ADVANCES IN MANUFACTURING SCIENCE AND TECHNOLOGY Vol. 34, No. 1, 2010

STUDIES ON THE INFLUENCE OF TECHNOLOGICAL VARIANTS OF FINISHING MACHINING ON FLOW OF PARTS IN FLEXIBLE MANUFACTURING

Włodzimierz Przybylski, Bogdan Ścibiorski

Summary

This paper present the problems of influence of variants of finishing processing on flow of machining parts in flexible manufacturing system. The technological processes for piston rods and rams of hydraulic cylinders. A model variants of technological processes for piston rods finished with the burnishing were also presented. In these studies the influence of technological variants including burnishing and grinding process on production scheduling was carefully analyzed. Basing on the idea of preliminary scheduling method the attempt of estimation how the technological variants influence the productions of flexible manufacturing system was made.

Keywords: burnishing, flexible manufacturing systems, scheduling, variants of technological processes

Ocena wpływu wariantów technologicznych obróbki wykończeniowej na przepływ elementów maszyn w produkcji elastycznej

Streszczenie

W artykule omówiono problematykę wpływu wariantów obróbki wykończeniowej na przepływ elementów maszyn obrabianych w elastycznym systemie produkcyjnym. Wykonano badania dla wybranych wariantów procesów technologicznych tłoczysk i nurników siłowników hydraulicznych. Podano przykładowe warianty procesów technologicznych dla tłoczysk z uwzględnieniem obróbki wykończeniowej przez nagniatanie. Przeprowadzono analizę wpływu wariantów technologicznych z uwzględnieniem obróbki przez szlifowanie i nagniatanie na harmonogram produkcji. Podjęto próbę oceny oddziaływania wariantów technologicznych na efektywność wytwarzania elastycznego systemu produkcyjnego na podstawie wstępnych harmonogramów produkcji.

Słowa kluczowe: nagniatanie, elastyczne systemy produkcyjne, harmonogramowanie, warianty procesów technologicznych

1. Introduction

The production of piston rods and driving shafts demands the sequence of technological operations such as: turning, drilling, milling, and grinding, polishing, burnishing, hardening and also galvanic plating [1, 2]. Figure 1

Address: Prof. Włodzimierz PRZYBYLSKI, Bogdan ŚCIBIORSKI, Ph. D. Eng., Department of Manufacturing Technology and Automation, Gdańsk University of Technology, Narutowicza 11/12, 80-233 Gdańsk, Poland, E-mail: wprzybyl@.pg.gda.pl, bscibior@pg.gda.pl

presents examples of shafts - piston roads of hydraulic. The requirements for treating this group of parts create a multiphase process structure including: preparation of basic form, preparation of part including shaping functional features, finishing, heat treatment or thermal-chemical processing [3, 4]. In the field of flexibly automated production, the concentration of phases on one operation is the aim, that helps to achieve spectacular technical and economical results. The advantages of concentration of manufacturing tasks are widly used in machining centers. The production of shaft can be an example of concentration of tasks in turning centers.

Burnishing techniques (smoothing or strengthening) applied as a finishing process on CNC lathes and center lathes is another example of concentration of operations.

Fig. 1. Piston rods for hydraulic cylinders – examples

The manufacturing cell is the most often used organizational structure of the flexible production. In practice, technological-organizational resemblance of parts produced in the cell can reach up to 50% at the quite big changeability of jobs [5].

Burnishing is one of more effective technologies of the finishing process for piston rods production [6]. Not all of the parts produced in the cell require or meet requirements of the burnishing technology. This can have an essential influence on the productivity of the flexible manufacturing cell.

2. Variants of technological processes

Burnishing, smoothing turning, center less grinding can be an example of an alternative method for replacing processing with center grinding or polishing.

In the technology of burnishing piston rods in the flexibly automated production it is possible to favor two criteria for the purpose of this processing:

- smoothing burnishing,
- strengthening burnishing.

