Application of Group Technology in Complex Cluster type Organizational Systems

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The aim of this research was to give contribution to the efforts that are being made to develop the procedures of structural designing of complex - cluster type organizational systems. Industrial clusters can help companies to improve their own market positions, effectiveness, productivity and product quality. Organization of the production process in a company is extremely complex process itself, and when we transfer it to the cluster level, we get a complex task which is difficult to solve. For that purpose, this paper analyses the conditions and possibilities that would enable those structures to adapt to changes in the surroundings - flexibility and management adequacy of production and organizational structures - by lowering the degree of complexity.

For the time being, there are no simple models developed which would enable increase of process effectiveness in a complex organizational units like clusters. One of the possible solutions which would decrease complexity of flows and increase process effectiveness within an industrial cluster is application of Group approach.

Keywords: Industrial clusters, Group technology, planning, work cells, complexity, flexibility

1. INTRODUCTION

Modern concepts of increasing effectiveness of production are based on the processes of automation, the application of modern materials and IT technology that significantly reduce production costs, increase productivity and reduce the need for labour. However, despite the revolutionary application of modern technology, the end of the 20th century and the beginning of the 21st century and further characterized by increased mobility of investments and recession, which is visible in the most developed countries, where the modern technology is most applied. All that has resulted in a constant decrease of production, what directly caused decrease of employment rate, increase of indebtedness of companies and reduced possibilities of investments in new development projects..

In competitive environment success of an organization is a function of industry attractiveness, its relative position in the industry, and the activities (strategy) it undertakes to remain ahead of others ([7] and [9]). Mintzberg explained that strategy is evolutionary, organic process and is unpredictable; [15] explained that core competence gives an organization competitive capability and remains central to its strategy planning process. Small and medium organizations (SME) encounter different kinds of problems such as resource limitations (especially human and financial resources), and market information [16], they face competition within and between large organizations [4].

Analyses that have been conducted in the world show that the reasons of the occurrence of these problems are not only the inability of companies or their production or service systems. Changes occur apart of how a company is capable to independently decrease its production costs or to increase the range of products. Changes often depend on other economic and non-economic entities, geo-political factors and changes on the global market.

For a company to create specific conditions for the business, it has to provide sufficient working capital and the accumulation big enough to be utilized in case of an unpredictable situation - see Figure 1.

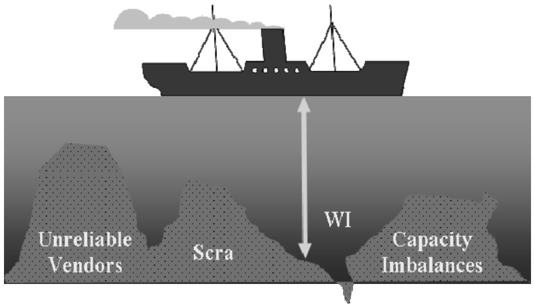

Figure 1: *The need for increased accumulation*

The first problem is obvious: increased accumulation affects the increase of production costs, decreases turnaround coefficients of capital and flexibility. On the other hand, the users' demands increase on a daily basis. They look for variety of products, tailored to their requirements, which must be produced in small series adjusted to a small number of users. Customers' demands are contradictory to each other: the period of development of a new product should be as short as possible and the price of a new product should be either same or even lower than the previous one. It brings us to the second problem: how to establish a system big enough to withstand the demands of the global market related to diversity, range and the amount of products and to be flexible enough to adapt to the changing demands of users.

To make this happen, it is needed to provide continuous financing of development, increase of coefficient of capital turnover, volume of production which will provide optimal use of production capacities, possibility for flexible specialization, possibility to enter global market, well trained and capable experts, as well as trust and connections on a very important local level.

It is clear that without the above mentioned elements, that the survival of companies is not possible, but it brings us to the question – how to achieve this in today's or tomorrow's business conditions? Investments in development are limited, so companies mainly have to find their development paths on their own, as well as their positions on the global market. One of important strategies of development which also provides competitive development, especially of Small and Medium-sized Enterprises (SMEs) and Regions, is to associate and develop complex organizational structures – clusters and business networks. Large enterprises merge and become even larger, and the best example is automotive industry. Small companies can survive on the market only if they associate with each other into systems which simulate large enterprise, but maintain their flexibility.

Although this form of associating provides a lot of advantages, which will be mentioned in the Chapter 2, there are also many problems in functioning of complex systems. One of these problems is how to organize and manage so complex systems and establish effective production process? In chapters 3 and 4, we will describe group approach as a possible solution.

2. CLUSTER AS A FORM FOR COMPANIES TO ASSOCIATE

Companies are constantly asked to improve performances in order to get the chance to maintain or to improve their own market positions and financial situation. Clusters have the possibility to develop their own specific mixture of competitive advantages which is created on the basis of locally-developed knowledge as a result of mutual relations, cultural heritage and local characteristics. This is evident in the focus on clusters as an important concept in understanding growth and in thinking about development policy [8].

The idea of localized economies of scale in geographic agglomerations has a long history in economics, going back to Adam Smith's early observations of labour specialization and to [24.] explanations of why companies continue to localize in the same areas. Clusters arise in the presence of Marshallian externalities, which signify that companies benefit from the production and innovation activities of neighbouring companies in the same and related industries. There is abundant evidence that such externalities exist and lead to industry-level agglomeration [13].

Development of clusters is an effective way to improve business operations and bring it to a higher level. Modern business is based on the fast response, quality, flexibility, innovation, connections and building the critical mass of capital and production / service potential. This relatively new style of doing business requires a team approach on the local level - cluster approach. Clusters represent the complex organizational systems that are flexible and can be quickly adjusted to oscillatory changes at the sale and purchase markets, generate employment, help the diversification of economic activities and make a significant contribution to exports and trade. Clusters also play an important role in innovation and businesses where there is a need for application of modern technology. Thanks to their innovative flexibility, many of them become more productive and efficient than some large international corporations. In this process, emphasis should be focused on creating a friendly business environment where the transformation of society towards a market economy shall take its place.

