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Prophilation of the Manufacturing Cells

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Abstract Article describes profiling production cells. It analyzes the methodological approach to design work cells. The conclusions are given alternative structures of production cells based on material flow analysis.

Keywords: *prophilation, manufacturing cells, material flow*

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1. Introduction

Cellular manufacturing became recently one of the most important studies of the production systems arrangement. It is understood as the production philosophy based on the fact that the parts are similar as their shape and manufacturing processes. Resolution of their similarity is enabled by the parts grouping into the groups according to the machines, which they share in course of their processing and such way the economical effect of the serial production is achieved

The classical manufacturing systems are not sufficient any more in connection with the still increasing requirements of the clients and growing innovation of the products. It has become necessary to solve the questions of the speedy adjustment of the manufacturing system to the client requirements even at the cost of the lower exploitation of the machines, small production batches and production without store reserves.

However the recent production is not in a position to follow the changing requirements of the global market. It is inflexible to meet that goal. Its shortage is particularly the slow reaction to the changes due to the following facts:

- complicated material flow
- complex operative control
- economically limitation of the minimum size of the batch
- low level of automation

Along with the above, its structure is determined for the stabile environment, in which possible are only the certain improvements. Problems arise when there is need for the broader improvements. Then its structuring determined for the selected activities, is not able to react broadly to the required tasks even if the distances between them are not large and communication is minor, which fact limits then to create the relationships among them for the mutual synchronising. This is the cause, in many cases, the creation of large reserves around machines and the long manufacturing time.

Changes of the strategies bring about new approach to the production forming, particularly to the flexible manufacturing. The flexible manufacturing has to achieve the effect based on the changes mainly. It means that the application of the principles according to which proceed have been until now in the design of the machinery productions actually are becoming invalid and front rank is becoming completely new view on the manufacturing forming and its organisation. Evaluation of the significance of the flexible manufacturing must be seen first of all in the possibility of the variety of parts of small size batches manufacturing automation. It follows out from the fact, that flexibility can be achieved not only on NC machines, robots – this can have even the classical production, based mainly on the structure of grouping.

2. Methodological Approach to the Manufacturing Cells design

Analysis of the approaches to the manufacturing cell prophilation has shown that this topic has got recently a high priority. Designed procedures of the prophilation solution based on the group technology have tendency to achieve the broadest versatility of the selected method. This approach provides good results in the broader dimensions. However for the specific cases, as for example when looking for the suitable structure for several parts, which may be allocated to more cells, needed are narrowly oriented methods taking into the consideration variety of the specifics, so for the parts as for the machines. Many of them require the unambiguous decisions in course of the solution, but many may be solved as variants. In case of the variant possibilities the proposed solutions are derived from the resultant grouping and its specifics as well as experience of designer.

The costs related to the manufacturing cell design are by order higher that it is in case of the classical manufacturing design. It is due to the fact that their structures draft requires solving of the complex problems connected to the selection of the similar parts for the groups and the spatial configuration of the manufacturing technology grouping. Prophilation of the cells based on

the analysis of the material flow of the parts defines the tasks for the determination of the machines composition, their number, and disposition and organisation structure. It is done in such way that ensured will be the maximum machining work in one cell, but at the same it controls whether the machines within the cell are adequately worked out by the manufacturing program even in case of the low batches. When executing the prophilation of the manufacturing cells one should decide, first of all, based on the following requirements:

- Which parts or products should be produced in the manufacturing cells
- What is the overall manufacturing capacity that is at the disposal, or which is required
- How could be this capacity most suitably distributed among the individual cells
- How could be the individual manufacturing cells specialised
- Where and how should they be distributed
- What manufacturing facilities should they be furnished with
- What controlling system should be designed and how to plan the production

The design of the prophilation of the manufacturing cells alone is based on the general methodology procedure for the designed manufacturing systems.

