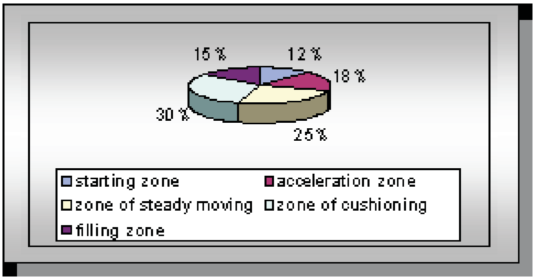

Figure 9: The percentages of the claim to time of zone

In fig.10. we can see the length of time of starting zone plottid against position of regulating screw. According to the fig. 10. the position of regulating screw is not have an adverse effect on the length of time of starting zone. The biggest energi-saving do not need longer time of starting zone. So the operating data will be no worse. The avarage length of time of starting zone: **0,38 sec.** This is **12 %** from the whole time of the moving of the piston. So we can say that the length of time is significant which passes beetwen the beginning of air flow into the cylinder and the start of the piston. In this period the moment is also significant when the $\mathbf{p}_1$ and $\mathbf{p}_2$ pressures turn into equal. It happen at the second third of the starting zone. At this moment the $\mathbf{p}_2$ pressure will be as big as the **80 %** of the starting pressure.

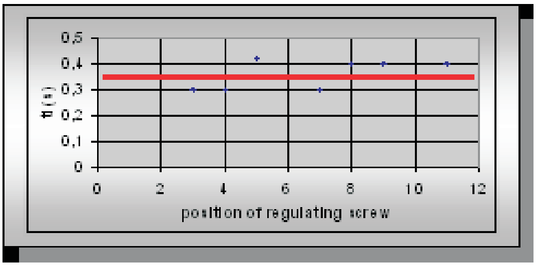

Figure 10: The length of time of starting zone plottid
against position of regulating screw

We must pay attention to the maximum pressure which built up at the moment of the start of piston at different posison of regulating screw. We can see this function in Fig. 11. The character is linear to 7,5 revolution of regulating screw then the character changes then the linear character returns. This charasteristic curve proves that inside-controlled valve has hindered not only the filling of the cylinder at the end of the stroke but in a very favourable way it has an energy-saving effect at the formation of the starting pressure as contrasting with the charasteristic curve in Fig. 6 the six bar pressure will not build up.

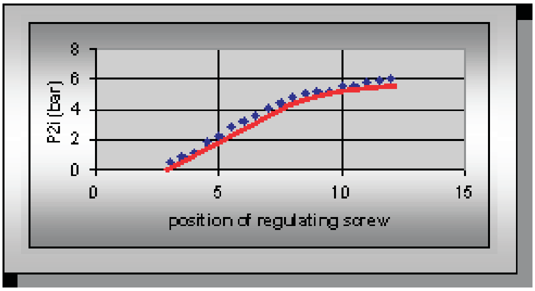

Figure 11: The length of time of starting zone plottid against position of regulating screw

- **acceleration zone**

In the „plus" chamber the pressure is decreasing due to the exhausting and at the same time the pressure is increasing in qonsequence of starting of piston. This pressure is definited by $\mathbf{p}_1$ on this side of piston. In the „minus" chamber the pressure is increasing due to compressed air is flowing into the chamber and at the same time the pressure is decreasing in qonsequence of the moving of the piston. This pressure is definited by $\mathbf{p}_2$ on this side of piston. So when the $\mathbf{p}_1$ is low sufficiently and at the same time the $\mathbf{p}_2$ is high fairly and the pressure difference is sufficiently large the force will be able to accelerate.The longer the cylinder the greater the acceleration. In most cylinder cases full speed is reached after 10-30% of the cylinder stroke. This is **18%** from the whole time of the moving of the piston.

- **zone of steady moving**

The zone of steady moving is characterized by $\mathbf{t}_{em}$ time.

The $\mathbf{t}_{em}$ time depends on:

- type of load
- bigness off load
- frictional force
- speed off piston
- length of cylinder

Zone of steady moving with little load is mostly steady acceleration and after than steady speed moving, with big load is generally damped swivel non steady speed and after than steady speed. Considering that zone of steady moving mainly depends on the length of cylinder the posison of regulating screw has no an effect on this zone.

In our case the value of speed is **4 m/sec.**

- **zone of cushioning**

When the piston reaches the cushioning bush the flow is forced over a throttle schrew. As a result the pressure increases on the exhaust side of the cylinder and the movement is retarded.

- **zone of filling**

After the piston stops without the inside-controlled valve the „minus" chamber will be filled up to 6,3 bar as you can see in Fig. 6. but with the application of inside-controlled valve this will not happen. So with the inside-controlled valve we can realize the energy-saving operation.
After the piston stops without the inside-controlled valve the „minus" chamber will be filled up to 6,3 bar as you can see in Fig. 6. but with the application of inside-controlled valve this will not happen. So with the inside-controlled valve we can realize the energy-saving operation.

To analyse my laborotory test further I have to take the most important feature of inside-controlled valve into consideration with fig. 12. There is no doubt that the diagram can prove a very useful feature of inside-controlled valve which is the linear nature of degree of energy-saving.

Figure 12: The degree of energy-saving against position of regulating screw

Conclusion

The paper has investigated on the operation features of pneumatically controlled linear engin in the wiev of energy saving

1. In this paper was determine the energy conversion efficiency of pneumatic actuation.

2. It was proven that with the aplication of inside-controlled valve we can reduce the air consumption of pneumatic cylinder.

3. It was proven that due to the laborotory test we can determine the zones of cylinder cycle operated with the inside-controlled valve.

4. It is very important to discass the energy-saving for pneumatic because the energy-saving in industry is a world-wide problem related to the protection of the environment. [3]

Nomenclature

$\mathbf{P}_{in}$	input power	%
$\mathbf{P}_{v1}$	power loss of compressor	%
$\mathbf{P}_{v2}$	power loss of air flow	%
$\mathbf{P}_{v3}$	power loss of cylinder	%
$\mathbf{P}_{m1}$	power loss bec. of warming	%
$\mathbf{P}_{s1}$	power loss bec. of friction	%
$\mathbf{P}_{e3}$	power loss bec. of unexploited of expansion and the back pressure	%
$\mathbf{P}_{s3}$	power loss because of friction of cylinder	%
$\mathbf{P}_{h}$	useful power	%
$\mathbf{P}_{vo}$	total power loss	
η_o	over-all efficiency	
$\mathbf{p}_1$	exhaust side pressure	Pa
$\mathbf{p}_2$	supply side pressure	Pa
t_k	switching zone	s
t_i	starting zone	s
t_{gy}	acceleration zone	s
t_{em}	zone of steady moving	s
t_{cs}	zone of cushioning	s
t_f	zone of filling	s
t	time	s

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