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MODERNIZATION OF SHOT BLASTING PROCEDURE

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Introduction

Every company has the intention to produce the best quality product and get the highest profit. In the 21st century, it has become much harder to stay competitive because consumers have a large selection of equivalent goods. According to the data of *Lithuanian Department* of *Statistics,* last year Lithuania has experienced an economic recovery. *The Gross Domestic Product (GDP)* in Lithuania is increasing [1]. *GDP* is a pecuniary measure of the market value of all the final goods and services produced in a period of time (quarterly or yearly). This is the final result of the production of all units operating within the territory of the country [2]. Thus, growth of GDP has an impact on the manufacturing in the country. In order to produce more goods over a period, companies have to be modernized. The article will examine the growth of company X from September 2017 till August 2018.

The aim of the article is to evaluate optimization possibilities of shot blasting procedure in order to ensure the safety of employees and make this procedure efficient.

Research objectives. 1. To identify the disadvantages of shot blasting procedure in company X. 2. To identify possibilities of modernizing shot blasting procedure while ensuring the safety of employees. 3. To evaluate the cost of upgrading and enhancing the process.

Analysis of collected data from company X

Our investigated company is an Original Equipment Manufacturer (OEM). This company produces goods that are marketed by another manufacturers. The main activity of this factory is the assembly of components to produce the final product. During the previous financial year that started in September 2017 and ended in August 2018 the company grew rapidly. So did the number of employees (see Fig. 1).

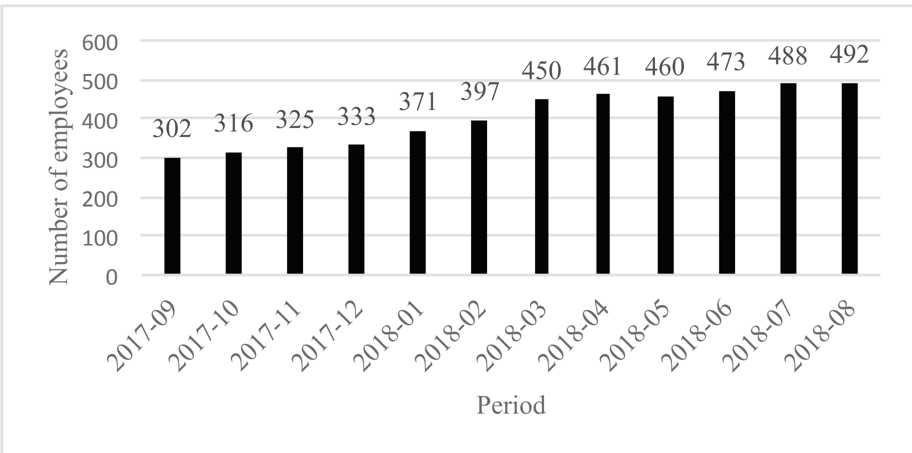

Fig. 1. Number of employees from 2017-09 to 2018-08

In order to carry out the company's activities even more efficiently, one has to think about its modernization. That is why nowadays factories become increasingly up-to-date and seek to start Industry 4.0. Industry 4.0 is a new digital industrial technology of automation and data exchange in manufacturing technologies. It includes the Internet of things, cloud computing, cognitive computing and cyber-physical systems [3].

At the moment company X is not equipped with a robotic line. Therefore it is very important to evaluate the costs of a new robotic line and predict on one hand when this investment will pay off and on the other that this modernization might not be profitable.

Company X receives large quantities of raw metal parts every day that come from the Far East. It takes about 4 months to get parts by trains or ships. During this period, parts get damaged by corrosion. The company could avoid this if all parts would come properly prepared from the supplier — coated by phosphate or anodized. Phosphate coatings are used on steel items for corrosion resistance. It serves as a conversion coating in which a dilute solution of phosphoric acid and phosphate salts is applied via spraying or dipping. The solution has a chemical reaction with the surface of the steel item being coated to form a layer of crystalline, insoluble phosphates. Anodizing is the most common method used to protect aluminum. It is an electrolytic passivation process used to increase the thickness of the natural oxide layer on the metal surface. This process increases resistance to corrosion and wear, and provides better adhesion for paint primers and glues than bare metal [4]. However, suppliers from the Far East do not ensure proper anti-corrosive procedures anymore. That is because from January 1st 2018 even more stringent environmental laws come into force in China [5]. So anodizing or phosphating are strictly limited. According to the data of the first half year of 2018, China is in the 12th place in the global pollution index. Meanwhile, for comparison, Lithuania is only in 86th [6].