Cluster differs from other forms of associations within its geographical boundaries, involvement and utilization of funds, ways of exchange of products and partially finished products, information management - knowledge chains, and the importance of how they are connected. Clusters can be best understood and used as a regional systems and they represent, according to Porter [10], "Geographic concentrations of mutually connected companies, specialized suppliers, service providers, companies from similar industries and institutions tied to them (i.e. universities, standardization agencies, trade unions), who compete, but also cooperate".

Basic characteristics of clusters are:

- Clusters are based on systemic connections among companies; ties can be built on common or complementary products, production processes, essential technologies, needs for natural resources, demands for certain qualifications and/or distribution channels;
- Clusters are geographically limited, defined mainly by distance and time that people are willing to take because of employment which job makers and company owners consider reasonable for meeting and creating business relationships; geographical range is under strong influence of travel and traffic systems, but also of cultural identity, personal priorities, and family and social conditions;
- Clusters represent natural connection of companies, it must be emphasized that clusters do not operate as an imposed agglomeration, or forced association for any reason; clusters nourish unique attributes of companies and make it possible for them to choose levels and types of cooperation within a cluster, and to define what part of its capacities they will bring into clusters, and what part will remain "freelance", taking into consideration common needs, but also their own benefits as a member of cluster association.

Associating into a cluster can bring a broad range of benefits to all partners as well as to the economy in general. Some of the benefits are the following:

- Increased level of expertise; associating gives companies better knowledge about supply chain and makes it possible to companies to learn from each other and to cooperate;
- Capability of companies to join complementary strengths and contract new works of larger scope for which, individually, they would not be able to bid in a public tender procedure;
- Potential for large scale production (economy of scale), which can only be realized via specialized production in each of the companies, through joint purchase of supplies with large discounts or through joint marketing;
- Strengthening of social and other informal connections, which leads towards creation of new ideas and new companies;
- Better information flow within a cluster, e.g. making it possible for investors to identify good entrepreneurs, and for business people to find good service providers;
- Enabling development of services' infrastructure: legal, financial and other specialized business services.

As a result of the functioning of clusters, there are effects shown in Figure 2:

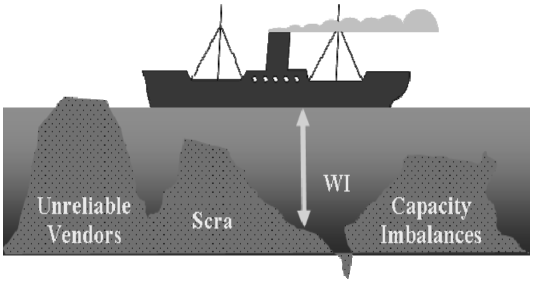

Figure 2: Reducing inventory reveals problems so they can be solved

This paper focuses on establishment of organizational and managerial mechanisms within a cluster, which will enable increase of production processes' effectiveness to the level of a cluster as a whole. That is why one of more important segments is to determine levels of specialization in companies – participants in a cluster, and what desirable levels of specialization for more effective business are in case we have specialization, in other words, economic diversity. Research that has been done shows that traditional production sectors are inclined to doing better business when densely concentrated in one geographical area. Contrary to this, newer, high-tech and service sectors are more comfortable with economic diversity environment.

General opinion is that specialization means lack of economic diversity and vice versa. If that is the case, then improving industrial clusters bears risk of creation of highly specialized local economies. If local economies are specialized in only one industrial sector or only couple of them, then they are indeed much more sensitive to cyclic falls in those sectors. However, other opinion suggests that specialization and diversification do not necessarily exclude each other. Malizia and Feser [27] define economic diversity as "existence of multiple specializations". It means it is possible for local economies to be highly specialized in certain sectors and, at the same time, to have sound combination of economic activities. So we come to the concept of flexible specialization, which represents possibility of companies to do what they do best, and cluster has the obligation to provide optimal utilization of capacities.

Establishment of organizational and managerial structures in complex organizational systems like cluster represents a big challenge because of diversity of clusters and characteristics of member companies. One of the possible models, which application shall enable optimal use of clusters' potentials is Group approach which is described in more details in Chapter 3.

3. THE GROUP APPROACH IN DESIGNING MATERIAL FLOWS

The concept of Group Technology [1] is based on the simplification and standardization process, which appeared at the beginning of 20th century. It originally emerged as a single machine concept that was created to reduce setup times [2]. Group approach in the design flows of material in the production system based on the idea of group technology which, since the work of Mitrofanov [18], never stopped being up-to-date in scientific and expert circles.

This concept was further extended by collecting machine parts with similar requirements, completely processing them within a machine group or cell [3]. The ideas for Group approach came from the fact that there is similarity in objects which enter production process of any company and that in real conditions there is a limited number of forms of these objects. In the basis of Group technology, set up by Mitrofanov, is unification of objects with similar characteristics into families, which creates conditions for "increase" of number of objects in a series and thus levels of series, along with gaining a range of effects during preparation of production and production itself:

- Orientation of process engineers toward a narrow area when solving problems of designing technological procedures – there are small differences between objects within a group in regard to shape, measures, quality, materials used, etc.
- Application of standardized – typical technological procedures for all objects within a group: same production flow, work places, same or similar tools for positioning of objects (possibly group accessories), same tools, same or similar processing modes, etc.
- Simplification of preparation of work places when transferring from one object to another and reduction of time for preparations and finalization.

