Cluster Manufacturing Management to Improve Equipment Efficiency and Productivity

Suthep Butdee[1] and Serge Tichkiewitch[2]
[1] Thai-French Innovation Center (TFIC) &
Integrated Manufacturing System Research Center, Department of Production Engineering
Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Thailand
[2] G-SCOP – Grenoble Science Conception Optimization and Production, Grenoble Institute of Technology

Abstract
This paper purposes concept of cluster manufacturing management in order to improve equipment efficiency and productivity for SMEs. The cluster group performs manufacturing tasks as collaborative engineering in the design phase. They share the process of designing information of product using CAD/CAPP/CAE and PDM. ERP (Enterprise Resource Planning) system management is implemented to manage the cluster company group with the same platform which would be established inside companies. Instead of working separately, those companies would share facilities to produce standard parts. Consequently, the lead time and cost of production are reduced; the quality standard is more consistent. Each company's ERP is linked to SCM in order to control the delivery of components to assembly parts of final production stage of the selected company which is considered the most capable and appropriate. The transportation cost is optimized at this stage. The productivity of equipment efficiency is increased clearly in this model.

Keywords:
Cluster Management, Overall Efficiency Equipment, Collaborative System

1 INTRODUCTION

Presently, business management requires new concept and model which are driven by technology in order to survive in today's highly competitive environment. In response to increasing customer demand and dynamic competition, companies are under high pressure to shorten time to market by providing tailored products to the customer for the economy of scope, to reduce time via mass production for the economy of scale, and to decrease time to profit by increasing efficiency of the entire lifecycle for the economy of service. The technology needs are included; the speed up product development, the enhancement of manufacturing and the capacity of supply; the improvement revenue from lifecycle efficiency [1]. The manufacturing productivity indicators are determined as the performance of enterprise competitiveness. They are divided into two stages: the undesirable stage and desirable stage. The undesirable stage consists of the inventory, quality cost, time to market according to schedule and unscheduled changes, whereas the desirable stage contains maximized overall productivity, quality, profitability and customer requirement. Overall productivity is the cumulative gain or loss. A higher level of productivity in one specific department or discipline is not a good measurement. Productivity means creating concepts that positively impact the whole system – both the upstream and the downstream operations. The overall productivity is defined as the ratio of the throughput to the operating expense. The throughput is defined as useful outputs so that the productivity entails the effective measure of how input (people, materials, means, etc.) are utilized in a certain period (measured in terms of operating expenses), in order to realize useful outputs [2]. The throughput is defined as follows:

$$T = \sum_{i=1}^{No} [P_i * N_i * P_{vi}] \quad (1)$$

The equation 1 represents the *Pi* as the proportion of acceptance outputs which are non-defective of variant *i*; the *Ni* as the total number of outputs produced of variant *i*; *Pvi* as the production (or throughput) value per acceptable output *i*; the *No* as the number of outputs or assembly variants.

In this study, the concept of company cluster, which means several companies are grouped together in order to share the process of designing information by using the digital tools, is grouped together. The ultimate target goal is to improve equipment efficiency and productivity. In addition, the cluster manufacturing model enhances the competitiveness. The cluster can serve big quantities of customer orders. They can control the product process to make the quality of product consistently. The digital tool consists of CAD/CAPP/CAE and PDM for the design stage where the cluster can share the product model, drawings, product structure and process planning. ERP is established in the same platform and used in such cluster. The supply chain management concept is employed to serve the effective transportation among the manufacturers and supplier inside the cluster.

