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ABOUT EFFICIENCY OF MODULAR DESIGNED DEVICES

Abstract: *Modern economy demands for control devices are: great constructive flexibility, rapidly adapting to the beneficiary requirements and the fastening error of the component modules tends to zero. The Control Devices made of modular elements using Safe Assembly engineering design concept (AS), present a series of technical-economic advantages as to other types of devices. As the cost of the module devices is higher than the specialized and group devices, their correct choice will only be made based on an economic analysis. In the paper will be presented how to determine the efficiency in order to select the optimum choice of the process and control technological equipment.*

Key words: *Engineering Design, Quality Concepts, control devices, modular elements, efficiency*.

1. PARTICULAR FEATURES FOR MODULAR DESIGNED DEVICES

If we characterize modular devices way through the Industrial Excellence for greater conformity with reality should we add an additional axis to the classic representation [2]. This axis represents the defining characteristic of modular devices – the flexibility. In Figure 1 we added this new dimension for Industrial Excellence definition, as it is perceived today in an agile economic environment.

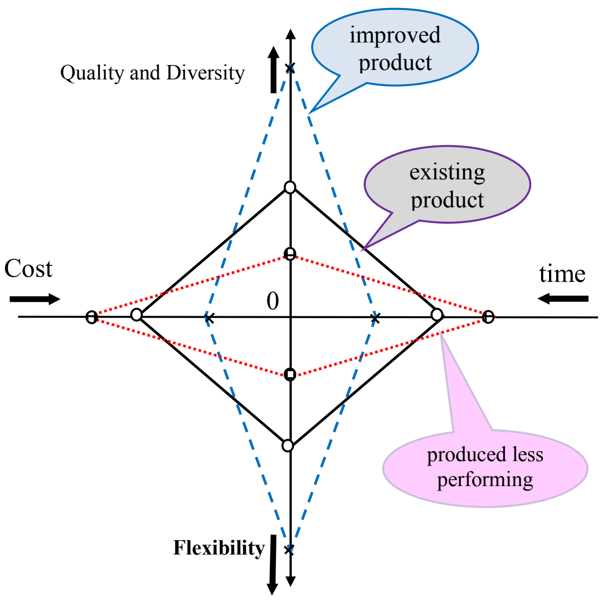

Fig. 1 Industrial Excellence formula for modular designed devices

Control devices (*Dc*), with respect to working devices on machine tools, hold a series of features peculiar to the function they are designed for.

The elements for parts' placing and orienting within control devices must have a higher degree of precision, productivity and accuracy of the execution that leads to a higher cost of *Dc*.

With respect to ergonomics, the adjustment of devices to operator's requirements and possibilities in order to ensure a technical and economic efficiency, which corresponds to the goal, are being taken into account.

Among the peculiar elements of control devices, which condition the technical-economic efficiency of these devices, we also mention:

- elements for feeling and transmitting-normal and amplified transmission the controlled values;
- mechanical or translating comparing devices of various types like pneumatic, electrical, inductive, etc.;
- orienting and fixing elements and mechanisms of indicating devices;
- control holders;
- standard parts;
- shock lacking operating elements and mechanisms;
- blocks for date feed, display and processing.

Using inductive translators within Dc makes possible the automate data processing. This is due to the fact that inductive translators may be connected to microprocessors or to electronic computer.

Control by means of Dc, can be one-parameter or multi-parameter control, direct or indirect control, comparative or absolute, classic or modernised – computer-aided.

2. THE EFFICIENT AREA FOR MODULAR DESIGNED DEVICES

With respect to the precision of control, the *Dc* precision must be about three times higher than that of the working devices [1], [2], [3], [4]. For this reason, *Dc* execution is much more exigent and, therefore, *Dc* is more expensive than the working one.

At the same time, the capability C_{dc} of control devices must be higher than the capability C_{dl} of working devices:

$$C_{dc} \cong 3C_{dl} \qquad (1)$$

where, C_{dc} can be determined by means of the following relation:

$$C_{dc} \cong \frac{\Delta LT}{t_p} \qquad (2)$$

where ΔLT is the gauging (control) total limit error, and *tp* – prescribed tolerance for parts to be controlled.

ΔLT can be determined by means of the known relation [1], [4], [6]:

$$\Delta LT = 10\ldots20\%\ \text{tp} \qquad (3)$$

Values for C_{dc}, according to relation (2) as well as for ΔLT, according to relation (3) are determined accordingly to the functional importance of the parameter to be controlled.

- For normal importance occurs:

$$C_{dc} \cong \frac{1}{6}\ldots\ldots\frac{1}{10} \qquad (4)$$

$$\Delta LT = 10\ldots25\% t_p \qquad (5)$$

- For high and very high functional importance, as happens in the case of vital parts, occurs:

$$C_{dc} \cong \frac{1}{10}\ldots\ldots\frac{1}{20} \qquad (6)$$

$$\Delta LT = 15\ldots20\% t_p \qquad (7)$$

By observing relations (1)…(7), it becomes possible to determine the ability of technological manufacturing processes, as well as to ensure high control objectivity.

