THE IMPORTANCE OF APPLYING SELECTED INDUSTRIAL ENGINEERING TOOLS AND METHODS IN PROCESS IMPROVEMENT

VANESSA PRAJOVA[1], KATARINA LESTYANSZKA SKURKOVA[1], FILIP PRAJ[1], VIERA BESTVINOVA[1]

[1]Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology in Trnava, Institute of Industrial Engineering and Management, Slovakia

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e-mail: vanessa.prajova@stuba.sk

Among the key activities of managing an organisation is to be able to make timely and correct decisions. Making the right decision is necessary to ensure the organisation's competitiveness [Lestyanszka 2014a]. Organisations are trying to reduce production costs as much as possible, but this, on the other hand, brings negatives in the form of products that do not meet customer expectations. This phenomenon, however, has other downstream processes that burden the organisation and make it more difficult to continue its activities. These are customer complaints, the cost of eliminating the claimed defects, downtime, etc. [Lestyanszka 2014b, Husain 2021].
Therefore, the successful functioning of any organisation depends on its ability to adapt to changing customer requirements, as these are a priority in the market [Szander 2014, McDonnell 2013]. An effective tool for quality improvement is statistical methods and tools, which are not only advisable but essential to be implemented in production processes. Without systematic quality management, an organisation cannot grow, as it has to combine enormous efforts in developing and introducing new products with maximum quality maintenance of the already established ones.

KEYWORDS

process, capability, scale, production equipment, tools and methods of industrial engineering

1 INTRODUCTION

Business processes according to their importance for the enterprise can be divided as follows [Basl 2012, Kucera 2017]:
- *Core / key processes* - they are designed to fulfill the mission of the company, satisfy the needs of all customers of the company. They create value in the form of a product or service.
- *Supporting / enabling processes* - create the conditions for the functioning of other processes by delivering tangible intangible outputs. They are not part of the value chain [Krenicky 2022].
- *Network / communication processes* - providing communication, information and knowledge flows, information logistics, etc.
- *Control / management processes* - provide for the development and management of business performance and create an enabling environment for the functioning of internal processes.

All kinds of processes are important for every enterprise, as each of the processes has its own importance in ensuring the operation of the enterprise and achieving the set objectives [Murcinkova 2021]. The main processes depend primarily on the business object, supporting and control processes occur in each type of enterprise with only minor variations.
The strength of the competitive environment forces enterprises to continuously optimise and improve business processes [Dima 2010, Modrak 2017]. Customers demand that their needs be met in sufficient quality and quantity and, if their needs are not met, they move to a competitor. Businesses that do not want to lose their competitive advantage and customers should measure, monitor, evaluate, improve and document their processes. This process can be repeated again and again to continuously improve business processes [Malega 2014].
Every company strives to produce the highest quality products as quickly as possible at the lowest cost. The unit prices of inputs for production materials, machinery and equipment, prices for the purchase of labour, prices for energy, etc., are approximately the same for all enterprises [Dyadyura 2021, Khosravi 2022]. For well-functioning enterprises, it is very difficult to look for margins in this respect that would lead to a reduction in production costs, an increase in quality and an improvement in on-time delivery. These costs are fairly fixed.
One possible way to improve the success of a business is through process improvement, which can be done as an activity from the top - engineering, a "select group" or an activity from the bottom by the workers closest to the process [ipaslovakia 2023]. There is no single pattern for how to use and interrelate the different types of improvement activities. Each enterprise adapts its improvement system to its specific conditions.
Process improvement is a process that changes key business processes in order to improve their performance. The agents of these changes are all employees in the company.

The importance of improvement for the company

- problem solving in the spirit of the internal supplier and customer principle;
- cost reduction;
- improving quality;
- increasing productivity;
- improving order and cleanliness in the workplace;
- ergonomics;
- improving safety at work;
- improving the working environment;
- improving the environment;
- improving communication;
- improving work organisation;
- reducing circulating inventories;
- improving company culture;
- improving material flows [ipaslovakia 2023].

The importance of improvement for workers

- evaluation and remuneration;
- self-education (when a worker wants to solve a problem, he/she must understand it);
- motivation to actively engage in problem solving;
- better opportunity to solve problems together with the customer;
- elimination of stereotyped, monotonous work;
- encouraging teamwork;
- improvements in company culture (communication, information, visualisation, etc.);
- improving work ergonomics;
- improving the working environment;
- improving safety at work [ipaslovakia 2023].

The importance of improvement for the customer

- improving the quality of supply;
- refining delivery deadlines;
- minimising delivery quantities;
- reducing prices;
- better possibility to solve problems together with the supplier [ipaslovakia 2023].

The importance of improvement for the supplier

- the possibility to refine planning;
- clear definition and standardisation of customer requirements;
- improved communication with the customer, participation in problem solving;
- revealing potentials for improvement [ipaslovakia 2023].

