XVII InternationalScientific Conference on Industrial Systems (IS'17)
Novi Sad, Serbia, October 4. – 6. 2017.
University of Novi Sad, Faculty of Technical Sciences,
Department for Industrial Engineering and Management
Available online at http://www.iim.ftn.uns.ac.rs/is17

Case studies – reducing consumption of compressed air in casings food industry

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Abstract

The aim of this paper is to present the results of reducing the consumption of compressed air, on example of one pneumatic, meat casings products machine located in Viscofan industry, Novi Sad, Serbia. The results are based on measurements before and after repairing the control unit on pneumatic machine, Plisirka KUKO 19. The idea is to change all old pneumatic components. In that way, there is a unique opportunity to measure effects that this repaired machine have on consumption of compressed air, beside other effects such as greater reliability, faster response of valve distributors etc. The results are presented in this article and shows that compressed air consumption can be reduced significantly.

Key words: *food industry, compressed air reducing, measuring, leakage*

1. INTRODUCTION

Compressed air represents one of the most widespread forms of energy that is used usually in industry. In factories, compressed air can be used to run various production processes such as cleaning jobs, packaging machines, running pneumatic tools, pneumatic transport etc. Due to the improper use and more energy transformations it is the most expensive form of energy carrier in industrial systems. For these reasons, it is necessary to constantly perform optimization of pneumatic systems to decrease the compressed air consumption.

Pneumatic technology is inexpensive, sturdy and simple to purchase. Despite this, the compressed air generation process is frequently said to offer limited overall efficiency. Evidence from practice has shown, however, that pneumatic drive technology can in fact be a highly economical and efficient choice if it is designed correctly and used in the right application. Body shop work involves many different clamping, gripping and holding tasks – and in these cases pneumatic drive technology proves to be a perfect match if it is used correctly, as not only can it generate high levels of force in small spaces, but it also requires no extra power for holding and clamping. Besaide that, a lot of devices that consume compressed air are energy inefficient. For example, applications of blowing out [1] and drying with compressed air, ventilation etc. often can be optimized in terms of energy efficiency. The basics of the managerial approach to increasing energy efficiency of the compressed air systems and the identification of the possibilities for efficient production, preparation, distribution and rational consumption of compressed air as well as the ways in which they can be applied for increasing the energy efficiency are shown in [2].

In this context, a systematic and holistic approach to efficiency of compressed air is very important. In most cases there is a lack of consistent coordination between the generation, distribution and use of compressed air. Against this backdrop, the purpose of this case studies is to illustrate and show how significantly can be reduced energy efficiency after reparing some of few important pneumatic components.

From this point of view, one of the primary aims of writting this paper was to create transparency in consumption and loss figures. The work in this area involved comprehensive analyses of air consumption in one part of facilities, a practice which enables more efficient coordination between generation and consumption [3].

In many companies, there is an urgent need for action due mainly to rising energy prices and an increased sense of environmental awareness. Here, simple

measures are often all that are needed to bring about significant reductions in energy consumption and costs.
During this case studies, it became clear that issues relating to achieving an increase in energy efficiency must be viewed in the overall context of the whole machine concerned.

Furthermore, many cases require detailed records of parameters such as a facility's size, age and type of installation. For that reason, this paper is unable to provide anything more than basic signposting: options and areas where savings could potentially be made must always be discussed based on the circumstances of the individual case.

The components of a compressed air system are usually connected with tubes and a wide range of screw and plug connectors. All of these components represents a potential leakage point through which the air is able to escape into the environment. Practice has shown that leakages can account 8 – 10 % of total air consumption as well as that abouth 30 % of a compressed air can be lost through a leakage points in an average pneumatic system. Leaks can be largely prevented during the planning phase of a compressed air system with appropriate connection of the components and during the system's operation phase. In that phase, several measurements can be carried out in order to detect leakage points. By eliminating the leakage points the energy efficiency of a compressed air system can be significantly increased. It can be done by constant maintenance of a compressed air system, locating and eliminating the leakage points especially in older facilities with outdated equipment and components. It is easy to detect and eliminate major leakages but special devices and experts are necessary to locate small leakages.

