human resources, scheduling,
loading, availability, simulation

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SIMULATION OF HUMAN RESOURCES ALLOCATION IN SCHEDULING PROCESSES

Abstract:

In the manufacturing planning process one of the main question is how many and what kind of employees we need to complete successfully orders and jobs. The best use of human resources at the shop floor level is one of the key issues. The problem is complex especially in unit and small batch production systems, where the changes in production program and production profile are much more frequent than in large batch and mass production ones, so it needs the computer support. This paper is focused on human resources planning at operational level, which deals with day-to-day work. The paper shows how different methods of scheduling influence human resource requirements.

1. RESOURCES IN COMPANY

For the correct production run a company needs some resources. They are especially machinery and equipment, materials, financial resources, human resources (labour), information technology and others.

One of the main resource's attribute is its availability which is most often constrained by many factors. Then, the resource capability is a key issue to determine its best use in the production systems. In computerized management systems, the resources are divided as:

- un-renewable production resources, such as materials, energy – they cannot be remade or regenerated to utilization,
- renewable production resources, as for example workstations, human resources, which can be re-used again. The availability of employees as well as machines is constrained by the labour calendar including working days, holidays and other breaks, by company's regulations defining daily number of working hours, number of shifts, length of breaks for rest, lunch etc. and by number of similar resources (e.g. machines, employees).

In the production planning process, the main problem is to allocate resources to orders and jobs in such way to maximize resource utilization and shop-floor productivity as well as minimizing flow times, wastes and costs. From viewpoint of resource capacity utilization there are possible three following situations:

– Overload – when the required resource capacity is more than available resource capacity.

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– Underload – when the required resource capacity is less than available resource capacity.
– Balance – required and available resource capacities are equal.

The full utilization of resources in the practice is very unlikely by reason of many constraints and unforeseen circumstances. For example employee absenteeism and tardiness, material shortage, machine failure are examples of day-to-day problems for managers.

2. PRODUCTION PLANNING AND SCHEDULING

Planning of resources can be made at one of the three levels – strategic, tactical and operational ones, which refer to different planning period (longer or shorter time scale) and are related to different levels of detailness (broader or narrower scope) [15].

Operational planning includes scheduling which aims at determining the optimal manufacturing programs, load for workstations (machines) and setting reserves needed to realize the production program in the required time span. In other words, scheduling comes down to allocate available resources from viewpoint of time and area in the best possible way.

To built the optimal schedule during the satisfied time is usually impossible due to complex nature of this problem and many constrains. The mathematical methods as well as techniques of simulation and Constraint Theory may be applied to find the best solution. Examples of solved problems for production planning and scheduling presented in the subject literature are usually unsatisfied because of their sub-optimal, approximate or specific character. The analyzed issues usually are narrowed and (or) they take into account scarce criteria. Therefore, in the practice, the planning and scheduling tasks are based on engineer's experience and intuition. Enterprises improve their planning and scheduling by gathering the real data from processes and creating the own knowledge data. [9]

In today's companies planning and scheduling without informatics support means practically impossible due to their complexity. Independently on the company's manufacturing system, the basic objective of the scheduling is to determine and calculate resources requirement. Scheduling is used to assign jobs to machines in such way that processing time and costs are minimized. There are also useful from viewpoint of planning human resources, purchasing materials. The scheduling process is influenced by start date and due date, but there are also many other variables and factors concerning it, for example kind of jobs to be processed, resource availability including especially human resource capacities, processing time, set-up time, planned maintenance, number of shifts etc.

2.1. Scheduling approaches

There are two classical approaches to scheduling: backward and forward. The both include "what-if" scenarios. The forward scheduling determine jobs starting from the earliest possible time, whereas the backward scheduling makes it in a reverse manner and determine jobs from viewpoint of the latest possible time [12].

The backward scheduling answers a question "When the job should be stared at the latest in order to finish it at the demanded date?". This method is useful from the viewpoint of the identification of bottlenecks. The manufacturing process should be started not later than in the latest start date. Having the data on operations time, it is possible to determine the load for particular machines (machine groups) used for manufacturing some products. The forward scheduling answers a question "When the job will be finished if we start at the defined date?". Besides of backward scheduling and forward scheduling, it can be also used combined scheduling approach [10]. First, the jobs are scheduled backward, but if a starting date for any job is found out of the determined date (usually current date), this job is rescheduled moving forward in time. This approach is called as midpoint scheduling.

2.2. Balancing

In today's company's practice there are usually some conflicts connected with resource allocation, for example we have resources in excess as appropriate to demanded goals and jobs, and conversely – we have resources' shortages to do jobs by required time. To solve these problems the load-capacity balancing function is used. It enables to compare resource capacity demanded versus available resource capacities and check if a production orders and (or) jobs are feasible or not by the required time and in consequence to make the best decision. The capacity of resources may be considered as infinite or finite. Infinite approach ignores capacity constraints, but can be helpful to identify bottlenecks in a proposed schedule.

