

INCREASING ENERGY EFFICIENCY OF THE EXECUTION PART OF PNEUMATIC SYSTEM BY RESTORING ENERGY

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Abstract. *The need for energy savings is on the rise. Pneumatic systems, as important parts of any branch of industry, are large consumers. The opportunities for saving energy in these systems are great. The paper presents a structure of pneumatic systems while a special emphasis is put on the saving of energy in the execution. A method of recovering energy is also presented.*

Key Words: *Pneumatic System, Energy Efficiency, New Energy*

1. INTRODUCTION

The need to reduce global energy consumption and to use efficiently its resources by applying energy efficient regimes is today indisputable and it has become an integral element in all international contracts and agreements. The Kyoto Protocol on climate change signed in 1997, known under the name of conference against global warming, among other things, determines the reduction of emission of harmful substances in the atmosphere (which is particularly related to the ingredients that may cause greenhouse effect) for each individual country and also a more efficient use of energy sources. As the pneumatic system is under the same obligation as a segment of industry, it is in this area that it must reduce the use.

Pneumatic systems offer many benefits in terms of small cost; they do not represent polluters and are easy for installation and maintenance, etc. For these and many other reasons they are used in many industries, and in the automotive, semiconductor industry, food processing, wood processing, textile industry, etc. The energy used in pneumatic systems is the energy of air under pressure which comes in special plants that are called compressors. Generally, the cost of electricity used to power air compressor in the production under pressure is around 20% of the cost of electricity for a factory. For these and many other reasons, it is very important to carefully manage expenditure air under pressure.

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2. INCREASE OF ENERGETIC EFFICIENCY PNEUMATIC SYSTEM

Generally, energy savings in pneumatic systems can be divided, as to where the energy is used, into:

- **Part of production**, where mechanical energy is converted into pneumatic energy, i.e. in the compressors;
- **Part of transmission**, where the air under pressure is transported through the line; and,
- **Part of execution**, where the potential energy of air under pressure is converted into mechanical work, the cylinders and motors.

The flow of compressed air energy is shown schematically in Fig. 1.

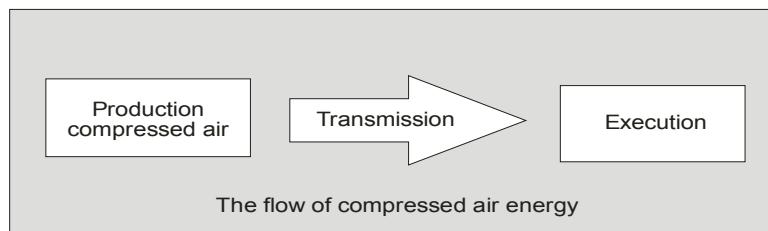


Fig. 1 Flow of Energy Air under Pressure.

The energy savings in these three parts of a pneumatic system are different. For instance, the energy savings in production compressed air part can be up to 16 % and in transmission part up to 25 – 30 %. In the execution part, energy savings can be up to 50 % for some actuators and work conditions and this paper deals with energy savings in the execution part.

3. REDUCING LOSSES OF COMPRESSED AIR IN THE EXECUTION PART BY MEANS OF RESTORING ENERGY

Pneumatic actuators are used in many different branches of industry. They are used for both linear and rotary movements. So, there are:

- Linear pneumatic actuators:
 - pneumatic cylinders,
 - rodless pneumatic cylinders,
 - linear pneumatic grippers and etc.
- Rotary pneumatic actuators:
 - pneumatic motors,
 - rotary pneumatic grippers and etc.

If the needed force is greater, the dimensions of pneumatic actuators are also greater. For example, if the rod diameter and stroke are increasing, the consumption of compressed air is also increasing. This consumption of compressed air is especially great in pneumatic systems which use the same pressure of compressed air in working and returning mode. It is a well known fact that the pressure of compressed air in the working

volume of pneumatic cylinder increases and reaches the final value equal to the supply pressure of compressed air, just after the cylinder rod reaches the end of the stroke of pneumatic cylinder. When the change of movement direction appears, during the returning mode, all the compressed air from previously working volume flows into the atmosphere. That is a great loss of compressed air, which has enough potential energy to do something else.

