THE MATLAB GUI FOR THE EQUIPMENT COMPUTATION OF THE PRODUCTION SYSTEM FOR INSTRUMENT TRANSFORMER MANUFACTURING

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ABSTRACT

In this paper, a Matlab application based on the graphical user interface (GUI) environment for sizing of technological equipment of a certain production system, designed for the current instrument transformer manufacturing, hereinafter referred to product, is presented. The designed product according to the customer requirements is part from the range of production of a Electrotechnical Company from Oltenia area. Based on data from the technological project of the product, the application allows checking the technical sizing of the production system. That means the application computes the machinery number needed for the manufacturing of the production which is requested by the customer through a order available for a year. At the same time, based on information regarding the technical equipment, the program allows to compute the equipment's production capacity. Finally, the production capacity of the whole system can be computed. Can also be computed the indicators of economic efficiency such as the efficiency index of time for each machine or the reserve of the production capacity for the whole production system. The user can apply the computation Matlab program through the GUI.

INTRODUCTION

The topic of production systems design is extensively approached in the references in the field. Production system aims to solve the tasks of production for manufacturing a product according to customer requirements. The general function of a production system is transforming a flow of materials, energy and information, considered as input data in the finished product or output data. The main components of a rigid/inflexible production system are the technical elements: machinery, equipment and human nature factor. The manufacturing of a product is based on manufacturing technology which requires the execution the technological processes in a predetermined succession, with specific equipment in a given normalized time. The level of technological development and technical equipment, the process technological control, the flexibility and the processes novelty involved in the manufacturing, allow the analysis of the production systems. In the electrotechnical industry, the companies producing high-voltage electrical equipment are mainly based on the application of the classical technological methods such as prefabrication processes (casting, rolling, forging and so on), machining processes (turning, milling, cutting, grinding and so on), heat treatment processes, plastic deformation processes and so on. At the same time, the developing of the products requires application of the new unconventional processes (electro discharge machining, laser welding, ultrasound processing, magnetic formation). As a consequence of the economic crisis, locally or globally, the electrical equipment manufacturing companies have closed, restructured or refocused on the other economic targets. These companies have acquired an impressive experience of design and manufacture of electrical equipment. Sometimes must be solved the problem of the manufacturing continuation of those products which were profitable in the range of products of the mentioned companies. This fact assumes the implementation of the manufacturing technology of these products in the structure of the other production system which has a similar technological structure. The topic of the production system design is approached in the references in the field (Brojboiu 2001), (Brojboiu 2008), (Ivanov 2008), (Badea 1999), (Mohammad 1997). Regarding the manufacturing implementation of the new product, there are two basic approaches. The first approach: there is a production system with the range of similar products; in this case should be met the restrictions of systematization of product or the efficiency degree of the technological integration and construction. Based on information from the technological execution documentation of the product is checked through computing if the existing technical equipment allows the fabrication in a given period, for example, one year, a Q production, which is ordered by a customer. The charging in time or the degree of the intensive use of the time for each equipment can be evaluated. Consequently, based on the computed results one or more decisions may be taken concerning the application of actions of intensive or extensive use of

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existing technical equipment. An action type refers to additional purchases of machinery or equipment which are specific for the manufacturing of the new product. The decision will be based on the assessments of economic efficiency indicators. The second approach corresponds to the case when there is not a production system with technological structure which should be proper for the production of new product. In this case, it will decide on the design of a new manufacturing system. The basic technological facilities can be designed based on the information from the technological documentation, such as type of equipment, normalized time per technological process, technological auxiliary time. For this technological equipment, the production capacity can be computed. The computation of the production capacity is carried out taking into account the equipment number and the specific planned working regime. The production capacity of the machinery/equipment which is stipulated in the technological documentation is computed based on the algorithms specific for the equipment with the technological specialization and related to the normalized durations per technological processes:

$$C_{pi} = N_{ui} \cdot \frac{T_{dimax}}{t_n}, \qquad (1)$$

where: N_{ui} is the number of same type equipment which defines the production link, T_{dimax} is the maximum available working time, computed for the period of time for which the production Q is ordered by a customer, t_n is the normalized execution time for the i technological process, which is stipulated in the manufacturing documentation. The degree of utilization of production capacity and the capacity reserve are calculated:

$$G_{ui} = \frac{Q}{C_{pi}} \cdot 100\ [\%],\ R_{ezi} = C_{pi} - Q, \qquad (2)$$

It should be note that the link production with the lowest value of the production capacity will determine the production capacity of the whole system. The excess or deficit of time for the same type of machines will be calculated:

$$D_{ui} = T_{tni} - N_{ui} \cdot T_{dimax} \qquad (3)$$

If $D_{ui}>0$, then will exist deficit of production capacity and if $D_{ui}<0$ then will exist the excess of production capacity and consequently appropriate decisions will be taken: either some technological processes will be outsourced if $D_{ui}<0$, or will be taken decisions to reduce the normalized time or to purchase a new machine. The production capacity of the equipment with the technological specialization can be determined based on value of the production P_r manufactured in a previous reference period.