The phases of the manufacturing cells design do not have strictly determined steps; however with the certain level of generalisation it is possible to divide the frame procedure into the following stages:

- analysis of the parts base (input parameters of the parts)
- creation of the matrix “parts-machines”
- looking for the clusters according to the identical material flow
- capacity calculations, determination of the machines number
- cells configuration (size of cells, number of cells)
- determination of the material and information bonds
- disposition solution of the cells
- spatial localisation of the cells

Every decision at every level has got the effect on the further decision and finally on the overall effectiveness of the cell. Therefore evaluated should be the scope of the consequences upon the further step at every level. These steps are usually executed in sequence; however at the same time it is possible to return to the previous steps to revise their solutions.

Decisive activities when creating the manufacturing cells are as follows:

2.1. Preparation of the Input Data

In the first place it is necessary to obtain data needed for the decision whether the group technology is suitable for the concrete plant. Matrix “machines –parts” is the example of the data which may assist to this decision. Data related to the manufacturing activities, products life cycle, expected range of the products and required volume, are decisive in this stage.

If the matrix is very dense, then this fact signalizes the difficulty for creating the “natural” groups of the parts. However this may not mean that the manufacturing cells should be disapproved. In case when the deviations in the set of the manufacturing procedures of the parts and required volume are expected in short intervals, flexibility must be deeply enrooted into the structure of the cells. Determination upon the flexible cells must be done when analysing situation as soon as possible, for it is necessary to identify correctly the demands on the flexibility and identify the factors which increase them. Many factors affect the creation of the groups and cells. Because it is very difficult to consider all these factors when creating the above, for those which seem to be significant for the given situation and may affect the creation of the manufacturing cells structure, it is necessary to identify the data, which represent them.

2.2. Creation of the Groups of Parts and Machines (Cells)

Decision upon the fact, whether to create the design of the cell arrangement along with that of the groups of the parts, should be executed in this step. Then it is necessary to select the approach to the creation of the groups of parts and cells of machines. There are several methodologies for this purpose. The aim is to select the suitable procedure in frame the observed goals, or possibly to create the new one, particularly directed to the solution of the given situation. It is not known, which procedure or approach produce, when applied to the same problem, the similar solutions. Therefore it might be inevitable to experiment with several procedures and generate several solutions for the comparison.

2.3. Elimination of the Narrow Places

The special parts and machines, decisive from the point of the throughput, should also be solved. Beside that, when the intercellular transitions are rather significant, decision should be done whether to combine several or all decisive machines intone or more cells. Problems related to the manufacturing cells prophilation are such that parts grouped into the groups may require the same machines in several cells and then problem arises to which cells they should be allocated. This problem, in the terminology of the group technology, means so called “narrow places”.

The aim is to eliminate the effect of the narrow place to minimum. This elimination may be achieved in such way that the given type of machine will be allocated to the cell and excluded will be transfers. But the machine exploitation will be insufficient because the investments will increase and so the demands for the manufacturing area. These are the serious problems when investigating the elimination of the narrow places for the manufacturing cells prophilation.

2.4. Elaboration of the Design for the Cell Arrangement

If the groups and cells formation was carried out simultaneously, this design may be in this step revised with the regard to the factors which have not been considered previously.

Though among the first rate advantages of the manufacturing cell rank the costs reduction related to the material movement, this advantage is not gained automatically. Analysed must be the parts movement between the machines and based on it the machines in the cell on the

manufacturing area should be distributed so that such movement would be minimal. When determining the structure of the material flows, the decisive factors include:

- Achieving the maximum one-way type of movement of the parts, i.e. excluding the return movements,
- Minimization of the intercellular movements,
- Estimation of the orientation of the input- output points,
- Analysis of the distribution of the decisive machines.

The decisive machines may not be always correctly allocated to the cells. Therefore their location must be checked after the design of their distribution within the cell and cells; and in case that the machine relocation would bring improvement, also revised. The task of the spatial distribution of the individual facilities within the cell is understood as the mathematical task of the looking for the minimal disposable area. Defined are the geometrical limitations following out from the manufacturing area restrictions.