In this paper are presented the results of reducing the consumption of compressed air, on example of one pneumatic, meat casings products machine located in Viscofan industry, Novi Sad, Serbia, before and after the machine has been repaired. The paper is organized in the following manner: in the Section 2 is given a short description of measurement process. Section 3 shows a results of compressed air consumption before and after measured measurements. At the end, in sections 4 and 5 the most important conclusions are performed together with cost analysis.

2. THE MEASUREMENT PROCESS

The factory has already made a decision to replace all pneumatic components in the control box (service unit and valves), due to the time-worn of control valves and compressed air equipment so there was good opportunity to measure, in addition to other effects (higher reliability, quick response of control valves, etc.) and the effects that this repairing will have on the consumption of compressed air.

2.1 Measuring equipment

For the experimental determination of compressed air consumption the AirBox [4] unit was used, Fig. 1. AirBox measures the consumption of compressed air based on the value of the characteristic flow and collects pressure values from the pressure sensor. The compressed air flows over a surface that is constantly heated and absorbs thermal energy from the warm surface. The heat sensor quantifies variations in temperatures representing a specific flow. The AirBox pressure measurements are less than 100 mbar at a measuring frequency of 100 Hz.

Measurement of compressed air consumption is provided in two ranges (two flow meters are built in) and the recording of these results:

- Small flows ranging from 10 to 200 Nl/min
- Large flow rates ranging from 100 to 5000 Nl/min
- *data logger* utilization with or without a computer.

Figure 1. Measuring device AirBox

2.2 Measurement procedure

AirBOX is positioned at the measuring position in the compressed air supply line before the service unit as is shown in Fig. 2. When adjusting the measuring device to the external conditions through the display of the flow sensor, the data settings in Table 1 have been made.

Figure 2. Position of AirBox during measurements

Table 1. Adjusting AirBox during measurements

Options	Off
Normal liters [Nl] based on standard	DIN 1343
Absolute pressure	1.01325
Temperature [°C]	0

The determination of compressed air consumption was done in static and dynamic mode. Measurements in static mode determine the level of compressed air leakage when the machine is under pressure and not operating, while the measurements in the dynamic mode indicate total consumption (leak + useful work) during the machine operating.

In order to measure consumption of compressed air in static mode, the machine was set for a certain period of time under the influence of compressed air without the active participation of the system's operating elements. After that, the consumption of compressed air is completely measured, which is fully allocated to leakage.

When determining the consumption of compressed air for the machine "Plisirka KUKO 19", several cycles were performed in the dynamic operating mode. One cycle is selected, determined its duration and the compressed air consumption is calculated. As the length of the cycle can vary depending on the operating conditions, an average value of 30 s was used for further calculations.

3. MEASURING CONSUMPTION OF COMPRESSED AIR

3.1 Consumption before repairing of the machine

The first measurement was done before the repairing the control box of pneumatic system was performed on this machine. The measurement results in the static and dynamic operating mode are given in Fig. 3 and Fig. 4.

