Abstract

This paper looked into the area of manufacturing management with the hope of bringing some focus on the expected outcome of students, graduates and professionals in the field of manufacturing. To do so, it looked into the meaning, nature and characteristics of the term “control” in the context of manufacturing management, explored the starting point of control in manufacturing management, the various areas that need to be controlled including quality, material, processes, personnel, facilities and products, and then concluded with some implications for manufacturing and technology education professionals. The goal of this paper is to help both practicing and to-be manufacturing managers and other related professional not only to understand their career focus better, but also to have an aid in achieving that focus in a more meaningful way.

Controlling Manufacturing Systems

Introduction

A manager or controller of a manufacturing system can be compared to a vehicle driver who set out on a trip to a known destination. Often the destination has expected and, sometimes, unexpected volumes of traffic, different speed limits, accident and construction zones at different parts of the route. Sometimes, local weather conditions may affect the way the trip is executed.

The litany of challenges facing this imaginary driver can be as many and as diverse as the ones today's manufacturing managers face. Some of the challenges may include:

1. The driver must have a valid driver's license and must be in a good state of mind, a reflection of the technical, ethical and managerial training today's manufacturing managers should be given.
2. To avoid over-speeding and traffic violations, which may lead to accidents or citations, the driver needed to follow traffic rules and also stay within speed limits. This suggests that manufacturing managers must follow certain rules and expectations.
3. To arrive to the destination in time (assuming there were no mishaps), the driver must leave in time and follow all routes as specified. This is an indication that manufacturing managers have plans and schedules which guide their tasks.

4. To ensure that the car does not break down during the trip, it must be in good working condition, a suggestion that manufacturing facilities and other resources need constant maintenance to avoid problems.

Assuming there was no unexpected change in the rules surrounding the trip, and that the driver drove as expected, he or she is expected to arrive at the destination in time. However, if any of the underlying conditions changes, the outcome may not be as expected.

The field of manufacturing management can be confusing to the young and preparing minds. This paper looks into the area of manufacturing management with the hope of bringing some focus on the expected outcome of students, graduates and professionals in the field of manufacturing. To do so, it looked into the meaning, nature and characteristics of the term “control” in the context of manufacturing management, explored the starting point of control in manufacturing management, the various areas that need to be controlled, and then concluded with some implications for manufacturing and technology education professionals. The goal of this paper is to help every practicing and to-be manufacturing manager and professional not only to understand his or her career focus, but also to have an aid in achieving that focus.

Manufacturing Control And Management: A Definition

The terms management and control generally mean the same thing. In manufacturing, control is checking current performance of a system against pre-determined or set standards that have already been planned to ensure that

progress and satisfactory performance are being achieved. It involves seeing that tasks are being carried out according to the set plan. According to Koontz (2007), controlling is the measurement and correction of performance in order to make sure that enterprise objectives and the plans devised to attain them are accomplished.

It is implied in the above definitions that what are being managed or controlled are manufacturing systems components that are used in production systems. They include machines, tooling, equipment, facilities, production methods, processes, procedures, quality assurance, production control, materials, material moving and handling systems, people and the end products. (Obi, 2001) They all need to be controlled to ensure that they are all working as planned and that the goal and objectives of manufacturing are achieved.

Steps In Control

The control process has four steps with as many characteristics. (Allen, 1998). They are:

1. Establishment of performance standards,
2. Measuring the actual or realized performance,
3. Comparing the measured performance against the established standards, and
4. Taking corrective action as needed.

Performance standards are created when objectives are set during the planning process. Standards can be applied to every one of a company's

manufacturing resources and methods, such as equipment, inventory, materials, personnel, finance, operations, time, processes, procedures and quality. Standards are guidelines established as the basis for measurement and can be precise, explicit statements of expected results from a product, service, machine, individual, or organizational unit. They are usually expressed numerically and are a set for quality, quantity, and time. (Allen, 1998). Often tolerance of what is expected, permissible, or how much deviation can be tolerated from the standard is included to allow the manager room within which to maneuver.

Allen (1998) also noted that managers and supervisors collect data to measure actual performance to determine variation from the established standards, which may include time cards, production tallies, inspection reports, sales tickets, statistical reports, oral reports and written reports. The results thus gathered are used to compare with standards to determine variation. Any variation observed between the results and the established standards is a cause for the managers to take corrective action in order to rectify the situation.

The Starting Point of Control in Manufacturing: Planning

The natural starting point of control for any manufacturing entity is initiated by examining the performance standards set or established for that entity. An entity can be the employee, department, company etc. Erven, (2007) noted that these established standards are created when objectives are set during the planning process. In other words, standards are the results of planning.