2.5. Elaboration of the Proposal for the Cell System Distribution

Data on the precise or approximate forms of the cells and their areas, distribution of the input/output points and also the intercellular flows must be known in this stage and exploited for the elaboration of the design of the cells arrangement. When distributing the cells, it is necessary to observe the principle that high tightly connected cells should be adjacently located. Adherence between the cells is expressed by the frequency of the intercellular movements.

2.6. Evaluation of the Manufacturing Cells

In case of the manufacturing cells prophilation arise many questions as for example what will be the investments costs for the flexible cell building like, where are the limits of the display of the flexibility and how to discover it. These are the questions to which the answers are still being looked for. Difficulties exist also with the evaluation of the cell economical effectiveness. Into the foreground come the questions whether to achieve the higher level of the automation, whether there is the higher ability of the reaction to the changes, whether to orientate more at the achievement of the smooth material flow, whether to work without the reserves or whether to do everything possible to shorten, as much as possible, the current production time or whether to achieve the maximum machining of the part.

This number of the considered factors in the manufacturing cells prophilation does not enable to determine unambiguously which of them has the tendency in particular to increase or reduce the economical parameters of the cell. It is even not possible unambiguously state which of them upgrade the above.

The above factors in the manufacture prophilation into the flexible ones, arise the number of the conflict requirements:

- High productivity - broad assortment,
- Low production costs - high quality,
- Small series – short current production times and so on, which fact enables neither the estimation of the uniform key for the parts selection nor the content of the individual stages of the prophilation.

Every prophilation procedure of the manufacturing cells represents the combinatory variations problem, which calls for the application of the heuristics. The prophilation steps are usually carried out gradually even though there have already appeared the algorithms for the simultaneous formation of the groups of the parts and cell structure. These are mainly the expert systems.

Creation of the design of the methodology of the prophilation requires lot of time and work due to the large number of aspects of the project and factors of the mutual relations which should be considered

3. Alternatives of the Structures of the Manufaturing Cells Based on the Analysis of the Material Flow

As mentioned before, many alternatives of the solutions and problems in the manufacturing cells prophilation arise, which in many cases may not be to solve unambiguously without considering several criteria. As example for the presentation of the possible solutions of the manufacturing cells design I will choose the machining of three parts: P1, P2 and P3, which require the machines L1, L2, M1, D1, D2 and D3. The sequence of the operations for the individual parts is provided in Figure 1 and Figure 2 illustrates their movement through the individual machines in case of the technological arrangement of the production.

	L1	L2	D1	D2	D3	M1
P1	1	3		2		
P2			1		3	2
P3	1	3				2

L - lathe
M - mill
D - drill

Figure 1. Sequence of operations for the parts P1, P2, P3

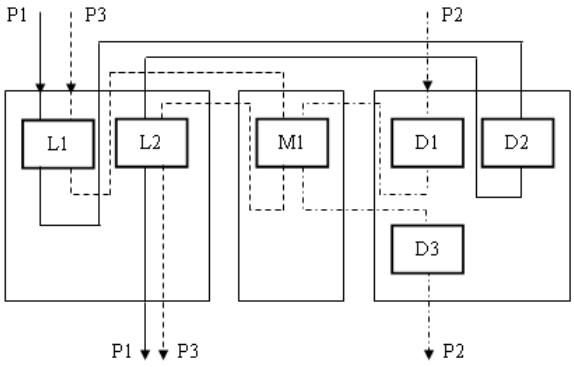

Figure 2. Material flow of the parts P1-P3 in the technological arrangement of the manufacture

Figure 3 illustrates the notation in form of the incidence matrix, based on which we look for the clusters for the cells generation. As the possible cases of the manufacturing cells generation are provided the following cases:

	L1	L2	D1	D2	D3	M1
P1	x	x		x		
P2			x		x	x
P3	x	x				x

Figure 3. Matrix notation part – machine

Generation of one cell for all parts. Such case exists in the practice rarely only and if, then for the smaller number of parts, which call for the lesser number of machines and are produced in the greater amount. Material flow of parts is given in Figure 4.