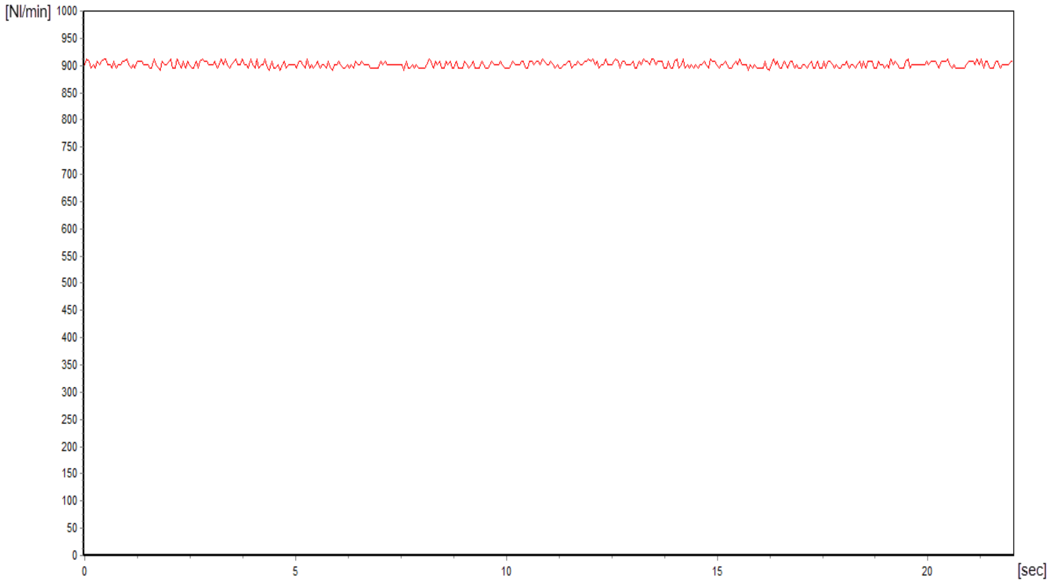

Figure 3. Consumption of compressed air of the machine “Plisirka KUKO 19” in static operating mode

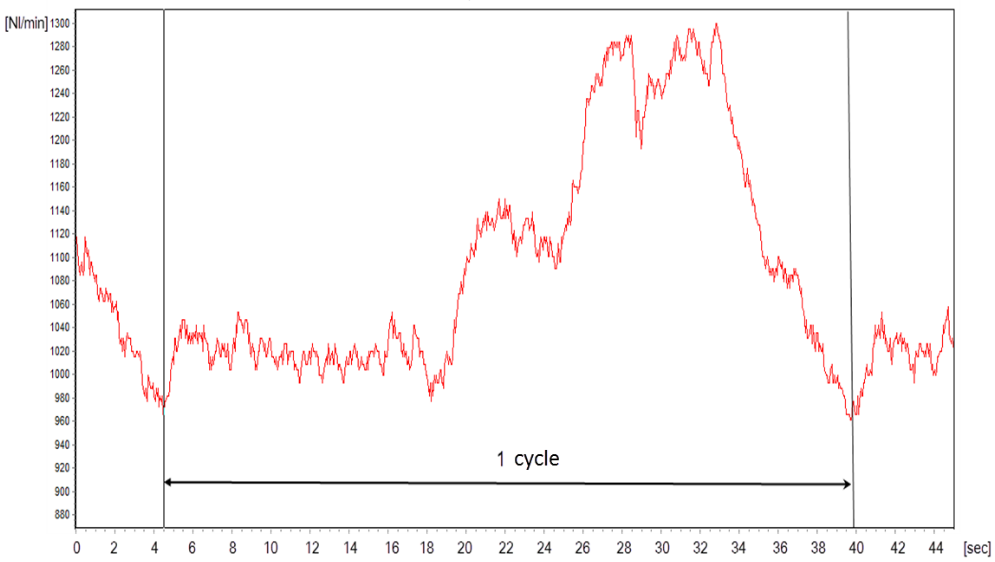

Figure 4. Consumption of compressed air of the machine “Plisirka KUKO 19” for one cycle in dynamic operating mode

Total consumption of compressed air in dynamic operating mode for one cycle amounts 650 l. Average consumption of compressed air in dynamic operating mode amounts 1114.29 l/min. Average consumption of compressed air in static operating mode amounts 905 l/min.

3.2 Consumption after repairing of the machine

The second measurement was performed after repairing the pneumatic control box system on this machine. The command valves and service unit have been replaced. The results of measurements in the static and dynamic mode are given in Fig. 5 and Fig. 6.

