ENERGY AUDIT OF AUTOMATED OPERATION

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Abstract

The article deals about fundamental areas of operation of automated production using compressed air. The balance of the savings potential also brings a number of proposals for tackling energy saving of compressed air.

Key words: compressed air, automated production, pneumatic energy saving,

INTRODUCTION

The balance of the operating costs in each of the automated manufacturing is now considered as one of the key issues.

Energy balance automated operation determines primarily the type of energy used. If the operation is the energy of the support of compressed air shall be analyzed size of consumption and the the manner of treatment of compressed air.

ENERGY AUDIT

However, although the predominant energy used in the operation is compressed air his essence of the electricity (compressor).

Therefore, energy audits, which should be in every operation performed regularly for costs not only directly related to the production, treatment and distribution of compressed air, but above all the cost of acquisition (purchase) of electricity.

Whereas with the use of compressed air is directly related to the purchase of electricity, we need to know where and to what extent appropriate measures can save operating costs.

If we do not take into account the impact of investigations on the state of the environment, at least they would be interested in costs, related to energy consumption.

In order to be satisfactory conclusions of the energy audit, it is necessary to know in which areas of possible savings and the extent to which additional costs are necessary to protect savings.

AREAS OF SAVING

Areas for savings in the use of compressed air is possible in terms of norms, such as the VDMA 24581 standard (Pneumatic fluid power - Application notes for the optimization of the energy efficiency of pneumatic systems), divided into twelve groups, Figure 1 [4].

The diagram in the figure, it is clear that the case-by-case amount of savings is more than interesting.

During the operation of automated production it is therefore necessary to know exactly what its specific features and utilize fully the facilities.

This process is quite lengthy and requires a certain degree of experience, therefore leading

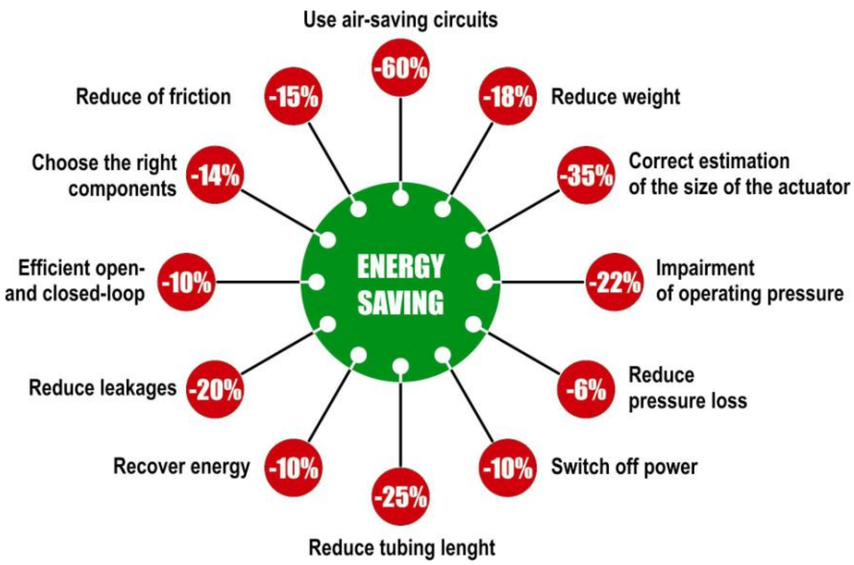

Fig 1 Twelve areas for the application of pneumatic energy savings in automated production
Source: [4] - edited by authors

producers of pneumatic components offer software systems serving to save energy (Energy Saving Systems).

Them on the basis of knowledge of options for saving on air seek to raise awareness of the customer to save energy (awareness of costs).

All systems operate with standard proviso awareness of the need to carry out changes in the circuit, leading to the improvement in the state [3].

ANALYSIS WAYS TO SAVE COMPRESSED AIR ENERGY

In order to understand the importance of saving of compressed air in use, it should be understood that the compressed air is a cost-shifting between the most expensive media.