Based on ideas of Group technology of Mitrofanov, as well as the results of the research made by John Burbidge [1], the Group approach in production was developed at the Institute for Industrial Systems in Novi Sad.

Using this approach, based on classification of objects within production process, groups of geometrically and technologically similar object are created – operational groups (families), which represent the basis for Group approach in planning of production technology. However, we have gone even further here, by merging individual operational groups which have mutually similar technologies (using the same work places) into larger groups. By assigning all the necessary work places into created large group, we create so called working unit (production cell, work cell), capable for production of all objects.

Working Unit has all characteristics of Production Cell but beside its executive (production) independence it has to have an organizational and controlling independence too, which means its total responsibility for quantity, quality, and delivery terms of similar working objects, and also for organizing and managing of processes.[33]

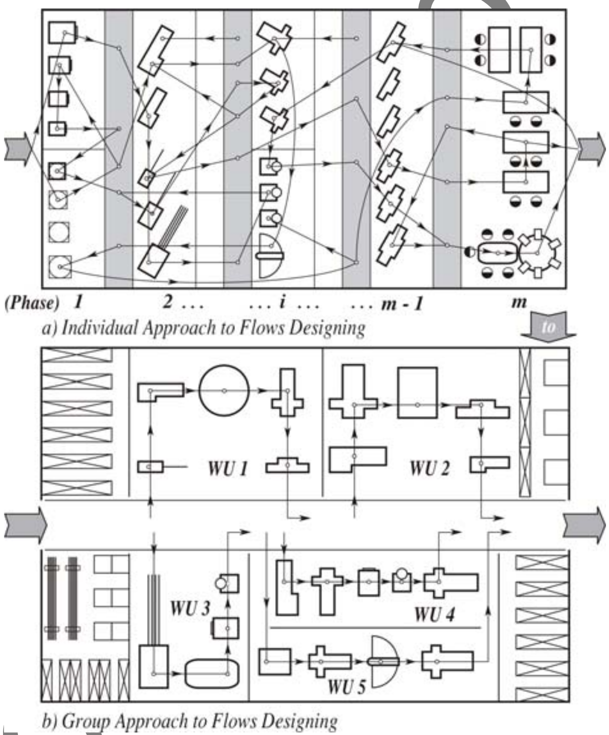

Figure 3: *Working unit, capable for production of all objects*

The final result is, as shown in Figure 3 [33], that the entire production program is divided in parts of the program - a group of objects, and the whole production system into independent operating units in which some parts of the program are made.

At the same time, each part of the production program consists of previously shaped operational groups of mutually very similar objects.

Apart from work places for production, as shown in Figure 4, other resources join composition of a working unit (technological preparation, operational preparation, distribution of materials and tools, process QA, operational maintenance), which gives independent (autonomous) unit – a part of production process which is fully capable to produce one separate component of production program.

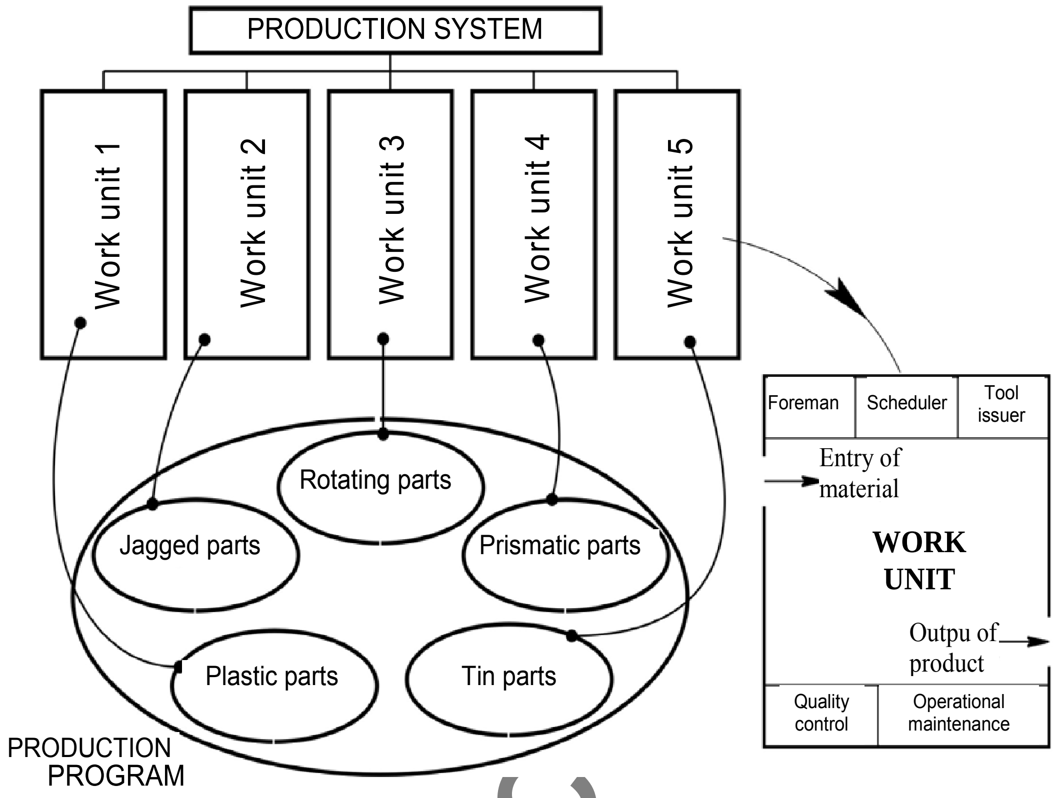

Figure 4: *Production system designed on the basis of Group approach*

This approach in designing material flows in a production system provides a range of advantages, including the following the most important ones:

- Significant simplification of material flows – with shorter transport paths (instead of one flow of all production program objects, several flows with smaller number of objects is realized in the entire production system through smaller sets – parts of production system),
- Simplified production management (each working unit is managed independently, where the number of launched objects and work places which are managed is significantly smaller in comparison to management of the entire production system),
- Production related problems, management, quality control, maintenance, etc, are located in much smaller parts of production processes – work units, which has positive effects when it comes to responsibility for work and motivation of participants in the work process.