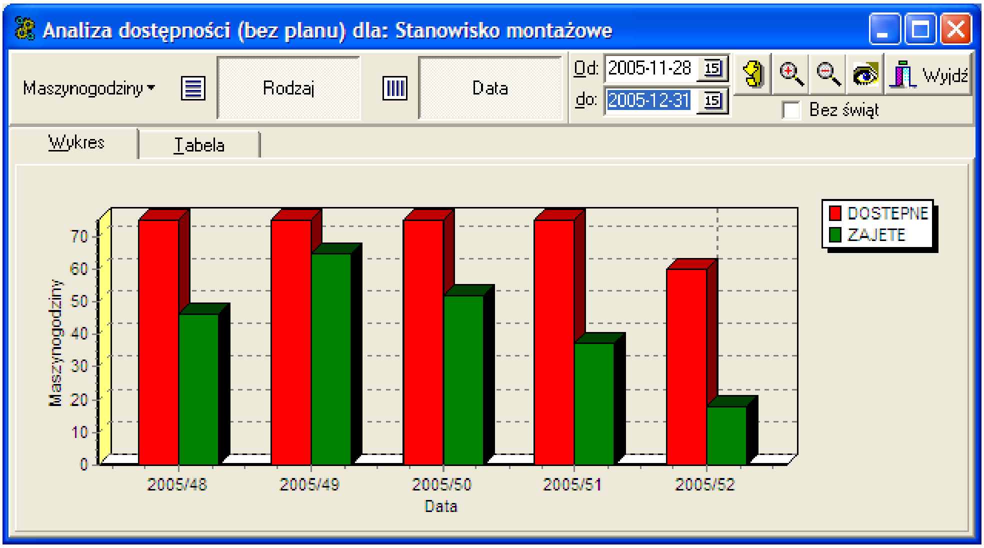

Fig. 1. Analysis of availability for workstations regarding balancing function [9]

3. HUMAN RESOURCES IN THE PRODUCTION PLANNING

3.1. Human resource planning process

The human resource planning aims especially at providing the company with the right people in the right place and at the right time and at motivating them to involvement and better and better productivity. It can assist the organization to foresee changes and identify trends in human resources and to adopt the personnel policies in order to avoid major problems [11].

At present, planning has a much shorter time-scale than in previous decades due to the unpredictable changes into organizations as well as around them and the need to respond in a flexible way. Moreover, there is more emphasis to develop multi-scenario plan that provides flexibility to take advantage of opportunities that arise and to cope with unexpected dangers that may befall [14].

Human resource planning process is divided into some steps which involve identifying future needs and internal supply, and next, identifying the discrepancies between the two and developing strategies to fill them – see Fig. 2.

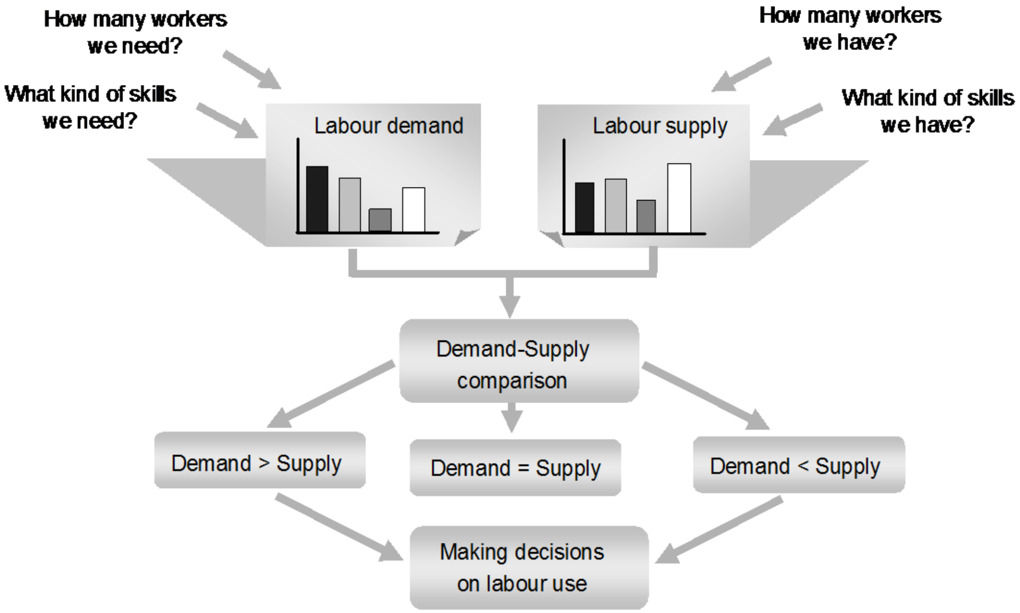

Fig. 2. Stages in human resources planning

Labour demand deals with the human resources that will be needed to carry out the future objectives and tasks from viewpoint of their number, competencies and locations. Labour supply involves the current staff profile available within the organization.

The result of the comparison of labour demand and supply is the identification of gaps (shortages or surpluses) in staffing needs [16]. A shortage indicates a future shortage of required employees. The strategies to attract and develop staff with demanded competencies will be needed. They could be for example training workers for new skills and knowledge, overtime work. A surplus indicates the future excess in some categories of employees. In this situation the strategies of dealing with excess in number of employees and (or) competencies no longer needed in the organization should be developed. The example of strategies to address surplus situations may be re-training, staff transfers, dismissal due to redundancy.

There are many different strategies the organization may use to address gaps, so the decision which strategy, or which combination of strategies to choose, should be considered carefully. During the process of analyzing the possible strategies the following factors should be also considered [16]:

– Time – is there enough time to develop competencies of own staff internally or is special, fast recruitment the best approach?

– Resources – the availability of demanded resources is also important as well as priorities and timing.
– Cost – which strategy is of the lowest cost?