In practice, at the production of piston rods the variant of the technological process with smoothing burnishing can eliminate operations of polishing and grinding. However, strengthening burnishing can result from design requirements and as the technological variant it can turn out a less efficient process than the inductive hardening surface.

In the research on variants of technological piston rods and rams variants of machining tasks for individual resources were accepted.

The variants of processing tasks have the common basic parameters of processing requirements for comparisons (Table 1), as:

S – shape of the surface,
D – dimension accuracy,
R – roughness,
H – surface hardness,
DH – depth of hardening outer layer,
MS – mistakes of shape,
ML – mistakes of location.

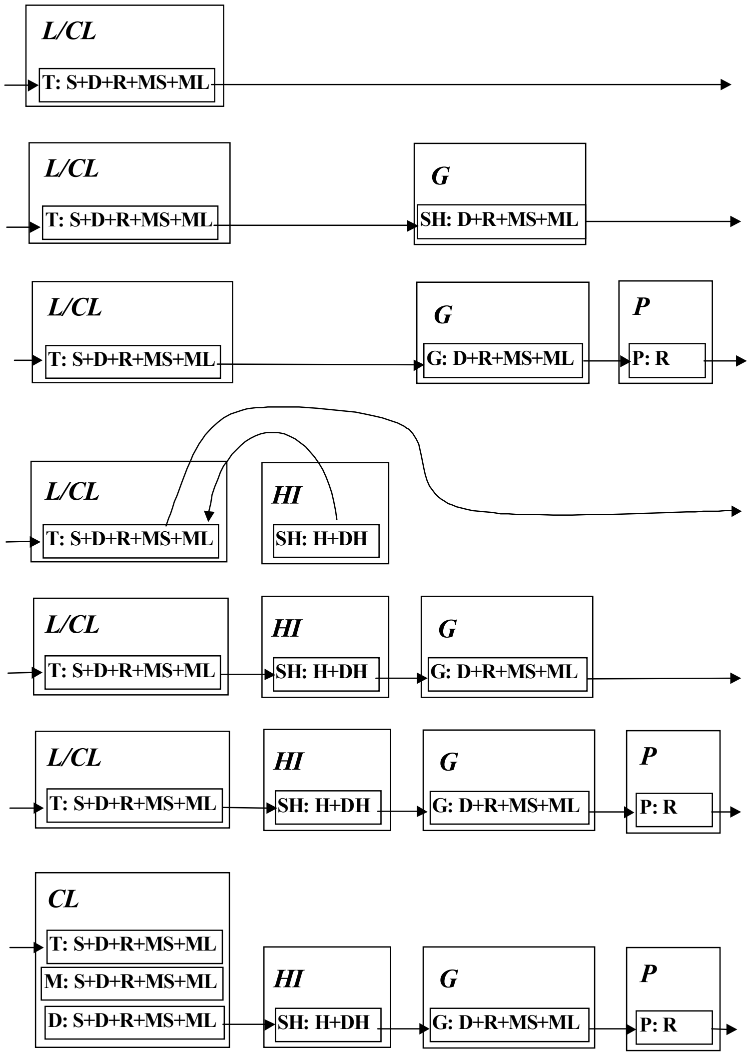
The above machining requirements for rotational surfaces were assigned to machining resources.

The concentration of turning with burnishing (in the limited range of parameters), can meet the largest number of machining requirements, that is shown in Table 1. Figure 2 presents examples of variants of technological processes without burnishing.

Table 1. Economically justified possibilities of the realization of machining requirements for rotational surfaces

Jobs	Processing parametres						
	S	**D**	**R**	**H**	**DH**	**MS**	**ML**
T – Turning	1	1	1			1	1
B – Burnishing			1	1	1		
TB – Turning + Burnishing	1	1	1	1	1	1	1
SH – Surface hardening			1	1			
G – Grinding		1	1			1	1
P - Polishing			1				

As a result of analysis of processes of technological piston rods examples – variants of technological processes with burnishing in flexible manufacturing cell were distinguished as shown in Fig. 3.



