

AUTOMATION OF PRODUCTION PROCESSES AS AN ELEMENT OF IMPROVEMENT OF THE PRODUCTS' QUALITY

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Tomasz Hermaniuk¹ – *orcid id: 0000-0001-5884-8408*

¹University of Rzeszow, **Poland**

Abstract: Increasing global competition, changes in the environment and the increasing complexity of supply chains force companies to look for more effective solutions that meet the needs and requirements of customers. The development of information and communication technologies (ICT) can help to cope with these challenges. It can be observed that automation and industrial robotics in production are increasingly attracting the attention of scientists and practitioners. The article presents the situation of selected production companies in terms of readiness and the level of interest in the implementation of solutions that automate manufacturing processes.

Keywords: quality, production, automation, process, cobot

1. INTRODUCTION

The modern approach to production optimization is mainly concentrated on turning traditional production into automatic. Traditional technology is associated with the need to employ an adequate number of qualified employees, which usually translates into high operating costs of the company. Modern economies struggle with the problem of the lack of employees with appropriate qualifications, which is becoming a significant problem in many industries.

Streamlining production processes with industrial devices, robots or dedicated solutions significantly helps to reduce the number of necessary employees and increases production efficiency, which in turn allows companies to optimize production costs. These solutions are related to automation processes that are constantly gaining the interest of entrepreneurs around the world.

Automation means a significant reduction or replacement (process of replacing) human physical and mental work by the work of machines operating on the principle of self-regulation and performing specific activities without human participation (i.e. self-acting). Also the use of machines for work impossible to be performed in any other way. Automation is the next stage after mechanization, where direct human work is necessary to produce the final product (Gupta, 2007).

2. METHODOLOGY OF RESEARCH

In order to determine the state of knowledge and the potential demand for solutions automating industrial production, a questionnaire survey was carried out. The survey was conducted in the period from April 28 to May 14, 2020. A questionnaire consisting of closed questions was used as a research tool.

The aim of the study was to find out the level of awareness and expectations of potential buyers of products and services related to the automation of production processes with the use of robots and cobots.

The survey was conducted among representatives of 28 companies from the manufacturing industry. The selection of the sample was deliberate. Respondents selected for the study had to have an appropriate knowledge about production processes, the possibilities of their automation and were able to assess the possibilities of automating processes in the represented companies.

Questionnaire used in the survey:

1. How can you assess the level of experience of your company in the field of automation of production processes?
 - no experience
 - small
 - average
 - high
 - very high
2. Have you considered implementing automation of the production process? If so, in what form?
 - robot
 - cobot
 - feeder
 - conveyor
 - we did not consider such an option
 - other, what kind?
3. What kind of barriers do you see in the automation of the production process in your plant (1 - insignificant barrier, 5 - very important barrier)
 - short production series
 - variable and unique assortment
 - lack of knowledge about technical possibilities in the field of automation
 - large financial outlay in relation to the potential benefits
4. If there was such a possibility, would you be interested in leasing automation solutions billed per hour of actual system operation?
 - definitely yes
 - rather yes
 - hard to say
 - rather not
 - definitely not
5. In case of interest in process automation, what kind of organizational changes that would improve efficiency and increase the efficiency of investment in process automation would you allow? (0 - not feasible option, 5 - very easy option)
 - introducing work in a two- or three-shift system

- change of machinery layout in production halls
 - changes in the way of operating CNC machines
 - changes in staffing employees
6. How would you rate the difficulty of integrating the cobot / robot into the production process in your company?
- very easy - 1
 - easy - 2
 - average - 3
 - difficult - 4
 - very difficult - 5
7. Would you consider supporting a specialized company in the process of implementing a production automation station?
- definitely yes
 - rather yes
 - hard to say
 - rather not
 - definitely not

3. RESULTS

In order to diagnose the degree of advancement of the surveyed companies in the field of implementing solutions that automate production, respondents were asked about the company's level of experience in the field of automation of production processes. The obtained results are shown in Figure 1.

