RESEARCH IN LOGISTICS & PRODUCTION

COMPUTER - AIDED DESIGN OF PRODUCTION SYSTEMS STRUCTURES

Jerzy Mazurczak* and Izabela Kudelska**

* Faculty of Management Engineering, Poznan University of Technology, Poznan, Strzelecka 11, 60-965, Poland, E-mail: Jerzy.Mazurczak@put.poznan.pl
** Faculty of Management Engineering, Poznan University of Technology, Poznan, Strzelecka 11, 60-965, Poland, E-mail: Izabela.Kudelska@put.poznan.pl

Abstract The multi-step process of design enterprises design plays a prominent role production structure. The designer is forced to perform time-consuming and laborious, while simple calculations. To make this calcilation, above all, to achieve optimal solutions is preferred computer support this work. The present program is apply to supporting the isolation of the complexity level I production units. Rusulting from the implementation of the data are the basic working material for the process of separation units. The authors of the first part describes the theoretical basis for isolation of the complexity level I production units. In the next part of the present computer program which support the process of calculation.

Paper type: Research Paper

Published online: 30 October 2014
Vol. 4, No. 4, pp. 341-355

ISSN 2083-4942 (Print)
ISSN 2083-4950 (Online)

Keywords: *isolation of the production units, computer system, design of the production structure*

1. INTRODUCTION

The designing of industrial enterprises, including machine building facilities is one of the most complex fields of technical design. It is a multistage calculation and decision-making process, an important element of which is the design of the production structure.

The production structure (the structure of the production system) should be understood as the division of the production process between the production units as the subjects of the production process, along with internal and external relations resulting from the collaboration between the workstations and the higher level production units (cells, lines, branches) within the production process of a department or facility (Boszko, 1973, p. 20).

The above definitions show that the production structure consists of production units (PUs) with different levels of complexity: 0 - workstation, I - cell, line, workshop, crew, II - branch, III - department (Głowacka-Fertsch & Fertsch, 2004, pp. 43-48).

It can be assumed that designing of the production structure is equal (equivalent) to the design and organization of the structures of the productions systems (Brzeziński, 2002), (Durlik 1993), (Jackowicz 1987). There are four main stages in the design of the production structure (Mazurczak, 2004):

- preparatory actions, covering the analysis of the production and organization conditions along with the existing structure,
- isolation of the complexity level I production units, understood as elementary groupings of workstations, where the grouping is based on the relations between these workstations in production of a given group of items,
- technical projects of the isolated production units (PU), including calculation of parameters characterizing the unit, determination of the form of production organization, detailed calculations of the production units, preparation of model schedules, placement of the workstations,
- implementation proposals and recommendations.

The scope of design usually covers large, diversified sets of assortment items described by the realization technology with respect to the workstations. The analysis of such sets is necessary both in the modernization of the structure of existing plants, and during the design of the structure of new plants. As a result, on some stages of the design, the designer has to perform dull, time consuming and at the same time relatively simple calculations. This occurs above all during:

- the selection of the assortment groups assigned to production units,
- the technical design of the most appropriate organization form for the particular production unit,
- the deployment of the workstations.

Computer aid is advantageous in making these calculations more efficient, and, above all, in finding the optimal (or suboptimal) solutions. It should be mentioned,

that the most optimal solutions are usually discovered by iteration, by applying the algorithm repeatedly and verifying project decisions taken.

The presented program applies the computer-aided stage of isolating the production units and is based on the methodical assumptions presented in the previous works of the author (Mazurczak, 2004, 2010) and (Boszko, 1973).

2. THE ISOLATION OF THE PRODUCTION UNITS

The isolation of the complexity level I production units (PU_I), understood as the elementary grouping of workstations (where such grouping is based on the relations between these workstations in the production of particular items) is crucial in the process of production structure design. The outcome of this stage influences the results of the next substages of the project, such as the agreed form of the production organization, creation of model schedules for downstream production, placement of the workstations and production units in the area, as well as other stages of the enterprise organization design (production control system, organization of auxiliary production processes, management system design).