There are many published papers which investigate the mentioned topic of reuse of energy, more exactly reuse of compressed air from previously working volume of pneumatic cylinder.

The basic principle is shown in the following Fig. 2. This figure shows the advantage of pneumatic system with restoring energy because the consumption of compressed air is less than in a system without restoring energy.

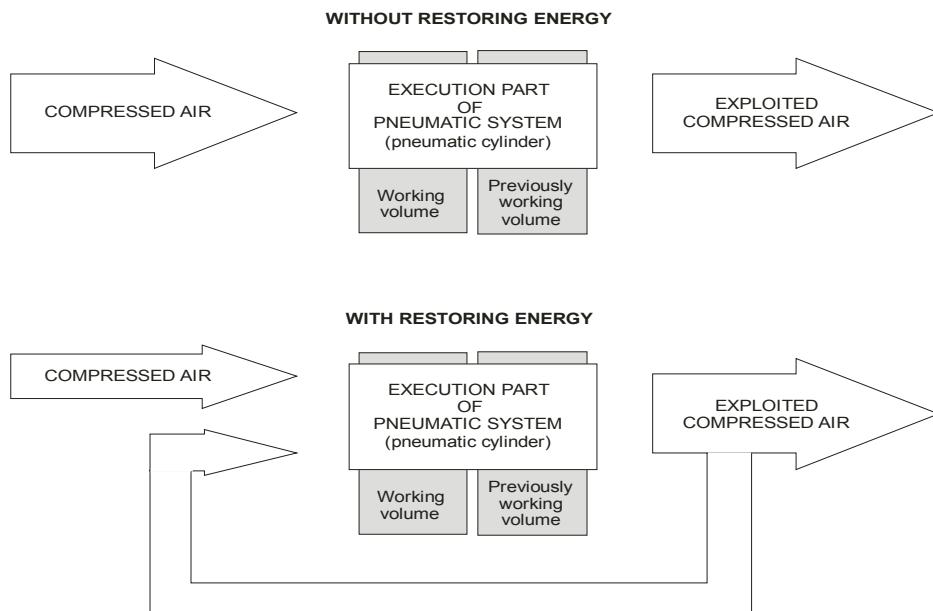


Fig. 2 Basic Principle of Restoring Energy in the Execution Part of Pneumatic System

This ensures that almost completely the use of air under pressure from the previously working chamber can be used in two ways:

1st way: Compressed air from the previous working volume is used in the other volume in the cylinder so that it generates sufficient force to move cylinder rod in the opposite direction.

2nd way: Compressed air from the previous working volume is used in the other volume in the cylinder where there is no enough force for back-stroke, but it reduces the need for a new amount of air under pressure. That is, you only need to bring in a small amount of air in order to pressure in the mentioned volume grown enough to enable the process of repeating walk. Fig. 3 shows the principle of the pneumatic scheme with bridging the chamber cylinder 1.0 in order to save energy and typical pneumatic system.

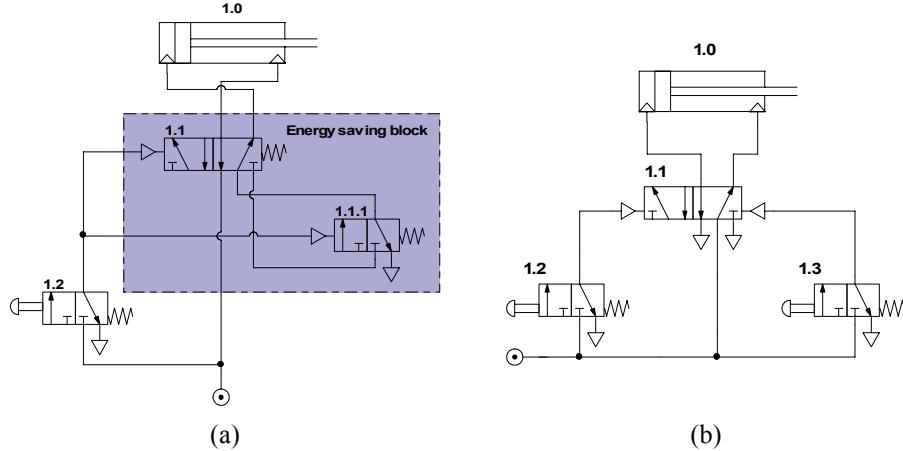


Fig. 3 View of Pneumatic System: a) with Energy Saving Block, b) Typical System.

