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METHODOLOGY OF DETERMINING OPTIMAL QUANTITY AND QUALITY OF HUMAN RESOURCES IN UNIT AND SMALL BATCH PRODUCTION ENVIRONMENT

1. Introduction

To realize production orders and carry out manufacturing tasks, according to pre-determined production program, some resources are required. They are especially: machinery and equipment, money, organization, information, time and people. Human resources are generally regarded as the organization's most valuable asset [3]. Employees' knowledge, skills, motivation, involvement and other personal attributes are essential source of organization competitive dominance in more and more demanding and changeable environment. Without involvement of employees in company's activities, it is impossible to transform raw material into finished product.

From viewpoint of production process planning and control it's very important to know how many and what kind of employees, i.e. what kind of competencies are required in the given period to complete orders successfully. Workers with the right qualifications and skills are needed to carry out manufacturing tasks and operations, to produce goods and services of high quality and in time. Knowing the quantity and quality of needed resources we can estimate the time of order completion, as well as the direct labour cost related to employees involved in the manufacturing processes. The problem is complex particularly 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. Capacity and utilization of human resources may be improved by multi-skilling. Multi-skilling enables an employee to be flexible and work on a variety of tasks [1]. In today's manufacturing systems, especially of unit and small batch production, operational flexibility and mobility between jobs and workplaces are desired.

The proper personnel management is crucial in managing an organization as a whole and has great impact on company's success. It should be noticed that results of human resource management are reflected by labour costs, which include all expenses on human resources, especially wages and other components. Among many components wages and salaries are fundamental because they are the greatest part of the total labour cost (in Polish practice they are about 75%). The key component of an employee's wage is the basic pay, which should be related to importance of the job done, level of education and skills required, responsibility involved in the job, intensity of mental and physical effort put into the job and inconvenience of environmental factors during work. In practice, pay rates are differentiated on the basis of job evaluation process integrated with employee appraisal process.

2. Planning human resource needs at the operational level

Human resource planning HRP (in other words: workforce planning) is an integral part of the broader process of the organizational planning. HRP complements and is follow-up to the corporate planning system. Just as strategic planning helps an organization map where it is, where it is going and how it plans to get there, a HRP lays out specific tasks and actions needed to ensure an organization has the resources to meet the mission and objectives. The use of HRP can assist an organization to foresee changes and identify trends in human resources and to adopt the personnel policy in order to avoid major problems in the future [6]. Human resource planning is one of fundamental processes for optimization of human resources in a company from the viewpoint of production cost and time for realization of orders.

Planning of resources can be performed at different levels – strategic, tactical and operational ones, which refer to diverse planning periods (longer or shorter time scale) and are related to various levels of detailness (broader or narrower scope) [8]. At the operational level human resource planning aims at providing a company with the right people in the right place and at the right time. So, the main stages of this process are (see Fig. 1):

- identify future human needs form viewpoint of production goals (labour demand),
- assess the current human availability (labour supply),
- compare labour demand versus supply in order to find discrepancies,
- prepare the best strategies to cope with a gap between demanded and supplied human resources.

At present, planning processes, also within human resources area, have a much shorter time-scale than in previous decades due to unpredictable changes in 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 [7].

The problem of human resource planning is complex because there are many constraints, which make the time and way of human resources use limited. Human resources are limited particularly by the number of available workers, as well as their competency level. Moreover, human factor is the most unforeseeable. It is very difficult to foresee future human behaviour, absenteeism and performance level. Additionally, labour calendar, labour legal regulations and work organization introduce many limitations related to way and time of human resource use.

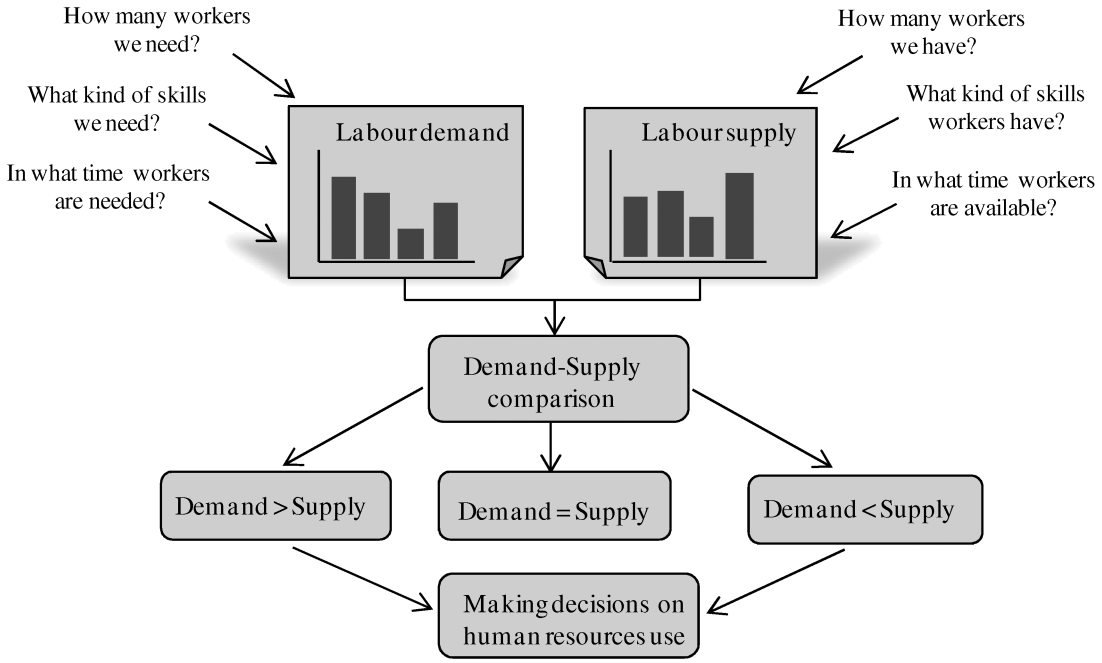

Fig. 1. Main steps of human resource planning

Human resource optimization from cost point of view involves allocation of employees to machines and jobs to ensure the minimal number of engaged operators, as well as the balance between over and under-staffing and the best matching between job's requirements and employee's competencies. That means the working time will be used in the best possible way, without the overtime and idle time and employees skills will be used in the best possible way.
Having the production plan, loads for machine groups, operating rules (including shift number, working time, breaks, absenteeism rate), human resource allocation may be developed and based on various optimization criteria, such as: minimal number of workers, maximal use of employee working time, maximal use of employee skills, balance between over and under staffing. Then, the target function is [2]:

$$Y = f(N, L_c, T_l, T_a) \tag{1}$$

where:
N – number of required workers,
L_c – staff competency level (the possibility to operate various machines by workers),
T_l – time of load 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 load time for a worker and his/her availability time should be minimal:

$$\sum_{i=1}^{N} |T_{li} - T_a| \rightarrow min \tag{2}$$

where:
i = 1,2,…, N – employees and N tends towards the minimum.

