Process and Quality Model for the Production Planning and Control Systems

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ABSTRACT

Over the last decades, many industrial sectors have been experiencing profound changes involving both the business environment and the internal organisation. This process has been so deep and radical as to suggest that a new operations management paradigm has emerged. In this new competitive and turbulent environment, effective production planning and control systems have become extremely important to drive improvement efforts. We consider production planning models from a different perspective, assuming that both production and quality are decision variables. Within this class of models, we consider various degrees of process on the part of the producer including the quality, process technology and control system to determine the acceptance or rejection of how the system is designed, implemented, run, improved and measured the quality of the outputs. Our intent is to provide an overview of applicable process and quality model; we present briefly how the quality is identified, designed, implemented, run, improved and measured in terms of the appropriate quantity, the appropriate time, the appropriate level of quantity. Especially, our purpose of the PP&C is to ensure that manufacturing run effectively and efficiently and produces products as required by customers.

In this article we focus on process and quality model for the production planning and control systems. We also have organized the article into two major sections. In the first section we present a framework for the process technology and system. In the second section we discuss control system and quality models for production planning.

I. INTRODUCTION

Over the last decades, many industrial sectors have been experiencing profound changes involving both the business environment and the internal organisation. Especially, today's changing industry dynamics have influenced the design, operation and objectives of production planning and control systems since CAD, CAM and CIM systems used in industry. These systems affected the production planning and control systems by increasing emphasis on: integrated information technology and process flows, flexibility of product customization to meet customer needs improved quality of products and services, reduced costs, planned and managed movement, and reduced cycle time, improved customer service levels(Bardi, E. J., Coyle, J. J., and Langley, Jr., C. J. 1996).

On the other hand, typical decisions include work force level, production planning and control, assignment of overtime and sequencing of production runs. Process models are widely applicable for providing decision support in this context.

In this article we focus on process and quality model for the production planning and control systems. We also have organized the article into two major sections. In the first section we present a framework for the process technology and system. In the second section we discuss control system and quality models for production planning. Our purpose of the PP&C are to ensure that manufacturing run effectively and efficiently and produces products as required by customers. We do not cover detailed scheduling or sequencing models (e. g., Graves, 1981), nor do we address production planning for continuous processes (e. g., Shapiro, 1993). We consider only various degrees of process on the part of the producer including the quality, process technology and control system to determine the acceptance or rejection of how the system is designed, implemented, run, improved and measured the quality of the outputs. And do not include continuous-time models such as developed by Hackman and Leachman (1989).

Our intent is to provide an overview of applicable process models; we present briefly How the quality is identified, designed, implemented, run, improved and measured in terms of the appropriate quantity, the appropriate time, the appropriate level of quantity. The process and quality model (PAQM), production planning & control and competitive advantage, effective PP&C and steps in setting up an effective PP&C system (Bardi, E. J., Coyle, J. J., and Langley, Jr., C. J. (1996),)

Production Planning and Control

"Production Planning and Control technology combine the physical and information flows to manage the production system. As with any complex entity, PP&C has several distinct elements. In figure 1 we superimpose these elements on the physical flow of a production system. We position these elements at different places along the physical flow route. Interaction between the elements is not shown. The PP&C function integrates material flow using the information system. Integration is achieved through a common data base. Interaction with the external environment is accomplished by forecasting and purchasing. Forecasting customer demand starts the production planning and control activity. Purchasing connects the production system with input provided by the external suppliers. Extending production planning and control to suppliers and customers is known as supply chain management