In manufacturing, planning is achieved through many ways. One of the most common ways is by forecasting. Forecasting can be done by simple prediction, time-series, regression or moving average methods, or some fairly sophisticated methods that may involve mathematical algorithms in trend exponential smoothing. One of the purposes of forecasting is to give a manufacturing manager a set number, quantity or volume of how many products to produce during the proposed season or period. The numerical results of forecasting are often shown in a document known as the master production schedule or MPS shown in figure 1. (Vollmann, Berry, Whybark & Jacobs, 2005). The numbers representing the periods in the figure are actual working days, weeks or months during the production of the product. These time elements are often referred to as periods. The forecasted numbers (in consideration of the

Figure 1: MPS Time-Phased Record

	Period									
	1	2	3	4	5	6	7	8	9	10
Forecast	5	5	5	5	5	5	20	20	20	20
Available	26	32	38	44	50	56	47	38	29	20
MPS	11	11	11	11	11	11	11	11	11	11
On hand	20									

numbers available and the numbers on hand) show how many would be needed to meet the demand during each period. The numbers each column are used by

the algorithm in the master production system to determine the amount needed to be produced during each period.

These forecasted results are eventually translated into the format that is understood by all managerial and production personnel. For example, such a result will help them to know exactly how many parts or assembled products they have to produce during a workday, workweek, or period. In this example, knowledge of the number of units to produce gives the managers a standard to go by, because it will help them to determine, for example, how many employees and machines they need to acquire in order to produce those quantities within the given period. Thus, planning is a process by which an organization's objectives and the methods to achieve the objectives are established, while control is a process which measures the actual performance against the planned objectives of the organization and takes corrective steps if necessary to achieve the planned objectives. The main objective of manufacturing control is to ensure that those forecasted and established standards are executed as laid out during the planning stage.

Some Characteristics Of Control In Manufacturing Management

In addition to the above steps just described, control has four characteristics. (Koontz, 2007). They are as follows:

1. Control is a continuos process
2. Control is a management process
3. Control is embedded in each level of organisational hierarchy

4. Control is forward looking

A brief explanation of these will help to understand them clearer.

Control As A Continuous Process

The continuity characteristic of control agrees with one of the principles of modern manufacturing practice known as Kiazen or continuous improvement. The continuity characteristic of control is also evidenced in the four control steps discribed in the previous section. The cyclical nature of this process maintains the continuity process. As a continous process, managers are constantly establishing new standards, meeting them, comparing results and taking corrective steps to address areas that need improvement.

One of the techniques employed by many manufacturing organizations to improve long-lasting quality today is total quality management (TQM). Described by International Systems Organization (ISO) as a management approach of an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society, TQM demands that everyone in the company must be part of its quality improvement efforts.

What gives TQM muscle to function and be sustained is management commitment to the company's quality improvement programs. With management support, TQM can become almost like a religion in a manufacturing organization, where quality awareness is constantly in the mind of every worker. The result is usually a general improvement in the company. Quality-related problems are

constantly identified and solved. In manufacturing industry, quality assurance uses statistical methods to identify quality problems. The causes of these problems are isolated, and measures of solving them are designed, and then the problems are corrected.

Control As A Management Process

It has already been noted that management and control mean basically the same thing, ie, the process of checking current performance of a system against pre-determined or set standards that have already been planned to ensure that progress and satisfactory performance are being achieved. To accomplish this task, management tools are often used, including measurement and evaluation techniques. For example, employees performances have to be monitored and measured, cell, workstation or plant outputs must be accounted for against proposed or expected quantities, and customers' opinions and satisfaction levels must be eccertained and compared against expected or planned levels.

Control Is Embedded In Each Level Of Organizational Hierarchy

With control as a management process comes the different levels of responsibilities that are associated with the various levels in a manufacturing organization. For example, the plant manager in the organizational chart shown in figure 2 has a different set of controlling tasks in his or her level of management. Some of this manager's controlling tasks may include hiring more

supervisors to man the second level and ensure that the various departments under him or her are functioning well, determining which of the various departments are not performing as expected, and ensuring that the plant is a safe and ergonomically sound place for all employees to work in.