In turn, the best use of employee skills and competencies is important from the standpoint of people motivation and satisfaction, as well as for satisfying the concept of "the right employee in the right place", so, for each j-th job performed by i-th worker is demanded:

$$\sum_{i=1}^{N} \sum_{j=1}^{M} (L_{caij} - L_{crij}) \rightarrow 0 \tag{3}$$

where:
j = 1,2…, M – jobs to be performed,
L_{caij} – competencies available by i-th worker to perform j-th job,
L_{crij} – competencies required from i-th worker to perform j-th job.
Available competencies may be determined by a worker's personal grade (category) resulting from employee appraisal process, but competencies required may be defined by a job grade (category) resulting from job evaluation process.

3. Job evaluation and pay differentiation

In order to forecast the optimal employment structure it is necessary to know the number of needed operators, as well as demanded qualifications, skills, personal characteristics and behaviours that operators engaged into accomplishing tasks and operations are required to possess. To answer what types of workers will be required in the future, it is necessary to identify competencies that employees will need to carry out the work [9]. Competencies include knowledge, skills and other personal attributes that are critical to successful work performance. This enables to define a set of competencies that describes ideal human resources in the future, and provides management and staff with understanding skills and behaviours important to an organization. Therefore, it plays a key role in further decisions on human resource management, particularly on recruitment

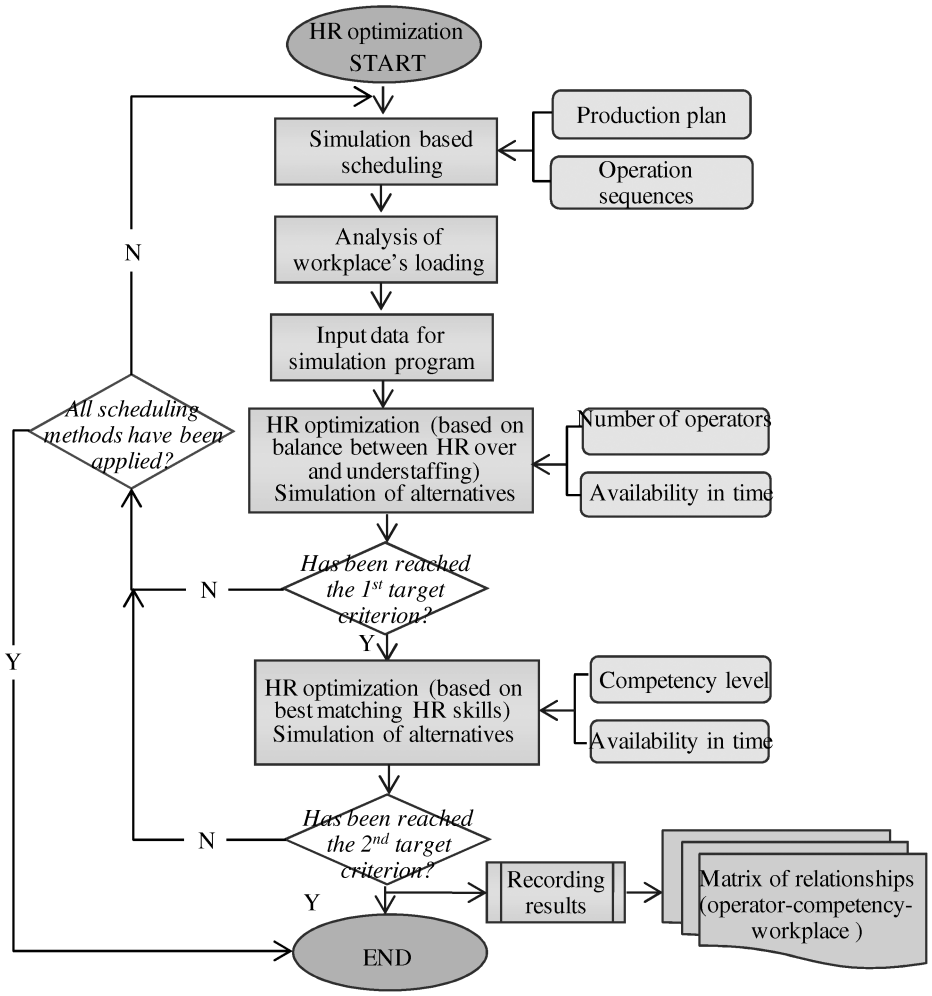

Fig. 2. Algorithm of simulation based on HR allocation

and selection, employee development, performance appraisal and remunerating.

In order to determine qualitative demand for human resources engaged in the production plan realization, job evaluation is used. It provides essential information about the most important job requirements for particular workplaces from the viewpoint of demanded qualifications (preferred knowledge and skills, scope of responsibility, effort etc.) and, in effect, it provides data about the competency level required to achieve goals and tasks related to the workplace. A sample job evaluation for production workplaces is presented in Fig. 3.

Job evaluation shows what main job requirements are, but moreover, it is a technique designed to assist the development of pay structure by defining relatives between jobs on a systematic basis. During job evaluation the content of jobs is analyzed and assessed according to the same factors, in order to put the job into a rank order in the organization. Assessing each job under particular specific factors of chosen job evaluation method and allocating adequate number of points, the obtained score enables to put the job in a produced rank order.

In the payment area job evaluation provides a disciplined framework for managerial pay decisions and expresses the concept of "equal pay for work of equal worth" [1]. This contrasts with the practice in some enterprises, where arbitrary judgments are made about payment of particular jobs, with no reference to common criteria and inadequate reference to the effect of pay decision on other jobs within the enterprise. Showing the relationships between jobs the job evaluation process gives objective and logical foundation of keeping a rational payment policy within an enterprise.

The hierarchy of evaluated jobs established by job evaluation is the basis for grouping jobs with similar level of work requirements into a number of job grades (job categories) and for basic pay rate differentiation, and finally, for simulation of labour costs related to the considered production plan. It is assumed that jobs of the same grade are similar about required knowledge and skills, responsibility, effort and working conditions, and therefore, they should be equally paid. The scatter-diagram is a helpful tool used in the process of job grouping – Fig. 4. At first, jobs are placed in increasing order of values. There are visible clusters of jobs, which may help in decision making about looping jobs into a job grade.

Taking into account clusters of jobs, the next step is to define the ranges of points for created job grades – see Tab. 1. The required number of grades should be also considered at this stage. It usually depends on the size of an organization and on the number of different jobs being evaluated, as well as on the company's policy about personnel development and possibilities of horizontal promotion for employees.