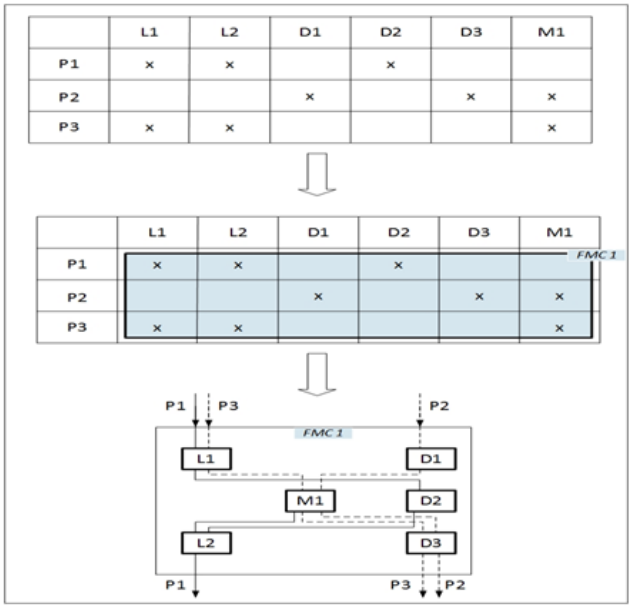

Figure 4. One manufacturing cells for all parts

Generation of the manufacturing cells for each part. This is only the seldom existing case in the practice and if, then possibly for some part only. Material flow and structure of the cells are illustrated in Figure 5. We can see that in this case instead of 6 machines we would nee 9 of them.

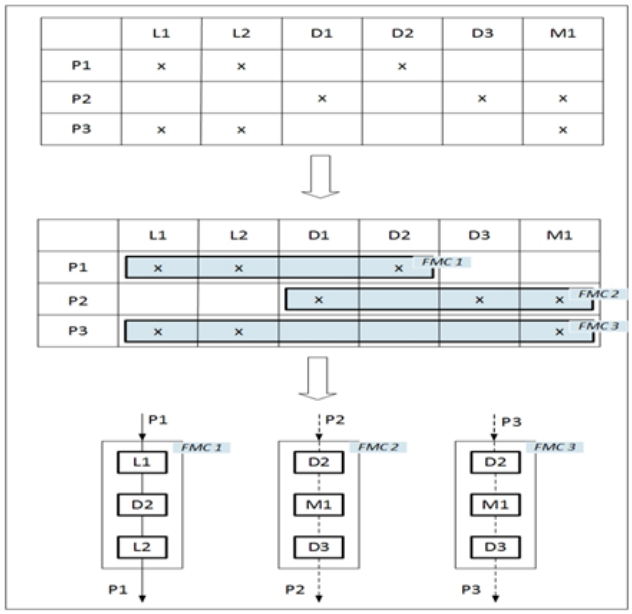

Figure 5. Cells generation for each part

In matrix provided in Figure 3 we shall look for the clusters, applying the single rearrangement of the rows and columns and formed is the matrix of the clusters according to Figure 6.

In this matrix evident are two clusters; the part P3 belongs so to cluster 1 and also to cluster 2. Similarly the machine M1 is in the cluster 1 and also in cluster 2. Such parts and machines used to be called troubleshooting. When solving the practical tasks of the prophilation are the common cases, where right on the base of the analysis of the troubleshooting parts and machines decide is the profile of the manufacturing cells.

