SYSTEM OF PRODUCTION FLOW PLANNING IN METALWORKING CLUSTERS

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Abstract

The cluster concept is becoming increasingly popular as an effective form of business organization. Clusters, which are a flexible form of horizontal cooperation among the three groups of players: companies, scientific research bodies and public authorities; provide an environment which facilitates the rapid development of innovative forms of cooperation between different players. In addition, they form an ideal base for the creation of production networks oriented to emerging business opportunities in the market.

The submitted paper concerns the production flow planning in a set of small and medium enterprises (SME's) functioning within regional metalworking industry clusters. Surveys conducted as part of research into one of the Polish metalworking clusters underline a need to combine the potential of enterprises in order to manufacture new production orders which significantly exceed the production capacity of any single cluster enterprise.

In this paper, a computer system which allows the integration of cooperating enterprises, sharing of production capacity of enterprises and the possibility of production order execution is presented. This system improves the productivity of the production resources of metalworking cluster enterprises and has a positive effect both on the development of small and medium enterprises belonging to the cluster and the region as a whole.

Keywords: industrial metalworking clusters, production orders planning, production flow planning, prototyping of production networks, SME's.

1. INTRODUCTION

The highly dynamic market challenges and the advantages of the facilities offered by advances in information and communication technologies mean that today's enterprises are increasingly operating in networked environments [4], [9]. Nowadays, participation in networks very often plays an important role for many organizations, especially small and medium enterprises, which strive to achieve a differentiated competitive advantage [3], [8]. Networked companies can increase their benefits through sharing competencies and resources [1]. Therefore, the cluster concept is becoming more popular in both the scientific and business communities. The potential that lies in the SME sector can, through appropriate policies to support the development of regional industrial clusters and the formation of production networks within them, provide an additional source of development across the region. This helps to maintain a high level of employment and innovation, and develops and improves the competitiveness of businesses connected to the cluster [3].

Nowadays, a very important problem highlighted in literature is the lack of tools supporting the process of production orders planning within small and medium enterprises of clusters [5]. This implies a need to develop procedures and computer systems that will evaluate the feasibility of a new production order given the available production capacity of potential partners (enterprises) of the cluster, and facilitate the selection of a set of companies to ensure its realization [3], [5].

The production flow planning in the cluster is based, on the one hand, on taking into account the requirements of carrying out the planned production order, and on the other hand, the possibilities of
potential partners (enterprises) [6], [7]. Possibilities for fulfilling the order are determined mainly by the available competencies, production and human resources and logistical constraints (transport, storage) in the cluster [2], [3].

One of the main problems considered is the new production order planning within enterprises of industrial cluster which are able to form temporary production networks. This paper presents a prototype computer system based on Web-service technology, which allows a set of acceptable variants of temporary production networks to be quickly created which guarantee timely new production order execution with consideration to capacity, costs and logistical constraints of the cluster.

2. PRODUCTION FLOW PLANNING IN A METALWORKING CLUSTER

In the considered case, there is a metalworking cluster, which consists of a set of small and medium production enterprises specialized in a limited field of production with specific production capacity and a set of transportation enterprises which can guarantee material flow between partners. There is a new production order specified by the size of the planned production, given time of execution and intended costs of realization (price). The production order realization is described by a set of tasks which are executed in various enterprises. Execution of this order often exceeds the potential of a single enterprise, according to its production capacity and the technology possessed. In this case, production order planning is based on rapid formation of temporary networks within cluster and acceptable variants of production flow between partners. Thus, in this paper the following research problem is considered: is there a production network of enterprises which can execute production order on time with the assumed costs?

In this approach, a very important component is the broker. In practice the broker is a trust manager of the cluster whose role is matching enterprises which are able to realize a given new production order according to resource and logistic constraints. A key role of the broker is new production order planning which consists of working out a production order (constructional and technological), selecting enterprises which function in logistics communications system of the cluster and prototyping of a production flow schedule which guarantees production order execution on time and with the acceptable total cost of production order realization [12].

The proposed method for the new production order planning can be represented as a three-phase procedure which is implemented in a computer system which is available for all participants. In the first phase, the cluster broker submits a planned production order to the computer system and details of the tasks are made available for potential partners to access via the network. This step must be preceded by preparation of design and technological documentation for the product with a precise description of the technological process, along with the separation of tasks and their technological implications in the process of execution. Due to the limited ability to instruct the broker, documentation must be supplied by the client or developed earlier in the design phase of the order. The order is placed in the system by the broker, who sets a deadline for submitting bids for the task and sends a notification to all members of the cluster [11].

In the second phase declarations are collected from enterprises with appropriate available capacity (production resources, warehousing), who declare the type of resource offered, periods of availability, time needed to complete the task and the total cost, which is the sum of the cost of resource utilization, the cost of materials used for the task and other costs. In this phase, bids are also collected from transport companies, which are able to guarantee the transport operation [11].

In the final phase, proposals from bidders are verified by the system and prototyping of acceptable production networks takes place. This stage is connected with the determination of a detailed production flow schedule for all partners in the network. Moreover, in this stage a deadline for the start and finish is set, along with the total cost of the planned order for each of the allowable variants. Particulars of the presented approach were presented in works [10], [11], [12]. A practical aspect of the presented method is a system of
computer-aided production order planning in a cluster which is a tool for handling the orders executed in the cluster.