This situation makes shot blasting process unavoidable in the factory. Shot blasting is used in almost every industry that deals with metal. It can be used to clean, strengthen (peen) or polish metal. This process is based on cleaning a surface by metal abrasives. Metal abrasives are round and chipped (with sharp angles) metal balls. This cleansing method is used to dishevel, give a matt effect, remove rust scurf or other impurities from various metal surfaces. Shot blasting allows reaching the highest efficiency and quality levels: metal is cleaned up to Sa 2 cleanliness grade. Properly machined, reinforced metal surface significantly lengthen the life of parts that are used in high load operations [7].

According to the ISO 8501-1 standard, there are four cleanliness grades – Sa 1, Sa 2, Sa 2½ and Sa 3. See Fig. 2 which represents the visual look of the grades [8].

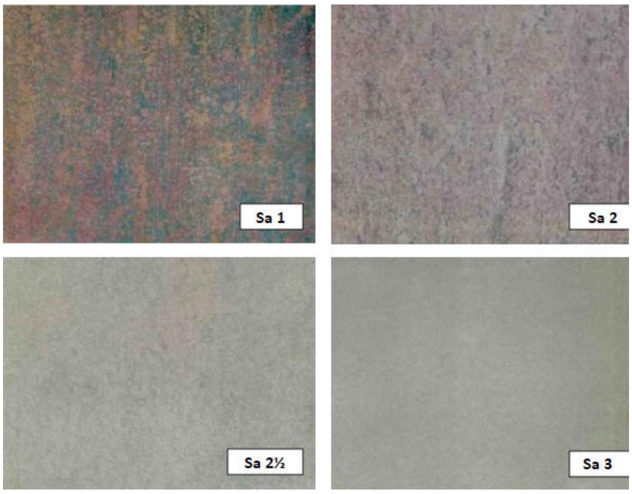

Fig. 2. Visual Sa cleanliness grades

All cleanliness grades are shortly described in table 1.

Table 1. ***Cleanliness grades***

Cleanliness grade	Cleanliness grade name	Short description
Sa 1	Light blast – cleaning	When viewed without magnification, the surface will be free from visible oil, grease, and dirt, poorly adhering mill scale, rust, paint coatings, and foreign matter.
Sa 2	Thorough blast – cleaning	When viewed without magnification, the surface will be free from visible oil, grease and dirt, most mill scale, rust, paint coatings and foreign matter. Any residual contamination will have firmly adhered.
Sa 2½	Very thorough blast – cleaning	When viewed without magnification, the surface will be free from visible oil, grease and dirt and from mill scale, rust, paint coatings and foreign matter. Any remaining traces of contamination will present only as insignificant stains in the form of spots or stripes.
Sa 3	Blast - cleaning to visually clean steel	When viewed without magnification, the surface shall be free from visible oil, grease and dirt and from mill scale, rust, paint coatings and foreign matter. It shall have a uniform metallic colour.

During a full working day of 8 hours, approximately 1000 pieces of metal parts go through the shot blasting machine. This workplace is operated by three employees. One employee hangs all of the parts on the rack and pushes it to the shot blasting machine and after approximately a three-minute procedure takes it out. Then two employees unhang the parts and strongly shake the parts that have tubes. The company paints all parts in the factory, thus it is very important not to leave metal abrasive inside or on top of the parts. That is why shaking parts after shot blasting is necessary. If parts go through painting with metal abrasives, the painting line gets dirty and the painted surface is damaged.

After closely analysing the shot blasting procedure, it is obvious that workers are facing hazardous conditions. The analysed data is submitted in table 2. Verification data is based on a professional risk identification card.

Table 2. ***Verification data***

Checked factor	Permissible size	Measured size	Risk evaluation
Air temperature	(15-21) °C	19 °C	Acceptable
Relative humidity of air	Up to 75 %	49 %	Acceptable
Air travel speed	Up to 0,4 m/s	0,05 m/s	Acceptable
Lighting	(300-500) lx	178 lx	Unacceptable
Noise	87 dB	83,5 dB	Acceptable
Work posture:			
Neck, shoulder	≤3	4	Unacceptable
Elbow, wrist		4	Unacceptable
Back		3	Acceptable
Clubs, legs		3	Acceptable
Single hand loaded weight	For men up to 30 kg	Up to 4 kg	Acceptable
Hand-held load mass distance from the worker's body	Up to 70 cm	Up to 50 cm	Acceptable
Static work by shift, holding weight with one arm	For men up to 43000 kg×s	22400 kg×s	Acceptable
Static work during the shift, holding weight with two hands	For men up to 97000 kg×s	38000 kg×s	Acceptable
Permanent repetitive movements (muscle of the arms and shoulders)	≤20 000 times per shift	5200 times per shift	Acceptable

The analysis allows us to draw conclusions that modernization in this part of production seems logical and necessary. In order to automate the current process, the company needs to have a robot that takes the parts from the delivered pallet, hang them on the hanger and push them into a shot blasting machine. After blasting, the robot removes the parts and shakes each of them. This would allow to eliminate the workload of three people.