2 RELATED PREVIOUS WORKS

Nylund et al [3] presented the concept of an adaptive and autonomous manufacturing system which is based on the principles of Holonic Manufacturing System (HMSs), fraction factory and service oriented architecture (SOA). The authors presented the FMS 2010 project framework which was based on manufacturing knowledge and skills that are used in every design and development case. The adaptive manufacturing system was based on the HMS which consists of six components. They are knowledge base, digital presentation, autonomous units, co-operative units, service oriented and self similarity. Jana et al [3] stated that OEE – overall equipment effectiveness is one of the critical measurement indicators of the TPM strategy that the main principle lies in maximizing the saleable output from equipments by enhancing productivity in the three areas – availability, performance and quality. OEE strives to focus in the areas of machine efficiency, operator performance and quality of products. The shop floor of a government tool organization was determined by the OEE criteria. After six months later, the productivity improvement increased from a meager 23%-56%. Silva and Houten [5] expressed that the advanced manufacturing business of concurrent engineering system is often complemented by a parallel team organization, which brings various functions together from the very beginning of product development. At the same time, there is a shift from a producer's market to a consumer's market. This means the increasing in the demand for a higher product variety. The introduction of such product variety increases two basic categories of costs: production costs and market mediation costs. Consequently, companies must carry out the paradoxical task of providing exclusive products at low cost, high quality, and at short delivery times. An advanced logistics management strategy must be determined together with a product's functional specifications to achieve an optimal life cycle performance. Jacobsen [6] stated that design of production system is a challenging activity. This paper presented MERIP model that means Human Resources in Production translating from the Danish language. Humans have an inborn curiosity, creativity and propensity to create a meaning in what they are doing, which are the basis for creating motivation. Humans have a dignity, which also should be considered. The human resources are involved in new ways in order to establish new competitive production system. The MERIP showed the production system consists of four equal valued building blocks, technology, human resources, information and organization. Gilad et al [7] presented a model partitioning and clustering algorithm (MPCA) which determines similarity between two models and assign to parallel assembly lines. According to their similarity, Lehman's algorithm deals with optimization for balancing mixed model assembly lines. Spath et al [8] presented that the globalization of markets has caused companies to become part of spatially distributed dynamic supply networks, in which, next to the fundamental production process, system and business overlapping cooperation of the processes has increased in importance. This paper created the organization and resource model with organization units and allocated resources. The model is divided into four levels: enterprise, plant, manufacturing and resource group. Therefore, the available resources are taken into account involving through customers and suppliers using the concept of supply chain management. In additions, the Enterprise Resources Planning – ERP systems are introduced to associate the company. However, they have not designed to simulate the company overlapping supply chains. They perform on fixed capacity quantities and production times as basis. The supply network simulation requires event orientation that considers production processes and stock keeping processes as well as transportation. The major objective is to optimize the task execution with reference to the time to market and target costs. The available resources and their organizational structures are mapped into an organization model in order to check whether the necessary resources for the appropriate time are available or engaged to other parallel activities. Consequently, the structure of business processes as well as the allocation of the resources can be clearly presented through the internal and intermediate organizational structure across collaborative companies. Zancul [9] stated that the ERPs are enterprise management systems whose main features include a wide scope of functionalities, capacity of adjustment to several kinds of enterprises and data integration. These systems are basically made up of modules and a central database. The modules have all the functionalities to support the enterprise, such as marketing, sales, purchase, production, human resources management, as well as management of physical and financial resources. Data employed by each module is stored in the central database in order to be handled by other modules, ensuring the integration among the business processes. The broadened scope of ERP, with the inclusion of new functionalities is product life cycle management (PLM). The main functionalities of ERP consist of project management, product data management (PDM), and computer-aided process planning (CAPP). Nyhuis [10] presented the process model for factory planning which contains a description of factory planning processes with the focus on the process and facility planning. It serves the extended demands in factory planning by defining interfaces to other planning departments. Murgu [11] expressed efficient management of the information flows that is critical for the efficiency of the whole system. High productivity in all operations conducted within manufacturing companies is needed in order to be a core player on the competitive market today and tomorrow. Basic tools and methods associated with lean production on the shop floor have been around since the beginning of the 80's and they are now mature, available and widely used. Ming et al [12] presented that in the modern global economy, companies are facing ever-increasing challenges for short time to market to enter into the market early, for reduced time to volume to occupy the market quickly, and for decreased time to profit to get return from market shortly. Product life cycle management –PLM is recognized as one of the key leading technologies to facilitate companies to overcome the challenges, which will offer companies a new way to rapidly plan, organize, manage, measure, and deliver new products and services much faster, better and cheaper in an integrated way. PLM has recently been recognized as a new strategic business approach in support of collaborative creation, management, dissemination, and use of product assets, including data, information, knowledge, etc., across extended enterprise from concept to end of life – integrating people, processes, and technology. Stefanovic [13] purposed the possibility of establishing relationships between processes in supply networks and functioning of the entire system. In this model, the integrated system, all relevant factors for supply network management, both at the global level and at the single process level are observed. The concept is to form up process library of supply network, which would contain process description, input, output, and the way the process is realized. Supply chain management in today's fast changing business environment is facing many challenges. Hilmes [15] studies the presentation of a specification supporting the production development under concurrent development to improve competitiveness. Lu [16] stated that the collaborative is characterized by more durable and pervasive relationships. The group works together toward a common goal which the team attempts to find solutions satisfying to all involvements. Figure 1 shows the revolution and comparison of the design engineering: (a) sequential engineering, (b) concurrent engineering and (c) collaborative engineering. The sequential one takes more time to finish the production, whereas the concurrent one take more advantages by using the overlapping process. However, the concurrent engineering is still lack of the cooperation. Therefore, the collaborative engineering takes the most advantages because it is overlapping method and cooperation. It can mean the integrated design.