3.2. Planning the number and skills of workers demanded

From viewpoint of production process planning and control it's very important to know how many and what kind of employees are required in a given period. Knowing the quantity and quality of needed resources we can estimate the time of order completion as well as the labour costs related to employees involved in the manufacturing processes. The problem of human resources planning is complex because human factor is the most unforeseeable. It is very difficult to foresee future human behaviour, absenteeism. Additionally, the labour law introduces many limitations related to way and time of human resources use.

There are many techniques used to calculate how many workers are demanded. One of them is technique based on the balance of working time [3, 13]. To estimate the number of required workers in the given period we need to know the data on available working time per one employee. The data necessary to calculate the number of employees demanded in a given period (N_e) for operating a given kind of workstation are following:

– number of workstations (machines, machine groups) of a given kind – n,
– labor hours required by one workstation in a given period – T_w,
– average available working hours per one employee in a given period – T_e.

The average available working time per one employee (T_e) is calculated considering standards complied from the labour code, as well as the average employee absenteeism. Absenteeism embraces average number of days when an employee is absent due to holidays, sickness and other reasons. Holidays are defined by labour law and labour calendar. On the contrary, the sickness absence is estimated on the basis of the company's statistical data. For example, an average employee is absent due to holidays – 20 days per year, due to ill-health about 10 days per year and 5 days due to other reasons. Total annual absence rate for this example is 35 days.

The formula for calculating the average available working time per one employee in the given planning period is following:

T_e = number of whole weeks[1] *within a planning period $\times$ 40 hours per week*
+ number of working days beyond whole weeks $\times$ 8 hours per day
– number of holidays within whole weeks (holidays $\neq$ Sundays) $\times$ 8 hours per day
– average absenteeism rate $\times$ 8 hours per day.

Having such data we can find N_e as follows:

$$N_e = \frac{n \times T_w}{T_e} \tag{1}$$

Planning the quality of workers demanded we have to know what are the main requirements of workstations, that means what knowledge and skills are needed, what is the responsibility and so on. Such data enable to define the profile of a preferred worker.

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[1] The first whole week includes period from 1st day of a given planning period to 7th day, the second – from 8th to 14th and so on.

In determining work requirements the job evaluation may be helpful. It is a process of analysis and assessment of a work content form viewpoint of demanded knowledge and skills, scope of responsibility, effort and working conditions. Job evaluation is a valuable tool used especially for basic pay differentiation purpose, but it can also be used in other areas, like defining the required professional qualifications, identifying training needs etc. [4]. There are a number of different job evaluation methods. Each analytical method consists of a set of factors defining main qualification requirements.

The present production systems want flexible and agile workers, who can be shifted dynamically to where they are needed [6]. The functional flexibility is one of the main types of labor flexibility within Atkinson's concept of flexible firm [2]. From cost point of view there is a question if the functional flexibility is really effective for a company. On one hand polyfunctional operators are more costly because higher qualifications should be compensated by higher payment, but on the other, they allow the company to reduce a number of employees, so in consequence this solution seems as more cost-effective. There is assumed that the labor flexibility is cost-effective, but there are a little evidence confirming this assumption [15]. However, today's enterprises seek qualified, motivated and open for changes operators.

3.3. The use of human resources at shop floor

One of the key aims of production planning at operational level is the best use of human resources at shop floor. Human resources optimization involves allocation of employees to machines and jobs to ensure that minimal number of engaged operators as well as the balance between over and under staffing. That means the working time of an employee will be used in the best way, without the overtime and idle time.

Availability of human resources is constrained by many factors – Fig. 3, such as: number of operators, their skills, maximal working time per a day and week which is limited by labour law, work organization including number of shifts, breaks within a working day.

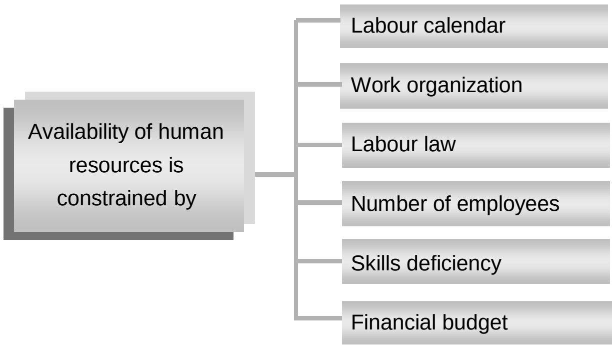


Fig. 3. Factors constrained the use of human resources

Capacity and utilization of human resources may be improved by multi-skilling. Multi-skilling enables an employee to work flexibly on a variety of tasks [1]. In today's manufacturing systems, especially of unit and small batch production, operational flexibility and mobility between vocations and workstations is required.

4. SIMULATION-BASED HUMAN RESOURCES ALLOCATION

To find the best solution on human resources use in the production scheduling, the simulation method is helpful. Simulation as a part of decision support systems for production scheduling provides a way to get detailed information about the consequences of scheduling decisions [8]. There are a number of reasons for using simulation versus analytical models, but the main usefulness of simulation is to identify the potential problems and prevent them before the schedule will be introduced at the shop floor [8].

The simulation method may be used in order to analyse what are the human needs taking into account different scheduling method and answer the questions: "How many operators and what kind of skills are required from viewpoint of a given scheduling method?" and "What scheduling method does enable to use the available human resources in the optimal way?". In subject literature related to computer integrated manufacturing management, employees are considered as the secondary resource with the less meaning for the decision process [9]. This approach is very simplified. Confining the role of human resources in decision making on a given solution may lead to higher labour costs and finally higher production costs. The role of employment is one of the key factors and it should be taken into consideration together with other resources, i.e. machines and workstations.