Evaluation of modernization

In order to evaluate the financial outlay, calculations are required.

The robot has the capacity to replace three employees. The amount of money paid per year for salary is calculated by a formula (1):

$$A = n * mw * k * 12; \quad (1)$$

where
A – the amount of money paid per year for salary, Euros;
n – the number of workers;
mw – minimal wage, Euros;
k – work factor ratio;

$$A = 3 * 400 * 1{,}4 * 12 = 20160 \text{ euros.}$$

Costs of a new robot in the factory consist of four main parts: the price of the robot, peripheral equipment (safety barriers, safety systems, safety sensors, HMI's), engineering costs (programming, installation, commissioning) and project management costs [9].

Industrial 6 axis robot costs an average of 15000 euros [10]. Selected IKV robot is shown in Fig. 3.

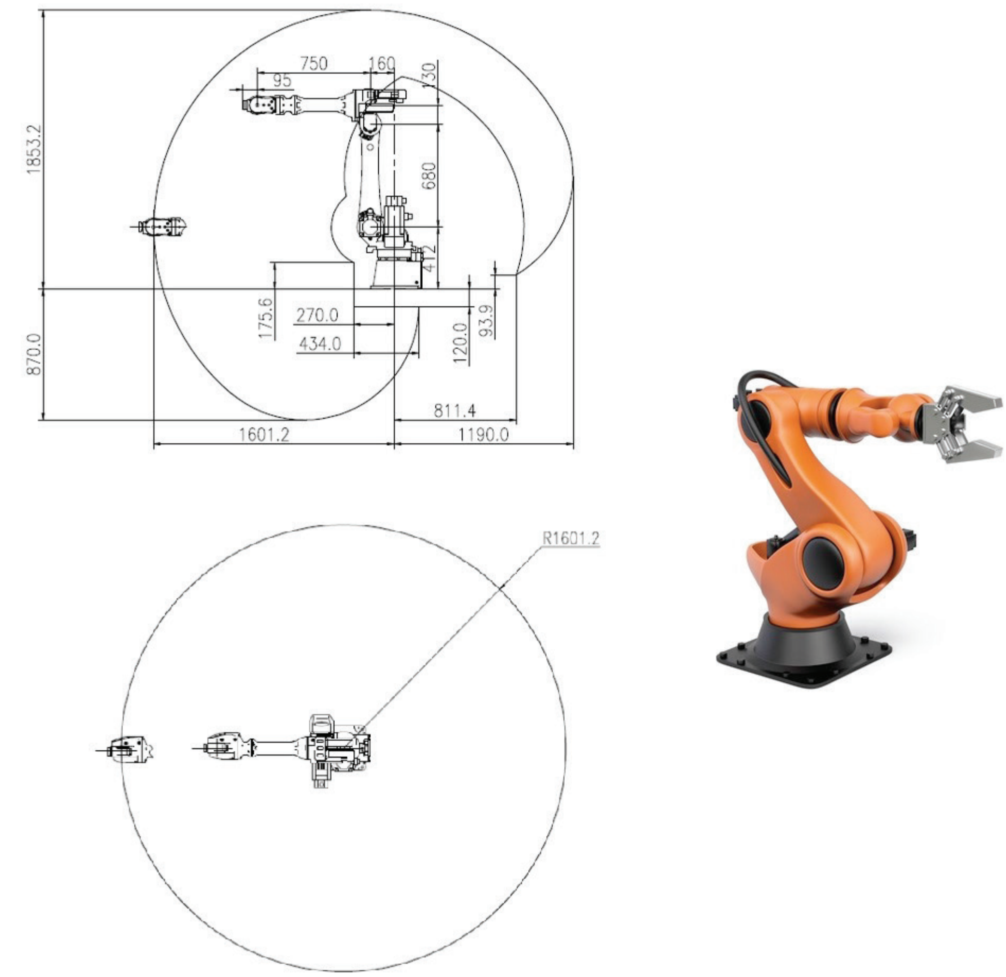

Fig. 3. Industrial 6 axis robot

All peripheral equipment costs around 15000 euros. This price includes a gripper, sensors, a platform, and all required installations. Engineering is the most expensive part of the costs. The robot would perform many different tasks (taking and transferring parts to the machine, taking them out, shaking and transferring them on the last rack) and replace three employees, hence the programming would be very advanced. It would take a few months until the robot would do all accurate tasks so the costs would reach around 18000 Euros. Project management would be related to one of the company's engineers. So no extra costs would be spent. The robot has 1-year warranty and the seller states that all necessary help is included in the price of the robot [10]. All costs are submitted in table 3.

Table 3. ***Costs of robot***

Name	Price, euros
Robot	15000
Peripheral equipment	15000
Engineering costs	18000
Project management	0
Total:	48000

All expenses estimate to 48000 euros. Compared to the salary paid for three employees, the numbers support robotisation as a valid measure. Below is the calculated time in which this project would start paying off by formula 2:

$$T = \frac{Rc}{\left(\frac{A}{12}\right)}; \tag{2}$$

where
Rc – Robot implementation costs, Euros;

$$T = \frac{48000}{\left(\frac{20160}{12}\right)} = 28{,}57 \approx 29\ months.$$

After 29 months into robot operation, the robotization would become profitable. Conditionally low costs of the robot indicate that nowadays robotization is becoming more and more popular and the market is becoming increasingly competitive.

The International Federation of Robotics (IFR) estimated that the annual worldwide supply of industrial robots will increase by almost 40% during the next two years (see Fig. 4) [11]. Sooner or later, robotization is unavoidable and Industry 4.0 will be implemented in all factories.

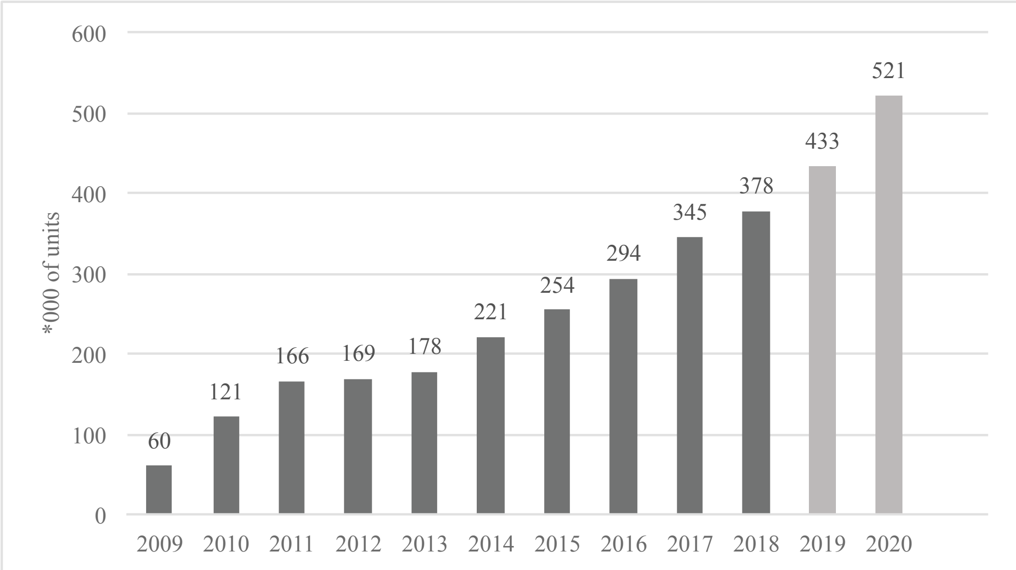

Fig. 4. Estimated annual worldwide supply of industrial robots according to IFR

Virtual checking

Nowadays there is a possibility validate company modernization before buying components using virtual manufacturing (VM) software. VM stands for the use of computers to model, simulate and optimize the critical operations and entities in a factory. VM started as a way to design and test machine tools but now expanded to production processes and the products themselves [12]. The software which is used in this article is *Visual Components*. It is a leading developer of 3D simulation software and solutions for manufacturing. The software was released 18 years ago [13] so the user can be sure that creating the simulation with this program will reach an advanced level. Creating simulations and making decisions with the help of *Visual Components* let us eliminate mistakes and unnecessary loss. The user can implement some of LEAN principles when creating simulation. The LEAN basic goal is to provide the biggest value to the customer through the biggest value creation process that has zero waste [14].