$$C_p = P_r \cdot \frac{100+\alpha\cdot\gamma}{100} \cdot \frac{\sum_{i=1}^{n} N_{ui}\cdot T_{di}}{\sum_{i=1}^{n} N_{oui}\cdot T_{di}} \cdot \varepsilon \qquad (4)$$

where, α is the coefficient of increasing work's productivity in the current period compared to the previous one, γ is the weight of intensive factors in increasing of work's productivity, $\sum_{i=1}^{n} N_{ui}$ is the equipment number of the main production link from technological group i from the current period, $\sum_{i=1}^{n} N_{oui}$ is the equipment number of the main production link from technological group i from the previous period, ε is the coefficient of simultaneity of equipment charging, whose value is specific to the type of production (i.e. $\varepsilon=0.82$ for small and medium series production). The main production link is that which has the biggest weight in the manufacturing duration of the product or the production task.

The value of the ordered production which should be possible manufactured can be calculated depending on the deficit of production capacity (Badea 1999):

$$P_p = C_p - D \qquad (5)$$

Accordingly, there is the relation: $C_p \geq P_p \geq Q$.

It should be note that the value of production capacity depends on the operating regime which is characterized by the number of working days of the period and the number of shifts per day. It is also very important the assessment of the repairs duration of the equipment, computed according to adopted maintenance regime. As it is known (Woohyun 2009), (Pascual 2006), (Hongye 2008), the maintenance is a combination of technical and administrative actions with the purpose to maintain in working the equipment to accomplish the required function by the technological flux. The maintenance actions can be classified in two main groups: corrective maintenance and preventive maintenance. In the companies for the electrical equipment fabrication, the scheduled preventive maintenance is implemented. This type of maintenance comprises the repairs actions which are scheduled in time depending on the a preset value of operating time of the equipment. The normalized types of repairs actions are: technical revision, current repair 1, or 2, and capital repair (Brojboiu 2001). The graphic of succession in time of interventions or repair cycle is normalized for each type of equipment, as shown in Figure 1.

Corresponding to a certain operation time of the equipment, in order to manufacturing of the ordered production Q, it can determine the number of interventions that restore the equipment performances. The number of equipment, considering the lengths of time of the repairs will be computed with the formula:

$$N_{ui} = \frac{T_{ni}+D_{ri}}{T_{di}}, \qquad (6)$$

where:

$$D_{ri} = \frac{D_{rni}}{n_s \cdot t_s \cdot n_o \cdot k}$$

where D_{rni} is the normalized length of time of the repair type.

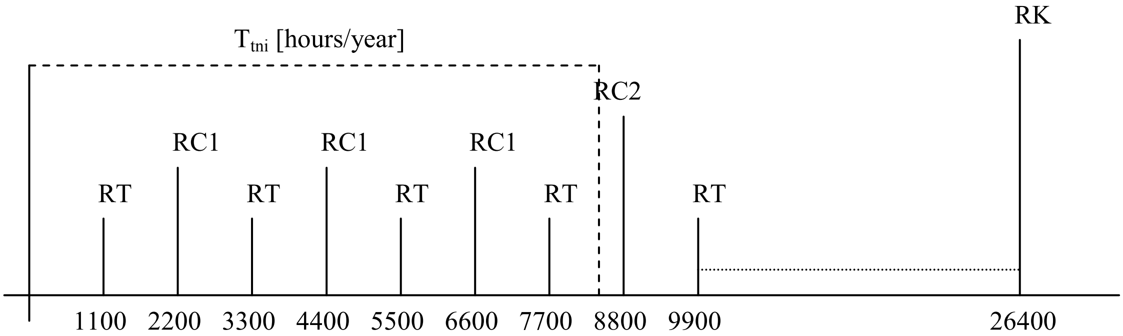

Figure 1: The succession in time of interventions or repairs cycle

In the references in the field are presented the advantages of each system type of maintenance that can be implemented from the point of view of production system optimization. The advantages of the condition-based maintenance, the corrective maintenance or preventive maintenance systems are described (Ivanov 2008), (Badea 1999), (Mohammad 1997), (Woohyun 2009) from the point of view of the minimum cost.