Presented Group approach in designing material flows, which was developed at the Institute in Novi Sad, has been applied in a large number of companies and described in details in the literature [17], [19], and the process of clustering and the formation of business units has been supported by a computer program system titled APOPS-08 [20].

The major advantages of Group technology have been reported in the literature as reduction in setup time, reduction in throughput time, reduction in work-in-process inventories, and reduction in material handling costs, better quality and production control, increment in flexibility, etc.., [21], [22], [6].

4. ADVANTAGES OF APPLICATION OF GROUP APPROACH IN CLUSTER ORGANIZATIONS

Productivity and productivity growth determine prosperity. Innovation is a key driver of productivity growth. Clustering supports both productivity and innovation. Porter's Diamond theory provides a useful concept that can help companies' business, government and other institutions to explore improvements in the productivity environment. Various models and solutions have been extensively studied in the previous literature. These models can be divided in the following categories:

- Integration of production planning at the level of industrial clusters
- Integration of production planning at the level of companies within the industrial cluster
- Integration of production planning and distribution on the spot of procurement of raw materials, transport and distribution of semi or finished products to customers.

The aim of this paper is to present the application of the Group approach as a model of optimization of planning and programming production processes in complex organizational structures like clusters. Application of group technology in cluster produces savings and benefits in almost every area of the business:

- It combines tasks, equipment, gages, tooling and schedules into larger groups of similar elements for similar solutions.
- Purchasing can group similar parts and achieve quantity discounts. For non-standard purchased parts, grouping helps suppliers achieve savings and reduce price.
- Accounting in industrial cluster is simpler in a group technology - costs are collected by cell and family rather than individual part.

Cluster production program can be diversified and consisted of all products which are made by the member companies. Disparity in regional economic development is strongly influenced by the proportion of trade, local industries, resources and mix of organizations present in the cluster [11]. Participating companies can enter a cluster with only one part of their production program, and produce or distribute other products on their own, or in cooperation with companies which are not in their cluster. It is necessary to define basic products which are offered by a cluster, and adjustments of organizational and managerial cluster structures is done in regard to these products. Production program is further divided into structures and sub- structures, where individual requests towards cluster companies are defined for processing and assembling. Possibilities for process control and shortening of production cycle depend on organization of a cluster.

Organization of the production process in a company is extremely complex process itself, and when we transfer it to the cluster level, we get a complex task which is difficult to solve. For the time being, there are no simple models developed which would enable increase of process effectiveness in a complex organizational units like clusters. In that regard, this paper makes a pioneering attempt. One of the possible solutions which would decrease complexity of flows and increase process effectiveness within a cluster is application of Group approach.

By applying a Group approach in complex cluster type organizational systems, the role of work units from the Figure 4 is replaced by cluster member companies, as shown in Figure 5. Previously, we stated that one of the significant characteristics of clusters is flexible specialization of companies for processing and assembling of structures and sub- structures from cluster production program. It enables processing of structures and sub- structures with minimum costs and minimum time required.

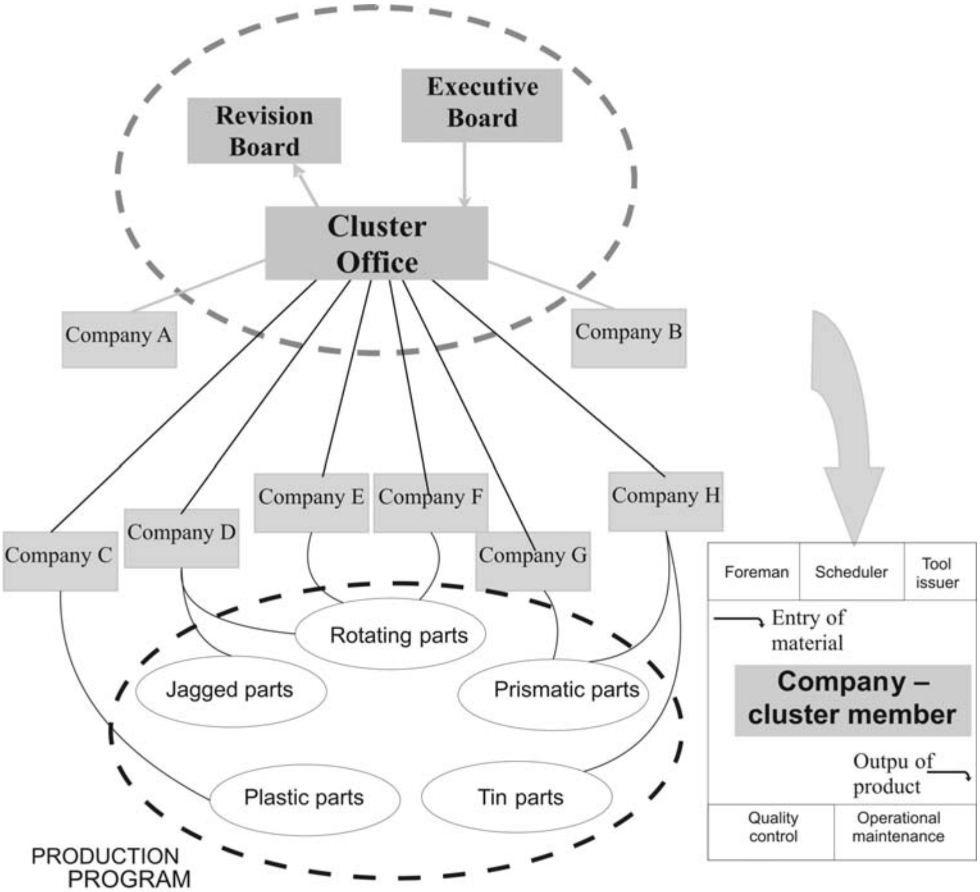

Figure 5: *Production realization within a cluster in accordance with the Group approach*

In accordance with the Group approach - the parts for processing are grouped according to two criteria: similarity of parts and potential of production system.