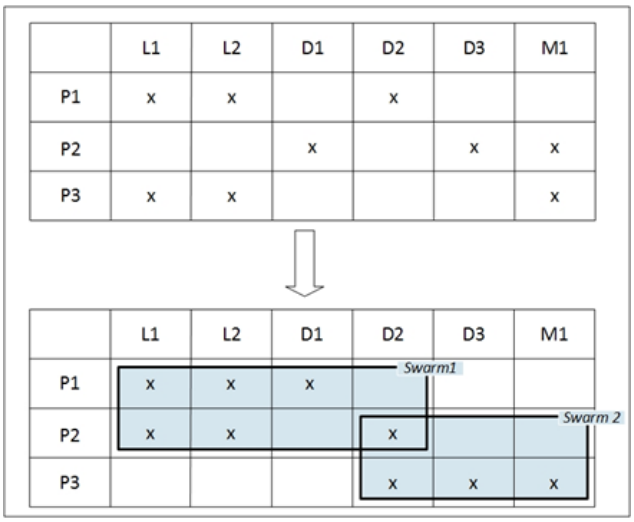

Figure 6. Matrix of clusters

As the examples of the solution of the trouble shooting or also designated as the narrow places, there are the possible solutions:

Exclusion of the troubleshooting parts. In our case it is part P3, and in such way we receive two cells. However on the contrary in the practice there is not the tendency to exclude the troubleshooting parts. The arisen manufacturing cells are illustrated in Figure 7.

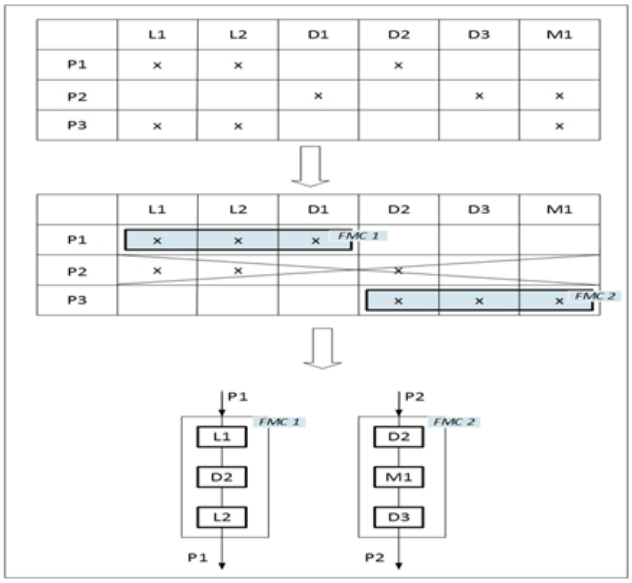

Figure 7. Matrix with the exclusion of the troubleshooting part

Machine M1 is allocated to the cell 1. In such case part P2 must conduct the inter-cellular transfer from the cell 2 to cell 1 and return back to the cell 2, Figure 8.

We allocate machine M1 to cell 2 and it is evident that the part P3 must execute the inter-cellular transfer from cell 1 to cell 2 and back, Figure 9.

We to generate the independent cell from the troubleshooting machines. In our case it is machine M1. In such case we obtain practically three cells and the part P3

from cell 1 must conduct intercellular transfer to cell 2 and back and also the part P2 from cell 3, Figure 10.

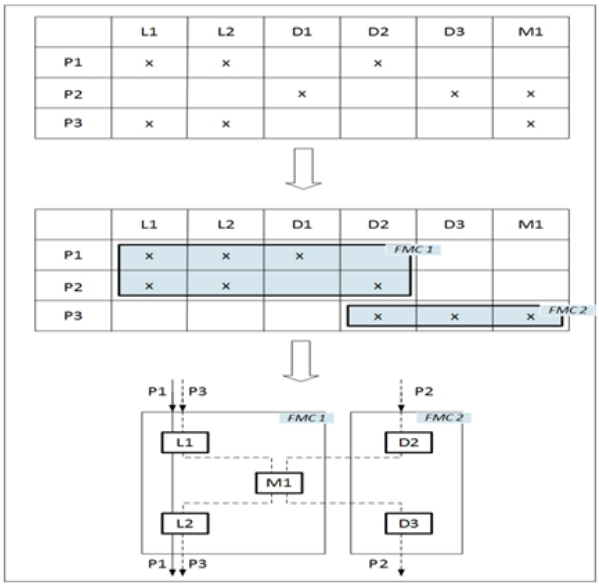

Figure 8. Matrix of clusters formation for parts P1 and P3 – cluster 1 and part P2 form the cluster 2