These bridging chambers are made in the energy saving block and they consist of two pneumatic actuated valves 5/2 and 3/2 and their appropriate connection. These valves in energy saving block are marked with 1.1 and 1.1.1. The energy saving block pulls in the piston of the pneumatic cylinder by compressed air from the supply to the end position, and pulls out the piston by compressed air from the rod side chamber, which otherwise would be released into the atmosphere. This way of energy saving is possible only with the pneumatic cylinders which are not loaded or where the load is less than the difference of forces by compressed air pressure, on the opposite sides of piston. This is in effect only when the piston of cylinder is pulled out. When the piston of pneumatic cylinder is pulled in the load has not any effect on this process if the cylinder is well designed. In the mentioned way of energy saving, Fig. 3a, the valve marked with 1.2 is for giving command for pulling out the piston of the pneumatic cylinder.

To check the proposed ideas on recovering energy through the energy saving block in the exploitation, we have used experimental measurements Air Box device for measuring the flow of Festo Company. The device is designed to allow measurement of low and high flow compressed air by parallel connection of two flow meters. By exporting the measured values, it is easily possible to further process the results of the ordinary PC, in a program such as Excel, Origin, MathLab or in the MSR that comes with the device. The appearance of the above-mentioned device is given in Fig. 4.

Chart of compressed air consumption in the typical pneumatic executive system shown in Fig. 3b, is presented in Fig. 5. The recording flow is done in the case of ten cycles in which the start was after 5s. Air pressure in the power sup-



Fig. 4 Photo device FESTO Air Box

ply was 680 kPa and environmental temperature was 25°C. The cylinder which was used was double acting made by FESTO.

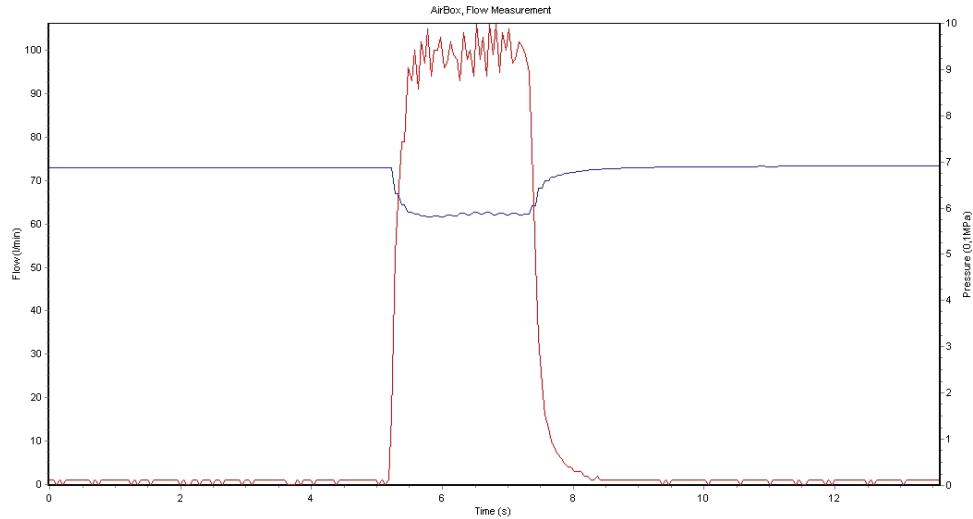


Fig. 5 Compressed Air Consumption in a Typical Pneumatic System for 10 cycles

By simple mathematics and the counting area under the curve of the compressed air flow we can get the value of consumption for this case, which is 3.6 l.

The implementation of the proposed model of energy efficient management, shown in Fig. 3a, the compressed air consumption is quite low. The cylinder - as well as the environmental and power parameters - is the same as in the previous measurement. The chart of the compressed air consumption for this case is shown in Fig. 6. The compressed air consumption for this case is 2.7 l.