Resources:	**L – lathe, CL – center lathe, HI – induction**
Jobs:	**T – turning, M – milling, D - drilling,** **SH – surface hardening, G – grinding, P - polishing**
Parameters:	**S – shape of the surface, D – dimension accuracy,** **R – roughness, H – surface hardness,** **DH – depth of hardening outer layer,** **MS – mistakes of shape, ML – mistakes of location**

Fig. 2. Variants of technological processes for piston rods without burnishing – examples

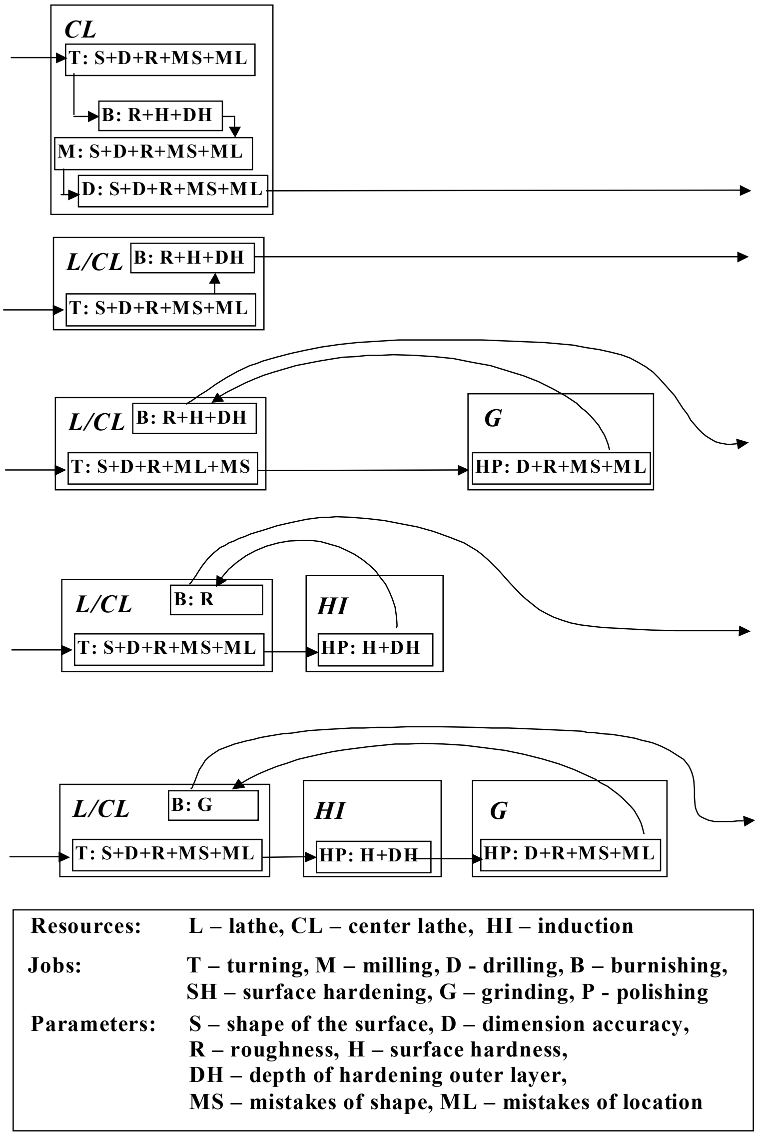


Fig. 3. Variants of technological processes for piston rods with burnishing – examples

3. Preliminary schedule of the production

The number of schedule problems in the flexibly automated production is limited to flow problems that is the order of stages of the production is determined in advance and it is the same for each of machining tasks [7, 8]. It is resulting from the increasing accuracy in the process of machining and the order of formation of the shape. Therefore the majority of the operation is being organized according to growing accuracy of the operation. However, the possibility of utilization burnishing can disturb the flow organization of production. It is resulting from the possibility of applying burnishing as final operation in resources (lathes or machining centers), being reasons of dimension accuracy, at the beginning of technological process. Theoretically every technological process can be done as the flow process but we do not always have the sufficient number of repeated resources in the production line. In many cases a considerable capital cost is inevitable what is an irrational problem at short-term planning.