		Job evaluation factors												
	Jobs	Education required	Experience required	Manual dexterity	Respons. for work run and results	Responsibility for equipment	Responsibility for safety of others	Responsibility for supervision	Physical effort	Mental effort	Material environment conditions	Unavoidable hazards	Monotony at work	Total scores:
1	Machining centre	30	25	10	25	15	5	0	20	20	5	0	0	155
2	Hobbing machine	20	20	5	20	15	0	0	15	15	10	0	5	125
3	Universal milling machine	20	15	10	20	10	0	0	10	5	5	0	0	95
4	Heat treatment station	20	15	10	15	10	5	0	10	5	10	5	5	110
5	Assembly station	25	30	10	30	10	0	0	20	20	5	0	5	155
6	Cutting-off machine	10	5	5	10	5	0	0	10	5	5	5	10	70
7	Grinding machine	20	15	5	20	10	0	0	10	10	10	5	0	105
8	Gear milling machine	25	25	10	20	15	0	0	10	15	5	0	5	130
9	NC lathe	25	25	5	25	15	0	0	10	20	5	0	5	135
10	Universal lathe	20	15	5	10	10	0	0	15	10	10	5	0	100
11	Drilling machine	10	5	5	10	5	0	0	20	5	10	5	0	75
12	Painting	10	5	5	20	5	0	0	10	5	10	0	10	80

Fig. 3. Matrix of job requirements evaluation – an example

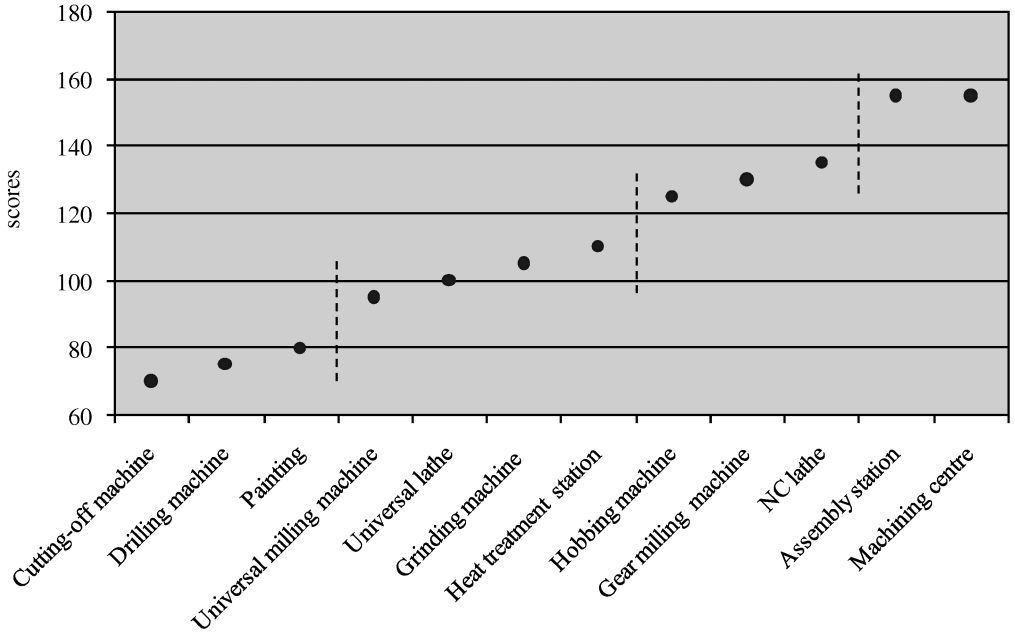

Fig. 4. Scatter-diagram for grouping jobs on the basis of job evaluation results

POINT RANGES	JOB GRADES	JOBS IN GRADES
… – 90	I	Cutting-off machine, Drilling machine, Painting
91 – 120	II	Universal milling machine, Universal lathe, Grinding machine, Heat treatment station
121 – 150	III	Hobbing machine, Gear milling machine, NC lathe
151 – 180	IV	Machining centre, Assembly
151 – …	V	

Tab. 1. Structure of job grades – an example

Above-presented table is a result of job evaluation process for the purpose of pay differentiation. It illustrates positions of particular jobs to reflect their relationships with other jobs, according to their different demands for knowledge and skills, responsibility, effort and environmental conditions. This table shows relationships between jobs resulting from job evaluation process and gives the basis to differentiate pay rates between jobs of particular categories. The money to be paid for each grade is tied up with the organization's general policy on the remuneration system. In pricing process, it is necessary to take into account such problems as labour shortage, union pressure, the level of basic rates for similar jobs in other organizations and company profitability.

After job evaluation process, the next problem is to classify job-holders to appropriate personal grades. The personal grade is usually equal to the grade of job a worker does, but the problem is more complicated when a worker is able to do many jobs with various levels of job requirements and classified to various job grades. Then, from the motivational point of view, a multi-skilled worker who is able to operate different machines from different grades should be classified to the highest grade of considered workplaces, according to the formula:

$$G_{ei} = max\{G_{wj}\} \tag{4}$$

where:
G_{ei} – employee's personal grade,
G_{wi} – job/workplace's grade,
j = 1,2, … n – workplaces which may be operated by i-th employee.

4. Labour costs

Results of human resource management are reflected in labour costs, which include all expenses on human resources, especially wages and other non-wage components called as retention costs. In the production cost system, labour costs are important part of total production costs – in production companies they are about 30-40% of total production costs and they usually depend on the nature of manufacturing processes and technological level.

In many production companies, especially of medium and large size, the general and common structure of labour costs consists of the following elements:

- basic wages and salaries,
- regular bonuses and rewards,
- supplements to wages and salaries, including overtime rates, supplements for night work, shift work, long service, environmental inconveniences etc.,
- social insurance rates,
- cost of training and personnel development,
- cost of safety at work,
- cost of health services,
- cost of recruitment and selection of new member of staff etc.

The knowledge of labour costs is a key for optimization of quantitative and qualitative employment structure due to company's development strategy. For management, the knowledge of labour costs is a basis for making many decisions on personnel management. The analysis of labour costs gives the valuable foundation for profitability of investment in higher qualifications and better skills of staff. The study of labour costs aims at providing the managers with detailed data about following issues:

- What are the real expenses carried on labour and employees?
- How will labour cost change if changes in quantity and quality of human resources due to changes in production plan and company's development strategy are introduced?
- How to optimize the relationship between work performance and expenses on staff (i.e. labour cost)?
- What decisions will be appropriate on better usage of human resources?

Study of labour costs is also useful for the purpose of improving ideas, methods and techniques of human resource management in order to use the human potential in the most rational and effective way. It determines the approach of the company towards human resources, which is also very important because just workers, not jobs, generate profits for an organization [4]. Moreover, the knowledge of labour costs is helpful for more precise calculation of production costs, just at the stage of planning and estimating costs of products and operations. The algorithm for labour cost calculation is shown in Fig 5.

Rationalization of labour cost structure aims at seeking the best links between expenditure for labour and work performance for a single workplace, group of workplaces, team, department, as well as for a whole organisation. To compare labour cost related to particular workplaces and to forecast changes in labour costs, it is needed the knowledge about basic rates and other remuneration components is needed. This knowledge is provided by well prepared, implemented and maintained job evaluation system. Having such data the simulation of labour costs depending on considered company's strategy may be carried out. For management, it is a valuable tool, which supports making decision process concerned with personnel policy and human resource management at all.

