CONSIDERATIONS REGARDING THE POLY-SERVICING OF THE WORKPLACES IN THE MACHINE BUILDING INDUSTRY

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Abstract
In the machine building industry it is met a wide variety of operations, and the most machines work after a regular cycle of processing, which generally takes place without the operator intervention, which favours the application of the workplaces poly-servicing system. In the first part of this article I made reference to the cycle of the processing on the machine tools, highlighting the analysis stages of the main aspects of the processing, as well as the determining procedure for the maintenance service cycle of the machine tools. Next I presented the main parameters used to characterize the poly-servicing and aspects of combining the processing operations under the poly-serving system, exemplifying the method of calculating of the optimal number of the machines that can be served by a single operator.
Keywords: Work cycle, Machine tools, Processing operations, Poly-servicing

1. INTRODUCTION

The concept of poly-servicing of the workplaces involves some issues that relate specifically to the various technical and organizational problems regarding the factory object, the regular participation in servicing the multiple workplaces, number of participants at the poly-servicing, type of the machines and the workplaces served.

In order to apply the poly-servicing, it is required a detailed analysis of the technical, organizational and economic aspects, in order to ensure optimal using of the processing capacity of the machines, and the efficiency of the worker's working time. In this regard, a special importance of determining the ratio between the operating time of the unattended machine and the manual time for training and supervision of the processing operation, highlighting the available time of the worker for servicing the multiple machines. On the other hand, the poly-serving implementation involves carrying out of the detailed studies based on knowledge of the characteristics and peculiarities of the processing cycle, from many solutions being chosen an optimal one, both technically and economically.

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2. PROCESSING-CYCLE FOR THE MACHINE TOOLS

Determining the ratio between the operating time of the unattended machine and the manual time for training and supervision of the processing operation, is a first step of analysis, which highlights the operator availability to serve more machines, and thus, to make a decision on the application or not of the poly- servicing. Where it is proved that this system is appropriate and it is decided its implementation, it will be analyzed the main aspects of the processing, as follows: the analysis of the operations characteristics for execution, establishing the working machine; taking action for the equipping the machine with the industrial technology equipment; TDC so as to provide a substantial reduction of the auxiliary time; the study of the opportunities to minimization the route cycle by the operator from one machine to another; establishing the optimal route for the operator, taking into account that he must constantly be able to monitor the processing; analysis of the optimum placement of the machine tools (in the flexible cells), taking into account the sequence of the technological operations.

Considering the above, a definition of poly-servicing, which comprising all these aspects, is very difficult to give, but I embrace the views of teachers Dima, Modrak, Pachura et Ciurea (2010), who defines the workplaces poly-serving *as a work system in which the workplace of a worker or more workers consists of several positions at which he or they act simultaneously or sequentially.* At the base of the poly-serving there is the multi-qualification, which Niculescu (1997) defines it as a *permanent process of acquiring of the new knowledge generated by scientific and technical progress.*

In the machine building industry, the most machines work after a regular cycle of processing, which generally takes place without the worker intervention. To determine the cycle of the machine tools maintenance service, grouped in a poly-servicing system, it must precisely known the component elements times of the servicing, namely: the processing time of the machine, without to be necessary the intervention of the worker; time for the piece servicing (grip and release it) and other tasks required to be performed by the worker; the time of servicing overlapped with processing time; the auxiliary time for the preparation and completion of processing; the time required to oversee the processing; the time to go from one machine to another; the time of waiting/standing man or machine; the idle time; the time for resting and the natural needs.

Thus, in the case of a synchronized production process, it will be explored the possibilities of reducing the processing time of the machine tools, will be tried as much as possible to simplify the maintenance tasks and will be studied the possibilities to reduce or eliminate the stagnation times of the machines, whereas in the opinion of Nicolescu et al (2003) today there are priority the *oriented operational* *objectives towards the productivity*: *zero defects, zero inventory, zero interruptions, zero defects, zero documents*. Also, Cârstea (1994) believes that for locating the equipment it is appropriate to respect the principle of the straight line, which is to ensure the shortest travel routes of the products and the continuity principle, which consists of cutting out the interruptions times between different phases or stages of the production process. So that, an analysis of the activities, which a worker must perform for each machine, becomes mandatory.

3. GROUPING OF THE PROCESSING OPERATIONS

Obtaining a minimum overall time for a product processing is possible by respecting the following two criteria (Moldoveanu, 1996):

- *Minimizing the waiting time of equipment;*
- *Minimizing the waiting time of the products.*

Practice has shown that the technological operations are carried out with consumption of time, both of the operator and of the basic machine. Generally, the norm of the time of the operator (t_e) for an operation, comprising: the manual action time (intervention) surveillance time, the waiting time (conditioned by the manufacturing technology) and the rest time periods and physiological needs. However, in the case of poly-servicing, the norm of the time includes the overlap time, namely the time of the equipment outage due to the fact that the operator is busy on other machines that have stopped.