Designing of the production structure may be treated as combinatorial joining of the workstations interrelated by the technological processes, along with the optimization of these relations, or also as grouping of the items (workpieces) intended for production in one production unit. Consequently, the process of designing (creating) the structures will consist of creating or dividing the existing production units (in the wider sense - organizational units OU). According to the principles of division and creation of the organizational units (Boszko, 1973, pp. 25-26), the division or creation of a production unit is decided by two equal factors:

- clearly visible, growing specialization of works,
- amount of work within a given specialization.

The first factor is related to the technological similarity of works and produced items. The aim is to narrow down their diversity. The necessity of reduction of the size of the OUs (naturally, including the production units) and the need for their efficient and competent management results in a twofold specialization character of these units - product and technological.

A. Product specialization. Expresses the need to enclose the whole production process of an item (complex and simple) within a single unit. The stations of the product specialized units are combined on the basis of their cooperation in production of particular item (items). This results in creation of such units as rollers' cell, sleeve production line, gears' cell, etc.

B. Technological specialization. Stations of the technologically specialized units are combined on the basis of similarities of technology utilized on the particular stations (Głowacka-Fertsch & Fertsch, 2004, p. 42). This results in creation of such units as lathe cells, grinder cells or milling cells.

In the machine industry, due to the technical and economical effects, production units have to be created according to the product specialization, with the possibility of flexible production (Lis, Santarek & Strzelczak, 1994). Large production units with a significant assortment of items should be examined and their product specialization should be optimally adjusted to the conditions of particular selected subsets of their assortment (Boszko, 1973, p. 58). Consequently, during the design of the production structure, one should struggle to create a maximum number of product specialized units.

The second factor is the amount of work, usually measured by its labor-intensity and recurrence. The amount of work needs to be high enough for the workstations and production units to remain fully occupied (proper workload). Often, due to the lack of full workload, a higher diversity needs to be accepted, thus combining production of less similar items and operations within the organizational unit.

In practice, appropriate data about technological processes and production programs should be gathered before isolating a production unit. Information about technological routes may be presented in tables (matrices) with the assortment-uniform stations group coordinates, or in the matrix system.

In other words, uniform stations group (USG) is a group of mutually replaceable stations. Such group contains workstations with similar characteristics, which allow mutual replacement in the production process of particular set of workpieces (Mazurczak, 2010).

Depending on the stage of the stage of calculations, these tables (matrices) may contain: numbers of technological operations performed on a given workpiece on a uniform stations group, operation labor-intensity t_j for a unit or operational load capacity of particular operations r_{op} calculated with a formula (Mazurczak & Wyrwicka, 1996, p. 27):

$$r_{\text{op}} = \frac{t_j \cdot P}{F} \tag{1}$$

where:

r_{op}- operational load capacity,
t_j - unit time for performing the operation,
P - yearly production program,
F - work time fund for a workstation.

An example of such table for 6 workpieces and 7 groups of uniform stations group (USG) containing unit times t_j is presented in the Figure 1.

	Workpiece/USG	GR1	GR2	GR3	GR4	GR5	GR6	GR7
1	WP 1	0.36	0.28	0.24	0.12	-	-	-
2	WP 2	0.28	0.16	0.20	-	-	-	-
3	WP 3	0.08	-	-	-	0.32	0.32	0.28
4	WP 4	-	-	-	-	0.32	0.20	0.24
5	WP 5	-	0.08	0.04	0.32	-	-	-
6	WP 6	-	-	-	-	0.24	0.36	0.24

Fig. 1 Example of a labor-intensity t_j table (matrix)

These tables (matrices) should be properly sorted (decomposed) in order to isolate production units from sets of workpieces and uniform stations groups (USGs). Figure 1 is an example of an unsorted matrix. Selecting subsets of workpieces to the production unit (PU_I) should begin with the positions ensuring maximum load for the workstations, i.e. having the highest average operational load capacities $r_{\text{opśr}}$ calculated with a formula:

$$r_{\text{opśr}} = \frac{\sum_{i=1}^{m_{\text{cz}}} r_{\text{op}i}}{m_{\text{cz}}} \tag{2}$$

where:

m_{cz} - number of operations within s technological route of a part (product).

The size of the average operational load capacity should be therefore a basic criterion of selecting workpieces in order to isolate the PU_I, next to the equivalent criterion of similarity.

Three basic assumptions regarding the process of isolating the PU_I were made.

Assumption 1. The process of isolating the production units cannot lead to the increase of the number of workstations within a particular USG compared to the number resulting from their total load, or, in case of modernization of the structure, resulting from the installed machinery stock.