At a cost of € 0.04/m^3 conditioned compressed air (this amount includes the price of electricity and all other processes to be fulfilled by the production of compressed air to pass so that it becomes a useful medium), Table 1, the annual costs represent a considerable financial burden of the operator [3].

Table 1 The cost of manufacturing and the compressed air preparation [3]

Compressed air consumption [m_n^3/min] at an operating pressure in the circuit 0,6 MPa	**The annual cost of production and treatment of compressed air at a price of 0,04 €/m^3** and operation of 6000 hours/year
1,00	14 400.- €
5,00	72 000.- €
10,00	144 000.- €
20,00	288 000.- €

Every inefficiently consumed liter of compressed air necessarily generating a loss.

As referred world analysis, Fig. 2, the largest share of consumption in air operating has air cooling air (cutting and drying processes) and develop vacuum in the jet steam generators (ejectors) for the purpose of grasping in handling operations.

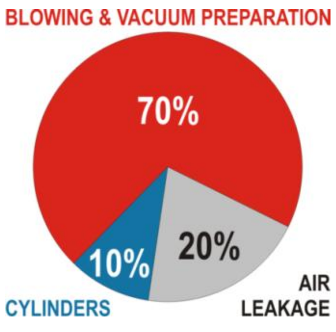

Fig 2 Areas of greatest consumption of compressed air

Source: [3], [5] - edited by authors

If, in the case of use of the said operations in compliance with the rules of operation of the circuits saving air, ideally, it can be up to a 60% savings in the consumption of compressed air.

If using compressed air to the air cooling may be used air-saving type nozzle, Fig 3a) that its construction permit (with unchanged output power) at the inlet to save up to 90% air.

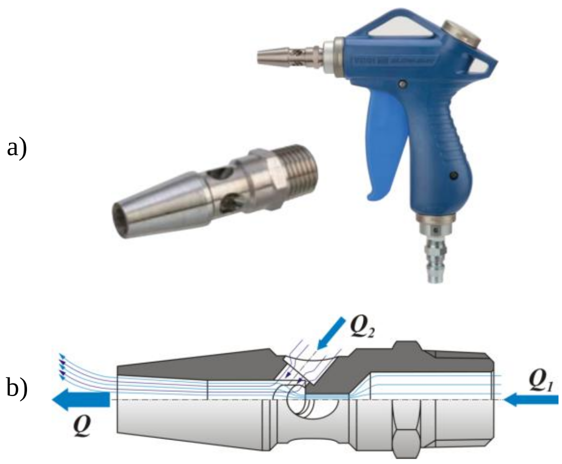

Fig 3 Blowgun with high efficiency nozzle and and its principle

Source: https://content2.smcetech.com/ pdf/VMG-F_EU.pdf - edited by authors

The special design of the nozzle causes the gun while in the standard type of nozzle, the ratio of the effective cross sections of 2.3:1, causing pressure loss to 0.04 MPa, in the figure, the combination of gun and efficiency nozzle the effective area ratio of 10.7:1, and pressure drop of only 0,003 MPa.

This effect is due to a phenomenon that is also used in the ejector (Bernoulli effect).

Compressed air velocity of giving a flow Q_1 by a configuration of congestion in the nozzle is increased, making the narrow addition site required pressure drop, Fig 3b).

After bottleneck created holes so suck the atmosphere of an additional volume of air (additional flow Q_2). The resulting flow exiting the nozzle $Q = Q_1 + Q_2$ is up to 10% higher (in the pressure drop as 0.003 MPa).

When using compressed air to prepare for the vacuum suction cups for grasping of objects (manipulation problems) is a proven tool for saving compressed air use the appropriate type of ejector, for example. two-stage, Fig. 4. The design of the ejector uses a pair of 2/2 valves (position 4 and 5) in combination with a check valve (position 6). This allows the activation of suction cup (creating a vacuum an ejector, causing power connection suction cup and object of manipulation) suspend the application of vacuum in ejector and during manipulation of objects thus saving compressed air required to generate vacuum.

Connection diagram of such an ejector is shown in Fig 5.