5. Determining the optimal employment structure

In determining an optimal employment structure, two parameters describing a work team are fundamental: quantity, i.e. number of employees, and quality, which takes into account employees' competencies. These parameters strongly influence time of orders realization, as well as labour costs and, in result, production costs related to an order. To find the best employment structure from the viewpoint of time and cost criteria, the simulation of different variants varying due to the number of workers and their competency level should be conducted. In turn, particular variants of quantitative and qualitative employment structures are related to different levels of labour costs and cause various times for completion of production plan.

In production environment, especially in unit and small batch production, the worth of workers is perceived by their multi-skilling level. It means their ability to operate different machines, to perform wider range of tasks and duties,

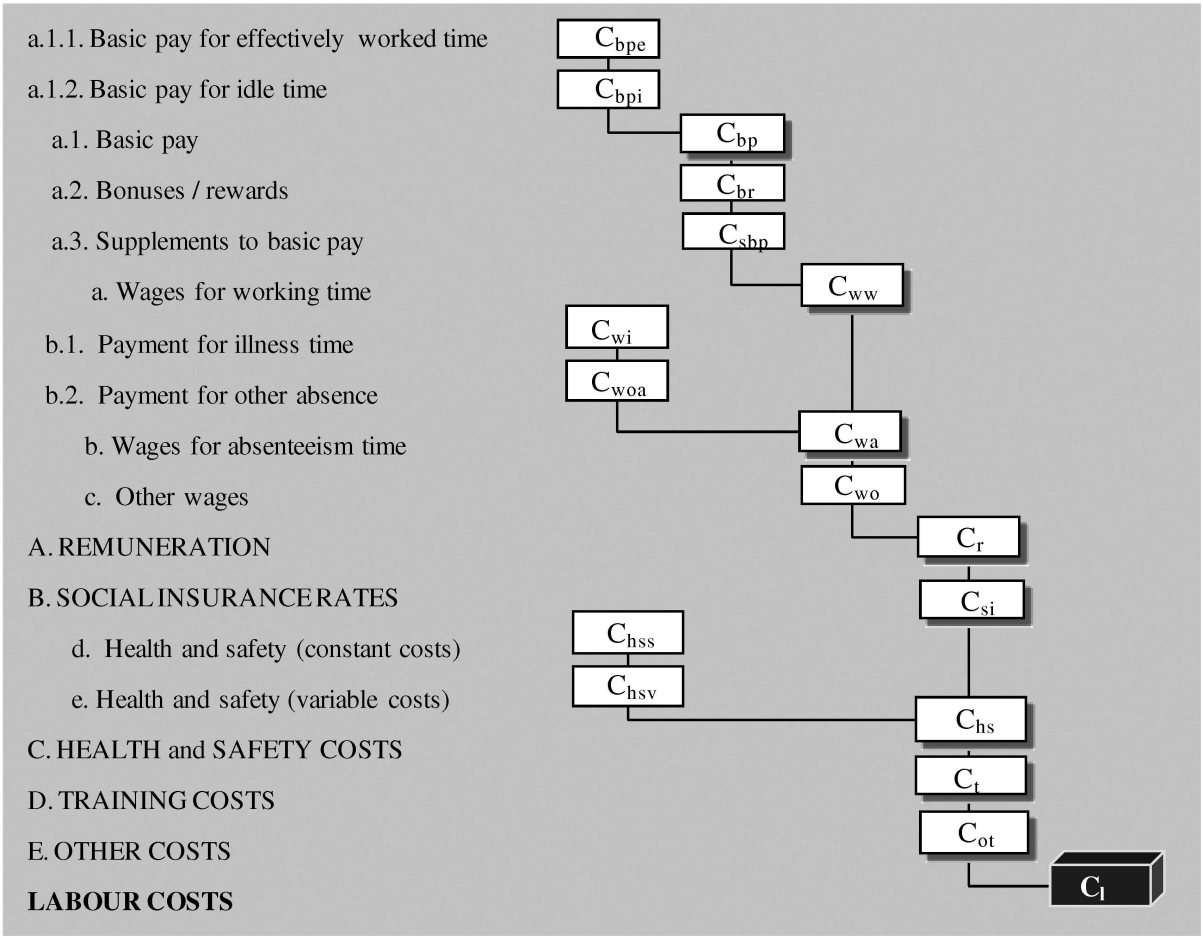

Fig. 5. Algorithm for calculation labour costs

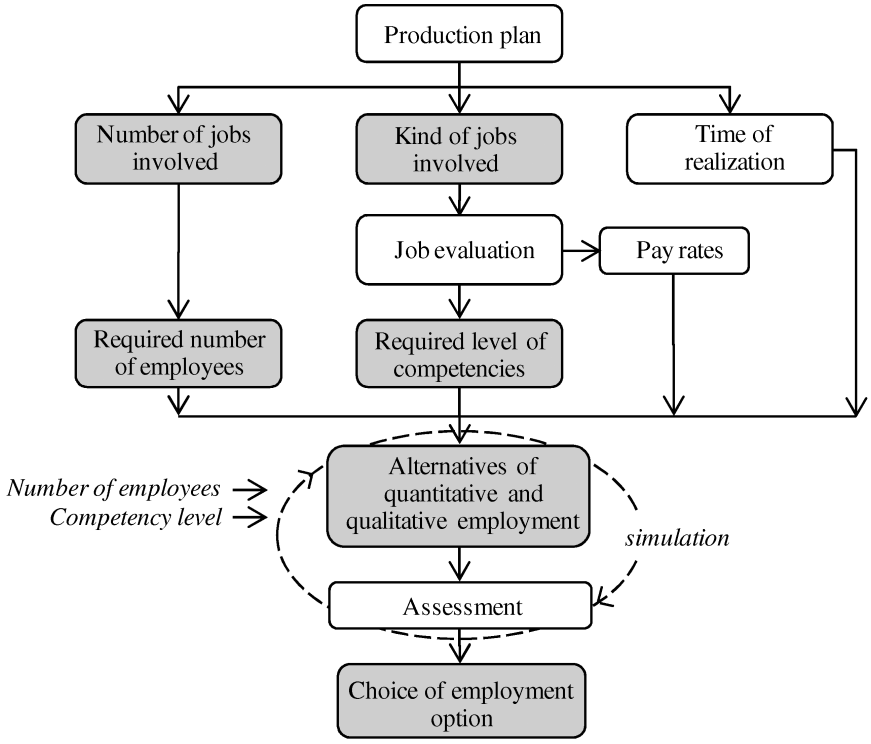

Fig. 6. Stages in determining quantity and quality of employment

to do various jobs depending on the company needs and on employee professional development. In such environment we can assume that the staff multi-skilling level, or in order words: competency level, is connected with their knowledge and skills range, enabling them to do different jobs in different workplaces.