A potential production unit may be selected from a given subset of workpieces and USGs if the division does not result in the increase of the number of stations. However, in most cases, additional burdening of the individual stations will be necessary, which results in the problem of adding supplementary assortment items, similar from the technological and organizational points of view.

Therefore, the technological and organizational similarity should be a basic criterion for selecting the complexity level I production units, along with the average operational load capacity. When adding workpieces to the PU_I, the workpieces with technological processes maximally similar to the processes of already selected workpieces should be chosen first, and only then (if necessary), less similar workpieces. The similarity level between two workpieces, calculated

by examining the degree of their technological routes overlapping may be may be determined by the α ratio (Mazurczak, 2004, p. 20), (Pająk, 2006, p. 165).

It allows to analyze the technological routes by comparing each workpiece against every other.

The process of decomposition (sorting) of the workpiece and USG relations matrix will be performed in the following way. Columns of the matrix (uniform stations group) shall be sorted by the total load descending, whereas rows (workpieces) are sorted in the following way. The workpiece with the largest average operational load capacity $r_{opśr}$ is placed in the matrix first, and then the remaining workpieces sorted by the technological and organizational similarity α descending, until reaching the value agreed in the input data as a limit (e.g. α = 0,8). Again, a workpiece with the largest $r_{opśr}$ value is chosen from the remaining workpieces, and additional workpieces with a agreed similarity level are assigned to it. This procedure is applied to the whole set of workpieces constituting the project area.

Consequently, the process of isolating the PU_I may be treated as the selection of workpieces according to the average operational load capacity and the ratio of technological and organizational similarity. However, this is not a one-off selection, but an iterative process of double steps for each of the created production units. It is realized according to the two equal criteria mentioned above: the amount of work (measured by the operational load capacity) and the technological and organizational similarity (α).

The process of sorting the workpieces and USG relations matrix shall therefore consist of shifts in the rows order, according to the average operational load capacity, and in the order of columns, according to the computational number of workstations (their total load). Such matrices, containing the loads of uniform stations groups with individual operations, are the basis for decisions regarding the isolation of the complexity level I production units.

Assumption 2. A workpiece should be assigned to a production when most of the operations of the technological route are performed within this unit. The literature sometimes accepts a threshold of 70% of operations of a route as a requirement for assigning to a production unit, which is the threshold of the product specialization completeness (Mazurczak 2011), (Boszko, 1973). However, it is difficult to precisely determine such a threshold in the real-life industrial conditions (Schmigalla, 1970).

The issue of the product specialization completeness is particularly significant when creating downstream production organizations. If the condition of the product specialization completeness is not fulfilled and there is a necessity of additional burdening of a particular group of stations, then only those workpiece operations, which will be performed cooperatively within a given PU, should be assigned to a production unit.

Assumption 3. Each workpiece needs to be unambiguously assigned to a specific complexity level I production unit.

The above methodological assumptions are the basis of the algorithm for isolating a PU_I during the design of a production system structure in the real-life conditions of machine industry.

The algorithm for separating complexity level I production units consists of the following calculating and decision-making steps:

Step 1. Preparation of the input data.

Step 2. Calculation of the average operational load capacity of individual workpieces and sorting the workpieces set according to this value (descending). Such sorting results from the assumption that the process of selecting the subset of workpieces for the PU_I shall begin with the workpieces ensuring maximum load for the workstations, i.e. having the highest average operational load capacities, in order to separate the downstream production units first.

Step 3. Calculation of the number of workstations necessary to perform the agreed plan of production of the whole set of workpieces - r.

Step 4. Organization of the USG (uniform group of workstations, in other words mutually replaceable stations) according to their total load.

Step 5. Creation of the matrix of relations between USG and workpieces according to step 2 and step 4 - such matrix shall consist of the operational load capacities.

Step 6. An attempt to isolate production units from the set of stations and the set of workpieces with high average operational load capacities in order to create downstream production organization form.

Step 7. Determination of the number of workstations in the isolated set of workpieces - r_1 and the number of stations in the remaining (not divided) set of workpieces - r_2. According to the assumption that the process of isolating the PU_I cannot increase the number of stations within the individual USG groups compared to the number resulting from their total load (r), it is necessary to check the condition:

$$r1+r2=r \tag{3}$$

If the condition is met, the production unit may be created, or possibly another workpiece may be added in order to achieve better parameters. After that, the selected PU_I is removed from the sets of workpieces and stations, and step 6 is performed again.