2 METHODOLOGY

Our research task was focused on the application of quality management in the form of a survey in various sectors of industrial practice. 135 organisations were contacted by questionnaires and the questionnaire contained 61 questions. Those questions were selected which are directly related to the issue of this paper. We dealt with the application of the questionnaire only in organizations that have a quality management system in place, which accounted for 87%. The surveyed organizations were divided according to whether they have an SMK in place according to ISO 9001, then organizations that have an SMK certified according to TS 16949 and the last category was organizations focused on the military industry with an SMK in place according to the AQAP model.

In the following, only selected questions and their results related to the application of tools and methods in industrial practice will be presented.

Are criteria and methods specified to ensure effective operation and management of processes?

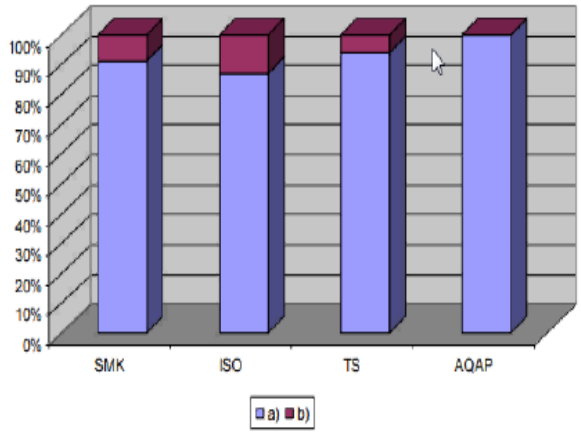

Figure 1. Graphical representation of responses

We found that 91% of the surveyed organizations have specified criteria and methods to ensure effective operation and management of processes, while 9% of the organizations do not have such criteria and methods.

In terms of the established SMK model, we can say that all organisations with established SMK according to AQAP have these criteria and methods specified. We do not find this specification of criteria and methods to ensure effective operation and management of processes in organisations with an ISO model (13%) and TS (6%). We consider that they are probably defined only for key processes that affect the quality of the output product.

Which industrial engineering methods do you currently use most often to improve processes in the context of Industry 4.0 elements?

The next question was about specific industrial engineering methods for process improvement. The results showed that FMEA was the most commonly used method in all the companies surveyed. KAIZEN was found to be the second most frequently used method, but SPC and MSA, which I am primarily involved with in my teaching and publishing activities, are not insignificant. The results from the survey related to this questionnaire question can be found in Figure 2.

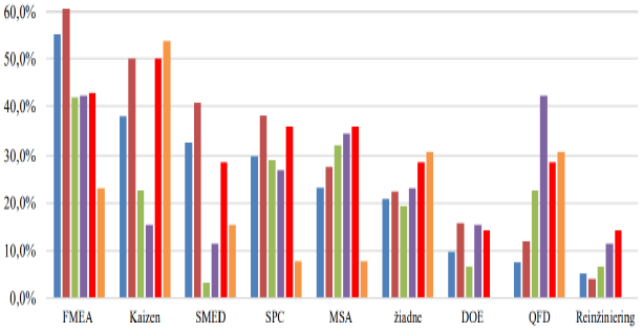

Figure 2. Methods applied in the monitored industries

The results of both projects demonstrated the need for monitoring, evaluation and improvement of processes and also the implementation of methods for process analysis and improvement. By analysing the questions and conclusions of the project VEGA 1467 1/0721/20, it can be concluded that although industrial engineering methods for process improvement are used in practice, this does not mean that there is no further scope for their application, whether on a wider scale, e.g., in the automotive industry or in those sectors where their current application is at a low level. We would also argue that the application of SPC and MSA, which came out below 40%, is inadequate in terms of what their actual application in processes can bring to an organisation.

It is therefore worth noting that the application of industrial engineering methods in process improvement is still highly topical, especially in the current situation where the customer is increasingly demanding and placing high requirements on the product he buys from the manufacturer. The manufacturer is under pressure to meet the customer's requirements in the required quality, time, at low cost, so as not to have unnecessary losses due to any kind of wastage, etc. At the same time, the use of industrial engineering methods in process improvement is an essential part of any organization in the context of the Industry 4.0 concept.

3 PRACTICAL APPLICATION OF PRODUCTION FACILITY CAPABILITY ASSESSMENT

The process monitored in the evaluation of the capability of the production facility was the injection moulding process. The product monitored in this process was a plastic box weighing 16,000 g with a tolerance of 0.2 g. The production takes place on an injection moulding press.

Table 1 shows the 50 measured values with partial calculations (for the purpose of constructing the control chart).

Table 1. Weights values of plastic boxes in injection moulding process

	1	2	3	4	5	Sample selection	Standard deviation
1	15.987	16.020	16.000	16.022	15.989	16.004	0.015
2	16.001	15.991	15.986	16.016	15.998	15.998	0.010
3	15.999	15.992	15.978	15.995	16.003	15.993	0.009
4	16.023	16.001	15.987	15.996	16.023	16.006	0.015
5	15.995	16.002	15.999	16.001	15.992	15.998	0.004
6	16.003	15.991	15.977	16.019	15.986	15.995	0.015
7	16.021	16.016	16.003	16.021	15.975	16.007	0.017
8	16.013	15.991	15.989	15.962	15.990	15.989	0.016
9	16.002	15.966	15.963	16.000	15.992	15.985	0.017
10	16.000	16.011	15.988	15.995	16.024	16.004	0.013

Figure 3 presents the data card from which normality was assessed.