Taking into account aforementioned, we can find the competency level as the following:

$$L_C = \frac{\sum_M^{j=1}(G_j \times n_j)}{\sum_M^{j=1}(G_j \times N)} \quad (5)$$

where:

j = 1,2,…, M – workplaces (jobs),

L_c – staff competency level,

G_j – job grade for j-th workplace resulting from job evaluation,

n_j – number of employees able to do a job classified to G_j grade,

N – total number of employees.

Example

In a production department there are 10 different jobs (workplaces) engaged in the manufacturing process (j = 1,2,…10). Using job evaluation scheme, workplaces have been allocated to particular categories named as workplace grades (categories), as shown in Tab. 2.

To ensure the correct and smooth run of manufacturing process, the right number of operators with right level of knowledge and skills are required.

There are presented some variants of employment indicated as X.k, where X indicates the number of operators, but k – their competency levels – see Tab. 3. There are considered five situations connected with particular numbers of workers (X: A, B, C, D, E), and it is assumed that the number of operators is no more than the number of workplaces, and no less than one person, so the number varies from 1 to 10. Then, for the appointed number of operators, different variants related to various competency levels are considered, these levels are indicated with k (k varies from 1 to 5).

Workplace grade	Number of different workplaces classified to the grade
I	2
II	1
III	2
IV	3
V	2

Tab. 2. Workplaces in grades

X	Number of employees	Variants of staff competency level X.k
A	10	from A.1 to A.5 (100%)
B	8	from B.1 to B.5 (100%)
C	5	from C.1 to C.5 (100%)
D	3	from D.1 to D.5 (100%)
E	1	E.1 (100%)

Tab. 3. Considered variants

X.1 variant appointed for a certain number of operators presents their minimal level of skills. It means an operator is able to do little range of jobs, e.g. only one job. On the other hand, X.5 variant illustrates the maximal staff competency level (100%), that means every employee is able to do each job.

There are considered five situations, named as alternatives, related to different numbers of employees, and several variants of employee competency level are then defined for the assumed number of workers. Considered competency levels for chosen A alternative are presented below as competency matrices (see tables 4÷8).

Alternative A

It is assumed that for this alternative the number of employees is the same as the total number of workplaces, N = M, so N = 10. Variants from A.1 to A.5 indicate various levels of staff competency, from A.1 variant, when every person is able to do only one job (operate one workplace) to A.5 variant, when every worker is multi-skilled and can operate every workplace.

Taking into account proposed formula (5), calculations considering different variants presenting various numbers of employees and various levels of their competencies are made. Obtained results are depicted in Tab 9.

Analogical considerations are made for other X employment alternatives (X: B, C, D, E) and competency options related to each situation X.k, where k = 1,..,5. Considered variants of different quantitative and qualitative employment structures belong to the area of possible solutions for described alternatives from A to E – see Fig. 7.

The curve obtained by variants X.1 indicates the minimal competency level for the particular number of employees – Fig. 7. The minimal level means that a given worker is able to do only one job or more than one job, in the situation when number of workers is less than number of workplaces (n<m). At the minimal competency level an order is possible to be completed in general. Possibility ensures order feasibility; that means each task of order may be performed because there is at least one worker able to do it.

As we can see in Fig. 8, the lower number of employees the higher level of competencies is required in order to make the process of task realization possible. Reducing the number of employees should be compensated by increasing the required competency level (except for E variant, where n=1).

It is obvious that particular employment variants have a great impact on time for production order realization. Small number of employees and low their competency level may be accepted from the viewpoint of order feasibility in general, but this makes time of order realization longer. The load of machines

	Workplace grades G_j										
	I	I	II	III	III	IV	IV	IV	V	V	
Workplace no. / Operator	01	02	03	04	05	06	07	08	09	10	
a	x										
b		x									
c			x								
d				x							
e					x						
f						x					
g							x				
h								x			
o									x		
p										x	
n_j	1	1	1	1	1	1	1	1	1	1	
$G_j \times n_j$	1	1	2	3	3	4	4	4	5	5	$\Sigma(G_j \times n_j)=32$

Tab. 4. Competency matrix for A.1 variant

	Workplace grades G_j										
	I	I	II	III	III	IV	IV	IV	V	V	
Workplace no. / Operator	01	02	03	04	05	06	07	08	09	10	
a	x		x								
b		x					x				
c	x		x	x							
d	x			x							
e			x		x						
f	x	x	x			x					
g					x	x	x				
h								x			
o		x							x		
p		x	x							x	
n_j	4	4	5	2	2	2	2	1	1	1	
$G_j \times n_j$	4	4	10	6	6	8	8	4	5	5	$\Sigma(G_j \times n_j)=60$

Tab. 5. Competency matrix for A.2 variant

	Workplace grades G_j										
	I	I	II	III	III	IV	IV	IV	V	V	
Workplace no. / Operator	01	02	03	04	05	06	07	08	09	10	
a	x		x								
b		x	x				x				
c	x		x	x							
d	x			x			x		x		
e			x		x						
f	x	x	x			x					
g					x	x	x		x		
h			x					x		x	
o	x	x	x			x			x		
p	x	x	x	x		x				x	
n_j	6	4	8	3	2	4	3	1	3	2	
$G_j \times n_j$	6	4	16	9	6	16	12	4	15	10	$\Sigma(G_j \times n_j)=98$

Tab. 6. Competency matrix for A.3 variant

	Workplace grades G_j										
	I	I	II	III	III	IV	IV	IV	V	V	
Workplace no. / Operator	01	02	03	04	05	06	07	08	09	10	
a	x	x	x		x	x			x		
b		x	x				x			x	
c	x		x	x	x	x		x	x		
d	x	x		x			x		x		
e		x	x		x		x				
f	x	x	x			x		x		x	
g	x		x		x	x	x		x	x	
h			x				x	x		x	
o	x	x	x			x	x		x		
p	x	x	x	x		x				x	
n_j	6	4	9	3	4	6	6	3	5	5	
$G_j \times n_j$	7	7	18	9	12	24	24	12	25	25	$\Sigma(G_j \times n_j)=163$

Tab. 7. Competency matrix for A.4 variant

	Workplace grades G_j										
	I	I	II	III	III	IV	IV	IV	V	V	
Workplace no. / Operator	01	02	03	04	05	06	07	08	09	10	
a	x	x	x	x	x	x	x	x	x	x	
b	x	x	x	x	x	x	x	x	x	x	
c	x	x	x	x	x	x	x	x	x	x	
d	x	x	x	x	x	x	x	x	x	x	
e	x	x	x	x	x	x	x	x	x	x	
f	x	x	x	x	x	x	x	x	x	x	
g	x	x	x	x	x	x	x	x	x	x	
h	x	x	x	x	x	x	x	x	x	x	
o	x	x	x	x	x	x	x	x	x	x	
p	x	x	x	x	x	x	x	x	x	x	
n_j	10	10	10	10	10	10	10	10	10	10	
$G_j \times n_j$	10	10	20	30	30	40	40	40	50	50	$\Sigma(G_j \times n_j)=320$