In this paper, a dimensioning algorithm of the technical equipment based on the technological project of the high voltage current instrument transformer is applied. With this purpose, a Matlab GUI was developed. The input data are the technological information from technology project of the transformer. The GUI allows to the user to input data and the selection of different data, which are required by the design algorithm. GUI provides friendly communications and it can be used more conveniently.

Description of the GUI

A Matlab application based on the GUI environment was developed. This GUI can be used for the sizing of the technical equipment needed for the manufacturing of the high voltage instrument transformer given that there is a ordered value Q of the production. The GUI Matlab allows also the computation of the production capacity, knowing the equipment number. Using the developed GUI, the information concerning the efficiency of using of *the equipment's maximum time* can be also provided. At the same time, the production capacity reserve of each equipment as well as the weight of the normalized values of the equipment working time in the total normalized time of the main link production can be evaluated.

The input data are:

a) The normalized values/allowed times for each equipment specified in technological sheet;

b) an estimated quantity of ordered production based on information from previous periods of time

c) data relating to scheduled preventive maintenance system, provided in the national standards and regulations in force.

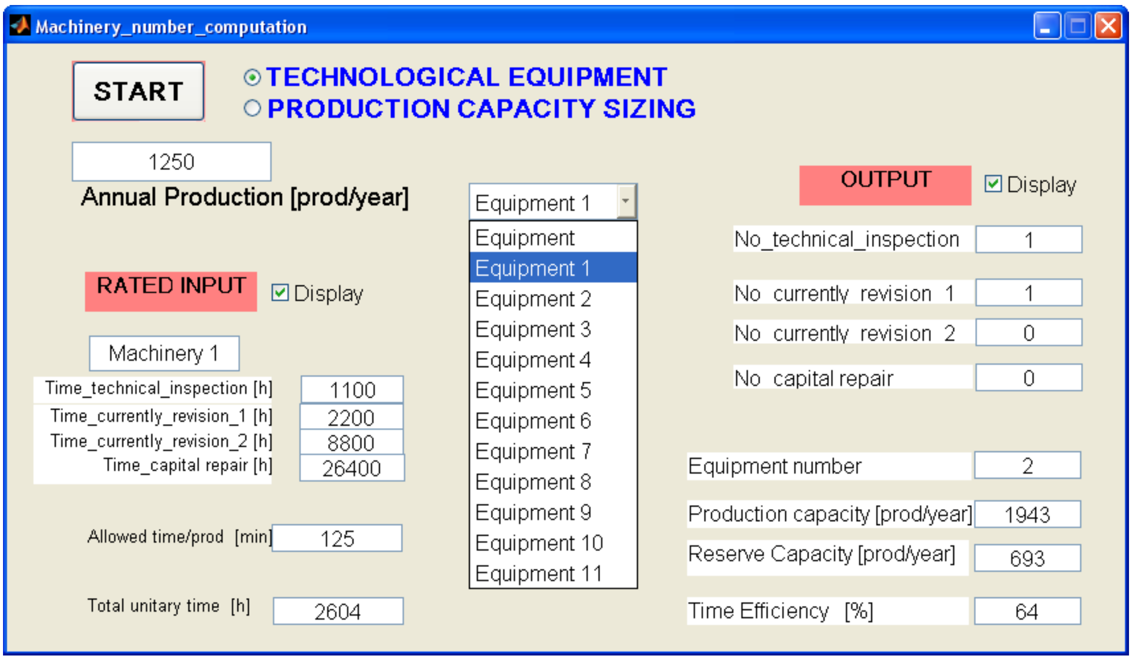

Figure 2: The main window of GUI

This data allows the computation of the time duration of repairs, corresponding to the total working time values for each of equipment, needed for the manufacturing of the *Q* production value. The Matlab application is developed into an interactive manner so that certain data can be enter from the keyboard by the user. At the product manufacturing are involved 11 equipment for which the technological project provide the normalized values of the time durations for the fabrication of each component of the whole product. All the 11 equipment are of the type with technological specialization and each of them execute the manufacturing operations, such as: cutting, lathering, wrapping, welding, fitting, thermal treatment, galvanizing, testing and assemblage. From the point of view of the transformer manufacturing, the equipment for drying, vacuuming and oil filling is the main production link because the normalized durations are much bigger than the other from the technological flux. The main configuration of the GUI comprises the component palette to enter the input data and computation of the output data.