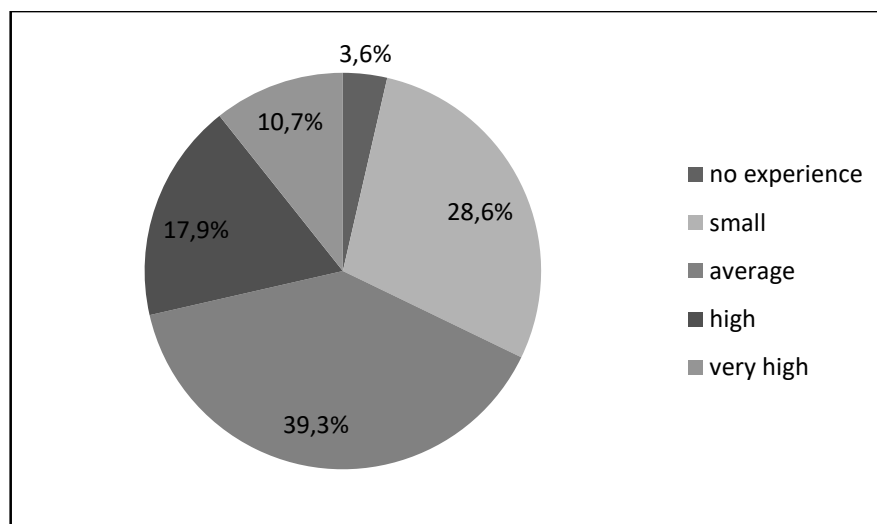


Fig. 1. The level of experience of companies in the field of automation

According to the presented data, the largest part of companies representatives (39.3%) declares an average level of experience in the field of process automation. A low level was declared by 28.6% of the respondents, and zero experience was indicated by a representative of only one company. In turn, the high level was indicated by 17.9% of the respondents, and the very high - 10.7%. The results allow to state the existence of a certain level of experience of the surveyed companies in the studied area.

In the next question, the respondents were asked to provide information on whether (and in what form) they had already considered implementing automation of production processes in factories. The obtained results are shown in Figure 2.

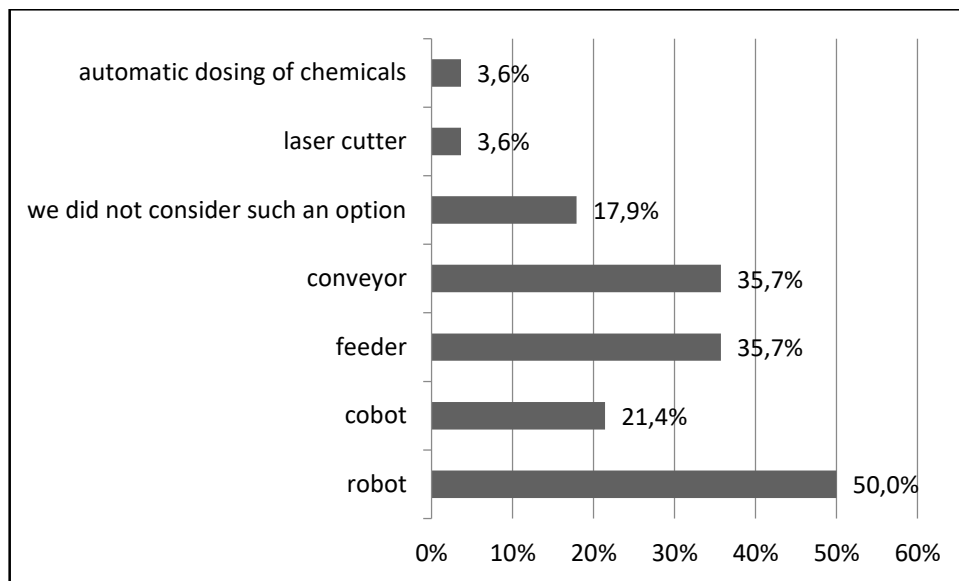


Fig. 2. Process automation forms considered in the surveyed companies

According to the presented data, exactly half of the representatives of the surveyed companies confirmed that the plant board was considering the implementation of process automation with the use of robots. The second place in terms of the number of responses (35.7%) was taken ex aequo: the feeder and the conveyor. The solution considered by 21.4% of respondents was the cobot. In turn, five companies have not considered such an option at all, and the representatives of two plants chose the "other" option, declaring their interest in a laser cutter and automatic chemical dosing.

In the further part of the study, the respondents were asked to indicate the most important barriers to the implementation of solutions automating the processes occurring in the plants they represent. Individual barriers could be assessed on a scale from 1 to 5, where 1 meant a barrier of little importance, and 5 - a barrier that was very important. The most important internal barrier (rating 3.18 / 5), hindering the implementation of automation of production processes in the surveyed companies, turned out to be short production series. Second in terms of the scale of limitations (3.07 / 5) were ex aequo: the variability of the assortment and the high level of outlays in relation to the potential benefits. The least significant barrier (2.36 / 5) was the lack of knowledge about the possibilities of production automation.