Tab. 8. Competency matrix for A.5 variant

Variants / Workplace grade	A.1		A.2		A.3		A.4		A.5	
	n_j	$G_j \times n_j$	n_j	$G_j \times n_j$	n_j	$G_j \times n_j$	n_j	$G_j \times n_j$	n_j	$G_j \times n_j$
I	2	2	8	8	10	10	14	14	20	20
II	1	2	5	10	8	16	9	18	10	20
III	2	6	4	12	5	15	7	21	20	60
IV	3	12	5	20	8	32	15	60	30	120
V	2	10	2	10	5	25	10	50	20	100
Total		32		60		98		163		320
Staff competency level L_c [%]	**10%**		**19%**		**31%**		**51%**		**100%**	

Comments to calculations in Tab. 9:

$G_j \times n_j$ is a product of j-th job's grade and number of workers who can operate workplaces of j-th grade. For example, in the case of A.5 option, there are two different workplaces classified to the I job grade (as shown in Tab. 2) G_1 and G_2 (and $G_1=G_2=1$), therefore, when we assume that each of 10 workers is able to operate each of two machines (workplaces), so when 10 workers are assumed, it means that each of them is able to operate two machines of the I job grade, thus we obtain $n_j=20$, and finally the total result is $G_j \times n_j=1 \times 20=20$.

Tab. 9. Calculations of competency levels for "A" employment alternative

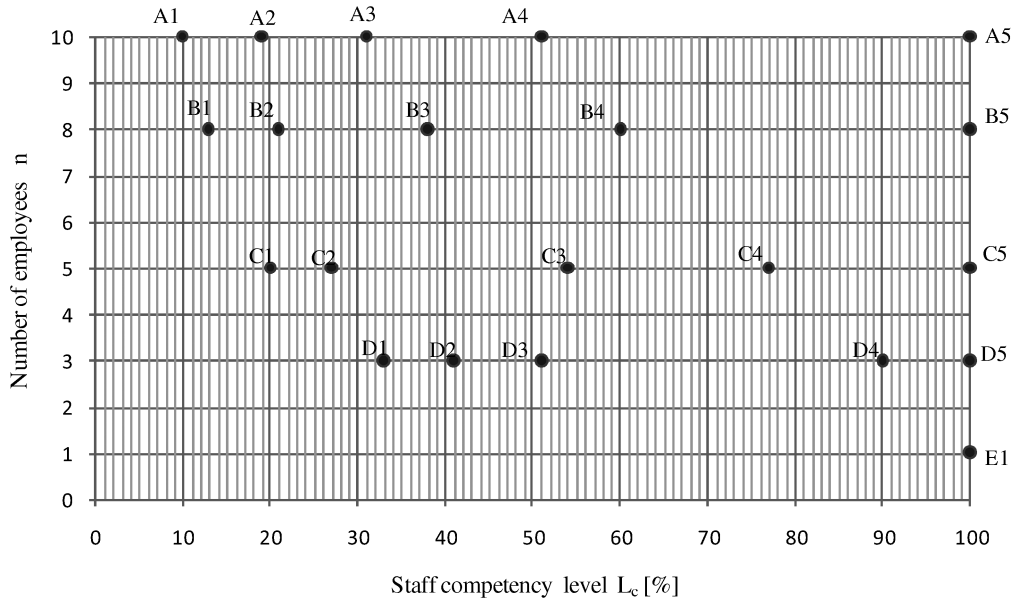

Fig. 7. Quantitative and qualitative variants for employment

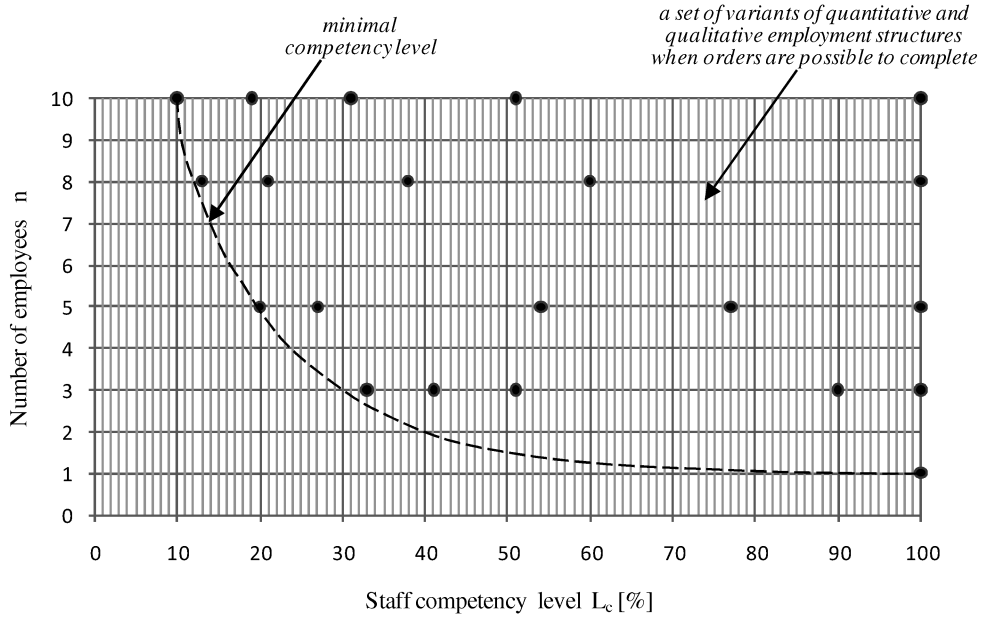

Fig. 8. A set of employment variants acceptable from viewpoint of possibility to perform tasks by workers

may be also inefficient in such situation, some of them may be under or overloaded in particular periods.

Therefore, the set of variants of quantitative and qualitative employment models possible to accept from the viewpoint of feasibility of order completing should be then verified taking into account time demanded for the order completion. These requirements may cause possible variants narrowed to smaller set of them (Fig. 9). T_{ac} means time of order realization, which may be accepted taking into accounts client's demands. For particular orders various times may be accepted, so we can have T_{ac1}, T_{ac2} etc.

In addition, the set of solutions may be considered taking into account another criteria, important for further evaluation of variants, e.g. form the viewpoint of cost criteria, including labour cost. Above-mentioned relationships are presented considering direct labour costs. It should be noticed, that not each optimum determined in Fig. 10 lays in the area of possible solutions, for example due to required time for order realization.

