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FORMATION AND PLANNING OF VIRTUAL PRODUCTION NETWORKS (VPN)IN METALLURGICAL CLUSTERS

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A significant problem of small and medium enterprises in the metallurgical sector is that submitted orders very often exceed the individual production capacity at the disposal of each company according to production capacity limitations (machinery, equipment and time availability), competencies, skills, etc. Therefore, the idea of the creation of virtual production networks (VPN) of small and medium enterprises within a metallurgical cluster appears to be particularly attractive. The development of such networks depends on design solutions and tools which help companies to quickly plan a VPN to jointly execute production orders. In the paper, the new method for formation and rapid planning of virtual production network within metallurgical clusters is proposed.

Key words: Metallurgical sector, planning, cluster, virtual production network

INTRODUCTION

A major problem for small and medium enterprises (SME's) in the metallurgical sector is that production orders often exceed the capacity of any single company. An increasingly attractive opportunity for the development of this type of enterprises is a partnership consisting of combined specialist expertise and exchange of production capacity to better meet the expectations of the customer. The strategic use of long-term or temporary cooperation with other stakeholders to create network organizations to reduce costs and make use of business opportunities unattainable for each of them individually is becoming more frequently observed. Enterprises in such an arrangement provide production capacity at their disposal necessary for the implementation of the type of production order.

One of the fastest growing forms of cooperation is industrial clusters, which, through their close geographical concentration of SME's and using the synergy effect, can achieve better economic results and, consequently, a competitive advantage. They also enable the development of SME's operating in the local market and the region.

The article presents proposal of a new method for formation and rapid planning of the virtual production networks (VPN) within metallurgical clusters. In the proposed solution the network broker plays a significant role, initiating contact between partners and coordinating the activities of the cluster, but does not represent any of the companies.

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THEORETICAL BASIS

A virtual production network (VPN) is understood as a temporary or permanent coalition of geographically dispersed organizations that pool resources in order to achieve common goals [1] or a temporary subset of production enterprises and related support institutions within a cluster, which is formed for the purpose of timely implementation of a new production order (project) for the lowest possible cost of implementation [2].

The most significant is that the potential partners are ready and prepared to participate in collaboration.

DESIGNED METHOD

The method of forming and rapid planning of a VPN within metallurgical clusters proposed in the article is based on the procedure performed by the broker cluster, and consists of three phases: offer, declaration and formation phase (see Figure 1).

Before the implementation of the proposed method must be prepared design documentation and technological product with a detailed description of the technological processes with the separation of tasks and their technological implications in the order realization. Due to the limited capacity to instruct the broker documentation must be provided by the client or developed early in the design phase of the order.

In the first offer phase, the broker collects information about the order and a production capacity of potential contractors and brings order to offer planning system VPN in the cluster. It also specifies the deadline for bids for the task sends a notification and provides data to potential network partners.

In the second phase offers are collected from businesses with appropriate potential (production resources)

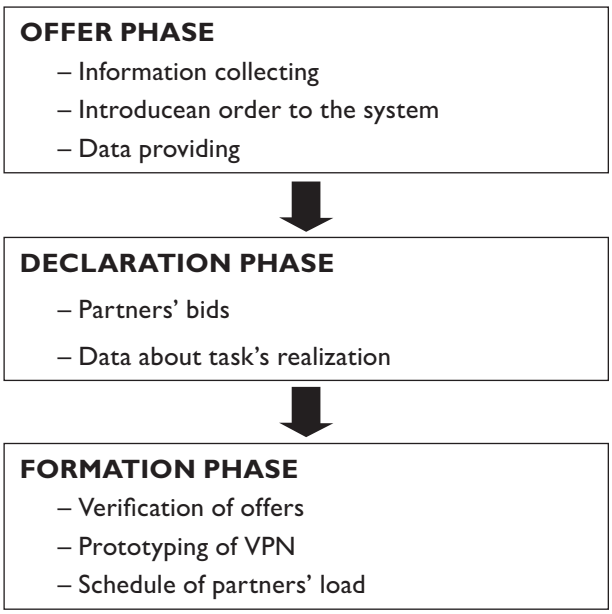

Figure 1 Scheme of the proposed method

in which the declared type of the offered resource, periods of its availability, the time needed to complete the task and the total cost of representing the sum of the cost of resource use, costs of materials used and other costs chargeable to the data task are submitted. In this phase bids are also collected from transport companies who can guarantee the implementation of the transport operation.

The main objective of the formation phase is to select partners who can, in a variety of cooperative systems, ensure timely implementation of the order. For this purpose, the permissible period of any of the tasks planned for orders is determined by the declared individual offers from businesses for the time of execution of tasks and the execution time of transport operations. Therefore, in the last phase, the verification of offers submitted to the system and prototyping of acceptable variants of production networks takes place. This stage is connected with the preparation of a detailed schedule of the load of all the partners in the network. In addition, the stage is followed by the appointment of a start and end date and the total cost of the planned order according to each of he permitted variations.

Due to the high combinatorial complexity of the problem being solved the proposed virtual production network prototyping approach is based on the examination of sufficient conditions to be met to ensure acceptable variants of an order.