As shown in Fig. 4 the proposed simulation-based human resources allocation system includes three sub-systems:

– ERP system, which is necessary to download the operative data and generate production schedules,
– sub-system for defining optimization procedures,
– sub-system for preparing and conducting simulation processes.

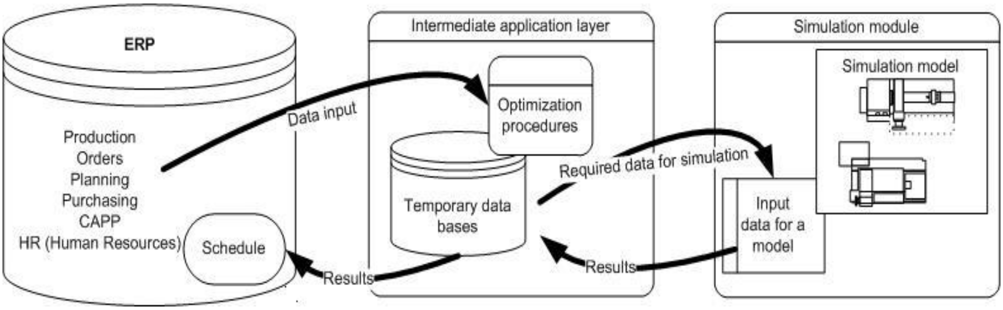


Fig. 4. Simulation-based HR allocation system

Simulation-based HR allocation system may support to optimize human resources. HR optimization involves allocation of employees to machines and jobs to ensure the minimal number of workers and balance between over and under staffing. The algorithm presented in Fig. 5 includes stages of simulation of human resources allocation based on accepted criteria and scheduling methods.

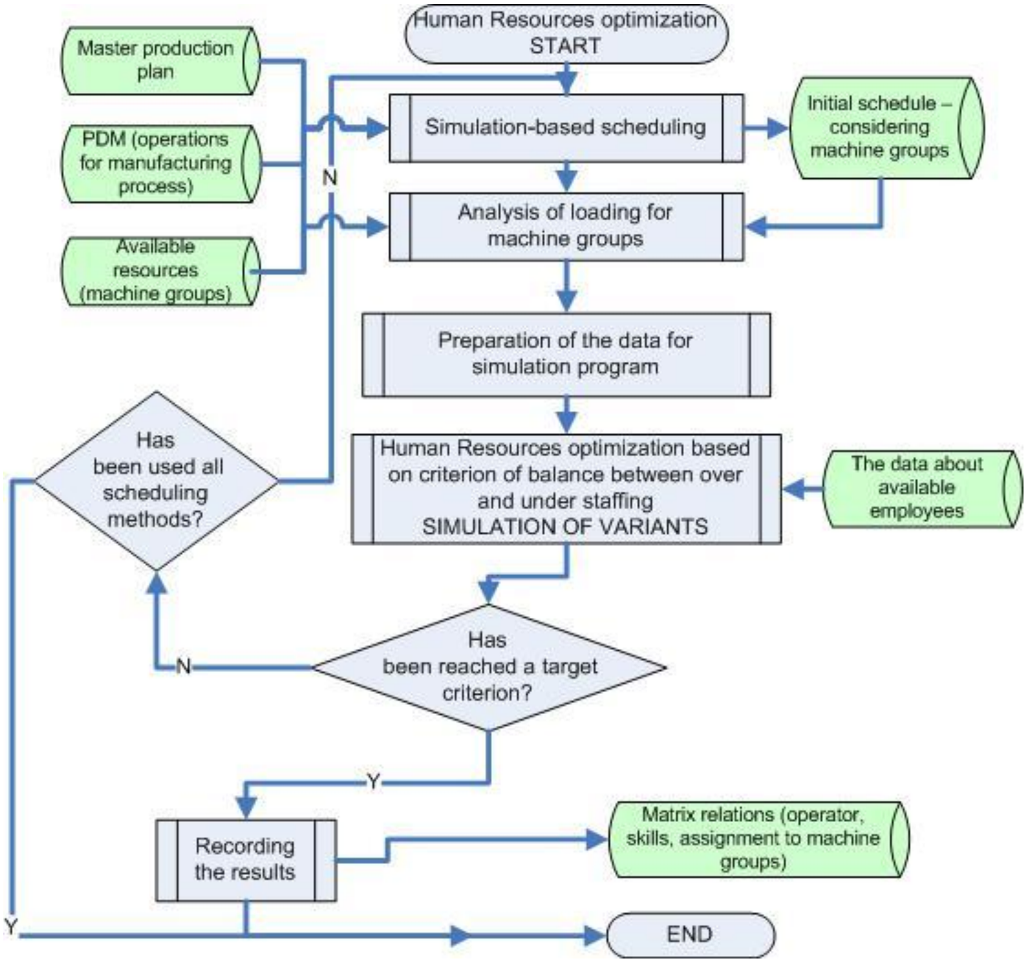


Fig. 5. Algorithm of simulation based HR allocation

Having the production plan, loading for machine groups, operating rules (including shift number, working time, breaks, absenteeism rate), the human resources allocation may be developed based on various optimization criteria, such as: minimal number of workers, maximal use of employee' working time, maximal use of employees' skills, balance between over and under staffing. Then, the target function is:

$$Y = f(N, S, T_l, T_a) \quad (2)$$

where:

N – number of required workers,

S – worker's skill range (the possibility to operate different machines by a worker),

T_l – time of loading for a worker,

T_a – time of availability of an average worker.