With a control voltage **U_1** is activated ejector (and with it the suction cup); at a sufficient level of vacuum of the vacuum switch is detected by the control voltage **U_1** canceled a vacuum check valve closed for a time of manipulation effect suction cup provides power to object of manipulation (**O_M**).

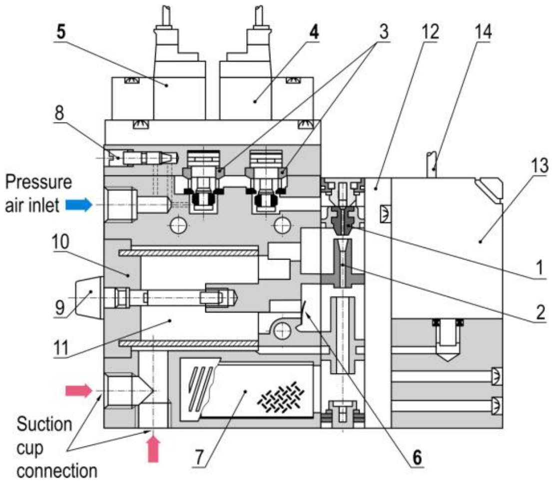

Fig 4 Two-stage ejector
Source: [1], [5] - edited by authors

After completion of handling task is to by short activation of the control voltage **U_2** disabled suction cup gripping force exerted on **O_M**.

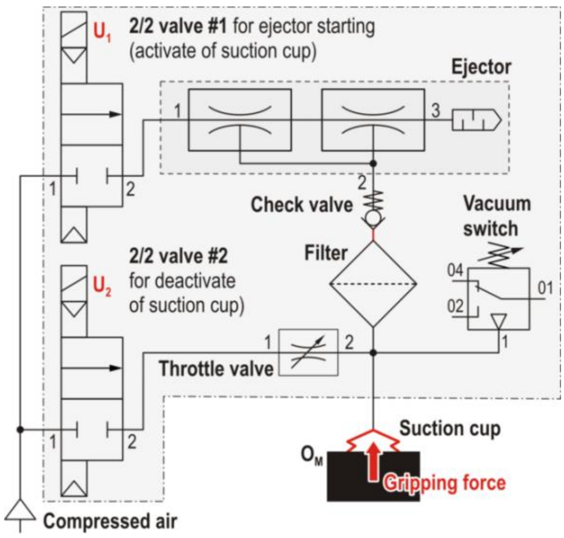

Fig 5 Connection diagram a two-stage ejector with the possibility of switching off the vacuum generating
Source: [5] - edited by authors

As is clear from the graph in Fig 1, up to 35% savings in the compressed air can be achieved by correct dimensioning of drive.

Drive size is determined by the necessary force effects. Often, however solver the construction of a pneumatic mechanism chosen larger actuator than it should, according to calculations (the pursuit of security or insurance only own calculations).

As the force effect of the drive determines the diameter, with a choice of higher force to drive the circuit by introducing a greater air consumption. As the piston diameter drives are not differentiated sufficiently "sensitive" (the manufacturer of the dimensions, Table 2, are particularly at larger diameters drives significant separation in diameter), the differences in active volumes are quite large.

Table 2 Theoretical force and volume of cylinders

Ø of cylinder piston [mm]	**Theoretical force of cylinder** [N] **by pressure**			**Active volume** [dm^3]
	0,4 MPa	**0,5 MPa**	**0,6 MPa**	
16	80,4	100,5	120,6	0,63
20	125,7	157,1	188,5	0,79
25	196,3	245,4	294,5	0,98
32	321,7	402,1	482,5	1,26
40	503	628	754	1,57
50	785	982	1178	1,96
63	1247	1559	1870	2,47
80	2011	2513	3016	3,14
100	3142	3927	4712	3,93
125	4909	6136	7363	4,91
140	6158	7697	9236	5,50
160	8042	10053	12064	6,28
180	10179	12723	15286	7,07
200	12566	15708	18850	7,85

Therefore, in some borderline cases it preferred to use the nearest smaller size of the drive and secure (with suitable monitoring systems) stability required pressure.