Number of variants is reduced by eliminating these variants in which offers cannot guarantee the availability of resources at certain times of the tasks or where, taking into account the total costs of the task indicated by the bidder and transport costs, the total exceeds the maximum cost of the order.

The set of options is subsequently limited to those options that meet the conditions associated with the transportation system. Each of the options is evaluated in terms of the available means of transport and their capacity to declare the implementation of transport operations.

Finally, those variants that guarantee the execution of the production order dictated by the specified maximum cost and the assumed time horizon of the order are identified. Each of the obtained solutions is a collection of selected listings of companies that can create a VPN. Based on the range of total costs of the order, dates of commencement and completion of tasks by selected companies, the most appropriate variant can be chosen and a VPN of cluster enterprises can be formed.

Knowledge of scheduling not only allows for efficient organization and control of the manufacturing process throughout the network, but also allows even distribution of the load on the cluster companies, which in turn allows for balanced development of companies throughout the cluster. The final decision concerning the configuration of the network shall be made by the network manager, on the basis of the proposed variants generated by the broker. The role of the broker is therefore limited specifically to the selection of a set of variations, supervision and coordination of the course pursued in the cluster production orders.

RESULTS AND DISCUSSION

Despite intensive research on the formulation of production networks in the framework of metallurgical industrial clusters, existing solutions are characterized by a very long duration of the formation of networks and low yield configuration and reconfiguration of network components. Both in literature and in practice, there is a scarcity of methods and tools for rapid prototyping of manufacturing networks taking into account resource constraints and logistics system in the environment of industrial clusters.

The formation of VPN is essentially a multi-criteria decision-making problem. In such cases, involving solving problems of forming virtual networks, optimization and simulation methods are often chosen, however they are both very time-consuming and work-consuming. Some researchers have suggested methods based on multi-attribute value theory or Analytic Hierarchy Process (AHP) [3], fuzzy programming method [4] or genetic algorithms [5], which can help evaluate the certainty of decisions made. Another method which has recently been developed is the method of Robust Portfolio Modeling (RPM) [6]. This method is especially suitable for solving multi-criteria portfolio-selection problems and can be used in solving linear problems. The fault of these methods is that the setting of acceptable solutions in "on-line" mode in this way is not allowed. Thus, research should be conducted into the implementation of methods which can quickly set acceptable variants of a planned production network with consideration to capacities and logistics constraints [7]. Summarized, a major problem in the formation of a network is the lack of methods for the secure collection of data needed by the broker for network design and scheduling implementation of the new order.

The main reason for the formation of a network is a reaction to an emerging market opportunity which has a form of a production order characterized by the need to achieve an acceptable quality of production flow based on the available competence and capacity of enterprises using information technologies. Participation in the VPN is particularly attractive to small and medium metallurgical enterprises. It gives access to various resources and economies resulting from a much more efficient use of production capacity and employee competencies of individual businesses [8]. Therefore, the idea of metallurgical companies forming a community with others as a virtual network allows more complex, innovative products and services to be offered on the local, regional and even global markets [9].

The realization of the production order in the cluster depends on the requirements of carrying out the planned production order (project), and the possibilities of potential partners. Possibilities for fulfilling the order are determined mainly by the available competencies, production and human resources and logistical constraints (transport, storage) in the cluster. The proposed method of formation of the networks in the cluster resolves most concerns related to the accession of enterprises to the VPN [10]. This applies above all to building trust between partners, defining the basic framework for cooperation, responsibilities in providing information and acceding to the virtual network to achieve a single production order, along with rules for division of the costs and benefits of its implementation. The proposed method reduces the risk of unfair competition and loss of know-how of the participants of the cluster.

The experience of many researchers who have studied the functioning of clusters underlines the importance of a separate leader (person or institution) responsible for initiating and coordinating collaboration both within and outside the group. The function of cluster management can be fulfilled by a large enterprise, or a strong scientific research unit or board of the cluster [11].

In proposed solution the broker works for the cluster and his activity is not competitive in relation to the members of the cluster. The introduction of an entity that is not a competitor to the partners and the organizer initiating and motivating cooperation of all members of the cluster provides the confidence of partners and maintains the confidentiality of information provided by the participants of the data network. The broker's orientation exclusively to cluster development contributes to the fulfillment of its basic statutory objectives relating to innovation, staff training, maintaining a common competition policy of large corporations with high potential for capital support for the development of small and medium enterprises.

CONCLUSION

The proposed method enables the efficient formation of virtual production networks of small and medium enterprises operating in a metallurgical cluster environment in order to execute joint production orders. The system is, in essence, a platform for the sharing of unused resources of enterprises and order tasks, allowing production to significantly exceed the capacity of any one company.

The proposed concept for exchanging information in the system with the broker to avoid the dangers of unfair competition such as the use of information on the state of charge of resources, unit costs of resource, etc. by a dishonest partner, considerably increases the level of trust between partners to jointly undertaken actions. Also noteworthy is the ability to create dynamic networks, which may be involved in many different projects realized within the metallurgical cluster, providing a continuous flow of production orders using excess production capacity of enterprises.

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