Taking account of relations (1)…(7), *Dc* must be designed, built and used to provide due objectiveness for control operations at convenient costs.

For modular devices, economic calculations must be performed correctly and have determined expenditure control process, as exemplified in Figure 2.

To use at maximum efficiency and safety the modular decices, it is a must to determine the optimum number of types or number of sizes of parts controlled manner Dc and the maximum operating efficiency.

3. ADVANTAGES OF MODULAR DESIGNED DEVICES – CEMAS TYPE

According to certain long-term studies and researches [1]… [5], it was possible to design, build, test and put into practice a set of control devices with modular design – shortly called *CEMAS* devices, of genuine devising [4], [5].

The original design of technically and economically efficient CEMAS devices was possible due to an in-depth study about classic control devices [1], [4], [5], and so on, based on a generalised methodology and relations for the determination of the gauging total limit error (Δ_{LT}) and the set up of a logical system of modern criteria and concepts that should be taken into account when generally accomplishing control devices as well as when

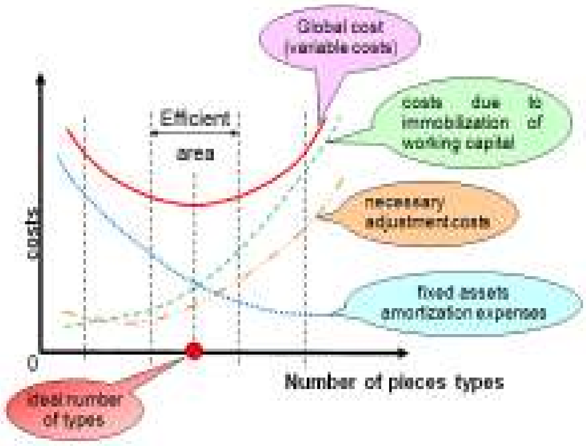

Fig. 2 Correct determination of maximum efficiency for modular design due to global costs and due to number of various pieces types [1]

choosing their destination within the control technologies.

Using the safe assembling principle (*SA* principle) [1], [4], [5] it became possible to partially or totally remove the errors of orienting and fixing modules within the control devices of different type-size parts, which confers high technical efficiency to said devices.

Remember that [1], [4], and [5]: *SA* principle consists in the unidirectional taking over of clearances, either for fixed assemblies (base supports, with modular motherboard), or for movable assemblies (gliding axes, body or points for orienting and fixing parts to be controlled etc.).

Control total limit error ΔLT according to relation (3) as well as the ability of CEMAS devices according to relation (2) hold values, which provide a high objectiveness to control operations, as well as to determining the ability of processing operations.

All these considerations, principles and measures led to obtain certain technical and economic advantages due to modular designed devices [1], [2], [3]. Among these advantages, we can mention precision, productivity, high flexibility in use and lower costs of control operations.

4. ECONOMICALLY JUSTIFIED CHOICE OF MODULAR CONTROL DEVICES

Considering that modular control devices and implicitly CEMAS devices have been designed in order to satisfy a wide range of requirements of use, they are much more complex than the specialised ones. Subsequently, the cost of these devices is more expensive than that of specialised devices.