In many cases, there is little attention to the length of tubing used in connecting devices pneumatic mechanisms. When using the valve islands are often designers make the mistake that either because of easier maintenance of clarity or just concentrate valve islands in one place, which sometimes enormously growing volumes of compressed air attributable to the volume of tubing.

Decentralization valve islands, although slightly increased acquisition costs (greater number of smaller islands and cabled in the case of bus systems), but the operating costs associated with the consumption of compressed air goes in some cases up to 25%

The same attention should be paid to the diameter of the tubes and their justification in relation to the required flow in the circuit.

Up to 22% can reduce losses during the operation of pneumatic mechanisms, where we provide a reduction in pressure in the return movement of the drive. It suffices to move the periphery of the regulator for the return movement of the piston takes place a pressure value of 0.3 MPa lower than the operating pressure, Fig 6.

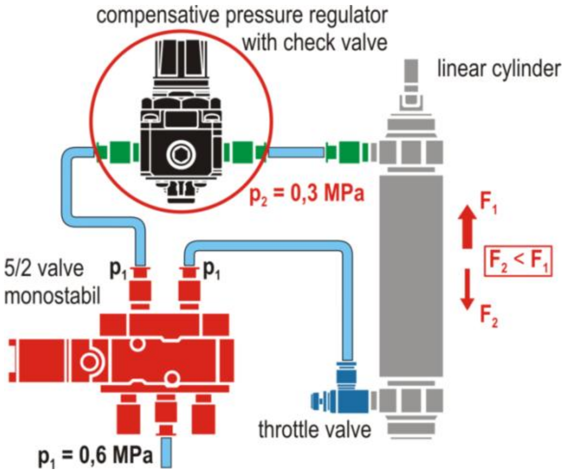

Fig 6 Reducing of pressure for back motion of drive

The area, which is now with reasonable seriousness receiving increasing attention from the maintenance departments of companies with automated production based on pneumatic mechanisms, is monitoring and elimination of leaks in circuits of compressed air and pneumatic mechanisms.

Neglecting this issue brings the company significant loss, Table 3.

Table 3 Financial statement of losses due leaks in the circuit, Source: [1]

Diameter of hole (overall leakage)		**The amount of air leakage** $[m_n^3/min]$ by pressure 0,6 MPa	**The annual cost at a price 0,04 €/m^3** and operation of 6000 hours/year
Ø [mm]	equivalent area [mm^2]		
1	0,786	0,06	864.- €
3	7,069	0,55	7 920.- €
5	19,635	1,52	21 888.- €
10	78,540	6,10	87 840.- €

Even when from a technical viewpoint is a effortless operation it is labor intensive [1]. However, regular checking and eliminating compressed air leaks of the circuits traffic enables the company to save up to 20% in energy costs.

Relatively significant percentage of savings you can get a good choice of mechanical properties of components used in construction machinery. E.g. suitable combination of the technologies of the drive unit (electric unit loads in the X and Y axes, in combination with the pneumatic drive of the Z axis) may be obtained up to 18% savings, savings of 15% can be obtained by reducing the friction of the motion unit and the brake unit using the motion axes, which are eligible for the prolonged persistence in the terminal position up to 14% energy savings.

To complete the more potential for energy saving shutdown supply (solenoid-start or standard 3/2 valves) compressed air, which reduces the impact of any unsolved leaks. Total savings in this area are up to 10%.

Similarly, the option setting circuit for recuperation of kinetic energy, which can save up to 10% as much energy.

The same level of savings provides system optimization controller for controlling the circuit using open and closed cycles.

Finally, one more opportunity to save energy compressed air: optimize the diameters of the circuit tubing and pressure reduction in circuit the necessary height (eg. pressure reduction circuit from 0.8 MPa to 0.7 MPa will save energy up to 6%).

CONCLUSION

Cost companies strongly influences the operating costs. In automated operation, this includes the cost of producing and distributing compressed air in operation. It is necessary to know the area in which the "losing" a lot of energy and apply these necessary adjustments. In addition to improve the economics of the savings reflected to a large extent also to improve the energy balance, which ultimately brings additional savings.

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