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Increasing the Efficiency of Automation of Production Processes by Reporting the Parameters of the Parts' Flow

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Abstract **– In this paper are presented the analysis and the proposal to increasing the efficiency of automation of production processes by reporting the parameters of the parts' flow. As a main focus are defined the correlation and the dependence between the input and the output parameters of the automated production process. On that basis, the contemporary requirements for development of the production process call for it to be considered as a whole, regardless of the stage in which the process automation is performed.**

Keywords: **Automation, Efficiency, Production Processes**

1. Introduction

The technical development based on new technologies, electronic management, artificial intelligence and computer-integrated production activities essentially determines the development of automation. The pursuit of a complex improvement of the technological, auxiliary and information activities and the minimization of the human involvement in the production activity will increasingly become a major factor in the development of automation. This means that on the basis of new communication and computer achievements, nanotechnology and other technical solutions, not only the manufacturing structure will change globally, but also the approaches and ways of automation of production processes will change. For the future, production will be considered as a whole, including both technology, technological and information processes and the automated, functionally integrated manufacturing components. This development will in the future also determine the efficiency of automation in the production processes.

2. Production development and automation

In the production process, a qualitative change is already taking place, based on the innovations and the automation. This, in turn, also raises the question of the essence and the distinctive features of highly automated production processes. The characteristic of enterprises with such type of production is that their distinctive features are beginning to melt in the general trend of global industrial development [1],[7]. They are increasingly dependent on the pace of development of innovation, industrial technology, communications, and the impact of factors that shape the trends of global automation policy. Their highly automated character has already begun to adapt to the innovative nature of technological and information processes. That is why it is of utmost importance in this respect to determine not only the distinctive features of the modern industrial world that shape this policy imposed by the automation and innovation development, but also the effectiveness of its application [6]. All this will lead to change in the long-term strategies and methods of construction and production of automated technological equipment.

The accelerated technological development has quickly begun to impose the notion of Industrie 4.0 or the fourth industrial revolution, with which an absolutely new direction of development has also emerged [5]. It encompasses the so-called cyber physical systems underlying the new industrial

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philosophy. In these systems, each device (machine, complex, etc.) has its product memory that defines its past or future involvement in the process, and it includes everything from the initial processing stage to the logistics stage (2.3). Conditions are created to access information about the status of different devices at any time. All this change will result in a complete synchronization of all business structures of the enterprise and the possibility of changing the system in case of changing the client's requirements.

Of particular importance in the spectrum of the unexpected problems in this automation development is also the method of determining the efficiency of applying automation in production of products.

3. Efficiency of automated production processes

The determination of the efficiency of automated production processes is closely related to and dependent on the above-mentioned industrial development [2],[3]. Therefore, the improvement of current productions is characterized by the fact that efficiency gains can be successfully realized by choosing the best design solutions for the automation of production processes at the various stages of the flow of parts. Characteristic here is that multi-variety is a feature of most production processes. It depends on many parameters, such as speed, processing accuracy, temperature, management mode, etc. Moreover, the existing multi-variety at the individual production stages is not as quantitative as qualitative, characterized by the different parameters of both the machining of the parts and the degree of automation of the process. In addition, major production processes are closely related to the auxiliary and service, incl. management processes, the impacts of which also affect efficiency [8]. Therefore, the automation of production processes should take into account the impact of all these factors that determine the parameters of the design solutions and hence the efficiency and quality of the products produced.

4. Correlation and dependence between the input and output parameters of the automated production process

The choice of a model [4] to meet product quality requirements and to define the restrictive parameters of the design solutions for automation is of paramount importance for enhancing production efficiency. Due to the fact that the parts' flow passes through different processing stages, we can talk about a multi-stage production process. Process modeling in the individual stages (partial processes) does not mean optimization of the whole process. One of the regularities is that automation in a given stage may be ineffective for the next stage of the processing of parts, etc. This is because the parts of the different sections may have different quality requirements as well as different performances in terms of these requirements. Whatever the differences in the partial automation of the production process (individual stage automation), they affect the entire process flow of parts in terms of time, quality and other parameters. Therefore, the process should be considered as multivariate for the entire flow of parts, but including the specific requirements and constraints of all processing stages using certain parameters [9]. These parameters also determine the impact of individual factors on the production and, in particular, on the efficiency of the introduced automation. They carry the characteristic features that determine the technical and economic requirements and are expressed in the quality of a specific target function. They also affect specific types of constraints such as changes in the production conditions resulting from automation, the impact of different conditions on them, etc. Most of these impacts, expressed through parametric definitions (reporting and statistical data), have a determinate nature, and the other smaller part has a probabilistic nature (dispersion of parameters). The aim is to find the correlation between them, which will allow for maximum elimination of their negative impact on efficiency. This can be achieved by using determined information in determining the correlation between the parameters of the production process (parts' flow). In this information, these dependencies, usually expressed by statistics, are based on the influence of factors impacting both the technical and the economic parameters of production. These are the share of the profit (a) from the introduced automation considered as income from the automated equipment including automated machinery, facilities and other means of production, the parameter (b) defining the ratio of the profit to these means of automation and (T) -reporting the operating life of these automated machines and equipment. The functioning of the production system consists of complex processes, influenced by a number of factors, the manifestation of which occurs at all stages of the process parts' flow. If automation is introduced at separate stages, the parameters (a, b, T) are usually calculated for these stages only, and for others they are assumed to be constant, i.e. they do not change over time (t). The effect is then recorded for each individual processing stage or,