Application of the Group Technology on complex Cluster type organizational systems represents a new approach in creating effective production systems, and it is being developed as the integral part of the Center for Competitiveness and Cluster Development at the Faculty for Technical Sciences in Novi Sad. Given approach1 is based on concepts of flexible specialization and Working Units with extended flexibility. Flexible specialization, as one of the basic advantages of Clusters, provides companies in Cluster to work on what they do best, for what they have trained labor force or technical-technological capacities, and still to have enough volume of work. Companies, Cluster members, considered from the aspect of flexible specialization represent Working Units of extended flexibility. Having in mind that Companies participating in a Cluster can choose which part of the Cluster production program or production capacity they will be part of, then the same applies for branches of the Companies as well.

Application of the Group Technology covers many issues. On the basis of the Analyses of the methods applied in designing technological procedures and designing the organization of work processes in Clusters on the territories of Serbia, Croatia, Slovenia and Italy, there have been determined the basic processes of Application of Group Approach on the level of an Industrial Cluster:

- Harmonizing a common Cluster production program.

- Classification of objects of work:
  - Adjusting the Systems of Classifications of objects of work according to the increase of performances of technical-technological systems of Work Units with extended flexibility,
  - Defining the Systems of Classifications of companies participating in Clusters and companies cooperating with a Cluster from the aspect of performances of technical-technological systems, organizational and managerial structures,
  - Defining correlations between the above mentioned Systems of Classifications.

Adjusting organizational and managerial structures of Clusters and member companies which will provide both more efficient information flow amongst the companies in a Cluster and increased quality in controlling working processes.

4.1 Harmonizing a common Cluster production program

Companies in a Cluster have to harmonize which products, assembles, subassemblies and parts are important on the Cluster level from the aspect of requests coming from the environment and from the aspect of companies participating in producing them. In that way, two basic goals are being accomplished: directing activities towards fulfilling customers' demands and creating the synergy effect amongst the companies participating in the production. Researches carried out in the period 2007 – 2009 by the Center for Competitiveness and Cluster Development both individually and also participating in GIFIP1, and UNIDO projects supporting development of the Cluster AC Serbia2, demonstrate that without the existence of the above mentioned elements it is very difficult to accomplish effective functioning of Clusters.

4.2 Classification of objects of work

Production program of a Cluster can comprise a huge number of different elements – assembles, subassemblies or parts (Picture 6 on the left). These elements can differ in regard to shape, material, technical-technological specifics etc. Also, these elements are integral part of different products which can be produced in different companies. For each of individual elements being produced in a Cluster, it is necessary to define the technological procedure starting from geometrical and technological characteristics of an element what, in case of huge number of elements, requires a considerable waste of time. Group approach has in its basis the procedure of grouping of objects according to their similarities. In order, from non-homogenous group of elements (Picture 6 on the left), to make a homogenous group of elements (Picture 6 on the right), it is necessary to have the existence of Unique System for Classification which is applied on the level of the whole Cluster.

When the homogenous groups of elements are generated, then the designing of technological procedure for a Group is carried out, and then and finally the designing of individual technological procedures including utilizing defined technological procedure for a Group as the starting point. The essential is that due to similarities of elements in a Group, there are existing technological procedures covering the whole Group what reduces the waste of time in regard to individually defined technologies. Modification of an application of the Group approach in a Cluster is also in the fact that the process of designing a Group technology is placed on the Cluster level – what significantly relieves resources of participating companies and decreasing the costs.

[1] BILATERAL COOPERATION PROGRAMME ITALY – SERBIA : Integrated Governance of productive companies in sectoral clusters (GIFIP)

[2] UNIDO project: and title: Facilitating International Market Access for Manufacturing Suppliers in the Automotive Component Industry in Serbia

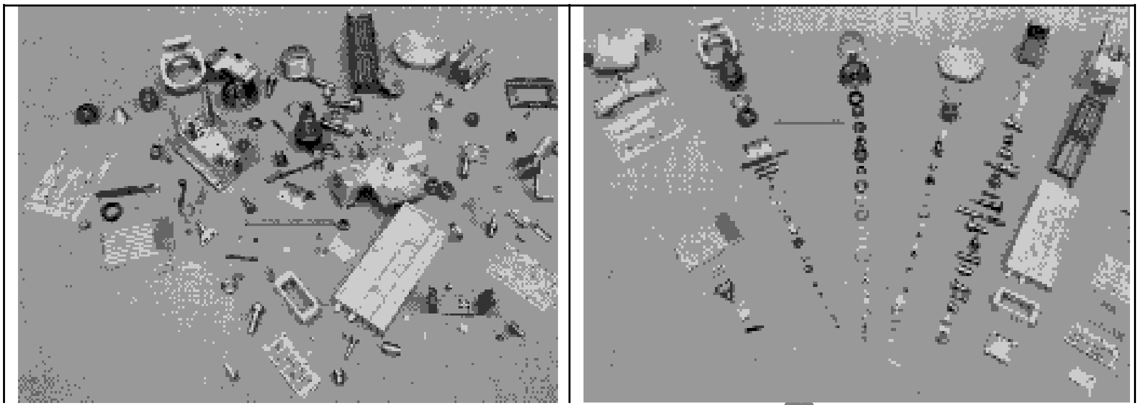

Figure 6: *Grouped and ungrouped parts*

In the practice, there has been developed a series of more or less similar systems of classification. All developed systems provide gradual classification in terms of identifying classes, families and groups - types of parts with similar characteristics and specific measurement areas. Defining operational groups at the clusters level brings certain limitations in the implementation of classification systems. Classification system KS - IIS - 08 * developed for the needs of the industrial systems of geometrically shaped products, basically includes characteristics related to design operational groups in relatively simple way. The structure of the system is schematically shown in Figure 7.