Unit and small batch production is determined particularly by changeable environmental factors. That is why the demand for a certain number and appropriate skills of workers is changeable, too. Taking into account the methodology based on presented figures, it is possible to determine:

- changes in the employment from the viewpoint of quantitative and qualitative requirements,
- consequences of changes introduced in company's remuneration systems,
- impact of changes in manufactured products and changes in performed tasks and operations on order realization time and direct labour costs, for example, more or less manual tasks, more assembly operations, less machining ones etc.

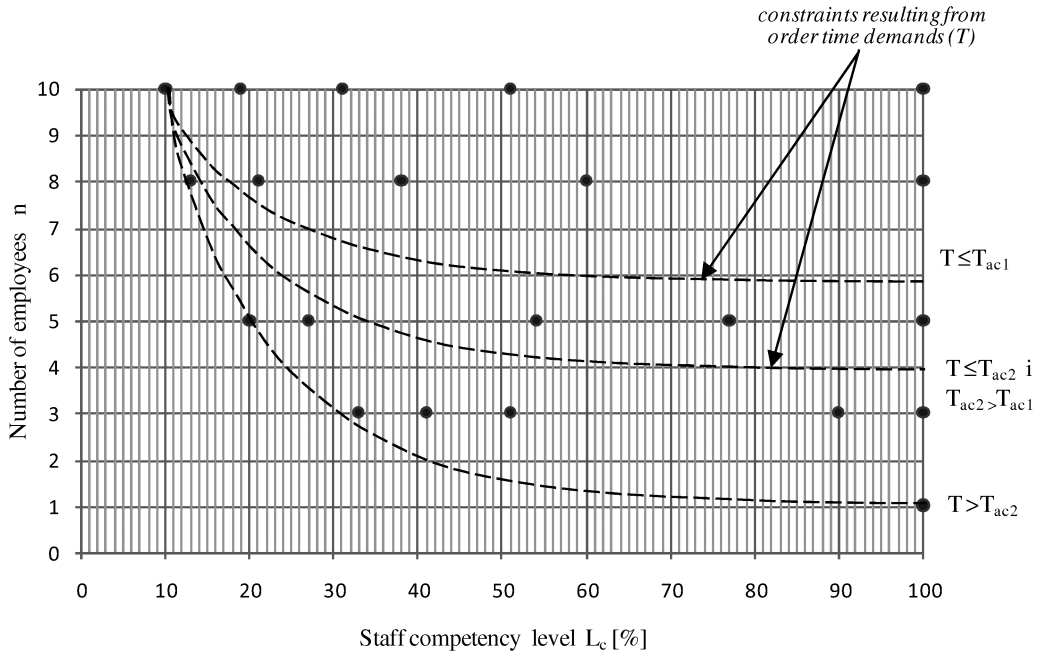

Fig. 9. A set of employment structure variants from viewpoint of possibility to perform tasks by workers as well as of time demanded

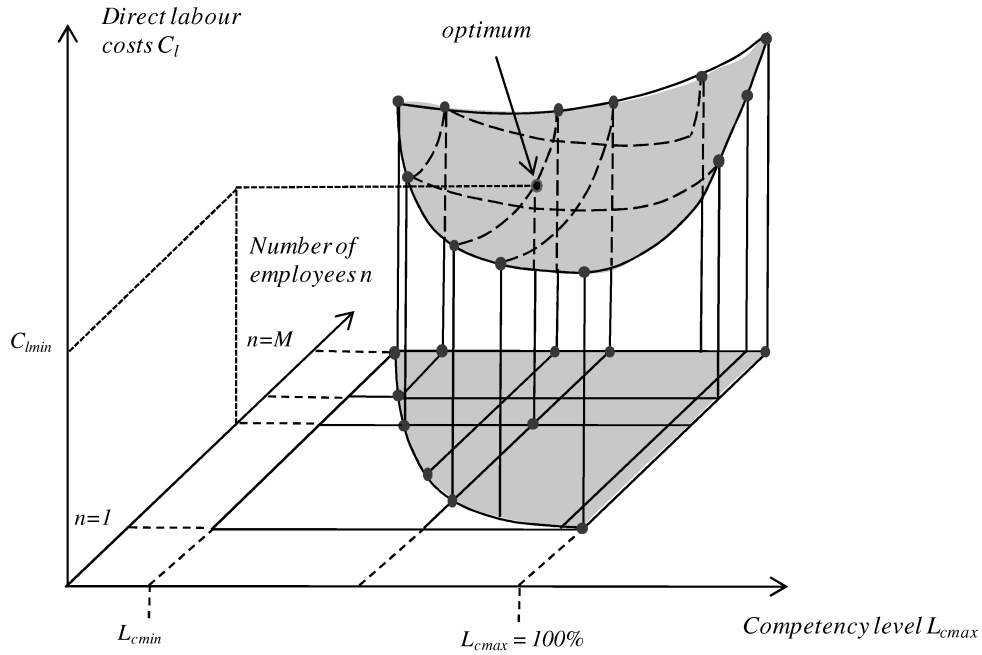

Fig. 10. Direct labour costs depending on quantitative and qualitative employment variants

Technological and organisational changes introduced in companies have a great impact on employment structure. There are new or modified and redesigned workplaces demanding new skills, larger knowledge, higher responsibility from a worker. To meet requirements of these workplaces it may be necessary to make decisions about:

- offering workers training possibilities in order to acquire by them new skills,
- reallocations of current workers to other workplaces and departments due to their qualification level,
- recruitment of new persons from external labour market who fulfill job requirements with simultaneous dismissal of employees who have not demanded qualifications.

From the above mentioned suggestions, the first seems especially valuable. Contemporary market economy forces enlarging and up-to-dating knowledge and skills upon people. Companies within the framework of their personnel policy should assist employees in developing their skills and proper behaviours. A well-qualified worker is more flexible, able to do a wider range of jobs and to cope with higher responsibility. Today, multi-occupational or multi-job-tasking training plays an important role for personal growth. It leads to master doing different tasks at different workplaces by a worker. The training makes expanding worker's knowledge and professional skills.

Well prepared and organized training scheme helps to avoid the social problems, for example concerned with dismissal of a great number of employees.

6. Conclusions

To realize the production program in time, 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 time and way of human resources use limited. 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.
In unit and small batch production the demand for required number and skills of employees varies over time. In such environment employees are required to be more mobile and flexible between jobs and workplaces, as well as between vocations, so workers should be encouraged to develop their multi-skills.
To find the best solution on human resources allocated to jobs in the production scheduling, the simulation method could be helpful. Simulation as a part of decision support system for production scheduling provides a way to get detailed information about the consequences of scheduling decisions [5]. It is also useful to get information about main requirements on quantity and quality of human resources engaged in achieving production goals and tasks and, in consequence, it enables to assess financial aspects of used human resources. 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 knowledge of labour costs is important for their rationalisation and optimisation from the viewpoint of quantitative and qualitative employment structure due to company's development strategy.
In decision making process, labour cost analysis for employment alternatives is important. Particular variants of quantitative and qualitative employment are related to different levels of labour costs and cause various times of production plan completion. Smaller number of employees and lower level of their competencies make the production cycle longer and workplaces are ineffectively loaded. In turn, better qualified employees (multi-skilled or poly-functional operators) implicate the higher level of labour costs, because they should be highly paid due to principles of job evaluation and considering the motivational point of view. But, on the other hand, more flexible and agile staff makes production process planning easier, and work is more rhythmical without too much machine idle time, as well as without expensive overtime work.