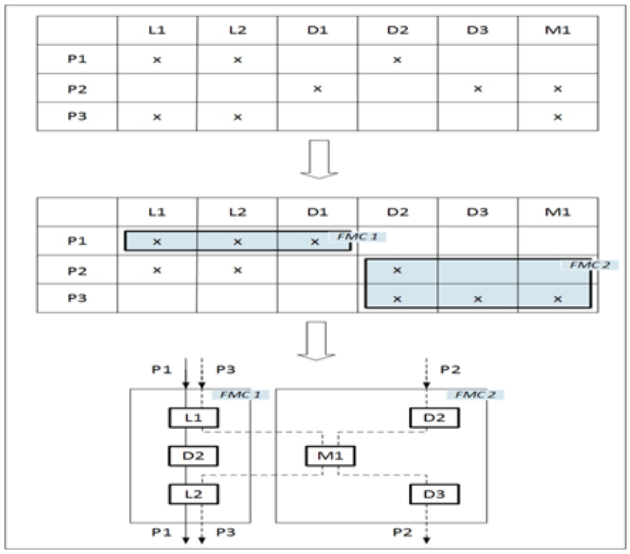

Figure 9. Matrix of clusters formation from parts P3 and P2 –cluster 1 and part P1 forms cluster 2

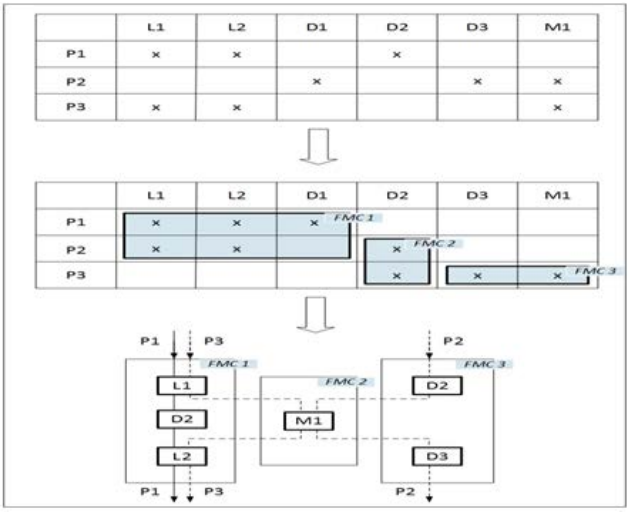

Figure 10. Matrix of three cluster formation

The troubleshooting machine is allocated to each cell. In our case it is machine M1. From Figure 11 it can be seen that parts do not conduct intercellular transfer, however the manufacturing system is overpriced by machine M1.