From viewpoint of optimization of labour time and costs, the minimal number of operators is demanded as well as the best use of their working time without over time work and idle time. In other words, the absolute difference between loading time for a worker and his (her) availability time should be minimal:

$$\sum_{i=1}^{N} \left| T_{li} - T_a \right| \rightarrow \min \tag{3}$$

where:

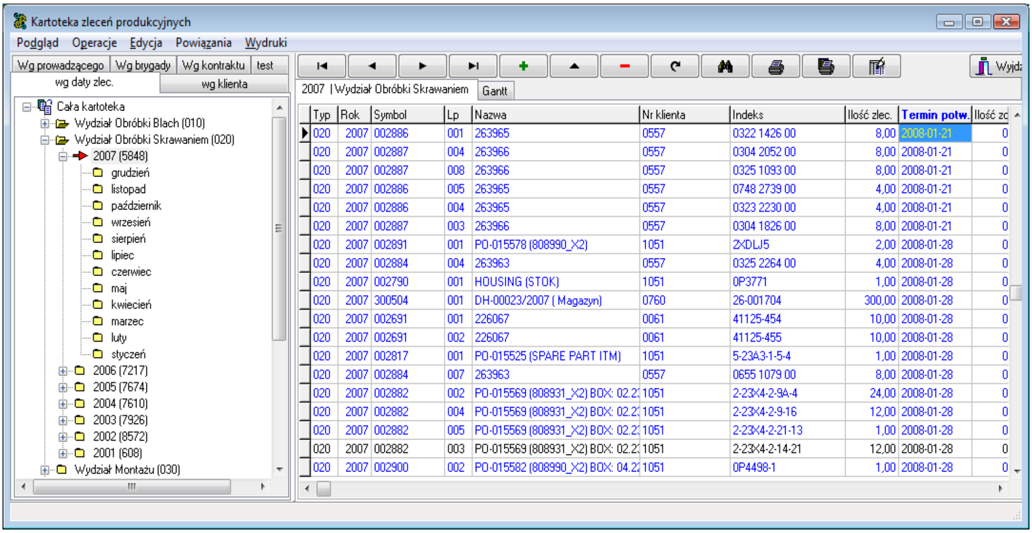
n = 1,2,…,N – employees and N tends towards the minimum

5. SIMULATION OF HUMAN RESOURCE DEMANDS IN DIFFERENT SCHEDULING APPROACHS - example

5.1. The input data

There is a medium production company employing about 80 shop floor workers. The products are manufactured in unit and small batches and that's why the machines' loading as well as required workers' numbers are changeable. The example for human resources simulation is concerned to the Machining Department. It is conducted in order to simulate how different scheduling methods influence quantitative and qualitative requirements for operators.

The analysis is made for 4 weeks' planning period (from the 1st to 28th of January 2008). The ERP integrated system is used to download the operative date, generate orders in the planning period and allocate them to machines. The part of the production plan is presented in Fig. 6.



Typ	Rok	Symbol	Lp	Nazwa	Nr klienta	Indeks	Ilość zlec.	Termin potw.	Ilość zd
020	2007	002886	001	263965	0557	0322 1426 00	8,00	2008-01-21	0
020	2007	002887	004	263966	0557	0304 2052 00	8,00	2008-01-21	0
020	2007	002887	008	263966	0557	0325 1093 00	8,00	2008-01-21	0
020	2007	002886	005	263965	0557	0748 2739 00	4,00	2008-01-21	0
020	2007	002886	004	263965	0557	0323 2230 00	4,00	2008-01-21	0
020	2007	002887	003	263966	0557	0304 1826 00	8,00	2008-01-21	0
020	2007	002891	001	PO-015578 (808990_X2)	1051	2XDLJ5	2,00	2008-01-28	0
020	2007	002884	004	263963	0557	0325 2264 00	4,00	2008-01-28	0
020	2007	002790	001	HOUSING (STOK)	1051	0P3771	1,00	2008-01-28	0
020	2007	300504	001	DH-00023/2007 (Magazyn)	0760	26-001704	300,00	2008-01-28	0
020	2007	002691	001	226067	0061	41125-454	10,00	2008-01-28	0
020	2007	002691	002	226067	0061	41125-455	10,00	2008-01-28	0
020	2007	002817	001	PO-015525 (SPARE PART ITM)	1051	5-23A3-1-5-4	1,00	2008-01-28	0
020	2007	002884	007	263963	0557	0655 1079 00	8,00	2008-01-28	0
020	2007	002882	002	PO-015569 (808931_X2) BOX: 02.2	1051	2-23X4-2-9A-4	24,00	2008-01-28	0
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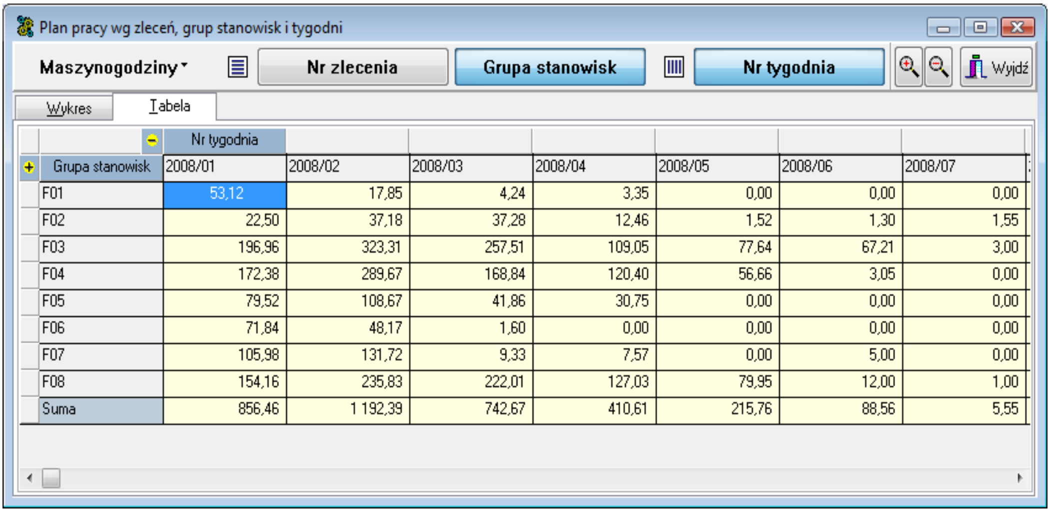
020	2007	002882	003	PO-015569 (808931_X2) BOX: 02.2	1051	2-23X4-2-14-21	12,00	2008-01-28	0
020	2007	002900	002	PO-015582 (808990_X2) BOX: 04.2	1051	0P4498-1	1,00	2008-01-28	0