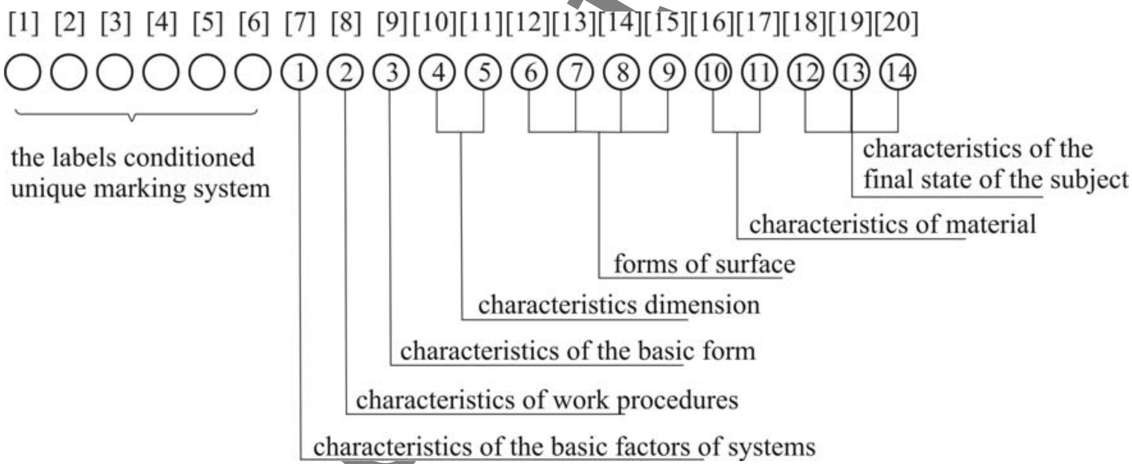

Figure 7: *Structure of the Classification system*

General characteristics of the above mentioned Classification system are the following:

- classification label has 14 areas - features (1 to 14),
- Each feature has 10 fields (0 to 9),
- Each field has a specific meaning.

Depending on the combination of technical-technological systems of companies, it is later chosen which company will process which group of selected parts including specific operations..

Classification System KS-IIS-08*, shown at the Picture 7, represents the modification of the System which has been developed and utilized at the Faculty for Technical Sciences in many projects related to Application of Group Approaches for individual companies. Having in mind that homogenous groups of elements are created in regard to Working Units with extended flexibility – the degree of decomposition of Classification System is being kept on a lower level of details what simplifies the process of classification. It is also important to classify companies, or branches of companies, from the following aspects: type of industry, technical-technological potential, the degree of automation and organizational and managerial structures.

In order to reach the optimal choice of companies, in other words, the effective distribution of homogenous groups of objects of work amongst the companies, the following matrix is used, shown at the Picture 8, on which basis a comparison is being done, comparing companies' capabilities and technological requirements of of group of elements. In that way, the problem of participating companies having similar technical-technological potentials is being solved.

Before

PART#	DESCRIPTION	Broach 10071	HMC 10148	Lathe-Chucker 10210	Hob 10094	Lathe-Manual 10211	Hob 10096	Lathe-Barfeed 10214	Lathe-Vertical 10233
61354	COVER BEARING			1					
70852	GEAR DRIVEN: 8P 56T RH	1		2	1		1		
52594	SPACER CPLG SHAFT							1	
81357-T	IMPELLER	1		3					
50547-D	GLAND MJ 6" DI CLASS B					1			
70935	GEAR DRIVEN: 8P 26T	1		2	1		1		
51171	RETAINER BUSHING							1	
81176	BODY VOLUTE		1						1
72246	ELBOW RELIEF VALVE		1						
50763	SPACER BEARING							1	
71972-8	ADAPTER INTAKE 6"		1			1			1
62575	SHAFT SHIFT							1	
63160	SEAT-SPRING							2	
62966	GENERATOR TACH PULSE			2	1				
71928	HEAD PUMP					1			1

After

PART#	DESCRIPTION	Lathe-Manual 10211	Lathe-Vertical 10233	HMC 10148	Lathe-Chucker 10210	Broach 10071	Hob 10094	Hob 10096	Lathe-Barfeed 10214
50547-D	GLAND MJ 6" DI CLASS B	1							
71928	HEAD PUMP	1	1						
71972-8	ADAPTER INTAKE 6"	1	1	1					
81176	BODY VOLUTE		1	1					
72246	ELBOW RELIEF VALVE			1					
81357-T	IMPELLER				3	1			
62966	GENERATOR TACH PULSE				2		1		
70935	GEAR DRIVEN: 8P 26T				2	1	1	1	
70852	GEAR DRIVEN: 8P 56T RH				2	1	1	1	
61354	COVER BEARING				1				
52594	SPACER CPLG SHAFT								1
62575	SHAFT SHIFT								1
63160	SEAT-SPRING								2
51171	RETAINER BUSHING								1
50763	SPACER BEARING								1

Turn-Mill Cell; Chucking Lathe Cell; Barfeed Lathe Cell

Figure 8: *Uses a matrix of part numbers and machine numbers to group families*

The result of the above mentioned activities is demonstrated with decrease of system complexity (Picture 9), creation of simplified and more effective information flows and creation of the basis for development of effective and efficient organizational and managerial structure of a Cluster.