In the next question, the respondents were asked to indicate the level of interest in the possibility of leasing solutions that automate processes. The results are shown in Figure 3.

An enthusiastic attitude prevails among the representatives of the surveyed enterprises. Positive answers "definitely yes" (10.7%) and "rather yes" (42.9%) were given by the majority of respondents (53.6%). The answer "rather not" was given by 14.3% of the respondents. Nearly one third (32.1%) of the respondents were unable to take an unequivocal position. The answer "definitely not" was not given by any of the respondents. The obtained results allow to assume that there is a potential for offering

automation implementations that will not require large investment outlays on the part of production plants.

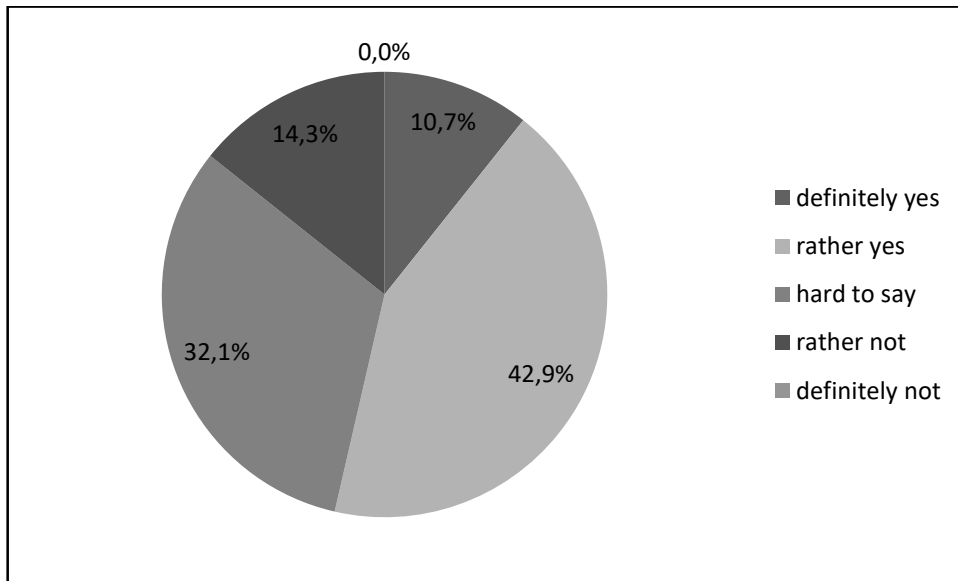


Fig. 3. The level of interest in leasing automation solutions

Each implementation of solutions that automate processes entails the need to introduce certain organizational changes aimed at adapting the plant to the new realities of operation. Therefore, the next question of the survey concerned the area of changes that companies anticipate and allow in such a situation. The expected changes pointed out by respondents were: the introduction of work in a two- or three-shift system, a change in the layout of machines in the production halls, changes in the way CNC machines are operated, changes in staffing employees. The level of difficulty of the proposed changes was assessed by the respondents on a scale from 0 to 5, where 0 meant an impossible change, and 5 - a very easy option.

Despite the apparent dispersion of the results, the averaged values are surprisingly similar to each other and amounted to, respectively:

- introducing work in a two- or three-shift system - 2.71,
- change of machinery layout in production halls - 2.68,
- changes in the way of operating CNC machines - 2.75,
- changes in staffing employees - 2.71.

In all investigated plants, potential changes associated with with the implementation of automation solutions were rated at an almost identical, moderate level. This means that company representatives did not see any significant obstacles on the way to introducing solutions that can automate production processes.

In the next question, the respondents were asked to assess the degree of difficulty of integrating a cobot or a robot into the production processes carried out in their companies on a scale of 1 to 5, where 1 meant very low, and 5 - a very high level of difficulty. The obtained results are shown on Figure 4.

