The Development of Computer Integrated Manufacturing (CIM) System for Corrugated Box Manufacturers

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Abstract

Computer Integrated Manufacturing (CIM) is a solution to the international competition and increasing labour cost, as it takes a systematic approach to utilize the resources and addresses coordination among the various departments. CIMS-PACK, a CIM software system for the corrugated box manufacturers, has been developed, and successfully implemented on one manufacturer's site, the first of this kind in this region. This paper analyses the characteristics of corrugated box manufacturers, describes the distinguished features of CIMS-PACK, and briefly the implementation project.

Keywords

CIM, corrugated box, continuous process, discrete process, IDEF, lead time, scheduling, integration, database

1. Introduction

Computer Integrated Manufacturing (CIM) has gained more and more attention because of the commercial incentives, advancement in automation, and development in information technology. CIM takes a systematic approach to utilise the resources and technologies, addresses coordination among the various departments.

The system described in this paper is specially designed and developed for the Corrugated Box Manufacturers. It provides a cost-effective, one-stop solution to medium-size manufacturing companies in the region. Furthermore, various software modules can be adapted to suit particular requirements in either large or small size manufacturing companies. The system has been successfully implemented in one Corrugated Box Manufacturing company, and this papers describes the system functions and the implementation process.

2. Characteristics of the corrugated box manufacturing industry

The primary objective of the corrugated box manufacturing industry is to delivery all orders on time at the lowest practical cost. However, the industry in this region is unique from many other industries, as described below:

(1). ***Mixture of continuous and discrete types of manufacture***: The production consists of a corrugating process which transforms plain papers into corrugated boards; and a converting process which converts the corrugated boards into specifically designed boxes. The former is a continuous process which requires combining orders and sequencing jobs in order to minimize setup time and paper roll exchange. The latter is discrete in nature, which is in favour of the 'make-to-order' approach to minimize work-in-process and maximize throughput. This has led to a conflict in meeting production objectives[1].

(2). ***Material flow pattern:*** Unlike electronic or engineering industries, a corrugated box manufacturer tends to have a few types of input materials (e.g. paper rolls) but produce many different types of boxes. Despite that there are various types of boxes, the structure of each product is quite simple. This makes it easy to plan the material requirement.

(3). ***Short lead time:*** A lead time for corrugated boxes is very short, typically two to three days, as most of the box customers demand Just-in-time delivery. This allows very little time for a production manager or planner to fine-tune anything except the most predominant and far-reaching elements of the production process. Major problems occur when a customer wants JIT delivery but has no schedule for the manufacturer to follow. The short lead time together with rush orders has caused a real problem in managing the combination of orders, scheduling, production and delivery. Opportunities for conflict are great. For instance, sales/services may accept everything a customer requests; it is up to production to carry out these demands. Consequently there would be late deliveries and low production efficiency.

3. Current Situations of Corrugated Box Manufacturers

In the packaging industry in this region, the existing production management is not efficient. The present management method often leads to an inefficient production. According to our informal survey, average machine utilization in the paper packaging industry is only around 40% and the material wastage is considerably higher than their counterpart in the developed countries.

To meet the challenge of international competition, computer integrated manufacturing is a solution. However, for many of the corrugated manufacturers in this region, CIM seems a dream distant away, because of the following reasons:

(1). ***Lack of cost-effective solution***: Although there are various computer systems commercially available, nearly all of them have been developed by vendors in industrialized countries. They tend to be over-sophisticated for many medium-sized companies, and yet may not be able to solve some peculiar problems faced by those companies as discussed above. For example, the time-consuming Material Requirement Planning (MRP)[2] bring s little benefit to support the paper roll purchasing decisions.

(2). ***Lack of in-house resource and expertise***: Apart from effectiveness, most of CIM related products tend to be expensive. Moreover, they require a large amount of customization effort. Unfortunately, this has made many medium-sized companies regard CIM as 'something nice to have but not cost-effective at the moment'.

It is against the background that the development of a computer integrated manufacturing system for the medium-sized companies characterized by mixture of continuous and discrete processes and a high variety of orders with short delivery time commenced in 1993. Today the CIM software system for corrugated box manufactures in this region have been developed (the software system is named as CIMS-PACK), and it has been successfully implemented on one manufacturer's site, the first of this kind in this region.