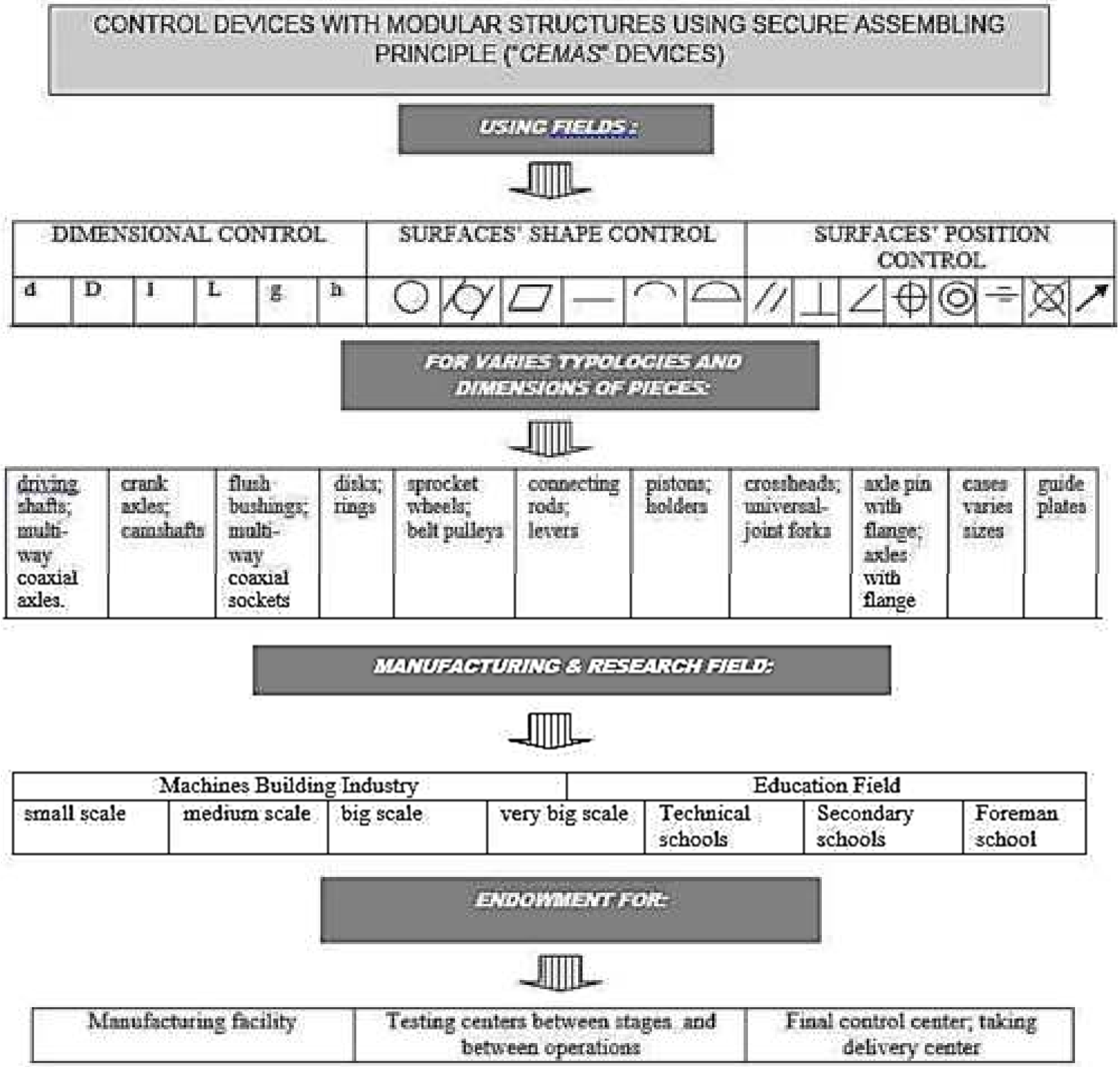

Fig. 3 Field of use and specifications of modular structure devices- CEMAS type

That is why, the economically justified choice of modular devices will occur according to economic calculations.

Calculation of special expenses (costs) will be made in the well known manner [1], [5] either for the use of specialised control devices, determining C_{sp} special costs or for the use of $C_{s\cdot mod.}$ modular devices, taking into account special costs dependent on the investment of modular devices procurement. Current costs of labour (cost of labour, excise cost and indirect expenses) are, concomitantly, taken into account [3], [4] when using specialised devices $C_{man.s.}$, namely, when using modular devices $C_{man.mod.}$.

The comparison of total expenses due to carrying out the control of all kinds of parts according to individual technology (Ci) to total expenses (costs) due to carrying out the control of the same parts by using modular control devices (C_{mod}) [2], [3], [5], occurs in a different manner.

The economic efficiency (E_{ec}) is below determined as difference between C_i and C_{mod} costs, as well as P_{am} amortisation period:

$$E_{ec}=C_i - C_{mod} \tag{8}$$

$$P_{am} = \frac{I_{mod} - I_i}{E_{ec}\,/\,year} = \frac{I_{mod} - I_i}{NE_{ec}\,/\,piece}, \tag{9}$$

where: C_i and C_{mod} represent costs due to control by using individual (specialised) devices and by using modular control devices; I_i and I_{mod} – investments due to control by means of individual (specialised) devices and by means of modular devices; N – annual production program, pieces/year; E_{ec} – economic efficiency per year in ROL or in currency.

Control by means of modular devices shall be adopted only if it observes the following relation:

$$P_{am} \leq P_{am_{ad}} \qquad (10)$$

where Pam_{ad} is the acceptable amortisation period, which in the case of modular control devices is equal to ≈ 10 years.

Annual production volume N (in pieces/year), for which control by means of modular devices is enough, can be determined according to the following relation:

$$N = \frac{1}{C_{mansp} - C_{man\text{mod}}} \left[\frac{I_{\text{mod}} - I_i}{P_{amad}} + C_{s \cdot \text{mod}} - C_{sp} \right] \qquad (11)$$

where: $C_{man.sp.}$ and $C_{man.mod}$ represent costs of labour when using specialised or modular devices; the other notations have the meaning showed within relations (9) and (10).

5. CONCLUSIONS

Control devices can furthermore be stable - in the case of control of small and medium-sized parts or portable - in the case of big-sized parts. But most important feature for control devices is the efficiency. Regarding this feature, can be used specialised control devices – efficiently used for mass serial production; group control devices – for control on groups of parts for small mass production and modular devices - for diversified unique products and small mass production.

CEMAS devices have been designed for the endowment of production places and control spots for small mass production and unique products, as well as for the equipment of tool rooms, repairing shops and prototype shops. By means of these devices, parameters of dimensional and geometric precision for different type-size parts can be controlled as it is shown in Figure 3. With small adjustments, CEMAS devices can be advantageously applied to mass production as well. In this case, for instance, the motherboard will bear the number of channels, lowered to a strictly necessary number, whereas modules will be designed in a simplified manner, with strictly necessary facilities.

Concomitantly, CEMAS devices may be used for the control operations carried out on coordinate gauging machines (MMC) as well.

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