Step 8. If the above condition is not met, i.e. such division would result in the increase of the number of stations, it is necessary to select additional workpieces with similar technological routes to this particular PU. Such selection is made on the basis of the technological and organizational similarity ratio α.

Step 9. When the possibilities of creating a downstream production PU_I are exhausted, identical steps are taken with the next workpieces and groups of sta-

tions. Production units isolated according to the above method become potential PU_I.

Step 9. When the possibilities of creating a downstream production PU_I are exhausted, identical steps are taken with the next workpieces and groups of stations. Production units isolated according to the above method become potential PU_I.

Research on applying the methodology of isolating production units in the real-life industrial conditions proved that the most laborious and time-consuming are (Mazurczak, 2004):

- calculations of the load capacity of individual operations (i.e. the demand for a particular number of stations),
- calculations of total load of workstations,
- calculation of the average load capacity, and above all
- sorting the matrix of relations between workpieces and stations according to the technological and organizational similarities in order to associate them into production units.

The selection of workpieces with the required technological and organizational similarity (i.e. workpieces requiring the same groups of mutually replaceable workstations USG) for the production units causes significant difficulties during the calculations. These factors were the spur for creating the computer application aiding the process of selection of the PU_I.

3. COMPUTER – AIDED SEPARATION OF THE PRODUCTION UNITS

The created program perform steps 1-5 of the algorithm described above and directly prepares data for the steps 8 and 9. The program performs the selection of the workpieces according to the various criteria: e.g. only according to the average operational load capacity or according to the degree of overlapping of the USG by the technological routes of the workpieces ρ (Boszko, 1973, p. 61).

The rate ρ will not denote any similarity, but the overlapping of the set (i.e. uniform stations group) of the isolated production unit by the routes of a given assortment item. Therefore, it is not possible to group workpieces into sets according to their technological and organizational similarity determined by this rate. It is however very useful to determine the average technological and organizational similarity within a set of workpieces (production unit), in order to initially examine the production organization conditions, and especially to normatively determine the proper ranges for individual forms of production organization (Mazurczak, 2004, p. 19).

The most useful function of the program is the selection of workpieces according to the average operational load capacity and the similarity rate α. The program

selects the workpieces according to the average operational load capacity and the similarity rate α. It means that the workpiece with the maximum average operational load capacity is placed in the load matrix first. All the remaining workpieces of the set, with the technological and organizational similarity given in the input data (denoted by the α rate), are then added to it. This results in the creation of the "load submatix". Then, as a next element of the matrix, the workpiece with the highest average load ability is chosen from the remaining workpieces. And again, subsequent assortment items with the assumed similarity level α are added to this workpiece. This results in the creation of another "submatrix". The above steps are performed with the remaining elements of the set, until it is empty.

The "load submatrices" created by the program allow to quickly and effectively select workpieces and operations for creation of the complexity level I production units and provide proper load for the USG. It is possible to introduce additional limiting values of the α rate (e.g. with a 0.1 step) after analyzing the results of the PU separation, i.e. according to the needs of further workpiece joining. Calculated load of the workstations allows also to constantly track and control the workstations number condition within individual USG. The isolation of production units is therefore a process of selecting workpieces and operations for a PU by choosing the correct elements constituting the production unit from the sorted load matrix.

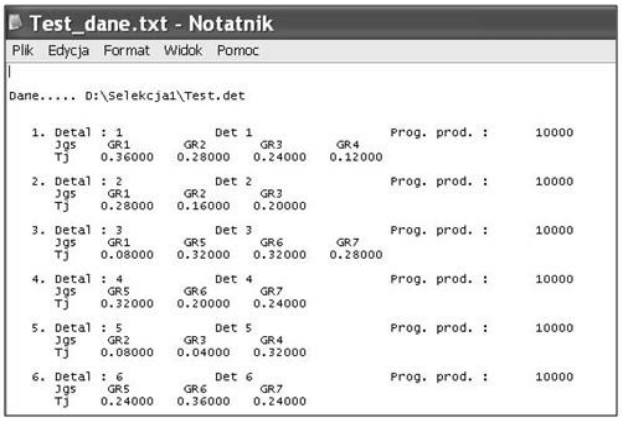


Fig. 2 The „Selection" program – printing data

The functions of the SELECTION program are described below.