Figure 4 presents network organization of production which enables recording of every variant of the technological process for every sequence of operations.

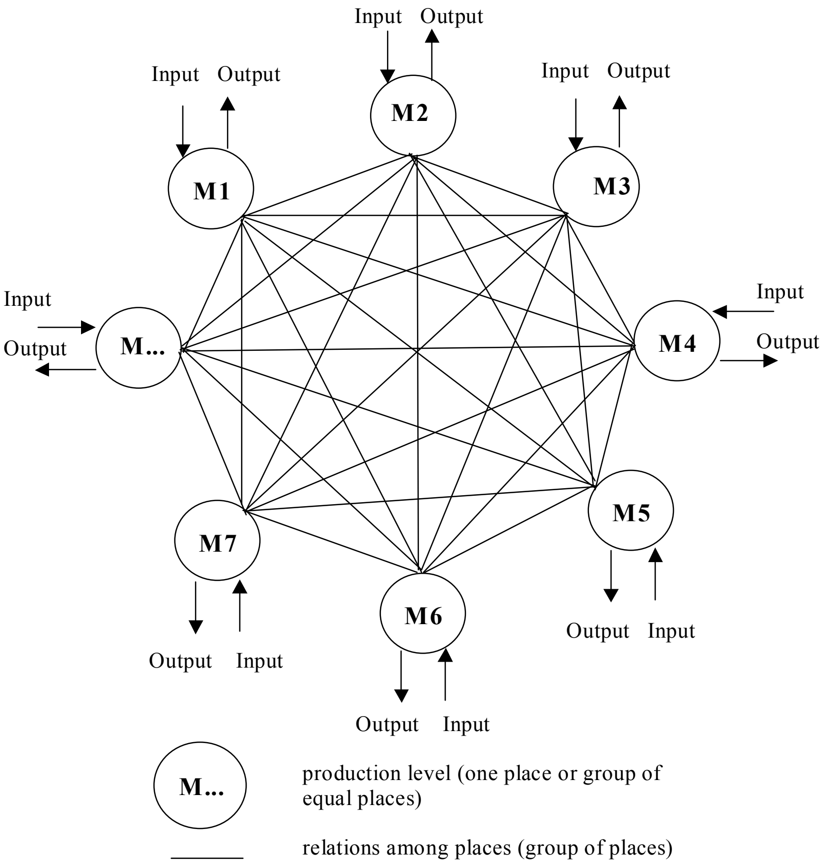


Fig. 4. Network conception of production

The contemporary requirements of market require the quick reaction on appearing orders of manufacturers [9]. The preliminary schedules of production (and even the detailed schedules of production) are prepared at the early stage of preparation of production plan to estimate production capacity of the system.

In planning production we can distinguish the following principle stages:

- determining the variants of production plans:
  - determining production of productive parts,
  - distribution of operations and tools to machines,
- preparing preliminary schedules of different plans of production,
- the estimation of the preliminary schedule and choice of the production plan.

Preliminary scheduling, is giving the information about requirements of manufacturing cell. Such a planning strains the system less and gives results earlier.

As the next step, it is possible to make a scheduling support based on the limited productivity, in order to estimate consequences of limiting the availability of the manufacturing cell. As a result, more reliable and exact scheduling of resources can be received.

At the study we limited our divagations and researches to one flexible manufacturing cell oriented to the production of shafts. The flexible manufacturing cell consists of: two turners centers CNC (CL1 and CL2), induction hardening station (HI), three cylinder grinders (G) and polishing machine (P). The selection of the number and type of machines was dictated by balancing of the production plan. With regard to high automation of CNC machine tools, to eliminate rearming, small batches of similar products were grouped together (Group Technology), for example, in one-day production plan [10, 11]. In the analysis the time of transportation between resources was set as 6s. The times of transportation and setups were included in processing times for batch. Fourteen carts were used for transportation and as mid operation stores as well. Every cart is being treated as a batch of the product. The match that exceeds the capacity of the cart is passed to the next cart. The galvanic processing was not analyzed in the considered cell. Researches were carried out for 14 types of piston rods and rams. The analysis for 11 variants of production plans were carried out (of variants of plans of loads of resources, Fig. 5). The growing number of alternative technological processes with burnishing on center lathes CNC in plans was considered.