On the other hand, for a single operation, the norm of the time of the machine (t_f) includes: the manufacturing time of the machine, the auxiliary time when the machine is not working and the stationary time due to the regulatory or non-regulatory interruptions.

Poly-servicing is possible only if the worker can perform tasks from one machine, while the remaining machines in the cluster have a useful function without supervision. Therefore, in order to implement the poly-servicing must satisfy the condition: $t_f > t_e$. To determine the approximate number of machines (n), which can be reached by an operator, it is used the formula $n = t_f / t_e$. The requesting coefficient of the operator for a single post (k_e), when the operator request is completed at his workplace (100%), it is determined using the formula: $k_e = 1/n = t_e / t_f$.

The time norms are based on the values of the requesting coefficient (k), determined by the calculations and measurements. Analyzing the machine times and the operator times it can be calculated the following indices, which express the quality of servicing:

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- *index of using of the machine* (k_M), which is given by the using time and the total available time of the machine:

$$k_M = \frac{t_{Mb} + t_{Ma}}{t_{mb} + t_{Ma} + t_{Ms}}$$

where:

t_{Mb} = base time of the machine; t_{Ma} = auxiliary time of the machine; t_{Ms} = retention time of the machine.

- *index of actual use of the machine* (η_u), defined as the ratio between the base time and the total available time of the machine:

$$\eta_u = \frac{t_{Mb}}{t_{Mb} + t_{Ma} + t_{Ms}}$$

Because this index emphasizes usability of the machines, it is recommended that value to be as close to number 1, but this value never can be reached. Basically, by analyzing the poly-servicing we seek to establish the optimal number of machines so that the timeouts to be minimal, both in terms of the operator activity and the operation of the machines. In this respect, the analysis of poly-servicing is performed by two criteria.

- *Structure and duration of the operations for realizing the product* that relate to servicing the machines which perform the same operations with the same durations; servicing machines that are running different operations, but they have the same structure and length; servicing machines that are running multiple operations between them; servicing machines that are running operations with different durations.
- *Machine type*, which refers to servicing machines of the same typo dimensions and servicing machines of different typo dimensions.

4. PARAMETERS USED TO CHARACTERIZE THE POLY-SERVICING

Poly-servicing can be characterized by several parameters, namely:

- *working cycle time of a machine* (T_e^c), which is determined by the relation:

$$T_e^c = t_f + t_e$$

where: t_f = operation time of the machine without supervision;

t_e = executant's time (worker).

$$t_e = t_d + t_s + t_{pi} + t_{on}$$

where: t_d = servicing time of the worker, which includes the most times the supervision time of the equipment;

t_s = supervision time of the machine operation;

t_{pi} = preparing-closing time;

t_{on} = rest periods and physiological needs time.

In the case of the same operations with the same lasting, the time of the poly-servicing cycle (T^c) is determined by the relation:

$$T^c = t_f + t_e,$$

While the optimal number of machines that can be served is determined by the relation:

$$n = \frac{t_f + t_e}{t_e} = \frac{t_f}{t_e} + 1$$

If ***n*** is a fractional number, it rounded to integer. It is obvious that in order to apply servicing, it is necessary to respect the condition $t_f > t_e$, otherwise, it can not be servicing the multiple machines. Usually, in the machine building industry, the intervention times of the worker are well-established, the processing in the poly-serving system is a cyclic one, during the loading or unloading period, the machines do not work, and between these operations are carried out the working time of the machines, without to be needed the operator intervention. The machines tools, that during the processing require the operator intervention or supervision, not can be placed in the poly-servicing system. Coefficient of utilization of the executant's available time can be expressed in the form:

$$K_{et} = \frac{T_a^c - T_e^a}{T^c} = 1 - \frac{T_e^a}{T^c} = \sum_{i=1}^{n} t_{ei} / T^c$$

If it is admitted an arithmetic average value of the servicing time of the machine group, the relation can be written as:

$$T^c = n \times \overline{T_e} + T_e^a$$

$$\text{Result: } \overline{T_e} = \sum_{i=1}^{n} t_{ei} / n, \text{ and } n = k_{et} \times \frac{T^c}{\overline{T}_e}$$

Thus, if we know the maximum cycle time (T^c_{max}), by determining the arithmetic average of the servicing times of the ***n*** machines and we previous calculated the coefficient of utilization of the executant's time (k_{et}), we can determine the number of the machines likely to be served. Practice has shown that depending on the work conditions, the values of the coefficient of utilization of the executant's time is from 0.6 to 0.8.

Example of calculation: Considering the values presented in Table 1 and assuming a coefficient of utilization of the executant's time k_{et} = 0.7, it will be calculated the number of machines that can be serviced by an operator.

TABLE 1 – MEASURED VALUES FOR THE RELATED TIMES OF THE EXAMPLE OF CALCULATION

Machine	1	2	3	4	5
tei (min)	0,5	1	2	2,5	2,5
tfi (min)	7	7,5	6	7	6
Tic (min)	7,5	8,5	8	9,5	8,5

where: t_{ei} = executant's time;

t_{fi} = operation time of the machine without supervision;

T_i^c = working cycle time of a machine.