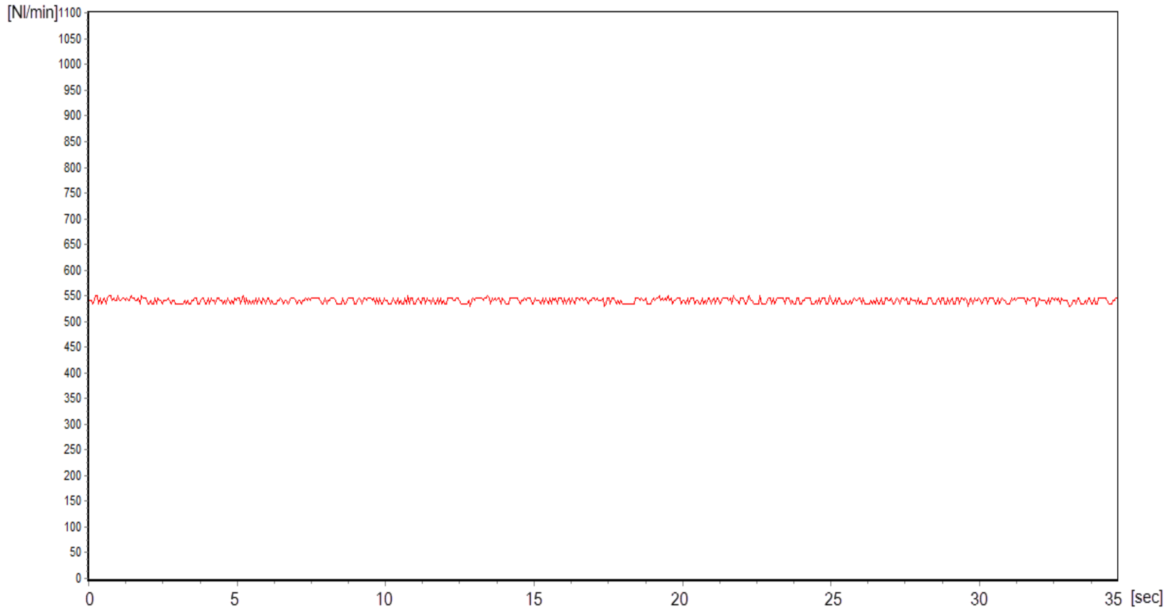

Figure 5. Consumption of compressed air of the machine “Plisirka KUKO 19” in static operating mode

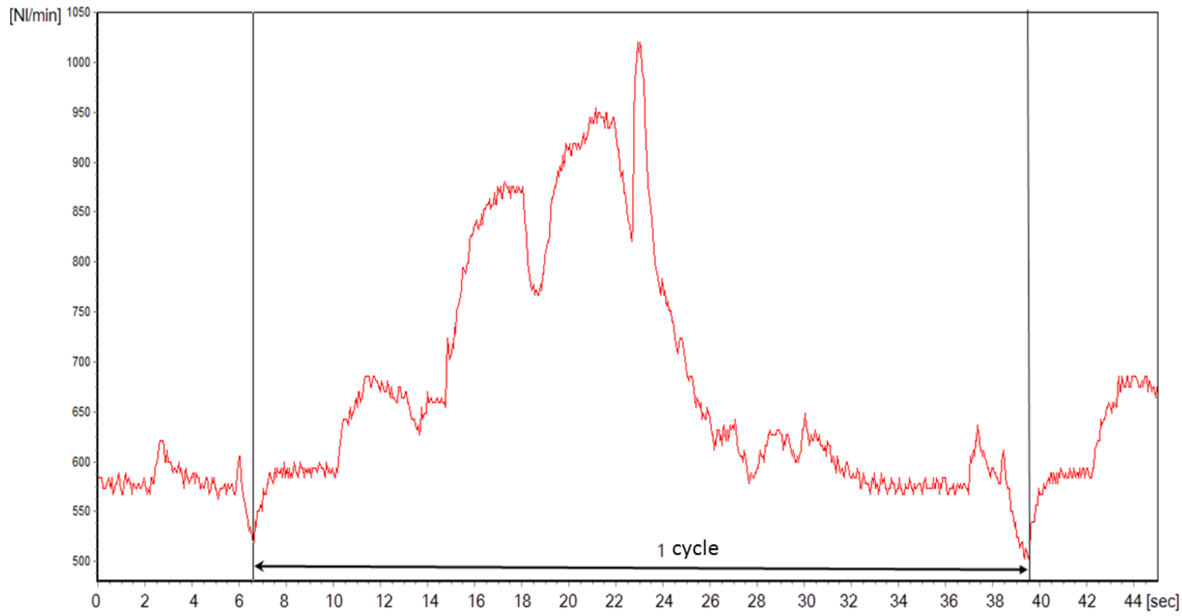

Figure 6. Consumption of compressed air of the machine “Plisirka KUKO 19” for one cycle in dynamic operating mode

Total consumption of compressed air in dynamic operating mode for one cycle amounts 370 l. Average consumption of compressed air in dynamic operating mode amounts 634.29 l/min. Average consumption of compressed air in static operating mode amounts 540 l/min.