In the next stage of research the analysis of the influence of quantitative leading variants with burnishing to the flexible manufacturing cell (FMC) on the plan of production was carried out.

Variant „1” is an entrance variant without processing with burnishing (Fig. 6 and first variant of Fig. 5). Variant „2” contains one technological process with burnishing, variant „3” – two processes with burnishing, etc. Variant „10” contains nine processes with burnishing. In every variant of the plan there are realized 14 technological processes.

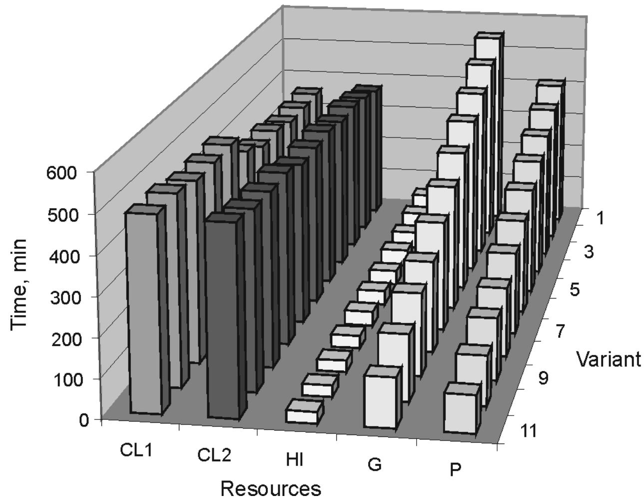


Fig. 5. Variants of plans of loads of resources

In next step preliminary schedules were generated which were used for further analysis. The graph of loading of resources on basis of preliminary schedules was prepared (Fig. 7).

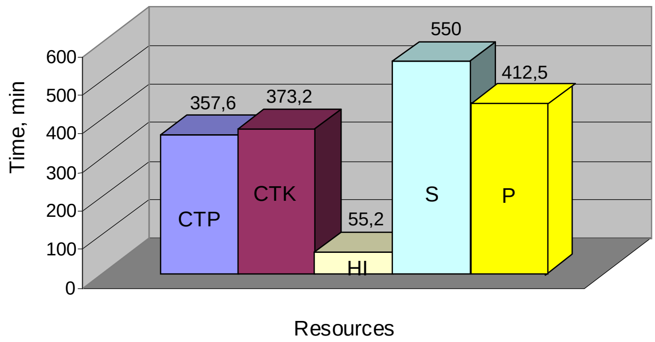


Fig. 6. Variants „1" of plans of loads of resources

Exemplary schedules are presented in Fig. 8 for variant „1" – without burnishing and for variant „6" – with burnishing for five different technological processes.