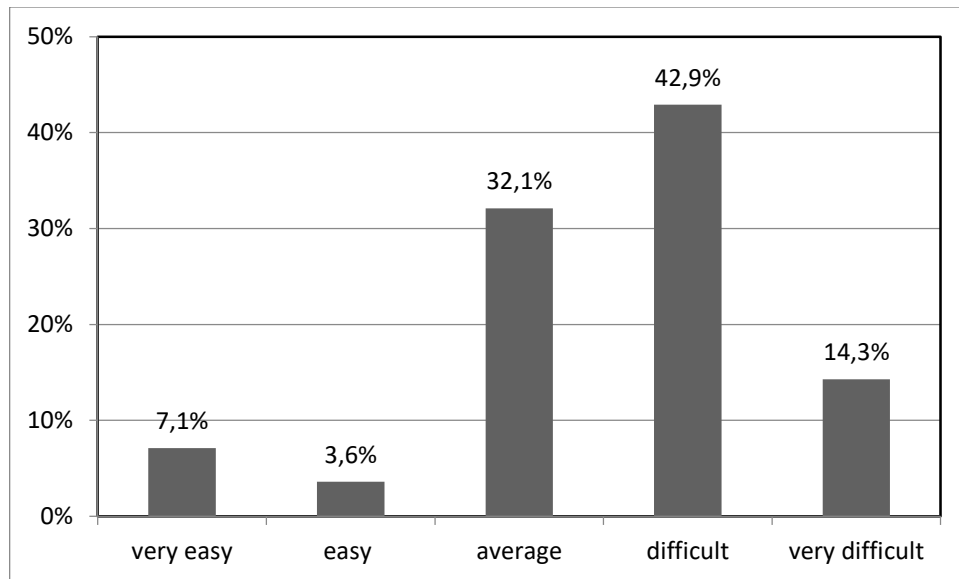


Fig. 4. Expected degree of difficulty in integrating the cobot/robot in the company

According to most respondents, the level of difficulty involved with implementation is high. The answer "difficult" was given by 42.9% of the respondents, and "very difficult" - 14.3%. According to 32.1% of respondents, the anticipated level of difficulty turned out to be "average". Only in 10.7% of cases, the respondents assessed it as "easy" or "very easy". On the one hand, the obtained results may indicate competency gaps or ignorance of the respondents in the topic under study. On the other hand, they suggest the need for specialist advice from the implementing company.

In the next question, the respondents were asked to state whether they would undertake the implementation of a production automation station on their own. As many as 67.9% answered this question positively, and 32.1% negatively.

An equally important issue is information on whether companies are interested in the implementation of solutions that automate production processes by specialized units. The last question was about this issue, and the results are shown in Figure 5.

As can be deduced from the presented data, most of the representatives of the surveyed units express interest in external support during the implementation of processes that automate production. Positive answers were given by a total of 60.7% of the respondents, 25% answered "definitely yes", and "rather yes" - 35.7%. Negative answers ("definitely not" were given by only two (7.1%) respondents.

In turn, 32.1% of the respondents did not take an unequivocal position on this issue. The obtained results allow conclusions about the existing potential in the scope of providing implementation services in the field of production automation.

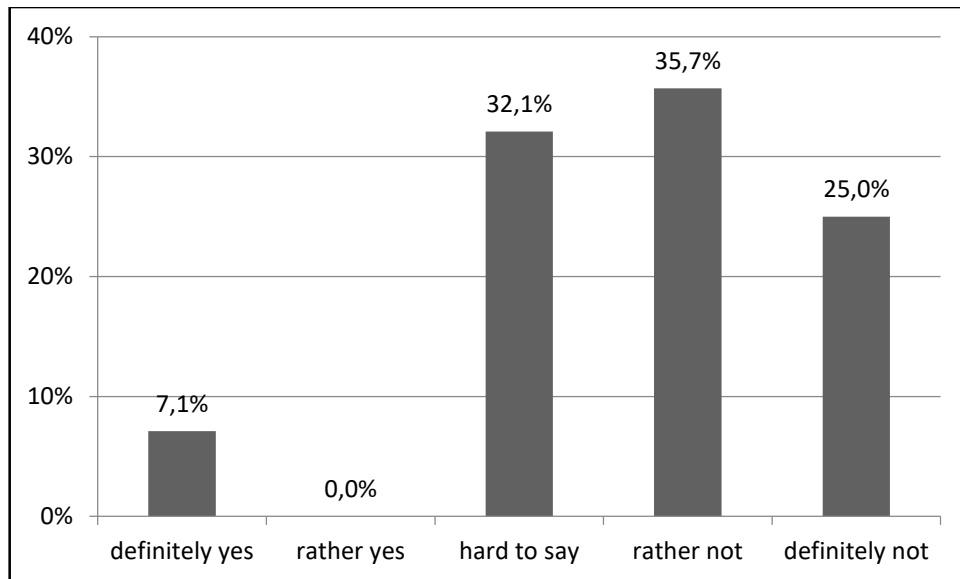


Fig. 5. The degree of interest in external support in the implementation of production automation stations

4. DISCUSSION

Growing global competition, changes in environments and increasing complexity of supply chains force companies to find more efficient solutions for satisfying customer needs and requirements. The developments of Information and Communications Technologies (ICT) can help to deal with these challenges. It can be observed that automation and industrial robotics in manufacturing are increasingly getting attention of academics and practitioners.