4. Functions of the CIMS-PACK system

The first phase of the development involved a detailed study of the requirements and constraints for a Computer Integrated Manufacturing (CIM) system in corrugated box manufacturers in this region.

The Information Definition (IDEF)-based modelling technique was adopted to carry out the detailed study. The study has shown that what the industry concerns most is how to improve production performance through **effective planning together with integrated information flow**. In particular, the sales staff can predict the production capacity accurately in order to quote for customers; the planning staff will be able to issue schedules to minimise paper roller exchange, paint change, machine setting; the management can monitor production status, track inventory; and so on.

To meet the requirements, the CIMS-PACK was designed with a number of functional modules including the following:

1) Sales management
2) Production planning and control
3) Storage management
4) Delivery management
5) Data exchange box (linking to CAD)

The innovative part of the CIM-PACK system is to identify technology most relevant to the corrugated box manufactures in this region; to advance those concepts into problem-solving algorithms; and finally to develop computer-aided solutions which are cost-effective for the companies. Some of the advanced techniques are:

(1). ***Intelligent Purchasing Algorithms*** (in the Storage Management module): To cater for the diversity of material consumption patterns. The simulation technique is employed to choose the forecasting technique which fits the present situation best from a forecast technique library. In the library, the commonly used forecasting techniques (e.g. moving average, exponential smoothing, seasonal variation), accuracy measurements (e.g. Root Mean Square Error, Mean Absolute Percent Error), and inventory control algorithms have been developed. By adopting the scientific approach to forecast the material usage as devised in the software, a company will be able to reduce inventory cost, ease cash flow, and reduce raw material wastage thus enabling quicker response to the market demand.

(2). ***Dynamic Planning Board*** (in the Production Planning and Control module): Dynamic Planning Board assists activity scheduling on shopfloor. Computers available in the planning office of most companies merely play the role of a database and/or printer. The activity scheduling such as order loading sequence, job list for work stations, is usually done manually. They are either listed on paper by experienced planners and then keyed into the computer for printing, or randomly decided by shopfloor supervisors. The dynamic planning board provides an environment for planner to create and edit schedule dynamically and intuitively. The impact of every change will be automatically calculated. A good activity schedule will help reduce work-in-process, shorten lead time, increase equipment utilization, and have consistently higher product quality and lower reject rate.

(3). ***Rough-cut Planner*** (in the Sales Management module): The Dynamic Planning Board has also been extended to assist capacity planning. This provides the management with a clear picture of the customer requirement vs. production capacity in the forthcoming period. The communication between various departments created by the rough-cut plan enables Salesman to provide more accurate quotation to customers, Production planner to smooth workload and Delivery staff to have better goods delivery performance.

(4). ***Data Exchange Box***: The Data Exchange Box bridges the gap of different data requirement by various functional modules as stated above. Presently different departments in a manufacturing company exchange information by paper forms and then key into computer separately and repetitively. A data exchange box provides quicker and more accurate information flow thus enabling timely identification of problems, and better customer service. It is based on MAP (Manufacturing Automation Protocol) concept, particularly MMS (Manufacturing Message Service), which provides common data exchange format for manufacturing applications.

5. Distinguished Features of the CIMS-PACK system

From industrial users viewpoint, CIMS-PACK is characterised by the following features:

(1). ***Tailored to the local industrial needs:***. As CIMS-PACK is specially developed for the company after a detailed study, it "fits" the companies where the production environment is characterised by the mixture of continuous and discrete types of manufacture, high volume, short lead time, and relatively standardised product. It emphasizes on the forecasting on material requirement, the combination of orders to minimise machine setup for the continuous process, prompt information retrieval on the "make-to-order" discrete process, graphical monitoring on store management, and delivery scheduling. The system is very suitable for companies in this region.