I. Program menu.

After starting the program, a menu with two options appears - "Action" and "Description" (information about the program). Pressing the "Action" button allows to select from the following list of operations:

1. "Open data" - opening an existing set of data
2. "New data" - opening a new set of data

3. "Calculations" - performing calculations on the current set of data
4. "Print data" - viewing the results saved as a text file and opening it in Notepad (Fig. 2)
5. "Preview results" - previewing the results of the calculations saved as a text file
6. "End" - closing the program

II. Inputing and editing data (Fig. 3)

1. "Workpieces" - allows to view, add and remove workpieces. Numbers and names of the workpieces need to be input, along with the sizes of production programs. Pressing the "End" button will close the set of data
2. "USG" and "Tj" - allows to input and view the names of USG and unit times of the operation t_j; there is a possibility of changing (Edit) the parameters. In order to close the function and save changes, use the "Save" button

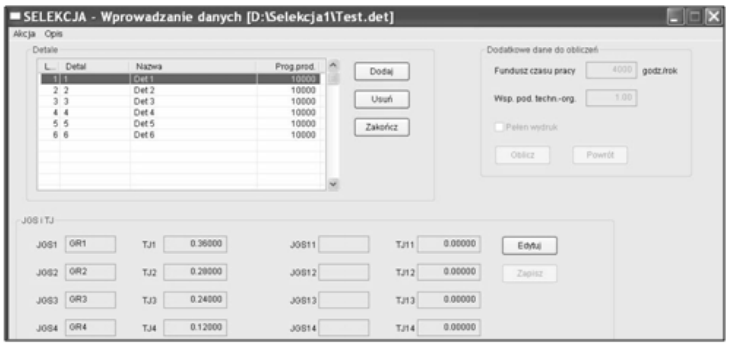


Fig. 3 The „Selection" program – inputing and editing data

III. Calculations

The "Calculations" function shall be used for a selected set of workpieces. The size of the work time fund F and the assumed technological and organizational similarity rate α has to be input.

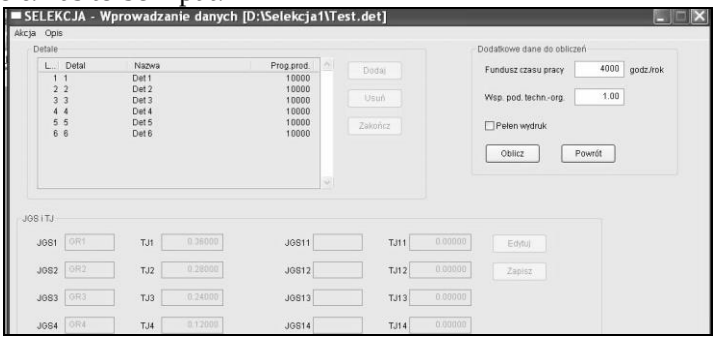
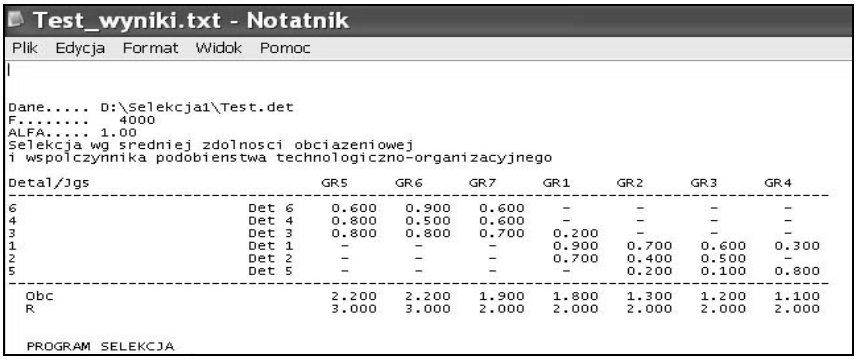


Fig. 4 The „Selection" program – calculations

It is possible to perform the calculations in two ways. The "Partial print" option produces the following screen after calculations (Fig. 5). This is the most useful version for direct isolation of the production units.