At Picture 9, there is shown the expected result of the Application of Group Technology on the Cluster level. Companies in the Cluster are marked with the characters of Alphabet, and flows of material and information are shown with the lines. Each group of products has its flow which is defined on the Cluster level what enables easier control and consideration of possible critical points and possibilities for improvement. On the other hand, each innovation implies small changes in the layout of such arranged processing structures of Clusters.

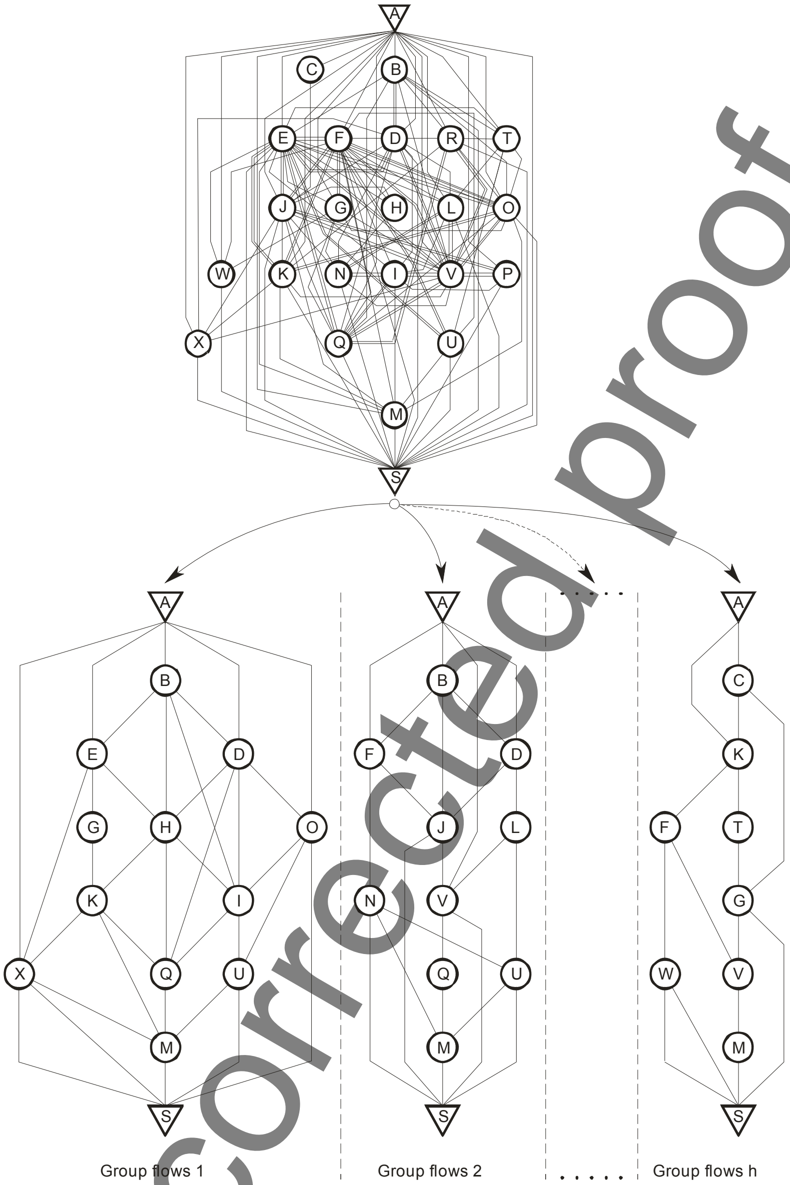

Figure 9: *Simplified network of flows at the cluster level*

The process of Adjusting organizational and managerial structures of Clusters and member companies is the next phase which shall provide utilization of established processing structures of Clusters.

5. PROGRAMMING AND PLANNING OF PRODUCTION IN CLUSTER

In order to achieve balanced utilizations of capacities, companies would have to submit in advance their production plans and engagement of their systems, e.g. by utilizing IT technologies, and on the basis of these plans to make detailed term-plans at the cluster level. Any change of term-plan is recorded and must be available to all participating enterprises.

Many intersections in the system, diversity of procedures mutually connected with connections of different degrees of strength, courses and directions and a lot of feedback connections, hamper the process of managing to the great extent. Directed control procedures, in the case of artificial (man-made) systems, have basically mandatory character which provides designed system operations. However, in the case of natural systems, management procedures based on the homeostasis self-regulating principle, have a natural character and maintain managed variable on the necessary level in the significantly narrower boundaries of tolerance fields and in significantly longer duration period.

Special environmental requirements, disorders in the work processes, delivery delays, organizational deficiencies and other similar influences condition the need for further settings of operational plans at the time of their performance. Since the above mentioned phenomena are constant in time, therefore the need for settings of operational plans is constant in time too. Only full harmonization of working elements of the system of execution of operational plans - working processes – provides anticipated effects. Here is illustrated what does this concept mean: We suppose that firms M, N, U are cooperating in the cluster. Firm M supplies (row materials and components) from firms N and U, and firm U supplies from firm N. If we want to apply group approach, it's considered that every firm has developed management production system and that at the beginning of making operating plan for next period has correct time schedule for all processes in a firm. Plan of processes can be illustrated through matrix (firm M) or through Gantt chart (firms N and U). See Figure 10. Deviations of the results of given phenomena leads also to deviations of designed effects.