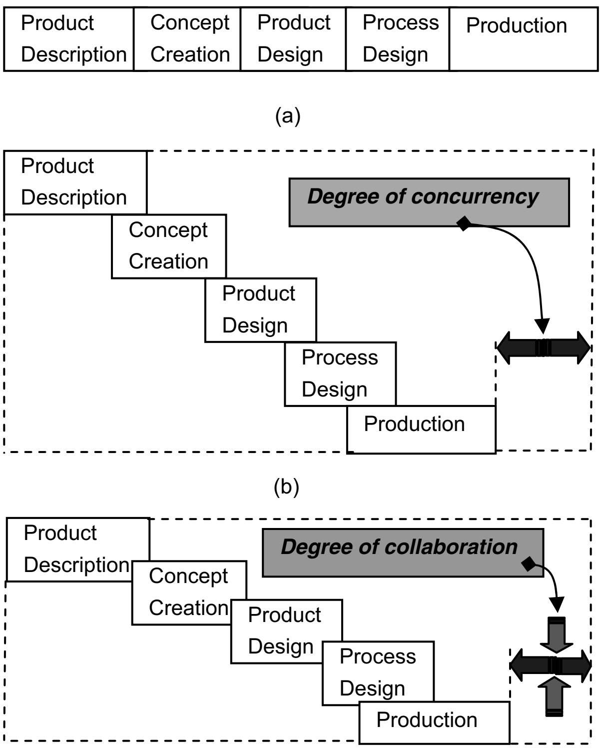

Figure 1 Revolution of Design Engineering Process [15]

3 CLUSTER MANUFACTURING MODEL

In this study, the five companies where they work together in the same area are collaborative as a manufacturing cluster. Four of them are bus body makers and the fifth is a supplier. This research objective is to integrate them in order to optimize and utilize the facilities. Figure 2 shows cycle of the company cluster that is managed as collaborative manufacturing system in order to improve productivity of the whole group cluster. It shows the link of FAC_1, FAC_2, FAC_3 until FAC_N. The system components consist of CAD – Computer Aided Design, CAPP – Computer Aided Process Planning, PDM – Product Data Management, ERP – Enterprise Resource Planning, SCM – Supply Chain Management and LCM – Life Cycle Management. The concept is linked as PLM – Product Life Cycle Management. The cluster shares the design of product via the product data management. The product data are shared and the job design works are distributed to each company of the group cluster. ERP system is used to manage the manufacturing activities. However, the ERP is applied for individual company. The SCM is managed by a company in the cluster. Raw materials, spare parts and other accessories for producing products are economically and effectively supplied. In cluster group of companies, it can be several factories.