References:

[1] Armstrong M.: *A Handbook of Human Resource Management Practice*. Kogan Page, London 2003.
[2] Baron-Puda M., Mleczko J.: *Simulation of human resources allocation in scheduling processes*. Applied Computer Science, Vol. 4, No 2, 2008, Wydawnictwo Akademii Techniczno-Humanistycznej, Bielsko-Biała 2008.
[3] Boselie P.: *Strategic Human Resource Management*. McGraw-Hill Higher Education, New York 2010.
[4] Cardy R.L., Miller J.S., Ellis A.D.: *Employee equity: Toward a person-based approach to HRM*. Human Resource Management Review, 17, 2007.
[5] Lehtonen J.M., Appelqvist P., Ruohola T., Mattila I.: *Simulation-based finite scheduling at Albany International*. Proceedings of the 2003 Winter Simulation Conference, Vol.2, 7-10 Dec. 2003.
[6] Mullins L.J.: *Management and Organizational Behaviour* (6/e). FT Prentice Hall, London 2002.
[7] Stredwick J.: *An Introduction to Human Resource Management.* Butterworth Heinemann, Oxford 2000.
[8] Valverde M., Tregaskis O., Brewster C.: *Labour flexibility and firm performance*. International Advances in Economic Research. Volume 6, No. 4, November 2000.
[9] Building Successful Organization: *A Guide to Strategic Workforce Planning*. National Academy of Public Administration, Washington 2000.

Keywords:
human resources, competency level, multi-skilled operators, job evaluation, labour cost.

Abstract:
Human resource planning (in other word: workforce planning) is the fundamental process for optimization of human resources in every company. The main purpose of this process is to identify future human needs form the viewpoint of future company's goals. Briefly, human resource planning aims especially at providing a company with the right people in the right place and at the right time, and next, motivating them to better and better performance.
In unit and small batch production systems, where changes in production program and production profile are much more frequent than in large batch and mass production ones, the demand for particular number of employees and their competencies varies over time. So, in such environment, workers are desired to be flexible and able to do different jobs in different workplaces. Worker's flexibility depends on his or her knowledge, skills and behaviour, for example a worker is highly qualified, motivated and willing to take new jobs and to keep expected efficiency. Present production systems want flexible and agile workers, who can be shifted dynamically to various range of jobs due to the current need of a company. From the financial point of view, it is a question if the functional flexibility is really effective for the company. It is obvious that polyfunctional operators are more costly because higher competencies should be adequately compensated by higher payment, but on the other hand, they allow a company to reduce the number of employees and make production planning process easier and smoother. That is way the rational staff competency level is a key for a company to realize production programs and stay competitive in the market.
In optimization of human resource quantity and quality the simulation technique is useful for analyzing, assessing and comparing employment alternatives different from the viewpoint of number of employees and their competency level. Particular variants of quantitative and qualitative employment are connected with different levels of labour cost and cause various lead times. The simulation enables to anticipate changes in labour cost due to considered company's course of action, e.g. due to changes in quantity and/or quality of employment, due to different times of order completion. Job evaluation system is the basis to make simulation of the labour cost because it is a foundation to develop the rational structure of basic pay rates, and among many components composing the labour cost, wages and salaries are the greatest and most important part of it.

METODOLOGIA OKREŚLANIA OPTYMALNEJ WIELKOŚCI I JAKOŚCI ZATRUDNIENIA W WARUNKACH PRODUKCJI JEDNOSTKOWEJ ORAZ MAŁOSERYJNEJ

Słowa kluczowe:
zasoby ludzkie, poziom kompetencji, ocena pracy, koszty pracy.

Streszczenie:
Planowanie zatrudnienia to podstawa racjonalizacji działań związanych z zarządzaniem kadrami w każdym przedsiębiorstwie. Określa ono zapotrzebowanie na pracowników w aspekcie ilościowym (ilu pracowników potrzeba), jakościowym (jakie kompetencje powinni mieć pracownicy), a także czasowym (w jakim czasie należy zapewnić potrzeby kadrowe).
Uwarunkowania produkcji jednostkowej i małoseryjnej związane ze zróżnicowanym asortymentem produkcji, większą zmiennością programu produkcyjnego powodują, iż zapotrzebowanie na określoną wielkość oraz kwalifikacje pracowników zmienia się dynamicznie. Dlatego też w takich warunkach pożądane jest, by pracownicy byli elastyczni funkcjonalnie, potrafili szybko i sprawnie dostosować się do nowych zadań pracy, potrafili zastępować współpracowników na różnych stanowiskach. O uniwersalności pracownika decydują jego kompetencje, czyli wiedza, zdobyte umiejętności, postawy i zachowanie, jak np. gotowość podejmowania się nowych zadań, szybkość adaptacji na innym stanowisku, utrzymanie wysokiej wydajności pracy. Elastyczność funkcjonalna pracowników ułatwia planowanie przebiegu procesu produkcji, powoduje, że stanowiska pracy są równomiernie obciążone, praca jest bardziej rytmiczna, bez przestojów i kosztownych godzin nadliczbowych. Znaczącym parametrem oceny wykonalności programu produkcyjnego oraz spełnienia wymagań czasowych zleceń jest odpowiedni wskaźnik kompetencji załogi. Z drugiej strony jednak, im wyższy poziom kompetencji załogi, tym wyższe koszty wynagrodzeń oraz koszty pracy, a w efekcie koszty produkcji. Wyzwaniem zatem staje się poszukiwanie optymalnej wielkości i jakości zasobów ludzkich, która będzie podstawą utrzymania konkurencyjności przedsiębiorstwa na rynku.
Analiza różnych wariantów ilościowo-jakościowego zatrudnienia wraz z oceną skutków czasowych oraz kosztowych poszczególnych wariantów jest możliwa przy wykorzystaniu metody symulacji. Symulacja pozwala na śledzenie zmian w kosztach pracy w zależności od przyjętych strategii działania przedsiębiorstwa, m.in. zmian w wielkości zatrudnienia, stanie kompetencji załogi, terminach wykonania zleceń itp. Podstawą przeprowadzenia symulacji kosztów pracy bezpośrednio produkcyjnej jest wdrożenie systemu wartościowania stanowisk pracy i różnicowania stawek płac. Systemy wynagrodzeń oparte na właściwie przeprowadzonym wartościowaniu pracy zapewniają przejrzystość struktury płacowej, zwiększają motywacyjną funkcję płac oraz pozwalają na przewidywanie kształtowania się kosztów pracy.

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