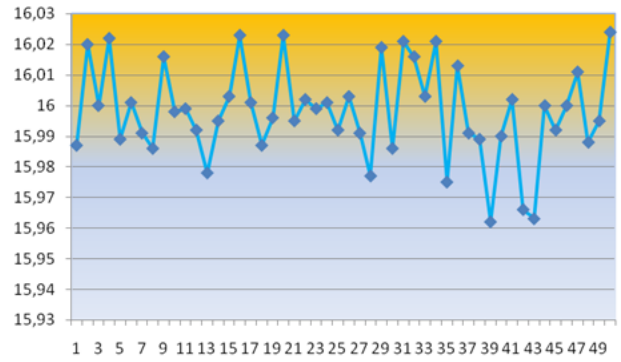

Figure 3. Injection moulding process data sheet

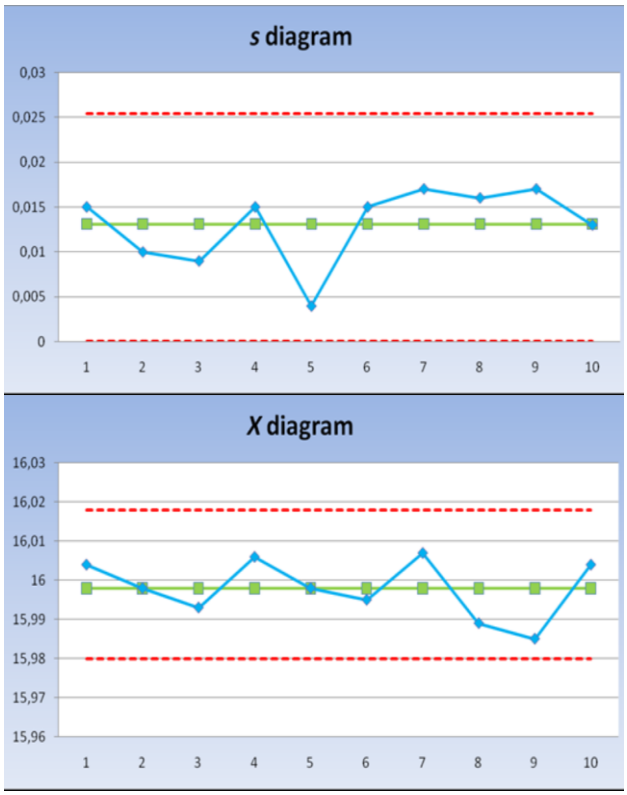

Figure 4. (X, s) control diagrams

By visual evaluation, we can conclude that the normality of the data from the monitored process is confirmed. Thus, we proceed to construct the control diagrams (Figure 4).

After evaluating the control charts, we can conclude that the injection moulding process is under statistical control. All the values lie within the control limits and only random influences are acting on the process.

After verifying the stability using the control charts, we can proceed to calculate the fitness coefficients. These have reached the values of C_m = 2.18 and C_{mk} = 2.13, therefore we consider the injection moulding machine to be fit.

CONCLUSION

Flexibility with respect to customer requirements is a necessity for any organisation operating in the market today. We can agree with the statement that no organisation can survive today if it does not offer what the customer wants and is willing to buy, and at the same time it must be able to adapt to the customer's demand as it comes. This involves setting up processes in the organisation and, of course, monitoring, evaluating and then improving them. Industrial engineering tools and methods are an effective tool for managing and subsequently improving processes.

Not all problems necessarily have the same impact on quality [Aikens 2011]. This statement is interesting, and we can say that it is both true and not true at the same time. However, organisations operating in the market cannot afford to make wrong decisions. Competition is fierce and a wrong decision (or a decision not taken on time) can have a negative impact on the organization's performance, employee turnover, customer attrition, etc.

Focusing on the problem at hand here and now, i.e. taking immediate action on the identified deficiency, is the only right solution to maintain your position in the market. It is essential to know your processes, to have them mapped out, to have a process owner who must also have defined powers, and it is also important to collect and analyse the data collected and interpret it correctly.

For this purpose, industrial engineering tools and methods are useful tools that not only significantly help to understand processes (e.g. process map, SIPOC diagram or process card), but also provide outputs in the form of graphs, figures or numerical values (control charts, Pareto analysis, process capability, gauge capability, production equipment capability, DMAIC cycle, 8D report, etc.). The outputs from these tools and methods are often input to the use of another industrial engineering tool or method.

Knowing the available industrial engineering tools and methods and being able to apply them correctly will greatly facilitate process setup or problem solving for managers in the organization.

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CONTACTS:

Ing. Vanessa Prajova, PhD.
Slovak University of Technology in Bratislava
Faculty of Science and Technology in Trnava
Jana Bottu 2781/25, Trnava, 917 24, Slovakia
+421 949 157 893
vanessa.prajova@stuba.sk