Test_wyniki.txt - Notatnik

Plik Edycja Format Widok Pomoc

Dane..... D:\Selekcja1\Test.det
F..... 4000
ALFA..... 1.00
Selekcja wg sredniej zdolnosci obciazeniowej
i wspolczynnika podobienstwa technologiczno-organizacyjnego

Detal/Jgs		GR5	GR6	GR7	GR1	GR2	GR3	GR4
6	Det 6	0.600	0.900	0.600	-	-	-	-
4	Det 4	0.800	0.500	0.600	-	-	-	-
3	Det 3	0.800	0.800	0.700	0.200	-	-	-
1	Det 1	-	-	-	0.900	0.700	0.600	0.300
2	Det 2	-	-	-	0.700	0.400	0.500	-
5	Det 5	-	-	-	-	0.200	0.100	0.800
Obc		2.200	2.200	1.900	1.800	1.300	1.200	1.100
R		3.000	3.000	2.000	2.000	2.000	2.000	2.000

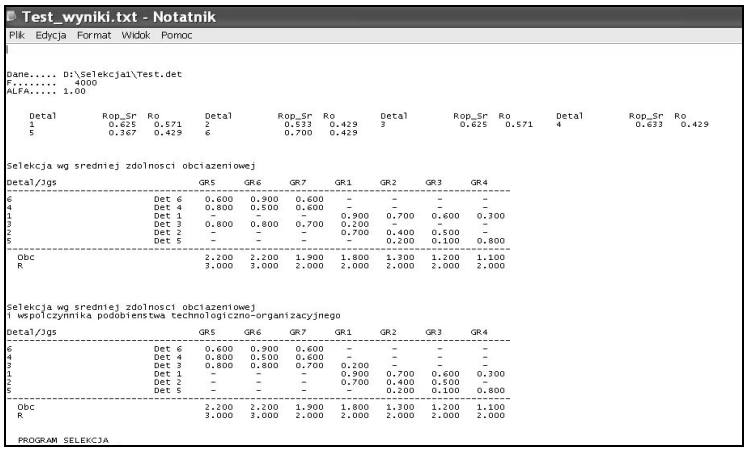
PROGRAM SELEKCJA

Fig. 5 The "Selection" program - result of calculations (partial print)

The "Full print" option produces the screen visible in the picture 6 after calculations. Additionally, a relations matrix sorted by the average operational load capacity of workpieces is printed, along with the values of the average operational load capacity $r_{opśr}$, and the ρ rate for each of the workpieces. These parameters will allow to choose the optimal forms of the production organization for the production units in the next stages of the design process.

The results of the calculations are saved in a text file; the "Return" option opens the workpiece data edition screen.

IV. Files



Test_wyniki.txt - Notatnik

Plik Edycja Format Widok Pomoc

Dane..... D:\Selekcja1\Test.det
F..... 4000
ALFA..... 1.00

Detal	Rop_Sr	Ro	Detal	Rop_Sr	Ro	Detal	Rop_Sr	Ro	Detal	Rop_Sr	Ro
1	0.625	0.571	2	0.533	0.429	3	0.625	0.571	4	0.633	0.429
5	0.367	0.429	6	0.700	0.429						

Selekcja wg sredniej zdolnosci obciazeniowej

Detal/Jgs		GR5	GR6	GR7	GR1	GR2	GR3	GR4
6	Det 6	0.600	0.900	0.600	-	-	-	-
4	Det 4	0.800	0.500	0.600	-	-	-	-
3	Det 3	0.800	0.800	0.700	0.200	-	-	-
1	Det 1	-	-	-	0.900	0.700	0.600	0.300
2	Det 2	-	-	-	0.700	0.400	0.500	-
5	Det 5	-	-	-	-	0.200	0.100	0.800
Obc		2.200	2.200	1.900	1.800	1.300	1.200	1.100
R		3.000	3.000	2.000	2.000	2.000	2.000	2.000

Selekcja wg sredniej zdolnosci obciazeniowej
i wspolczynnika podobienstwa technologiczno-organizacyjnego