Fig. 6. Production plan for the planning period – an example

Orders are then divided into jobs and jobs are assigned to machine groups, so we can find out how the particular machines are loaded. The loading may vary depending on used scheduling method. Changes in loading influence changes in required number and skills of workers.

In the manufacturing process different machines are engaged. The further analysis is narrowed only to the milling machines marked in Fig. 7 as F01 to F08 machines.



Nr tygodnia / Grupa stanowisk	2008/01	2008/02	2008/03	2008/04	2008/05	2008/06	2008/07
F01	53,12	17,85	4,24	3,35	0,00	0,00	0,00
F02	22,50	37,18	37,28	12,46	1,52	1,30	1,55
F03	196,96	323,31	257,51	109,05	77,64	67,21	3,00
F04	172,38	289,67	168,84	120,40	56,66	3,05	0,00
F05	79,52	108,67	41,86	30,75	0,00	0,00	0,00
F06	71,84	48,17	1,60	0,00	0,00	0,00	0,00
F07	105,98	131,72	9,33	7,57	0,00	5,00	0,00
F08	154,16	235,83	222,01	127,03	79,95	12,00	1,00
Suma	856,46	1 192,39	742,67	410,61	215,76	88,56	5,55

Fig. 7. Machine-hours for milling machines in particular weeks form viewpoint of forward scheduling approach

5.2. Simulation of quantitative human resources needs

The considered milling machines (millers) are divided into four sub-groups regarding their different qualification requirements to operator:

– CNC millers (include F01, F02, F03, F04 machines),
– CNC large millers (F05, F06),
– CNC millers for rough machining (F07),
– manual millers (F08).

The required number of operators (N) for particular machine sub-groups is calculated according to the following formula:

$$N = \frac{\text{total machine hours required in the given period}}{\text{labour hours available by one operator in the given period}} \qquad (4)$$

Total machine-hours for the specified machine sub-groups are related to the loading of milling machines. The loadings of particular machines in successive weeks of the planning period are determined considering different scheduling methods. Basing on the data derived form ERP system the machine-hours for considered machine sub-groups taking into account the forward schedule are presented in Fig. 8.

To calculate how many operators are needed in the following weeks, the time of availability of an average person is required to know. In considered example the labour hours available by one operator are calculated considering the planning period. From 1/1/2008 to 28/1/2008 there are four weeks and one holiday (1st of January). A working day per an operator lasts 8 hours. Excluding 30 minutes break, each operator works 7,5 hours a day (37,5 hours a week).

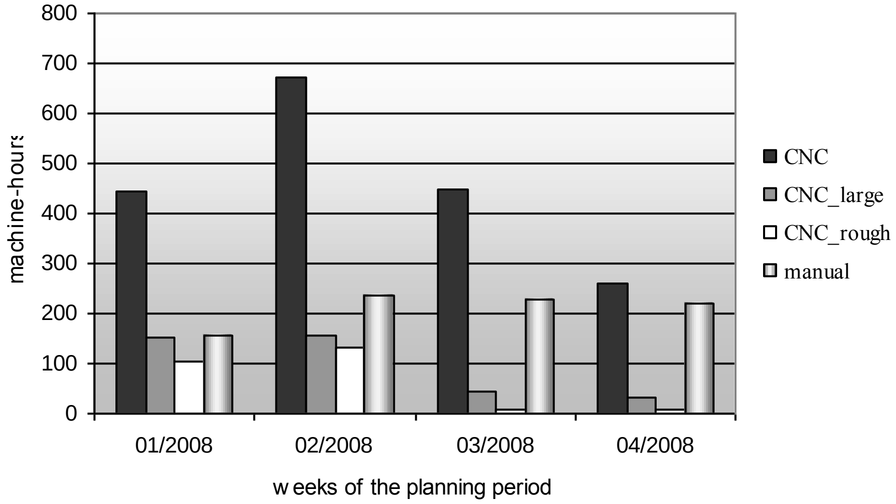


Fig. 8. Loading of milling machine sub-group in the planning period for forward schedule

Considering above assumed, the required number of workers for CNC machines in the first week (01/2008), considering the forward schedule, is:

$$N = \frac{444{,}48\ \text{hs.}}{37{,}5\ \text{hs.}} = 11{,}85 \cong 12\ \text{operators}$$

The scores for further weeks for CNC miller as well as other machine sub-groups are included in the Tab. 1. All results are up rounded to full time employment.