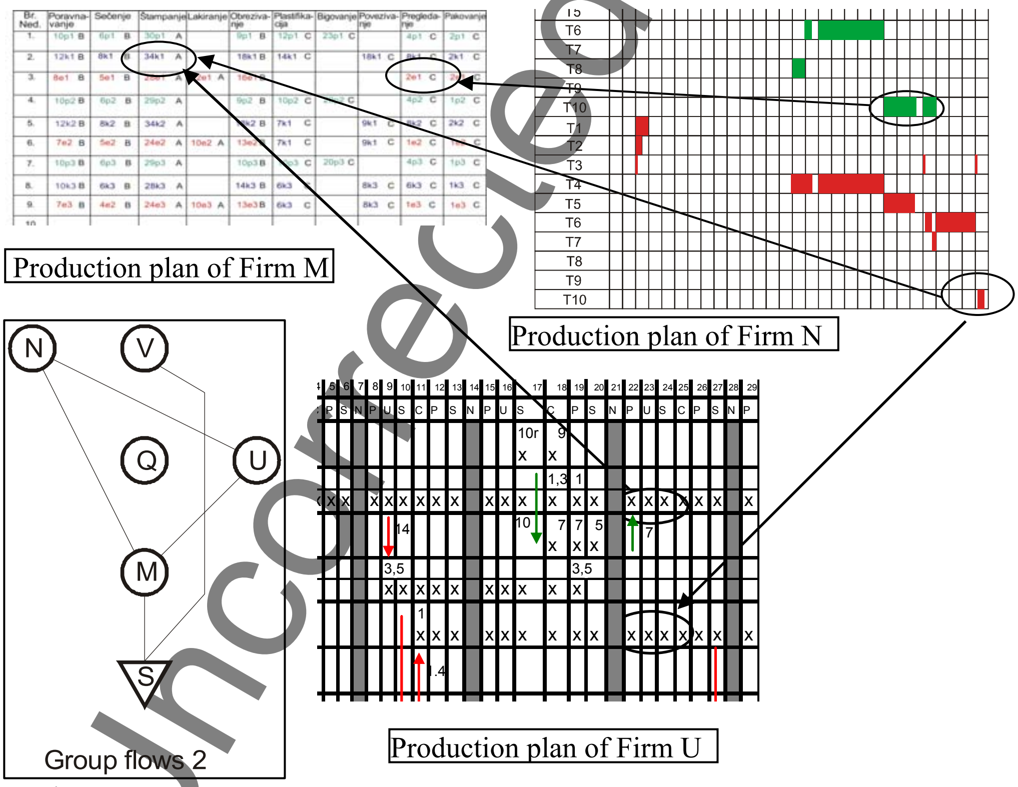

Figure 10: *Integration of production plans*

The basic problems which condition the need for planning in the most of the production system are reduced to the following elements:

- Maintenance of delivery deadlines,
- Control of the level of unfinished production,
- Minimization of waiting lines,
- Optimization of the sequence of inputs of orders in the working process,

- Harmonization of the work load (capacity),
- Elimination (minimization) of the time in the state of cancellation by providing integrated system support,
- Maintenance of a balanced relationship between the continuity of flow in the system and the cost of supplies (materials, participants, energy, money).

Having in mind the above mentioned, it is clear that data processing and information design about the system status in a specific cross-section, must be done continuously and in real-time in order to have the working process, when needed, adjusted before entering the next cross-section of the system. In the sense, there is no use to plan the status for the next day on the basis of the data of previous week. Information about the status of the cross-section "i" must be the basis for planning of the cross-section "i +1". The process must be carried out in the real-time – therefore, at the end of the operation that generates the status "i" it is necessary to design the status "i +1".

Knowing that with the hierarchy access there is practically no feedback connection between the system programming and system planning, therefore the decisions made by system programming - operating plan (part of the production program stipulating the structure and the quantity that will be produced in the upcoming, accurately specified period of time) is not affecting decisions made in the planning stage, but is limiting them. Therefore, it becomes difficult to carry out production plan taking into account the precise program for hierarchy systems. It is necessary to make the integration of programming and planning systems for the sake of global optimization of processes in order to have industrial clusters functioning as one entity.

Model of simultaneous planning and programming for more periods was suggested by Birewar & Grossmann (1990) [21], where programming decisions are built on the level of planning. It has been shown that planned profit becomes significantly increased when th planning and programming decisions are optimized simultaneously. The bad side of this approach is that the model of planning and monitoring is restricted to the specific category of simple problems, because it requires extremely large number of binary variables needed to solve the problems of integrated planning and programming.

6. CONCLUSIONS

Group technology adoption helps the small organizations acquire process competence and better process control. Investment on measurement and testing equipments leads to long term advantages. They can manufacture high precision products and get price advantage on these value added products as they grow through forward integration [5]. With this approach, a number of structural elements and a variety of relations between them are the basic parameters which define the complexity degree of organizational structure and simultaneously determine the complexity of clusters information flows. Therefore, the complexity degree of organizational structure determined upon those parameters enables comparison of the designed structure variants using the quality defined as control adequacy. With process expertise they can also develop many new products and also cater to the international market [12].

The system defined in this way enables high-performance production, and provides optimal use of capacities and great flexibility of the entire system. Such systems enable the production in small series with very low costs. Since there is a large number of small and medium-sized enterprises, any changes in processing, shaping or any changes of material are solved within a few enterprises either by replacement or purchase of a small number of machines or by including in the cluster some companies with required developed technology, and by doing so we achieve a very fast reaction to any disorder or any changes. It means that the processes of development are carried out simultaneously, because each company gets the task to develop a part of a product for which they are specialized, and doing so we achieve the development of shorter duration, and increased number of different combinations available for utilization.

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