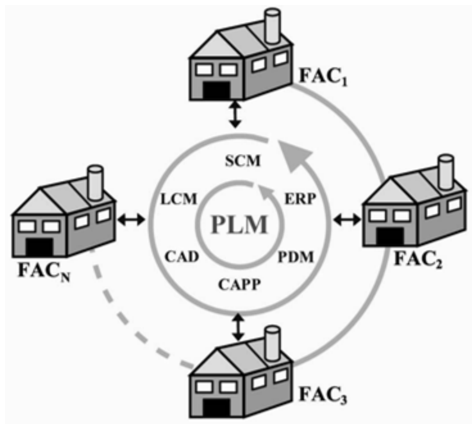

Figure 2. The Cycle of Collaborative Factory Cluster System Management

The relation of collaborative design occurs in the stage of design. The new product model is created on CAD. Then the process is designed based on the standard production route. CAPP is used in this step. The model is exported to the CAPP in STEP – Standard for the Exchange of Product Model Data. BOMs – Bill Of Materials are generated. Machine, equipments and tools are selected based on each process. The PDM linking the product model on CAD to ERP is used to manage the factory shop floor. The purchase orders are received from customers, which will be planned for production process both master plan and daily plan. Production time and cost are estimated. Finally, the finished products deliver to customers. The next section presents the case study of cluster manufacturing management.

4 CASE STUDY

The case study presents the process of the group of bus body manufacturing in Thailand where they join together under the concept of collaborative cluster manufacturing model. This project is supported by the Thai Government through the IMSRC consulting organization. There are more than 30 companies establishing since the last 20 years in the same areas. Five companies are selected and controlled as the pilot cluster. One of them is a supplier enterprise and the other four are bus body manufacturing companies. Currently, the pilot cluster is creating the sharing a large quantity order by sharing facilities and time. Collaborative system has been established based on working group. The six wheel bus is set as the pilot project. The quantity order is 500 buses that are over capacity for one company. Each designer of each company is shared in the design phase. The BOM data is then shared for each individual company in order to autonomous control their factory. However, the production plans are controlled by the cluster collaborators. Figure 4 shows the sample digital mockup bus body design. Collaborative engineering group cluster are linked and shared CAD design.

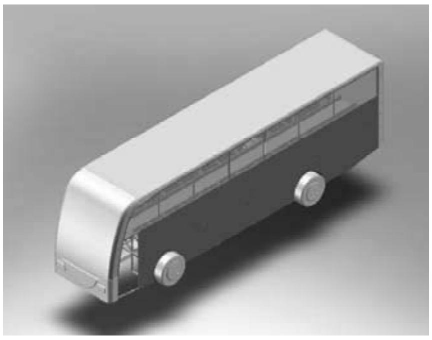

Figure 3. The Pilot Digital Mockup Bus Design

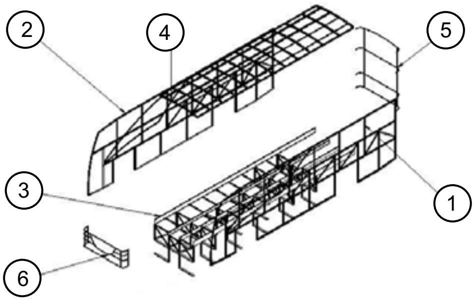

Figure 4. The Bus Body Frame Parts

The bus structure consists of eight main components. They are chassis, bus body frame including left side, right side, front side and back side, mirror, seat, interior parts, electrical control system, sound system and outside coating. All components are assembled as shown in Figure 4. They contain six parts. Each part is explored as the sub-components. In this step the planning process is created as the standard process that is then distributed to the cluster member and managed by ERP. It is composed of eleven modules: customer, supplier, design, marketing and sales, accounting, purchasing, production planning, inventory, manufacturing, quality control and maintenance.

5 SUMMARY

The concept of cluster manufacturing management has been presented. The related previous works are reviewed that some of the idea are adapted. The concept of collaborative design has been successfully implemented together with ERP program that is used to manage the factory which is controlled by the cluster collaborator. SCM, LCM and PLM concept are applied to be the effective cycle method of the manufacturing system management. This concept is clearly shown for the equipment efficiency and productivity improvement.

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