Tab. 1. Required and available human resources in forward scheduling

Milling machine sub-groups	Required number of operators in successive weeks				Available[2] number of operators in every week
	01/2008	02/2008	03/2008	04/2008	
CNC	12	18	12	7	13
CNC_large	4	5	2	1	3
CNC_rough	3	4	1	1	3
Manual	5	7	6	6	6
Total	24	34	21	15	25

[2] In presented example the available operators' number is assumed as average in the scale of the whole planning period.

The same calculation are made taking into account backward and midpoint scheduling methods.

Next step is to simulate the balance between under and over staffing. It consists in comparing demanded versus supplied (available) operators' numbers and defining the gas as surpluses or shortages considering different scheduling approaches. The comparison may be done for particular machine sub-groups as well as for the whole machine group.

The surplus is when available number of operator is more than required (marked as "+"), the shortage – when it is less (marked as "–"). The figures form 9 to 11 show the gaps in human resources for machine sub-groups as well as for all milling machines (total) in considered period.

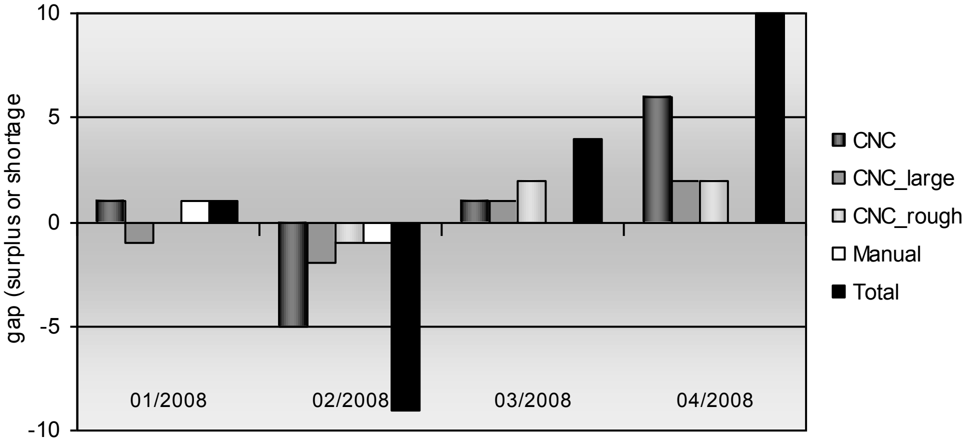


Fig. 9. Surpluses or shortages in human resources in forward scheduling

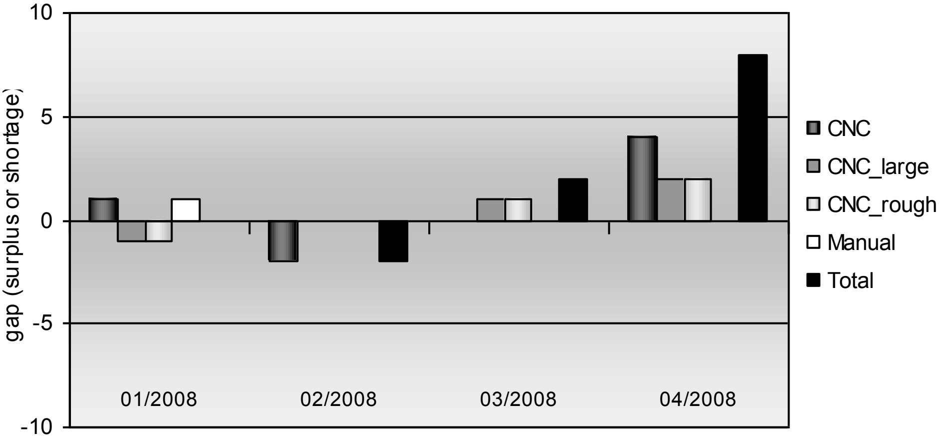


Fig. 10. Surpluses or shortages in human resources in backward scheduling

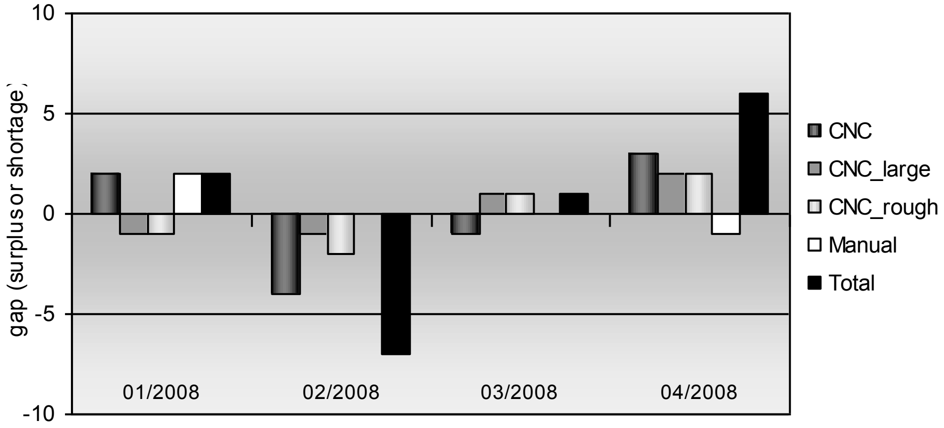


Fig. 11. Surpluses or shortages in human resources in midpoint scheduling

The quantitative needs should be next completed by defining qualifications requirements.