It is calculated the median time value of the group machine servicing ($T_{e\ med}$):

$$\overline{T_e} = \sum_{i=1}^{n} t_{ei} \ / \ n = (0.5 + 1 + 2 + 2.5 + 2.5) / 5 = 8.5 / 5 = 1.7 \text{ min}$$

$T^c_{max} = (t_{ei} + t_{fi})_{max}$ = 9,.5 min, for machine no. 4

In these conditions, the number of the machines (n) which can be servicing by an operator is:

$$n = k_{et} \text{ x } (T^c_{max} / \overline{T_e}) = 0,7 \text{ x } (9,5 / 1,7) \approx 4$$

Considering the group of machines from the poly-servicing system, consisting of 1-4 machines, I'll check the accepted version:

$$T^c_{max} = 9,5 \text{ min; } \overline{T_e} = (0,5 + 1 + 2 + 2,5) / 4 = 1,5 \text{ min; } n = 0,7 \text{ x } (9,5 / 1,5) = 4,43$$

and the admissible value of the coefficient of utilization of the executant's time is:

$$k_{et\ admis} = (n \text{ x } \overline{T_e}) / T^c_{max} = (4 \text{ x } 1,5) / 9,5 = 0,63$$

Therefore, a little smaller than the calculated value (0.70), which means that they can be served in the optimum conditions, the four machines by a single executor.

5. COMBINATION OF THE OPERATIONS IN THE POLY-SERVICING SYSTEM

In case of production of unique pieces*, the manufacturing of the various parts or products may be repeated at the undetermined intervals, it is possible that the production of the certain products not to repeat again* (Bărbulescu, 1997). Therefore, the combination of operations is difficult, selection of the rational combining variants takes place during the period of preparation of manufacture. In practice, it is studied the status of the order for a previous period of the random time, there are selected only those orders that are often repeated, it is determined the group of the machines that will perform these operations, it is prepared the operational plan according to the schedule, on the shift or on the 24 hours, which is implemented, aiming carefully its execution.

In the case of the serial production, there are established the different types of combinations and there are given to be executed a series of repeated operations by each operator. The preceding stages of the operations combination are: establishing the operations to be performed on each machine; conceiving the alternatives of the operations combining, setting the data in the charts of the individual combining for each variant.

A mass production *is characterized by a nomenclature of production limited to a few types of products, a stable nomenclature in time or a permanent one* (Crăciun, 2008), combining the operations has a stable character and it is the most important stage of the design plan of the technological flow and of the organization execution. Poly-servicing can be performed through the simultaneous or parallel servicing of the more machines, through the subsequent servicing of the machine, or through the simultaneous or subsequent servicing, which is possible only in the certain cases.

The technique of combining the operations for the simultaneous work on the multiple machines is: taking into account the principle of the territorial approach, taking into account only those operations that can be performed on a single line, it is executed an experimental control of the norms for the line, each operation individually timed and there are recorded the results in a general technological graph; based on the structure data of the actually time, constructing a summary chart for the operations performed on the line; studying this chart and comparing the structures of the different operations we can group the machines that are subject of poly-servicing and fix the servicing norms for each particular operation; the result of combining operations is recorded in the form of a regulation, which will be covered the rules of the machine servicing. So, we can say that in the case of the mass production, where each operation is continuously running at the same workplace, the poly-servicing and the cumulus of occupations lead to a high efficiency.

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6. CONCLUSIONS AND RECOMMENDATIONS

Application of the poly-servicing system requires a study elaboration of the way of workplace organization, which will include all aspects, from the spatial organization of the machines, continuing with the technical and technological endowment, to conclude with the supply system of the materials and tools, in order to create the best conditions for the production process. In the analysis that precedes making the decision to apply the poly-servicing, it is imperative to highlight the ambience, techniques, physiological and social factors, as well as the appropriate training of the workforce, to ensure technical, technological and intervention knowledge for processing.

In order to determine the interdependence between of all these factors, initially, it will be examined the servicing times and the timing of the machine, which will be reported to the product, taking into account the ratio of the time variation by increasing the number of the positions, from the situation of servicing a position to a number of positions, so as to achieve an optimum temporary load of the worker.

In the processing of the machines building, we can consider the basic and auxiliary time are not influenced by increasing the number of machine tools, because, the production is homogeneous, each product unit of the same kind required the same technological working time of the machines and the same auxiliary time. In contrast, the residence time of the car increases with increasing number of jobs served since times overlap and increase the worker. The servicing time per unit of product has an inverse proportion of increasing besides the increasing of the machine time, increasing with the decreasing the number of served machines, because the load index of the operator decreases, resulting an incomplete loading. To establish the optimal conditions for poly-servicing, it will be objectively estimated the effective participation of the main factors of production, “man” and “machine”, always expressed in “time”.

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