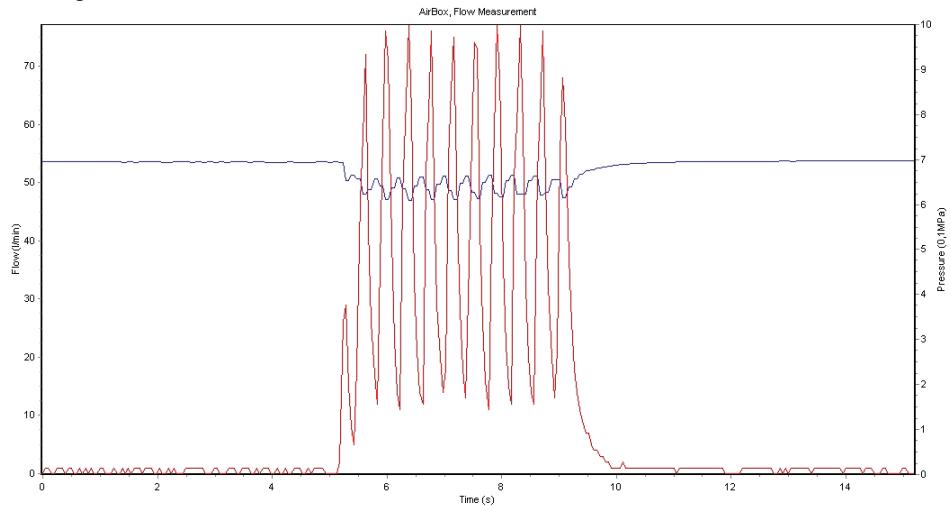


Fig. 6 Compressed Air Consumption in the Pneumatic System with Energy Saving Block for 10 cycles (538).

Comparative presentation of the compressed air consumption for these two cases is shown in Fig. 7 in the form of diagrams.

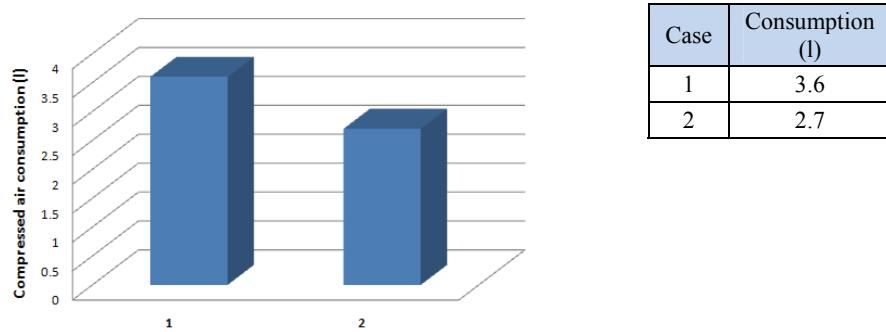


Fig. 7 Compressed Air Consumption

In order to make it much easier to note that the energy-efficient management, in the way it is done in Fig. 3a, can lead to big energy savings, the recording of the flow of compressed air for one cycle of the pulling in and out of the cylinder piston rod is done. This is the right way to see what the actual compressed air consumption is, when not in use and when in use of energy efficient management provided by bridging the chamber cylinder and in the execution makings. For this, as well as in the previous cases, the executive element is a pneumatic double acting cylinder.

Compressed air consumption for the case when not in use and efficient management of energy use are shown in a chart in Fig. 8.

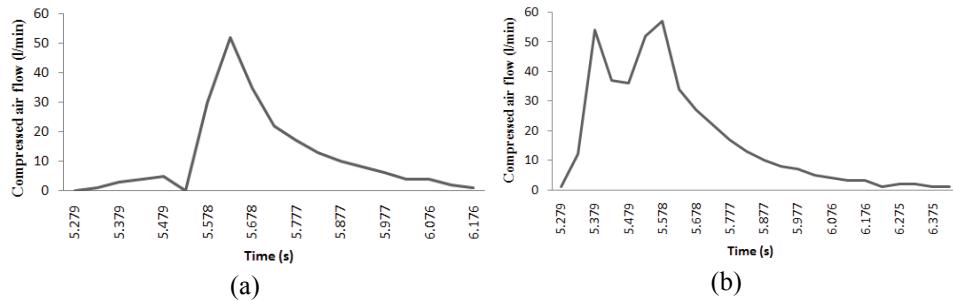


Fig. 8 Diagrams of Compressed Air Consumption to the Executive Element of Cases:
a) When Energy Efficient Management Is not in Use,
b) When Using Energy Efficient Management

Comparative presentation of the compressed air consumption to the executive element, in one cycle, when it is used and is not used, the energy-efficient management is shown in the diagram 9. The diagram shows that the reduction of compressed air in the pneumatic systems using the previously explained energy efficient management provided by bridging the cylinder chamber can reach the value of even 50%.