4. COST ANALYSIS

On the basis of the information obtained about compressed air consumption, the following annual consumption analysis can be performed with the obtained values of the elements of the machine's operating mode (working hours during the day, number of working days and prices of one cubic meter of compressed air). Table 2 gives data on the basis of which the financial effects of compressed air consumption are calculated.

With this data it is possible to obtain compressed air costs at an annual level as given in Table 3.

Table 2. Elements of operating mode and costs of compressed air

Working time in one working day 0:00 – 24:00 with 100 min break	1440 min – 100 min = 1340 min
Number of working days in one year	350 days/year
Costs of one cubic meter of compressed air	0.025 €/m^3
Effective capacity (dynamic operation)	1340 min x 350 days = 469 000 min/year
Effective capacity (static operation)	350 days x 100 min + 15 days x 1440 min = 56 600 min/year
Time of one cycle (dynamic operation)	35 s
Number of cycles in one year (dynamic operation)	804 000 cycles/year

Table 3. Annual operating costs of the compressed air system

Total consumption of compressed air on an annual level during machine operating	469.000 min operating * 1,11429 m^3/min * 0,025 €/m^3 = **13 065.05 €**	469.000 min operating * 0,63429 m^3/min * 0,025 €/m^3 = **7 437.05 €**	**5 628 €**
Total consumption of compressed air on an annual level when machine does not work	(350 days * 100 min + 15 days * 24 h * 60 min) * 0,905 m^3/min * 0,025 €/m^3 = **1 280.58 €**	(350 days * 100 min + 15 days* 24 h * 60 min) * 0,54 m^3/min * 0,025 €/m^3 = **764.1 €**	**516.48 €**
At an annual level, the machine consumes compressed air in amount of	**14 345.63 €**	**8 201.15 €**	**6 144.48 €**

Static consumption, i.e. the leak of compressed air is present all the time, so it is contained in the consumption when the machine is operating. Therefore, in the costs of compressed air during the operation of the machine, more than 85 % is wasted on leakages, i.e. (540 / 634.29) * 7 437.05 € = 6 331.5 €. The total leakage losses are, accordingly, 7 095.6 €.

5. CONCLUSION

Based on the measurements of the compressed air consumption before and after the repair of the machine Plisirka KUKO 19, the following conclusions can be drawn:

- The consumption of compressed air before the repairing machine parts was extremely high (1115 l/min) with an enormous leakage rate of as much as 81 %. Static consumption, i.e. the leak of compressed air is present all the time, so it is contained in consumption when the machine is operating (running). Therefore, in the costs of compressed air during the operation of the machine, on leakage is lost (905 / 1114,29) * 13,065.05 € = 10,611.13 €. The total leakage losses before the overhaul were 11,891.71 € per year.
- After the repairing of the control box (change of the control valves and the service unit), there was a significant reduction in the leakage both in static and dynamic mode. The total reduction of compressed air consumption is 480 l/min or 43 %. Now in the costs of compressed air during the operation of the machine, on leakage is lost (540 / 634,29) * 7,437.05 € = 6,331.5 €. Total leakage losses, after repairing, were 7,095.6 € per year. However, due to the better operation of the control valves, there has been a decrease consumption of compressed air in the dynamic operating mode, so that the costs of compressed air have been reduced by 6,144.48 € annually. If it is assumed that the installed equipment will work for 10 years, the expected savings will be as much as 60,000 €.
- Even though the consumption of compressed air has been reduced by as much as 43 %, it is still very large because of the current consumption of 635 l/min, as much as 85 % goes to static consumption or losses. This suggests that the reconstruction of the control part of the machine should be continued in order to eliminate the leakage in the part of the distribution network (hoses and fittings) and on the actuators themselves (leakage between the piston and the cylinder as well as the leak between the rod and the cylinder cover).

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