This market has witnessed a dynamic growth over the last few years (Covid 19 pandemic increased the speed of adoption of automation technologies) and it is still going to grow in the future. According to Mordor Intelligence data (Global Factory, 2020), the industrial automation market (and industrial control systems) was valued at USD 194.67 billion in 2020, and by 2026 it is expected to reach USD 339.56 billion, registering a CAGR of 9% in the period 2021-2026. Grand View Research (Smart Manufacturing, 2020), using the broad term Smart Manufacturing, estimated the market size in 2016 at USD 172 billion. According to forecasts, in 2025 the market should grow to USD 395.24 billion.

The report of the Mordor Intelligence group on the Industry 4.0 market (Industry 4.0, 2020) also shows the forecast of spectacular growth. Globally, revenues in this market were valued at USD 86.03 billion in 2020. In 2025, an increase to USD 220.43 billion is forecast with a CAGR of 20.71%.

Automation technology can be viewed from two approaches: Lean Production and Industry 4.0. This concept is gaining more attention as radical technological advancements of Industry 4.0 can help to foster lean manufacturing (Kolberg and Zühlke, 2015).

Industry 4.0 is a strategic initiative of German government presented in 2011 to transform manufacturing industrial sector (Rojko, 2017). Industry 4.0 enables real-time planning of production plans, along with dynamic self-optimization thanks to disruptive technologies such as Internet of Things, big data or machine learning (Kagermann et al., 2013). It offers enhanced connectivity and decentralized control, significantly changing organizations.

Lean manufacturing can be defined as “an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability” (Shah and Ward, 2007).

These authors presented 10 major elements of lean manufacturing i.e. (Shah and Ward, 2007): supplier feedback, Just-In-Time (JIT), supplier development, customer involvement, pull production, continuous flow, setup time reduction, total productive/preventive maintenance, statistical process control, employee involvement. These elements can be grouped into supplier factors, customer factors, process factors, as well as control and human factors. Process factors can be analyzed from automation potential point of view and automation offers a wide range of possibilities in this field helping to reduce waste which is a major goal of lean manufacturing.

The above-mentioned lean automation offers a lot of benefits. A research by Graetz suggests that increased automation contributed approximately 0.36 percentage points to annual labor productivity growth (Graetz and Michaels, 2018). Many authors (Shahin et al., 2020; Khanchanapong et al., 2014) suggest usage of automation can bring significant benefits in terms of operational performance (cost, flexibility, lead time or product quality). Hence, companies driven by the search for better result invest in automation.

5. CONCLUSION

Based on the conducted research, it can be concluded that among the surveyed units there is already a certain level of experience in the field of production automation. The largest part of companies representatives (39.3%) declares an average level of experience in the field of process automation. In turn, the high level was indicated by 17.9% of the respondents, and the very high - 10.7%.

Half of the representatives of the surveyed companies confirmed that their boards were considering the implementation of process automation with the use of robots. So far, five companies have not considered such an option at all.

In the vast majority of plants, there are activities that, due to their specificity, constitute a group that can be automated in the first place.

The most important internal barrier (rating 3.18 / 5), hindering the implementation of automation of production processes in the surveyed companies, turned out to be short production series. Second in terms of the scale of limitations (3.07 / 5) were *ex aequo*: the variability of the assortment and the high level of outlays in relation to the potential benefits. The least significant barrier (2.36 / 5) was the lack of knowledge about the possibilities of production automation.

The level of anticipated implementation difficulties is high. On the one hand, the obtained results may indicate competency gaps or ignorance of the respondents in the topic of the study. On the other hand, they suggest the need for specialist advice from the implementing company.

Most of the representatives of the surveyed units (60.7%) express interest in the possibility of supporting the implementation by an external company.

The obtained results indicate that in the future, the interest in automating processes through the use of robots and cobots should systematically grow.

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