Detal/Jgs		GR5	GR6	GR7	GR1	GR2	GR3	GR4
6	Det 6	0.600	0.900	0.600	-	-	-	-
4	Det 4	0.800	0.500	0.600	-	-	-	-
3	Det 3	0.800	0.800	0.700	0.200	-	-	-
1	Det 1	-	-	-	0.900	0.700	0.600	0.300
2	Det 2	-	-	-	0.700	0.400	0.500	-
5	Det 5	-	-	-	-	0.200	0.100	0.800
Obc		2.200	2.200	1.900	1.800	1.300	1.200	1.100
R		3.000	3.000	2.000	2.000	2.000	2.000	2.000

PROGRAM SELEKCJA

Fig. 6 The "Selection" program - result of calculations (full print)

The program saves data in the .DET files, whereas the printed data and calculations results are saved as .TXT files. These files are named by adding a proper suffix to the data file name:

- "results" to the results file
- "data" to the printed data file.

The files may be copied to a selected storage device.

Direct isolation of the production units from the sorted matrices (as in the Fig. 5) is performed according to the steps of the algorithm and the assumptions described above. An example of such isolation for the discussed example from the pic.1 is presented in the Fig. 7.

Data..... D:\ Selekcja1\Test.det
F..... 4000
ALFA..... 1.00

workpiece/USG		GR5	GR6	GR7	GR1	GR2	GR3	GR4
6	WP 6	0.900	0.600	0.600	*PU1*	-	-	
4	WP 4	0.500	0.800	0.600		-	-	
3	WP 3	0.800	0.800	0.700	0.200	-	-	-
1	WP 1	-	-	-	0.900	0.700	0.600	0.30
2	WP 2	-	-	-	*0.700*	0.400	0.500	-
5	WP 5	-	-	-	-	0.200	0.100	0.800
Obc		2.200	2.200	1.900	1.800	1.300	1.200	1.100
R		3.000	3.000	2.000	2.000	2.000	2.000	2.000

PU2

Fig. 7 The result of the PU isolation (first version)

As it results from the Fig. 7, two production units were isolated. They were temporarily named PU1 and PU2. Three workpieces with full technological process were assigned to the PU1 (No. 6, 4 and 3). It means that all of the operations of the routes of these workpieces are performed completely within one PU, on four USGs - on 9 workstations in total. The problem of exceeding the number of stations during the isolation of the PU (see Step 7 and model 2) occurred in the GR1 uniform stations group. It was necessary to burden this station additionally with the operation of the workpiece no. 2 - r_{op} = 0,7. This operation is thus performed in cooperation with the unit no. 2

Three workpieces (1, 2 and 5), performed on four USGs were assigned to the PU2. Because of the cooperation on the workpiece no. 2 (GR1), this unit is not completely product specialized.

There is also a possibility of a second solution of this simple example of 6 workpieces and seven USGs. It is presented in the Figure 8.

Three workpieces were assigned to the PU1 (6, 4 and 3). In the version, the product spelization is not complete. Workpiece no. 3 operation on the GR1 (r_{op} = 0,2) is performed in cooperation with PU2. At this stage of the design process, it is impossible to determine which of the solutions (Fig.7 or Fig. 8) is more profitable.

It would be necessary to analyze additional technological and organizational factors (parameters) and determine the criteria for choosing the optimal variant.

Dane..... D:\ Selekcja1\Dane1.det
F..... 4000
ALFA..... 1.00

Detal/Jgs		GR5	GR6	GR7	GR1	GR2	GR3	GR4
6	Det 6	0.900	0.600	0.600	-	-	-	-
4	Det 4	0.500	0.800	0.600	-	-	-	-
3	Det 3	0.800	0.800	0.700	0.200	-	-	-
1	Det 1	-	-	-	0.900	0.700	0.600	0.300
2	Det 2	-	-	-	0.700	0.400	0.500	-
5	Det 5	-	-	-	-	0.200	0.100	0.800
Obc		2.200	2.200	1.900	1.800	1.300	1.200	1.100
R		3.000	3.000	2.000	2.000	2.000	2.000	2.000

Fig. 8 The result of the PU isolation (second version)

The presented computer-aided production structures design program allows to design properly sorted matrices of relations between the workstations and workpieces, consisting of the workstations' loads. The isolation of the production units is performed by selecting the workpieces and operations for the unit by choosing proper elements for the unit from the sorted loads matrix (presented on the result tabulations as a submatrix of loads).