(2). ***Intelligent planning and scheduling***: The core function in the production management of the corrugated box industry is that of planning and scheduling. While orders need to be combined for minimising paper roll exchange, machine setup, all the orders must be scheduled in such a way that none of them would be late for delivery. Because of this unique characteristics of the corrugated box industry, conventional production planning methods such as MRP have been proved to be ineffective. The developed planning and scheduling system makes use of *computer simulation* for modelling the behaviour of the

production process and derives the control decision based on the heuristics developed in the *knowledge base*.

(3). ***Cost-effective*:** CIMS-PACK is implemented on personal computers linked by local area network as the hardware platform and make full use of graphics and powerful software development tools on personal computers. In this way the solution provided by the system are affordable by medium-size companies.

(4). ***Interactive user interface***: CIMS-PACK adopted the object-oriented modelling approach and a window-based interactive environment. Therefore it is easy-to-learn and easy-to-operate. In particular, the store management module allows detailed information of each storage location being monitored, the first of its kind in this region.

6. From the Concept to a Real CIM system

The development of the CIMS-PACK system commenced in 1993. Today a software system has been developed for corrugated box manufactures in this region. Throughout the system development, it has been successfully implemented on one corrugated box manufacturer's site. For the system implementation, a two-level approach was adopted:

6.1. Top-down System Design

The system analysis and design is to address two issues: i). Formalizing the functional structure of the computer integrated manufacturing system, on the basis of which the computer system can be developed; ii). Establishing operational policies and procedures in order to introduce disciplined and coordinated production environment, which is key to success of the computer integrated production management system.

To meet this requirement, the project has adopted IDEF0-based modelling approach, which was initially developed by the US Air Forces's ICAM programme in the early 1980's and has been widely used as both a descriptive and an analytical tool for manufacturing industry[3]. The modelling approach has been used for

(1). ***Analysis of Existing Operations*:** The existing operation and modelling major functions and information flows are analysed.

(2). ***Proposal of CIM System*:** The functional structure and detailed modules of the computer integrated manufacturing system are proposed, which constitutes the foundation for the computer system.

(3). ***Identification of Improvement*:** The areas for improvement are identified, each of which is associated with recommended operational policies and procedures.

6.2. Bottom-up System Implementation

The complete design provides a basis for the company to manage towards the computer integrated production management system. In this stage, the design needs to be expanded

into an action plan and schedule for a series of coordinated, discrete acquisitions and implementations chosen on a basis of most effective use of company resource.

The company has installed CIMS-PACK system in PC network environment. The network includes two severs and nearly thirty personnal computers. The information flows start with potential customer visits, conceptual product and process design, costing and pricing, quotation, detail product and process design, order entry, release order to production planning, production scheduling, goods receiving and storage, schedule lorry for delivery, picking goods from store, lorry departure and return, confirm customer accepted quantity and invoicing. All the information are fully integrated with help of CIMS-PACK software and the data entry has been minimized. At any time, the customer, product and order status can be traced from the screen.

7. Conclusions

CIM takes a systematic approach to utilize the resources and addresses coordination among the various departments. There is no generic CIM system to all types of industries. CIMS-PACK, is an attempt to provide advanced solutions to the Corrugated Box Manufacturers at a cost-effective way. CIMS-PACK is aimed at providing computer aided solutions to medium sized companies for improving their production planning and control in order to achieve a Computer Integrated Manufacturing environment.

CIMS-PACK consists of a number of functional modules such as Sales management, Production planning and control, Storage management, Delivery management and Data exchange box, each of which addresses a specific function in the Computer Integrated Manufacturing system.

The implementation of CIMS-PACK on one manufacturer's site has successfully achieved the efficient production management. The benefits include:

- Reduce production lead time;
- Reduce raw material wastage;
- Have great production flexibility;
- Increase equipment utilization;
- Have consistently higher product quality and lower reject rate.

8. References

[1] Kopelson, K.B., 1990. "A Computerized Plant Scheduling System". In *Proceedings of the 1990 TAPPI Conference*. USA.

[2] Orlicky. 1987. "Orlicky's Material Requirement Plannning - 2nd ed". The Oliver Wight Companies.

[3] Wang, M. and G. Smith. 1988. "Modelling CIM systems - Part I: methodologies". In *Computer Integrated Manufacturing Systems, Vol. 1, No. 1*