The main window of GUI is shown in the figure 2. As it can be noticed the input data is the value of the ordered production Q=1250 [prod/year]. The user can select the equipment type. For the equipment no. 1 the information regarding the working time $t_f = 1100$ hours, after which one type of repair can be made is displayed as well as the allowed/normanlized time for the operation execution t_{n1} = 125min., given in the technological sheet. The computed value of the total unitary working time, $T_{nu1} = 2604$ hours, for one product is also displayed. The computed output data are: the equipment number, $N_{u1} = 2$, the production capacity of the production link C_{pu1} = 1943 prod/year, the capacity reserve R_{ezu1} = 693prod/year and the efficiency of the maximum working time of the no. 1 equipment or time efficiency I_{u1} = 64%. All these output data are also displayed.

In the GUI window from figure 3, the computed data for all 11 equipment are displayed: the number of equipment, the total unitary length of time for each equipment, which working for the transformer component and the production capacity values.

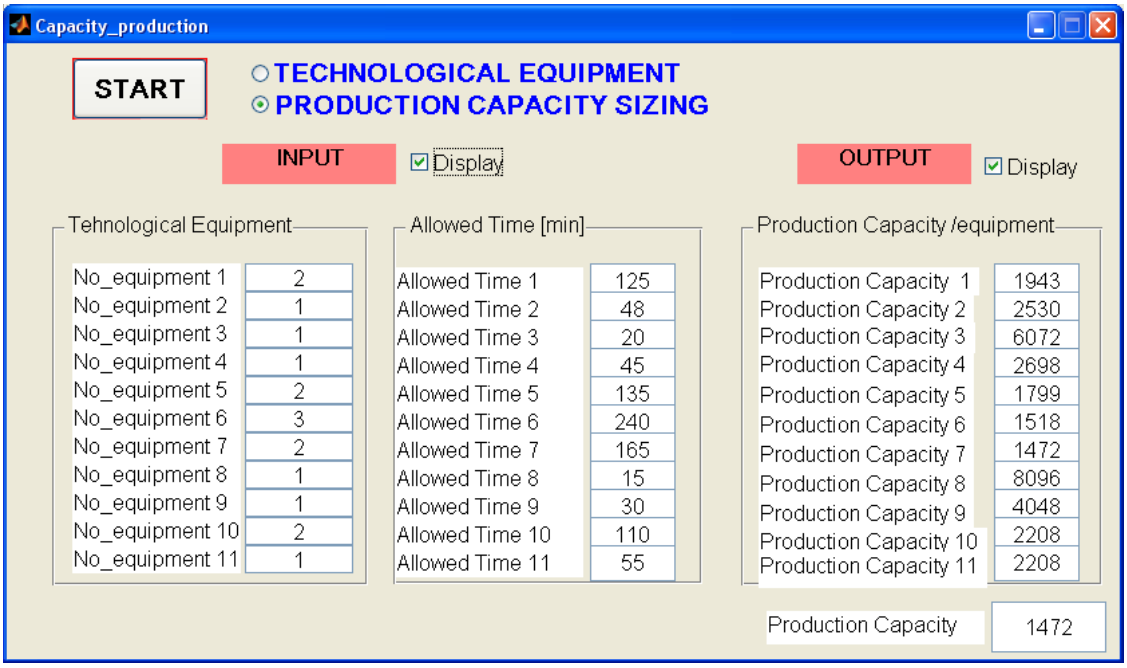

Figure 3: The window GUI

As value of the production capacity of the whole system in whose structure is implemented the new manufacturing technology will be adopted the minimum value from those 11 computed values.

A synthetic presentation of the computed results is made using the histograms from the Figures 4, 5, 6, 7, 8. In the histograms from figures 4 and 5 are displayed the production capacity values for those 11 equipment, respectively the capacity reserves. It is observed that the no.8 equipment has the biggest value of the capacity reserve which means that it works under full charging.