5.3. The quality of the required operators

To find out what are the main requirements of workstations (machine sub-groups) addressed to job-holders, the job evaluation process is needed. The job evaluation makes possible to define what are the main requirements of particular machines from viewpoint of demanded qualifications (preferred knowledge and skills, scope of responsibility, effort etc.).

	Milling machines			
Sub-factor	CNC	CNC_large	CNC_rough	Manual
Education and experience required	40	30	30	20
Additional skills	1	3	1	0
Dexterity	1	4	4	5
Complexity of work	15	9	9	10
Responsibility for own work	10	12	10	6
Responsibility for others' work	0	0	0	0
Responsibility for external contacts	0	0	0	0
Mental effort	15	13	10	8
Physical effort	6	10	9	13
Noxiousness of worktime schedules	0	0	0	0
Monotony at work	2	4	4	2
Material environment conditions	2	3	2	4
Total score:	92	88	79	68

Fig. 12. Job evaluation assessment sheet

The job evaluation exercise has been done using the method which is the most appropriate in respect of the kind of workstations in the company. During job evaluation process every workstation is considered according to specific factors and allocated in appropriate number of points related to a pre-defined scale. The same factors and point scales are used for every workstation. Each factor is broken down into levels of difficulty. The level is described in words and in appropriate number of points. The higher level the more demanding factors and in consequence the greater number of points. The results of job evaluation conducted for considered milling machines are presented in Fig. 12.

The final result of job evaluation is to group workstations into some grades with like level of qualification requirements – Tab. 2.

Tab. 2. Classification of machines into grades

Grade	Point range	Workstations
I	(… – 70)	Manual Miller
II	(71 – 85)	CNC miller (for rough machining)
III	(86 – 100)	CNC large miller, CNC miller
IV	(101 – 115)	…

Successively, job-holders are classified to appropriate grades. A multi-skilled worker able to operate different machines from different grades is classified to the highest grade, according the formula:

$$G_{ej} = \max\{G_{wi}\} \tag{5}$$

where:

G_{ej} – employee’s grade,

G_{wi} – workstation’s grade,

i= 1,2,…n – workstations which a j-employee can operate.

Table 2, as a result of the job evaluation, illustrates positions of particular workstations in their relationships with others according to their different demands for knowledge and skills, responsibility, effort, working conditions. This is next the fundamental for basic pay rate differentiation and finally, for simulation of the labour costs related to considered production plan.

5.4. Discussion of result

The simulation of three different cases of human resources demands has been made. Each simulation result is related with some gaps.

From viewpoint of the forward scheduling:

- the greatest number of employees engaged to particular machines as well as to all milling machines is needed,
- in the most critical week (02/2008) the human resources requirements are largest (34 operators in total are needed),
- the first week introduces 1 operator in excess,

– there are the greatest gaps (surpluses and shortages) in particular weeks (for ex. in the week 02/2008 9 workers are lacking and in turn, in the week 04/2008 10 employees are in excess),
– shortages in required staff in the second week may be balanced by surplus in 04/2008 week.

The backward scheduling:

– requires the smallest operators' number,
– in the starting week the shortages in certain machine sub-groups may be balanced by surpluses in others, so in the global sense there would be no gap,
– in the second week the staff requirements are covered with its availability in three machine sub-groups,
– there is relatively large surplus in human resources in the last week,
– generates the best matching between staff supply and demand for manual milling machines in particular weeks.

In the scheduling with midpoint approach:

– the first week starts with 2 operators in excess,
– there is relatively great deficit in needed staff in the week 02/2008 (7 operators are lacking in total), but this may be compensated by equivalent surpluses in the third and forth weeks,
– the surplus in the last week in the smallest,
– the number of demanded workers is generally more than in backward scheduling but less than in forward one.

In conclusion, comparing the available versus demanded human resources in numerical aspect for the assumed production plan, the backward scheduling approach is the best. It enables to realize orders in time with the minimum number of operators. The workers are used in the best way, that means numbers of available as well as demanded employees are consistent in most of cases (considering weeks and machine sub-groups). Additionally, introducing the adequate multi-skilling level where some workers would be able to operate different machines makes possible to improve the organization of working day (less inactivity time, less over-time work).

6. CONCLUSIONS

To realize the production plan in time, the required resources should be supplied. The human resources are one of them and they are very important because human factor is one of the most unforeseeable. There are many constraints, which make the time and way of human resources use limited.

In unit and small batch production the demand for number and skills of employees varies over time. In such environment employees are required to be more mobile and flexible between workstations as well as between vocations, so workers should be encouraged to develop multiple skills. To determine a number and quality of human resources required in the planning period, the support of computer integrated system is necessary. ERP system enable to have actual and integrated information on the company's state and condition as well as it gives the data to perform "what-if" analysis and see the impact of different changes in order to avoid making costly decisions.

With the use of ERP system we can simulate how different scheduling methods influence human resources needs, that means how many employees and what skills are required. These information may be useful in making decision on the best use of human resources from time and cost point of view.

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