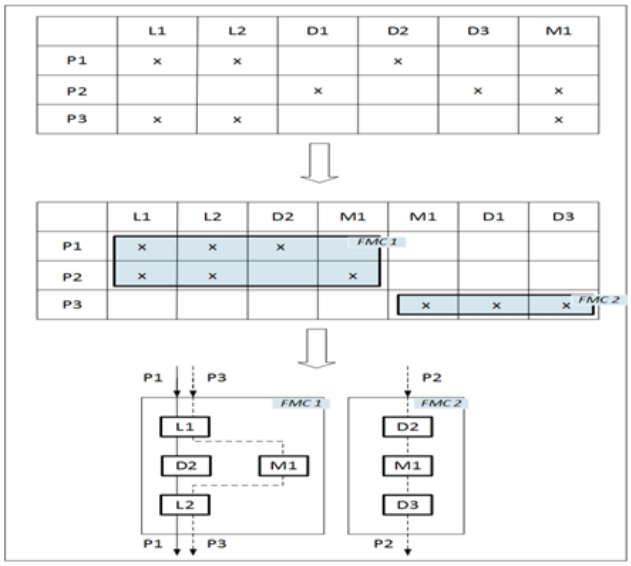

Figure 11. Matrix of troubleshooting machine M1 allocation to each cell

Other possible cases when exploited are the same machines in multiplied cells. In such case obtained are 3 cells, while as multiplied applied were the machines L1 and L2, and the machine M1 is allocated to the cell No.2. It means that part P2 must execute the intercellular transfer, Figure 12.

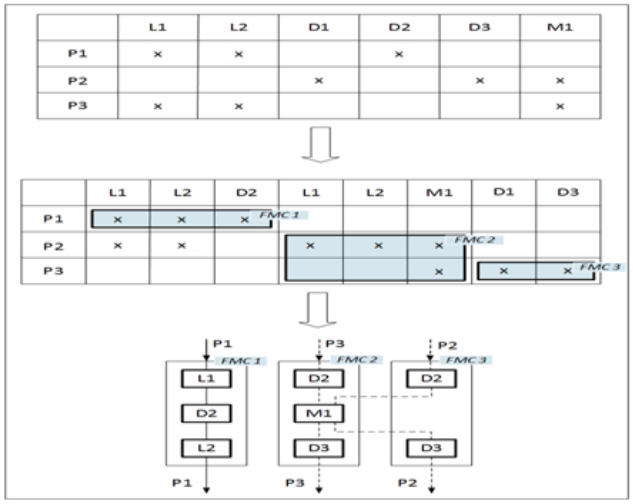

Figure 12. Matrix exploiting the duplicity of machines L1 and L2

Possible is also the case of the generation of three cells. Each cell has only two machines, but increased is the number of the intercellular transfers, Figure 13.

The above cases point at several possibilities of the solution of the manufacturing cells prophilation for the same parts. The aim of providing the possible, however not final number of cases is to stress that considering the material flow alone is not sufficient. This confirms that when deciding on the final profile of cell we have to consider also some other criteria.

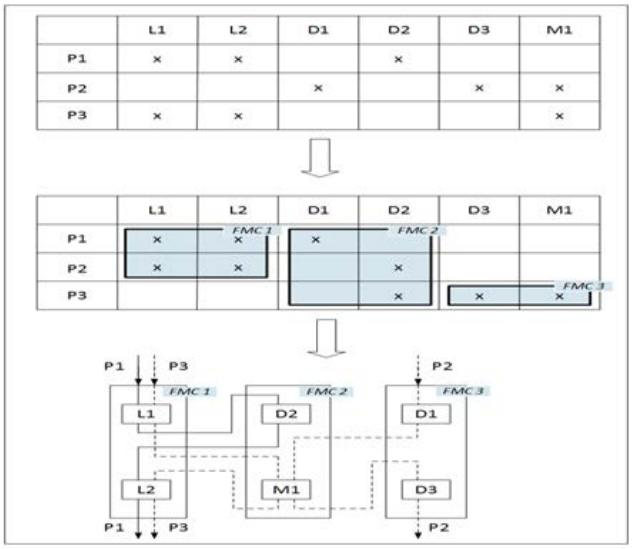

Figure 13. Manufacturing cells with 2 machines

4. Conclusion

There are no doubts today whether to build the flexible production. Even if there are rather numerous objections related to the effectiveness of the flexible manufacturing cells, their number still grows. In the field of the machining the open road in this direction provides mainly the automotive industry. The production of the machining machines and other, in which the dominating products are the engines of various size, gear boxes of variety of lines, coachworks and so on.

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