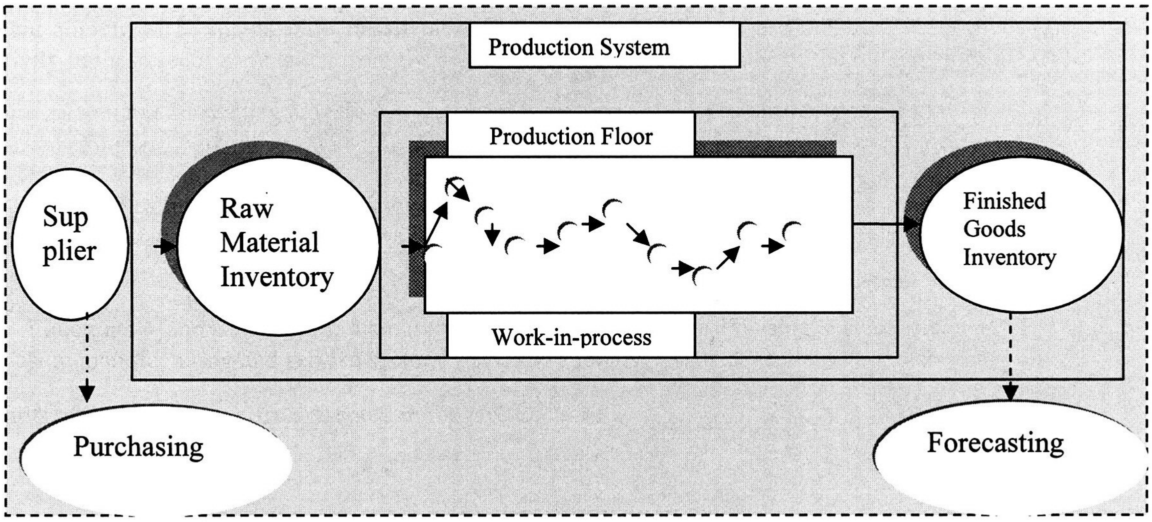

Figure : 1 Elements of Production Planning And Control

Long-rangc capacity planning
Production planning
Short-range requirements (material capacity)
Scheduling

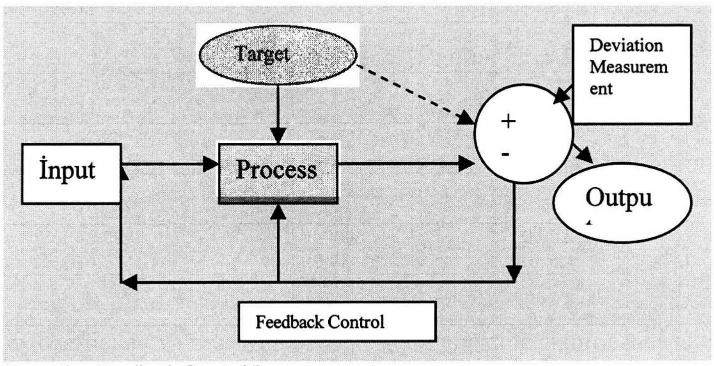

Figure 2 Feedback Control Loop

Some elements are associated with the production floor itself. Long-range capacity planning guarantees that future capacity will be adequate to meet future demand, and it may include equipment, people, and even material. This decision is aided by a technique known as aggregate planning. Production planning transforms the demand forecast into a master production plan, which considers overall availability of capacity and material. Detailed planning generates short-range requirements for material and capacity and performs short-term production scheduling. Additionally, inventory management maintains and controls raw material, work in process, and finished goods. Cost estimation and control and quality follow-up involve all parts of the production system. Many of these elements relate to activities performed by other functions, e.g., the purchasing department or the production function. PPC does exactly what the name implies: planning and control of production. To understand how we do this, we use a feedback loop (Sipper. D, Lrobert Bulfin, 1997,) (Figure: 2).

2. BACKGROUND FOR THE RESEARCH

Much of the research in process quality measurement and production planning and control has explored the question of how to assess the performance of individual supply chain functions. In 1978 and 1984, A.T. Kearney, Inc. established four stages of organizational sophistication in performance measurement of physical distribution activities. More specifically, this study established the following four stage classification scheme(Novich, N. S. 1992):

(1). Stage I organizations: inactive; use simple measures (e.g., total cost) to assess system performance.
(2). Stage II organizations: reactive; use measures of productivity to measure performance.
(3). Stage III organizations: proactive; have meaningful goals; most use engineered standards to measure performance.
(4). Stage IV organizations: exhibit completely integrated information, production, storage, transportation, and distribution systems, allowing for seamless communication across all supply chain functions.

This work established a basis for subsequent work in the performance of supply chain functions. Konrad & Mentzer (1991) propose that the evaluation of supply chain functions be divided into three areas: productivity, utilization, and performance.

Miller and Read (1991) examine the state of quality in supply chain systems. The results of a survey of 225 international businesses showed that only 40% of all companies have a satisfactory supply chain quality program in place. The authors conclude that the greatest stumbling block to quality programs in supply chain systems is in determining what to measure and then developing appropriate information systems to support this measurement.