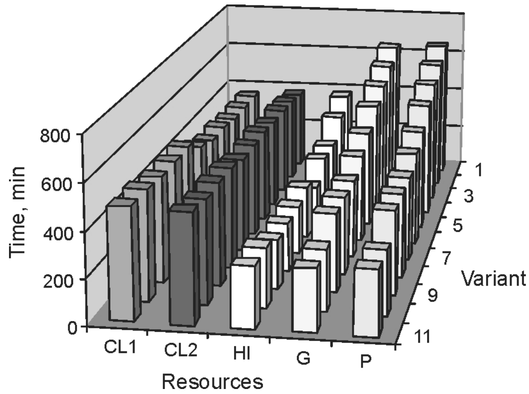


Fig. 7. Variants of loading of resources in the result preliminary schedules

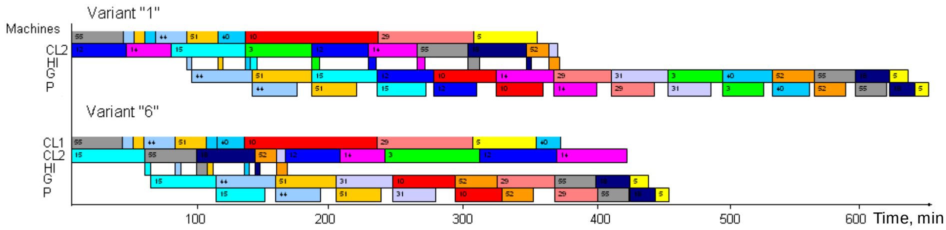


Fig. 8. Exemplary schedules for variant „1" and variant "6"

4. Estimation of the production plan variant

In order to make schedules our own system written in Visual Basic was used on basis of heuristic algorithms. The system generates the suboptimum area of solutions, according to criterion of the shortest time for the production in the FMC.

The structure of the system, given for the assessment and choice of the variant of the production program is presented in Fig. 9.

To start with the matrix of attributed processing task without burnishing (as a point of reference for further comparisons) is considered as well as the file of matrix of attributed processing task with burnishing. After generating schedules, the next step is choosing criteria for the estimation and variants of technology, based on the database of criteria.

The database contains the following criteria: productivity of FMC, effectiveness of resources usage, productivities of resources. However, in the concluding module the system is analyzing generated schedules on the basis of earlier estimation criteria and choosing the production plan for the realization.

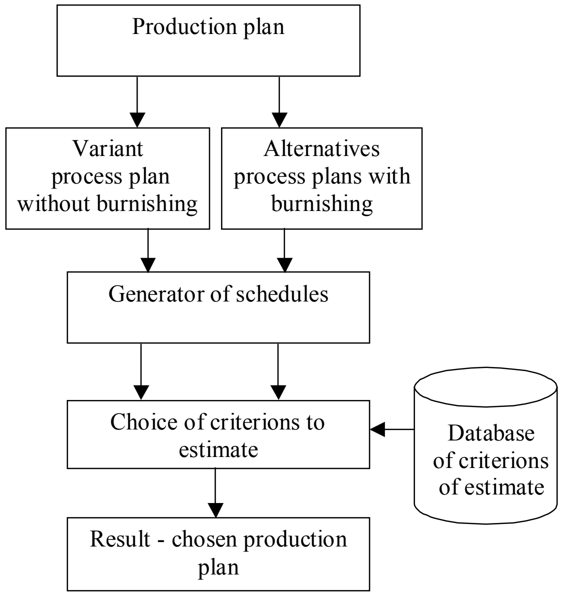


Fig. 9. The variants of loading the resources in result of preliminary schedule

On basis of schedules the graph was prepared Fig. 10, represents the influence of concentration of operation with burnishing on production time in resources and in FMC.

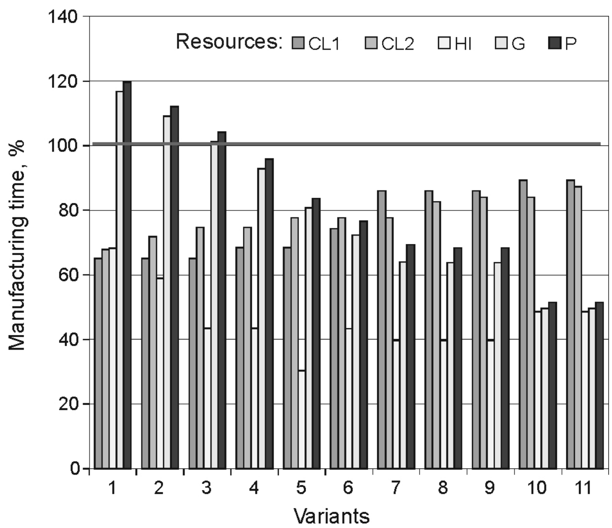


Fig. 10. Influence of the concentration of the operation with burnishing on the time of production in resources

The horizontal line marks 100% (550 min with 480 operations in the production plan) of realization of variant „1” of plan production in FMC (technological process without burnishing). As it can be seen on the graph, the shortest time of production and the best balanced loading of resources in FMC were obtained when 5 processes with burnishing were used in the production plan (variant „6” of production plan). Introducing more variants with burnishing for the manufacturing system did not bring such effective results because loaded turner centers extended the time of the work of the FMC.