Created visualization of modernized shot blasting procedure is shown in Fig. 5. Simulation of modernized shot blasting workplace was created according to all of the above information.

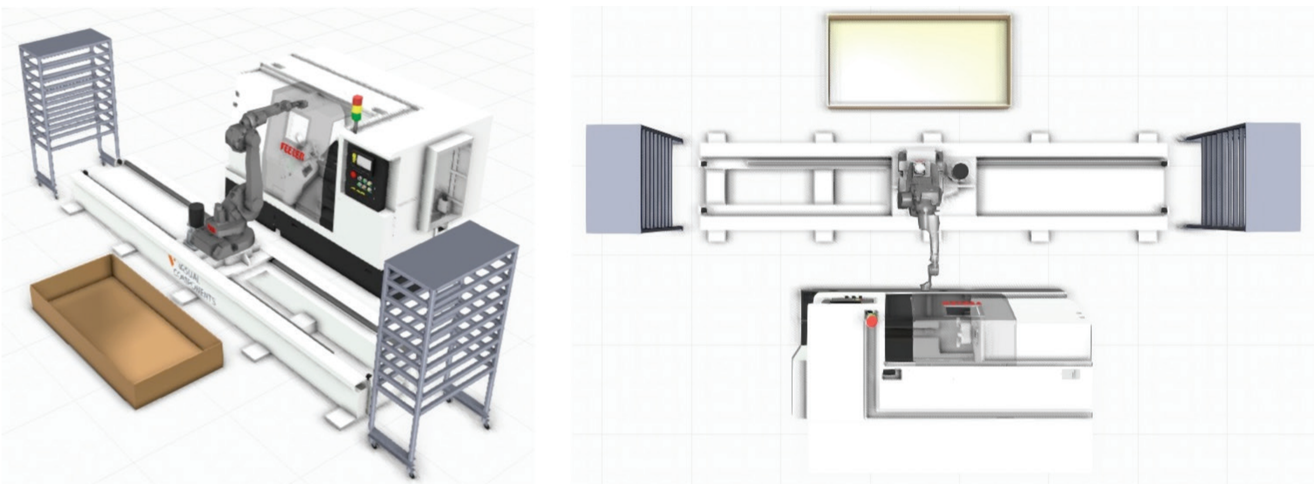

Fig. 5. Modernized shot blasting operation created with *Visual Components*

Conclusions

1. Analysis of collected data from company X showed that there was a huge growth during the last financial years.
2. In the article, the principle of shot blasting was briefly explained.
3. Cleanliness grades according to ISO 8501-1 standard were reviewed in this work.
4. Inspection in shot blasting work place was done and all verification data submitted according to a professional risk identification card.
5. In the first 29 months the modernization has the capacity to become a profitable investment.
6. Worldwide supply of industrial robots will increase almost 40% during next two years according IFR.
7. Virtual check was carried out with *Visual Components* software – virtualized work place was submitted in the article.

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Summary

MODERNIZATION OF SHOT BLASTING PROCEDURE

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Every company has the intention to produce the best quality product and get the highest profit. In the 21st century, it has become much harder to stay competitive because consumers have a large selection of equivalent goods. This article analyses company's X growth in reference to the shot blasting process in order to investigate if modernization is feasible. Tests of shot blasting work place safety were carried out and all information submitted in a professional risk identification card. Calculations were made to investigate if the robotisation is profitable. Virtual simulation of robotic line was created with *Visual Components* software.

Keywords: *modernization, shot blasting, robotisation, virtual manufacturing, Visual Components.*

Santrauka

SRAUTINIO VALYMO ŠRATAIS OPERACIJOS MODERNIZAVIMAS

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Visos kompanijos siekia pagaminti geriausios kokybės produktą ir gauti didžiausią pelną. XXI a. vis sunkiau išlikti konkurencingam, nes vartotojui pateikiamas platus to paties produkto pasirinkimas. Straipsnyje analizuojamas kompanijos X augimas ir aiškinamasi vienos iš gamybos operacijų (srautinio valymo šratais) modernizavimo galimybė. Atlikti srautinio valymo šratais darbo vietos saugos tyrimai ir visa informacija pateikta profesinės rizikos kortelėje. Straipsnyje pateikiami skaičiavimai, įrodantys operacijos modernizavimo naudingumą. Virtuali gamybos linija buvo sumodeliuota su *Visual Components* programa ir pateikta straipsnyje.

Prasminiai žodžiai: *modernizavimas, srautinis valymas šratais, robotizacija, virtuali gamyba.*

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