$$E = \prod_{t=1}^{n} E(t) \qquad (1)$$

E - efficiency
n –process stages
t – duration of the process

This approach of determining the efficiency of automation of production processes does not take into account the influence of all the factors induced by modern industrial development. It would be more adequate and more accurate to report the effect of automation on the whole system, regardless of the processing stage in which it was performed, or,

$$P = P' - {}^{A}/_{T}$$
$$P'=b'A$$
$$P = (b' - {}^{1}/_{T})A$$
$$b = b' - {}^{1}/_{T}$$
$$P=bA \qquad (2)$$

P – profit

P' – income (the difference between the value of the product and the cost of its production)

A – investment in equipment (automation).

b' – proportionality factor.

T – lifetime.

Together with the consideration of these impacts, which have a determinate nature in the process flow of parts, certain correlations between the parameters of the impact objects, which are of a dispersed nature, arise. Finding these dependencies using production data is usually based on the least squares method. In this case we look for the proportionality (b), which appears as an unknown coefficient in the equation,

$$y = b_0 + \sum_{j=1}^{m} b_j x_j \qquad (3)$$

x, y – input and output parameters.

The unknown coefficient (bj) in this equation can be found by solving the system,

$$\bar{y} = b_0 + \sum_{j=1}^{m} b_j \bar{x}_j \qquad R_{x_v y}(0) = \sum_{j=1}^{m} b_j R_{x_j x_v}(0)$$

v = 1,2,…m (4)

where:

$$\bar{x_j} = \frac{1}{n}\sum_{j=1}^{n} x_j^i \qquad \bar{y} = \frac{1}{n}\sum_{j=1}^{n} y^i$$

$$R_{x_v y}(0) = \frac{1}{n}\sum_{j=1}^{n}(y^i - \bar{y})(x_j^i - \bar{x_j})$$

$$R_{x_j x_v}(0) = \frac{1}{n}\sum_{j=1}^{n}(x_j^i - \bar{x_j})\,(x_v^i - \overline{x_v})$$

When production information is used, the correlation coefficient Rxi, xv (0), summing the dispersion of the actual process parameters, should also be taken into account. Table 1. illustrates the efficiency of this process for the same machine production process, taking into account the effect of automation at individual stages of the flow of parts and considering the automation process as a single process for the entire flow.

Table 1.

Name		Parameters x. €						
		E [€]	P [€]	A [€]	T	b	Rxi ,xv	Stages
Automation with individual stage reporting	Total	4/35	376/407	372	3	1,01/1,09	1, 0	1, 2, 4
	First stage	1	37	36	3	1,02	0, 00	1
	Second stage	3	318	315	3	1,01	0, 00	2
	Fourth stage	0	21	21	3	1,00	0, 00	4
Automation with full process reporting /all stages/		35	407	372	3	1,09	0,08	All

T – years of operation

b - Proportionality factor

Rxi,xv – Correlation factor reporting the dispersion of parameters.

Fig.1. shows a diagram of the flow of parts at automated and non-automated processing stages

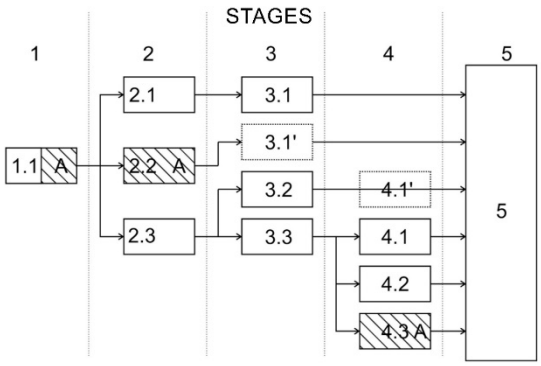

Fig. 1 Diagram of the flow of parts in a machine production enterprise, incl. automated and non-automated stages

Where:

1- Preparatory with Partial Automation (1.1)
2- Machining with Complex Automation (2.2)
3- Finishing with dropping of operation (3.1)
4- Assembling with automation of (4.3) and dropping of (4.1)
5- Comprehensive installation of the product.

5. Conclusion

The most important things to bear in mind when determining the parameters defining the efficiency model of the automation of production processes are;

- The flow of parts shall be regarded as continuous, rather than by the individual processing stages.
- The quality requirements for the final product shall be respected throughout all stages according to ISO.
- The parameter $R_{xj,xv}$ (0), characterizing the dispersion of the influence parameters, shall be inclined to – min.
- There shall be information on the costs that form the cost value of the produced product (by stages and in total).
- The parameters (a, b, T) shall have a determinate nature.

On the basis of the above, the following conclusions can be drawn;

1. The contemporary requirements for the development of the production process call for the same to be considered as a whole, regardless of the stage in which the process automation is performed.
2. The emergence of the economic benefit of automation is best seen and gives the best results if the process is viewed as a complex way for the entire flow of parts rather than as individual processing stages.

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