DeToro and Tenner (1997) provide a step-by-step approach to process improvement. Their model is based on the principles established by Crosby, Deming, Juran and Feigenbaum. The steps involved in their continuous improvement process are:

1. *Understand the customer.* Understand the requirements of the end customer and assess the organization's ability to meet these requirements.
2. *Assess efficiency.* Gather data on internal process measures and determine whether the process is meeting such demands as cost, cycle time or variability.
3. *Analyze the process.* Determine the efficiency and effectiveness of the process. at this step, the appropriate improvement path must be identified: continuous improvement, benchmarking, or reengineering. If continuous improvement is the appropriate path then step four is performed.
4. *Improve the process.* Plan-Do-Study-Act is used as an approach to improve the process.
5. *Implement changes.* Make necessary adjustments.
6. *Standardize and monitor.* Track performance, monitor process and continually improve.

The majority of previous research provides insight into measuring supply chain systems. Research in supply chain process quality, however, has been very limited. The objective of this research is to bridge the gap between supply chain systems analysis and quality control by developing a Process Quality Model (PQM) for the assessment, improvement and control of quality in supply chain systems.

Problem Description

Process and quality have important factors in production planning and control. Every stage which will be in the stage, have to be planned carefully step by step along the production planning and control process Much of the research in the measurement of production and planning processes has focused on the development and application of productivity, utilization, efficiency, and/or effectiveness equations. However, a model that provides a procedural approach to assessing, improving, and controlling the quality of the supply chain process has not been found in the literature. This research develops a Process and Quality Model (PQAM) that can be used to assess the performance of a supply chain system and its sub-systems, assist in identifying problem areas, and provide a framework for continuous improvement of supply chain systems. In particular, PQAM addresses the following questions:

1. What aspects of quality should be measured?
2. How should these aspects of quality be measured?
3. How can these measures be used to evaluate, improve and control the overall quality of the supply chain system?

Manufacturing in any company has at its disposal various resources. The nature and the constraints of these resources are determined by some strategic decisions. The day to day running of manufacturing rests with Production Planning and Control (PP&C). The purpose of PP&C is to ensure that manufacturing run effectively and efficiently and produces products as required by customers. Manufacturing should organise its resources so that they are available:

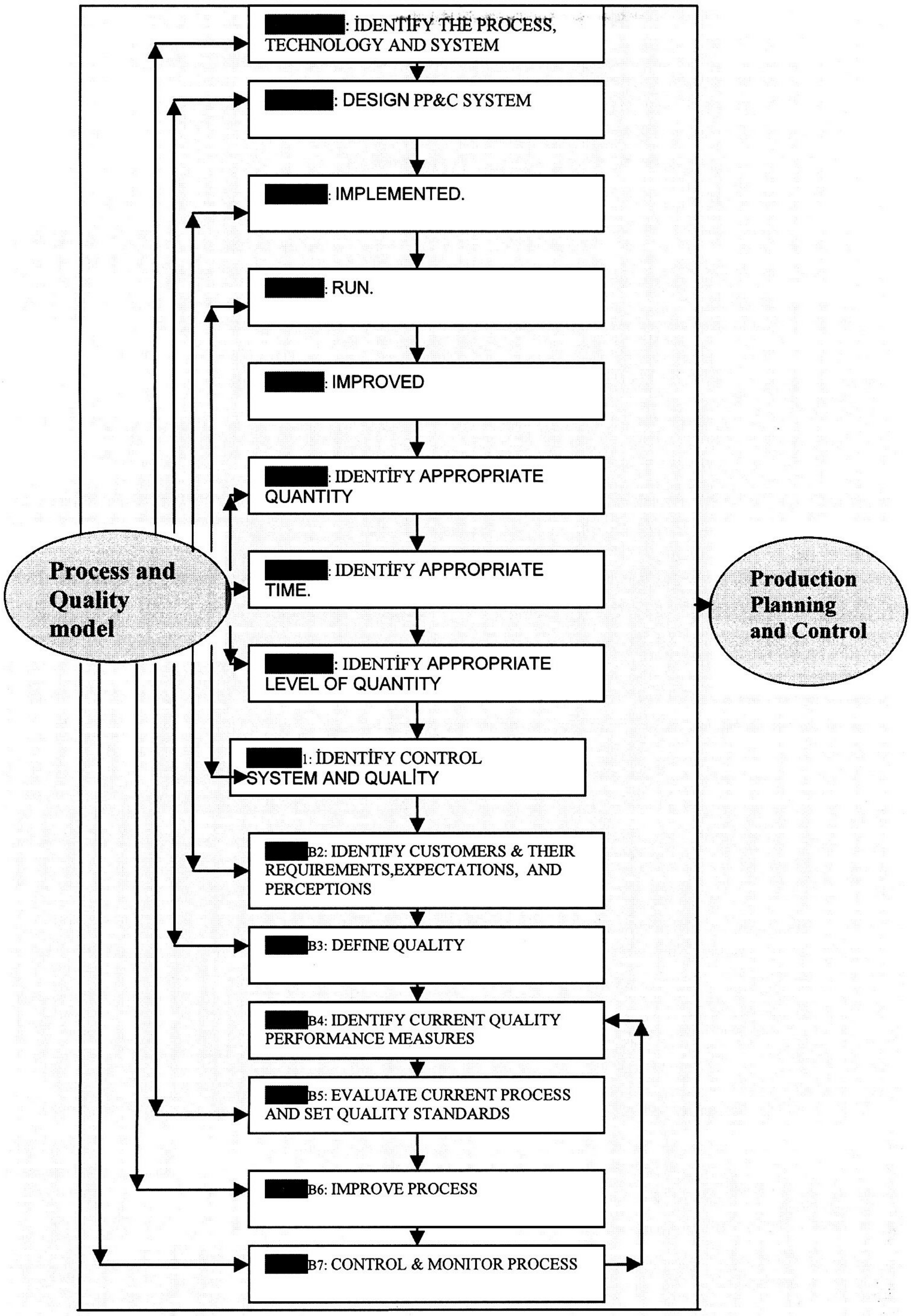

Figure 3. Process And Quality Model (PAQM)

1. In the appropriate quantity
2. At the appropriate time and
3. At the appropriate level of quantity

To do this manufacturing operations need to consider two elements:

The first one is the resources available to the operations such as labour, machines, material, etc. The second is the general and specific demands from the actual and potential customers. PP&C provide the systems, procedures and decisions to bring these two elements together and thus reconcile Demand and Supply. All manufacturing operations require planning and controlling, although the formality and detail may vary. Some operations are more difficult to plan than others. Those with high unpredictability can be difficult to plan. Some are more difficult to control than others. There are principles and techniques available to help production managers plan and control their operations. Some of these, such as MRP or MRPII and JIT have been developed into extensive concepts. In the case of MRP and MRPII the concept has developed from a tool that focused on manufacturing operations and helped in planning and controlling materials requirements to become a tool that applies to the whole scope of business which controls all business resource requirements. JIT has also developed from a method of planning and control to a Management philosophy.

3. THE PROCESS AND QUALITY MODEL (PAQM)

The basic framework of the PAQM is given above in Figure 3. The PAQM consists of fifteen integrated modules. The details and procedural steps associated with each module follow. The purpose of Module 1 is to define the process, technology and system and all required activities.

The first module A1 in the PAQM is to define the current system and all activities that are currently being performed. There are a number of graphical tools that are useful in determining the tasks performed in the process technology and system, such as flowcharts, flow process charts, Gantt charts, and relations diagrams(Straker, 1995). These stages may include inbound and outbound transport, warehousing, production planning/inventory control and customer service.

The purpose of Module A2 is to design PP&C System.
The purpose of Module A3 is to implemented the process, technology and system.
The purpose of Module A4 is to run the production planning and control systems.
The purpose of Module A5 is to improve the process, production planning and control systems.
The purpose of Module A6 is to identify appropriate quantity along the process in production.
The purpose of Module A7 is to identify appropriate time in the process, production planning and control systems.
The purpose of Module A8 is to identify appropriate level of quantity in the production line and control systems.

On the other hand, the purpose of Module B1 is to control system and quality along the production planning and control process.

The purpose of Module B2 is to identify customer requirements, expectations, and perceptions in order to continuously improve customer service performance. Module B2 of PAQM is to identify the external and internal customers and their requirements, expectations, and perceptions. The external customer(s) are the consumer(s) of the end product. The internal customer(s) are the department(s) that require goods/services from another department within the organizational boundaries.

The purpose of Module B3 is to establish and refine the definition of quality in the production planning and control system.

There are numerous definitions of quality. For example, W. Edwards Deming defines quality as a product or service "...[that] helps somebody and enjoys a good and sustainable market" (Deming, W. E., 1993),. Joseph Juran coined the phrase "fitness for use by the customer" as a definition of quality Juran, J. M. and Gyrna, F. M. (1980). Philip B. Crosby bases his approach to quality on four absolutes: (1) "Quality is conformance to requirements", (2) "Quality is caused by prevention", (3) "The performance standard is no defects", and (4) "The measure of quality is the price of nonconformance" (Crosby, P. B., 1980),. Feigenbaum defines quality as "the total composite product and service characteristics of marketing, engineering, manufacture and maintenance through which the product and service in use will meet the expectations of the customer" (Feigenbaum, A.V., 1991). Each definition maintains at its core that quality is defined by the customer. Therefore, each organization should create a quality definition based on the requirements of its customer. The definition should be a reflection of the types of tasks involved and the requirements and expectations of the customers. When developing a system definition of quality, the following questions must be answered:

(1). What are the goals of the process and quality model in the production planning and control systems? [Objectives]
(2). What are the internal and external customer requirements/expectations from the process and quality model in the production planning and control systems? [Customer requirements]
(3). What are our competitors definition of quality? [Benchmarking]

These questions should be used to formulate objectives for the tasks and processes involved (Berger, R. W. and Pyzdek, T. (1992). The goals of the supply chain process should be consistent with and supportive of organizational goals. If the current process and quality model have a definition of quality that does not reflect the stages of the process and the needs of the customers, then the gaps should be identified and the definition refined. The definition of quality should encompass the customer requirements and expectations for each stage in the process.

The purpose of Module B4 is to identify current cost, productivity and service measures and identify gaps in current measurements.

This Module facilitates an understanding of the types of process quality measures that are currently being employed. First, the gaps associated with the various process and quality stages and customer requirements are identified. Next, these gaps must be translated into measurements, and then the aspects of quality for the process may be identified. There are numerous aspects of quality that may be measured in a production planning process. Some examples are provided below (Bardi, E. J., Coyle, J. J., and Langley, Jr., C. J. (1996): Reliability, order accuracy, worker standards, customer satisfaction, worker quality cost. After the appropriate quality measures are identified, then procedures must be developed to capture these measurements. Finally, measurements are collected for all production planning process stages and for all customer requirements. Possible measurements for each step of the production planning process can be found in A.T. Kearney (1978) and Novack (1992).

The purpose of Module B5 is to evaluate current performance and set standards for cost productivity, and service objectives.

In Module B4, the gaps in the measurement process were identified. In Module 5, quantitative quality standards are developed. The first step is to examine the representative data (measurements) collected in Module B4. Before the standards are established, the process must be in control. A process is considered in control when there are no occurrences of special causes. Special causes are assignable causes of variation (Montgomery, D. C. (1991)). An example of a special variation in a production planning process is a raw material arriving late due to deliver goods. The sources of special causes are assignable to a cause that usually does not occur often within a process. The other type of variation present in a process is common causes. These are chance causes that processes experience every day. When only this type of variation is present, the process is said to be in control (Montgomery, D. C. 1991). Therefore, all special variation should be eliminated before quality standards are established. There are several advantages, stated by Deming (1986), associated with a process in control:

(1). The process performance is predictable.
(2). Costs are predictable.
(3). Output is predictable.
(4). The process has reached its maximum productivity.
(5). Supplier relation are simplified.
(6). Changes in the process can be detected more quickly.

Once the process is in control, current data may be used to develop quantitative process standards.

The purpose of Module B6 is to identify and implement changes to improve overall production planning process performance.

The first step within this module consists of identifying and prioritizing improvement areas. Once these areas have been prioritized, then the areas that must receive immediate attention are identified, considering time and cost restrictions. The purpose of continuous improvement is to reduce the amount of common cause variation present in the process. In planning the improvement, hypotheses must be made concerning the causes of variation. Once the causes have been identified, then a plan should be implemented to eliminate the cause. Next, these causes should be tested to determine whether the solution reduces variation. After the experiment has been tested, the improvement should be implemented throughout the process. The process should be tested again to determine whether it is in control; after the process is in control, then the quality standards are reset for the improved process.

The purpose of Module B7 is to control and monitor productivity and service performance to ensure that the process meets standards. The final step in the PAQM is to control and monitor the process. There are numerous quality tools that can be used in this step. Some examples of these tools are given below,

Tool Purpose
Control Chart: Process variability analysis
Cause and Effect Diagram: Process troubleshooting analysis
Histogram: Process variable frequency analysis

Scatter Diagram: Process variable relationship analysis
Run Chart: Process trend analysis

4. PRODUCTION PLANNING & CONTROL AND COMPETITIVE ADVANTAGE

Today's competitive environment imposes a great demand on the Production Planning and Control (PP&C) system of a company. There are many factors driving the demand for better, more effective PP&C systems:

1. Competition. Productivity is one important way to improve a company's competitive position. PP&C is a key element in productivity improvement.
2. Increased complexity of both the products manufactured and the markets that buy these products. These changes have placed greater demands on the manufacturing operations, which need to be planned and controlled more efficiently and responsively.