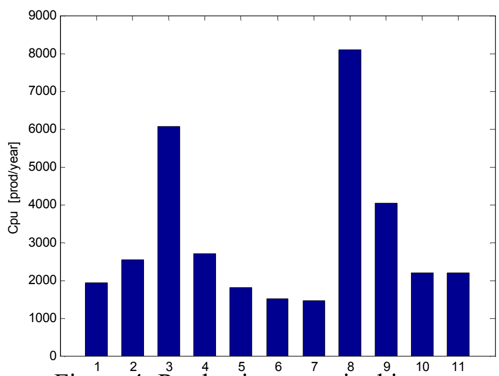

Figure 4: Production capacity histogram

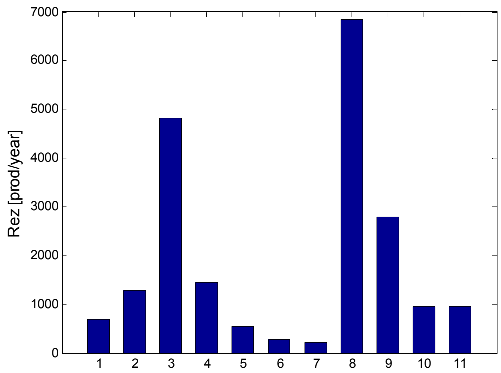

Figure 5: Capacity reserve histogram

The equipment no. 7 has the lowest capacity reserve value, that means it almost works at full charging. For the equipment having the bigger values of the capacity reserve can be taken decisions concerning to improve this cases.

In the histograms from the figures 6 and 7 are represented the values of the total normalized duration of time for the manufacturing of Q production, respectively the efficiency index of the maximum working time for one year duration. It is noticed that the lowest value of the efficiency index of time is computed for the no. 8 equipment which has the bigger capacity reserve also.

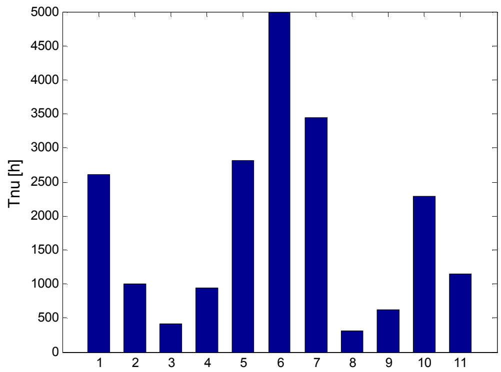

Figure 6: Total normalized time histogram

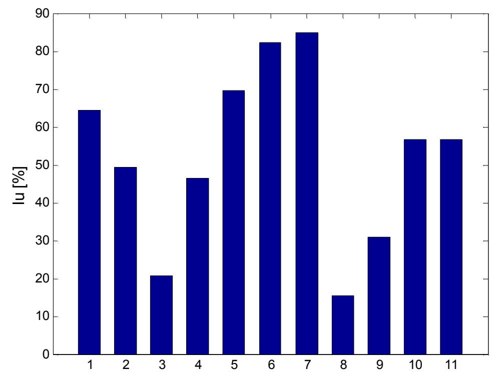

Figure 7: Efficiency index time histogram

The ratio between the normalized duration of time of the each equipment and the maximum value of the normalized duration of time (in this case the no.6 equipment) are represented in the histogram from figure 8. It must be mentioned that the numerical results presented in this paper are comparable to the real ones from the technological documentation of the current instrument transformer.

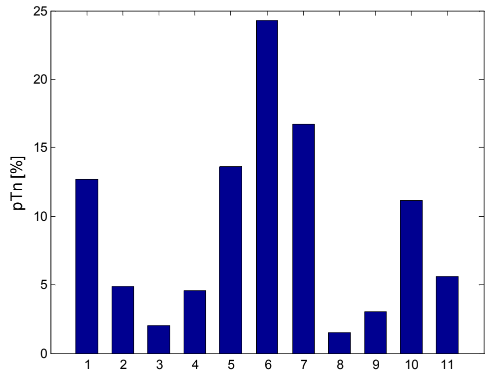

Figure 8: Weight of the normalized durations of time histogram

CONCLUSIONS

The article presents the obtained results with a Matlab GUI that was developed for the dimensioning of basic technique of a production system for manufacturing a high voltage instrument transformer. Using the input data, taken from the execution documentation, can be calculated the number of machines of the same type, required to execute a ordered volume of production. Also, it can be calculated the production capacity of the technical equipment, capacity reserve and efficiency index or charging degree of the maximum working time of the equipment. Based on the computed data into an interactive manner using the Matlab GUI, the decisions concerning the efficiency of the manufacturing technology can be taken.

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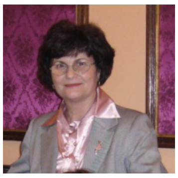

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