Figure 11 presents the way the growth of productivity in the manufacturing system for production plan depending on the number of operations. In the variant „6”, where 378 operations where included in the schedule, the production plan achieved the biggest productivity growth. Further reduction of quantity of operations, with elimination of transportation activities did not make any differences in straining the manufacturing system.

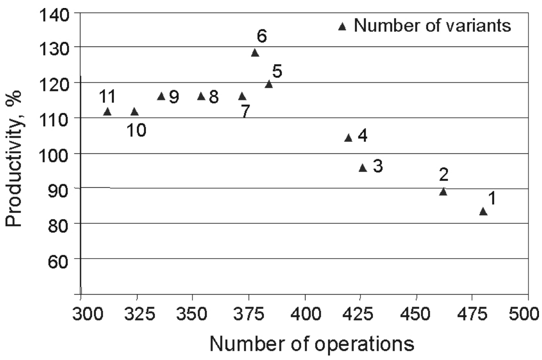


Fig. 11. Number of operations in variants of production plans

5. Conclusions

The investigations show that the network organizational mould of flexible system of production is profitable for realization of variants of technological processes in burnishing plastic processing on cutting off machine tools.

It results mainly from the network structure of some technological processes with burnishing.

Scheduling tasks in the network production demand heuristic algorithms in order to find temporal optimal solutions.

However, preliminary scheduling is very helpful in analysis of technological variants while preparing the production program.

On the grounds of the above researches one can notice some favourable possibilities of balancing loads of the producing system resources with process with burnishing.

References

[1] W. PRZYBYLSKI: The burnishing process on CNC-machining centres. *Proc. Inter. Conference on Computer Integrated Manufacturing*, Zakopane 1996.
[2] W. PRZYBYLSKI, M. SIEMIĄTKOWSKI: Creating manufacturing alternatives of axially symmetric parts incorporating burnishing technologies. [CD-ROM] *Proc.* 16th Inter. Conference on Production Research, ICPR-16, ed. D. Hanus, J. Talacko, Czech. Assoc. Sci. Tech., Prague 2001.
[3] W. PRZYBYLSKI, M. SIEMIĄTKOWSKI: Comparative analysis of process alternatives for manufacturing piston rods of hydraulic cylinders. Proc. 8th Inter. Research/Expert Conference „Trends in the Development of Machinery and Associated Technology", TMT 2004, Neum 2004.
[4] A. SAMEK: The activities in the machining process and their formalization. Proc. Inter. Conference CIM'99, vol. 2, WNT, Warszawa 1999, 227-234.
[5] J. MAZURCZAK: Projektowanie struktur systemów produkcyjnych. Wydawnictwo Politechniki Poznańskiej, Poznań 2002.
[6] W. PRZYBYLSKI: Technologia obróbki nagniataniem. WNT, Warszawa 1987.
[7] E.G. COFFMAN: Teoria szeregowania zadań. WNT, Warszawa 1980.
[8] A. JANIAK: Wybrane problemy i algorytmy szeregowania zadań i rozdziału zasobów. Akademicka Oficyna Wydawnicza PLJ, Warszawa 1999.
[9] M. INNOALA, S. TORVINEN: Integrating computer aided quality assurance in flexible engineering and production process. *International Journal of Production Economics*, **41**(1995).
[10] R. KNOSALA i inni: Zastosowanie metod sztucznej inteligencji w inżynierii produkcji. WNT, Warszawa 2002.
[11] I. KURIC; J. MATUSZEK, R. DENAR: Computer aide process planning in machinery industry. Wydawnictwo Politechniki Łódzkiej Filii w Bielsku Białej, Bielsko-Biała 1999.

Received in February 2010