The indications are that the company is increasing its product range and has ambitious marketing plans. Many manufacturing companies gain or lose their competitive advantage based on how they approach PP&C. i.e.

_ How the system is designed
_ How it is implemented
_ How it is run
_ How it is improved

A Manufacturing system may be designed to be efficient when Manufacturing to Stock or Manufacturing to Order or even somewhere in between. However the system is designed, the PP&C system must be able to serve it efficiently. Another possible consideration is the option whether to produce in-house or off-load part of the manufacturing operations to suppliers. Again however the system is designed, the PP&C should be capable of supporting it efficiently. There are many other considerations, which have an effect on the way of a PP&C system ought to be designed.

5. EFFECTIVE PP&C

As stated above, the PP&C system can not be designed for efficient manufacturing if some high level considerations are not taken into account.

A good approach is based on reviewing and examining the PP&C system whether it fits with the company's Business plan. The PP&C system must give the manufacturing operations the capability to fulfill the objectives set by the Business Plan in general and the marketing plans in particular. Therefore Sales forecasts must be linked with the PP&C system. This is the first step towards an aggregate production planning and Master Scheduling. The above form the starting point of an effective PP&C. Modern and effective approaches to PP&C have increased the demand on the level of knowledge and professionalism in the field. PP&C can not be maintained as a mere clerical function but it must be a properly set-up professional department, backed-up by a properly trained personnel equipped with an appropriate software based system.

6. STEPS IN SETTING UP AN EFFECTIVE PP&C SYSTEM

1. Review the whole manufacturing operations in relation to the Business plan. Consideration must be given whether the right balance has been achieved on many contradicting demands such as the following:

Manufacture to order Vs Manufacture to stock
Product focused i.e dedicated production lines Vs Flexible- process based - production
Or Cellular production (combination of above two basic systems)
Manufacture in house Vs Off-load policy

2. Generate a PP&C system to support effectively the type of manufacturing system that has been adopted. Assuming that a manual system will be maintained develop an implementation system then:

Develop a Production planning function to generate Aggregate Plans from sales forecasts and Marketing Plans. (Linking with the Sales and Marketing department). Examine process sequence of product. Generate Process Planning within the Manufacturing Engineering department. Establish manufacturing operations (Work) Centres.

Generate product structure to reflect process sequence. Generate BOM. Establish link between the product design and Production Engineering functions. Establish Master Production Schedule from Aggregate plans within the Production Planning and Control function. Establish Capacity planning of Resources (labour and machines) based on the manufacturing centres already established. Establish procedures to close loop between Capacity planning and Master Production Schedule. Related considerations would be procedures for:

- Changing employment levels, overtime, etc.
- Altering shifts
- Inventory stockpiling
- Subcontracting
- Investment on additional plant capacity

Link Production Planning and Control with Inventory Control and Purchasing

3. Review PP&C.
Create the necessary functions and resources (Manpower) to man the system. Create a training programme.
4. Assuming that the company will decide on purchasing a appropriate software based PP&C (ERP/MRP) select appropriate system.
5. Implement ERP/MRP system and train personnel.
6. Monitor implemented system.

7. CONCLUSION

PAQM provides a methodology for implementing a quality program or improving an existing one. The PAQM applies and extends the traditional principles of Total Quality Management (PAQM) for use in a manufacturing supply chain. From an implementation standpoint, each of the seven modules of the PAQM falls into one of two categories initialization or continuous improvement. That is, the first three steps are initialization steps that are designed to be executed infrequently (i.e., only if the process changes dramatically):

(1). Identify process, technology, and tasks being performed.
(2). Identify the customers and their requirements, expectations, and perceptions.
(3). Define quality as it pertains to the process of interest.
The last four steps of the PAQM are designed to facilitate continuous improvement and process control, and thus will be executed frequently:
(4). Identify quality performance measures.
(5). Evaluate the current process and setting quality standards.
(6). Improve the process.
(7). Control and monitoring.

Thus, through a series of modules, the model provides a method for process identification, measurement, and control. Moreover, PAQM is a systematic methodology that prescribes: (1) the specific aspects of quality that should be measured, (2) a method for measuring these aspects of quality, and (3) a method for using such measures to evaluate, improve, and control the overall quality of the supply chain system. Additionally, the PAQM represents a shift in supply chain philosophy. That is, previous emphasis has been placed on static models and/or localized study of various supply chain components. In contrast, PAQM emphasizes continuous improvement of the entire supply chain process.

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