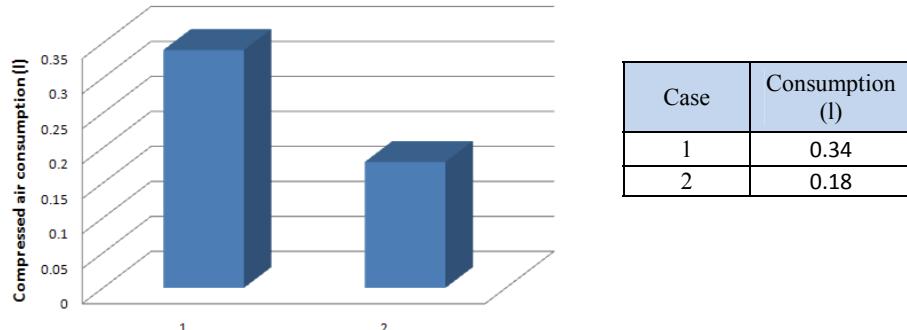


Fig. 9 Compressed Air Consumption for the Cases: 1 - When Energy Efficient management is not in Use and 2 – When Energy Efficient Management is in Use

Regarding the reduction of the compressed air of the solution given in Fig. 3a it is a lot better than the basic typical executive pneumatic system in Fig. 3b. The implementation of such solutions does not actually increase their prices because the valve serving the infliction commands for the indentation cylinder piston rod can be used to as a means for energy saving as well as a component for bridging the chamber cylinder. This solution, though it is a lot better compared to the classic one, should be used only in the cases that are previously described or in the cases when the pneumatic cylinder is used to draw.

Greater energy savings can be achieved by switching to the electro-pneumatic systems since such have a lesser need for compressed air because all the processing is done by electric power. The advantages are not only in energy saving compressed air, but also in the fact that work is more flexible while management and monitoring of the entire system are easier. The proposed ideas for saving energy in the executive part of pneumatic system can be applied to servo pneumatic systems as well as to pneumatic systems. A solution that would be added here would be expensive for the price of valve which will be made to bridging chamber cylinder, savings of compressed air again would be to even 50%.

4. CONCLUSION

The previous methods of supplying pneumatic cylinders are such that the use of compressed air from the cylinder chambers is always released into the atmosphere. Losses that have emerged during releasing compressed air into the atmosphere at the end of the process, and change of direction of movement cylinder rod, were important [1]. The presented way of restoring energy of compressed air through the bridge double acting cylinder chamber shows good characteristics. This way makes it possible to achieve energy savings of the compressed air consumption, in the interval from 35% to 50%. Air consumption is reduced due to the use of air under pressure from previously working cylinder chamber. Greater energy savings can be achieved by switching to the electro-pneumatic systems since they have less demand for compressed air because all the processing is done by electric power. The proposed model, in addition to the effects of energy savings, provides a good basis for further examination and verification in the field of servo pneumatics.

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POVEĆANJE ENERGETSKE EFIKASNOSTI IZVRŠNOG DELA SISTEMA VAZDUHA POD PRITISKOM OBNAVLJANJEM ENERGIJE

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Potreba za uštedama energije je danas u porastu. Pneumatski sistemi koji čine značajni segment bilo koje grane industrije predstavljaju velike potrošače. Mogućnosti za uštedom energije u ovim sistemima su velike. U radu je izvršeno strukturisanje pneumatskih sistema i poseban akcenat je dat na uštedi energije u delu izvršenja. Prezentovana je metoda obnavljanja energije.

Ključne reči: *pneumatski sistem, energetska efikasnost, obnavljanje energije*