4. CONCLUSION

In the multistage process of the industrial enterprises design, the design of the production structure is significantly important. The design area usually includes large, diversified sets of workpieces. The designer is forced to perform series of laborious and, at the same time, simple calculations. Computer aid is advantageous in making these calculations more efficient, and, above all, in finding the optimal solutions.

The presented computer-aided production structures design program allows to design properly sorted matrices of relations between the workstations and workpieces, consisting of the workstations' loads. The isolation of the production units is performed by selecting the workpieces and operations for the unit by choosing proper elements for the unit from the sorted loads matrix (presented on the result tabulations as a submatrix of loads). The analysis of such tabulations unambiguously shows the possibilities of applying product specialization in production organization. The values appearing in the rows indicate the form - a line or a cell.

Regardless of the manual isolation of the PUs, in these conditions the assignment of workpieces (and possibly operations) to the production units is efficient, even in the case of large sets of assortment items. It is performed by the analysis of tabulations, onto which individual PUs can be placed graphically. At the same time, this guarantees that it will be possible to utilize the achieved results in the real-life industrial conditions.

The program significantly reduces the time of calculations carried out by the designer, and, above all, facilitates decision making if more than one solution is possible. The usefulness of the program was proven not only in educational classes, but also in the research and design projects conducted for the industrial enterprises.

REFERENCES

Boszko J., (1973), Struktura organizacyjna przedsiębiorstwa i drogi jej optymalizacji, WNT, Warszawa.

Brzeziński M., (2002), Organizacja i sterowanie produkcją, Agencja Wydawnicza Placet, Warszawa.

Brzeziński M., (2002), Organizacja produkcji. Materiały do ćwiczeń i projektowania, Politechnika Lubelska, Lublin.

Durlik I., (1993), Inżynieria zarządzania, AMP WN, Katowice.

Fertsch M.,(2003), Logistyka produkcji, Biblioteka Logistyka, Poznań.

Głowacka-Fertsch D., & Fertsch M.,(2004), Zarządzanie produkcją, Wyższa Szkoła Logistyki, Poznań.

Jackowicz R., Lis S., (1987), Podstawy projektowania struktur przedsiębiorstw przemysłowych, PWN, Warszawa.

Lis S., (1984), Organizacja i ekonomika procesów produkcyjnych w przemyśle maszynowym, Warszawa, PWN, Warszawa.

Lis S., Santarek K., & Strzelczak S., (1994), Organizacja elastycznych systemów produkcyjnych, PWN, Warszawa.

Mazurczak J., & Wyrwicka M., (1996), „Das Kennzahlensystem zur Beurteilung der Produktionsstruktur“, Nase Gospodarstvo. Our Economy Review of Current Problems in Economics, 1-2 Letnik 42, Maribor, pp. 25-32.

Mazurczak J., (2004), Projektowanie struktur systemów produkcyjnych, Wydawnictwo Politechniki Poznańskiej, Poznań.

Mazurczak J., (2010), Mierniki kształtowania struktur produkcyjnych i form organizacji produkcji, Grzybowska K., Hadaś Ł, Metody i techniki doskonalenia w logistyce produkcji - studia przypadków. Wydawnictwo Politechniki Poznańskiej, Poznań.

Mazurczak J., Gania I. (2011), Object specialization parameters of production systems, in: Fertsch M. (Ed), Production systems – Selected Issues – Theory and Practice. Publishing House of Poznan University of Technology. Poznań , pp. 85-96.

Muhlemann A., Oakland J., Lockyer K., (1995), Zarządzanie. Produkcja i usługi, PWN, Warszawa.

Pająk E, (2006), Zarządzanie produkcją. Produkt, technologia, organizacja, PWN, Warszawa.

Schmigalla H., (1970), Methoden zur optimalen Maschinenanordnung, VEB Verlag Technik, Berlin.

BIOGRAPHICAL NOTES

Jerzy Mazurczak works as Assistant Professor at the Faculty of Management Engineering at Poznan University of Technology. Specializes in production management, design of production systems and production structure. Author and co-author of over 50 scientific publications in this thematic field, both in national and foreign journals, monographs, conference materials and magazines.

Izabela Kudelska works as Assistant at the Faculty of Management Engineering at Poznan University of Technology. Specializes in production management, computer systems ERP (Enterprise Resource Planning). The author and co-author of about 35 scientific publications in this thematic field.