3. THE SYSTEM OF COMPUTER-AIDED PRODUCTION ORDER PLANNING

The high costs of implementation and maintenance of computer-aided management systems, especially ERP (Enterprise Resource Planning) have resulted in limitations to the rapid development of small and medium enterprises. Often, companies use a simple application dedicated to particular areas of management with a low level of integration. The need to provide low-cost solutions with comparable capabilities, especially in the field of integration, have brought forth the idea of sharing a system through web-service. An important problem is that of cluster companies exchanging information related to, on the one hand, available capacities and on the other hand, requirements reported by the client. This study proposes a prototype platform based on Web-service technology, which allows integration of businesses related to the project without the need to equip businesses with often costly additional applications. This is especially necessary based on the results of the research into a cluster of companies, which shows that a considerable proportion of them do not have any system to plan and control production flow [11]. Thus, downloading any information from the system is impossible and the data necessary to design the network must be entered manually by the production manager of each of the potential participants in the network.

The proposed system is a tool to help facilitate the exchange of information between the broker, who provides information concerning tasks, and enterprises with the specific production capacity sufficient to carry out these tasks. Based on information collected in the system, a set of network variants capable of timely implementation of the order, and a schedule showing the load on individual resources of companies in a given scenario for the implementation of the new order are generated. Each variant is characterized by a set of selected companies with an indication of resources used, cost of implementation and the date of commencement and completion of the production order. This ultimately allows the best variant to be chosen in the system and available capacity to be reserved for the implementation of the production order by individual companies. Data on resources of companies is only made available for the purposes of the broker. This means there is no access to confidential data of other companies and therefore increases the security of the system against unfair competition [12]. Conversely, any of the companies registered in the cluster have access to information on orders and planned tasks.

Production order data input
The broker is responsible for entering the data of production orders planned for implementation in a cluster. Each order is divided into sub-tasks dedicated for different cluster enterprises. For the planned order, the following data should be entered [11]:
- deadline for receipt of tenders for the order tasks under consideration;
- the planned date for completion of the task (the deadline specified by the customer);
- expected number of pallets used in the delivery to the customer (standard Euro pallets);
- maximum permissible cost of the order.

In the middle window (Figure 1), all the tasks related to entering the order are added. The broker introduces another task while also specifying the sequence of tasks in accordance with the technological process. In the lower right-hand corner of the window, a tree structure is shown illustrating the sequence of tasks in the order. For each task, the forecast number of large pallets used in transporting the operation for the next task is determined. In the bottom pane for each task are placed documents describing the task, full technological documentation, technical drawings developed in a common format for all companies such as DWG, etc. After entering the job, the broker has the ability to send out e-mail information about the order to all cluster companies.
Making an offer for the implementation of a production order

An offer is made for a specific task belonging to the production order. Available information about the tasks, the deadline for submission of tenders and the deadline by which the task must be performed to ensure implementation of the entire order within the period specified by the customer are displayed on the right of the screen (Figure 2). In the lower left of the screen technological documentation for the required task is made available, which is essential for reliable assessment of the ability to complete the task.

On the right-hand side of the window (Figure 2), the production manager highlights available resources to achieve a given order, specifies the planned number of hours of resource commitment, the total cost of the task and the possibility of division of tasks into shorter time periods, specifies the minimum time commitment to the implementation of the resource, and introduces parameters that prevent the use of the resource in less than the indicated time periods. The company may submit several bids for production resources on several tasks simultaneously.
Generating permissible solutions of production flow

After entering the tasks data of the planned production order, and all tenders from enterprises within a specified period, the broker starts the procedure proposed in the work of the designation of the set of permissible variants for the network to ensure the implementation of the order. As a result of the proposed procedures for the planning of the order in the network, the broker receives a set of permissible solutions to ensure timely implementation at a total cost not exceeding that specified by the client.

Figure 3 presents a set of solutions generated for the sample order. Selected network variants are presented in the left-hand section of the results. In the right-hand pane, a set of selected companies assigned to a specific task is presented, with information about the selected company, use of resources defined in the system, the date of commencement and completion of the task, the deadline for completion of the transport operation, total cost of the task by the company and the cost of transportation for the task.

Fig. 3 Presentation of the set of permissible solutions.
Source: Own work.

For each of the identified variants, a schedule of the production flow of the production network is generated (Figure 4), which allows for the efficient completion of all tasks in individual enterprises, coordination of manufacturing operations performed, transport and monitoring of the progress of the planned orders in the system.

Fig. 4 The effect of prototyping of production networks in a regional metallurgical cluster.
Source: Own work.
4. CONCLUSION

The proposed computer system is a tool used by a broker for the prototyping of production networks within a cluster, and production flow planning of a new production order. The proposed system allows the integration of cooperating enterprises, sharing of production capacity of enterprises and the possibility of production order execution significantly exceeding the production capacity of any single cluster enterprise. Furthermore, the proper functioning of the proposed system will improve the productivity of the production resources of cluster enterprises and will have a positive effect on the development of small and medium enterprise belonging to the cluster.

Furthermore, the proposed method of exchanging information in a computer system uses a trading broker to avoid the risks of unfair competition (e.g., use of load state information resources, use of resource unit costs by a dishonest partner, etc.). Broker supervision over the production managers allows the level of trust between partners to be increased and also allows the integration of the metalworking cluster environment.

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LITERATURE