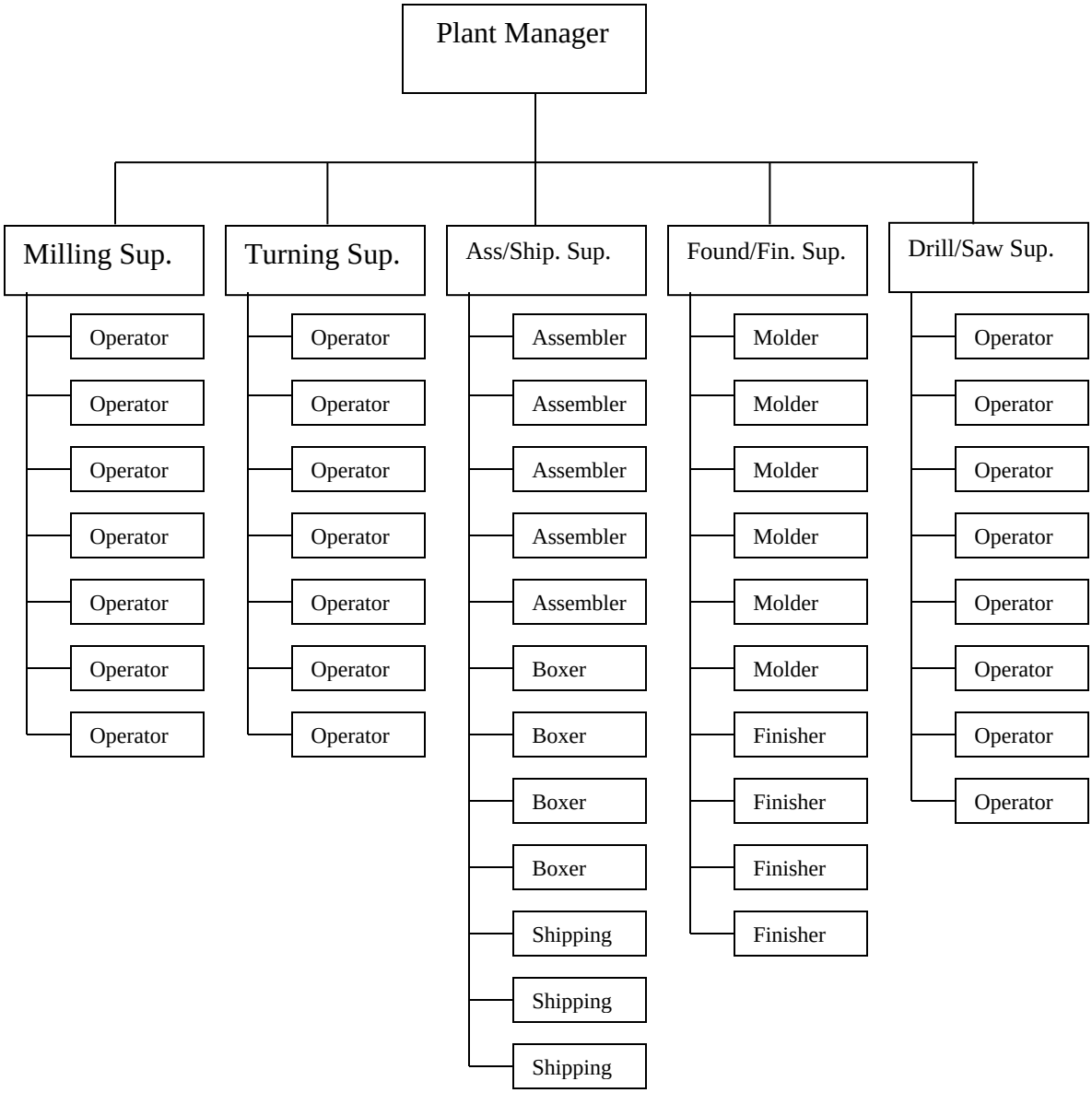

Figure 2: Controlling Tasks Are Different in Different Organizational Levels

But the controlling tasks of the supervisors in the second level of the organizational chart in figure 2 are completely different from those of the plant manager. While the plant manager's controlling tasks appear to be general in nature, the supervisors' tasks are more specific to their various areas of specialization. For example, these different supervisors will be concerned with not only ensuring that each of their various workstations is manned with capable operators, but they will each account for each employee's effective working hours, daily workstation output, machine downtime documentation, and the scheduled maintenance of their respective machines.

The same idea goes for all the other levels in a manufacturing company. From the chief executive officer to the machine operators and assemblers, differing controlling tasks are variously embedded in each level of the organization's hierarchy, reflecting the different roles of the workers in those ranks**.**

Control Is Forward Looking

The four steps in the control process describe the control process as a continuous flow between measuring, comparing and action. The fourth step where corrective action is taken depicts the process as a proactive one that prepares the systems for a productive future. From this, one can see a manager as future-oriented when he or she is devoted to employee development and training, facility renovation and equipment repair, or simply equipment upgrading

and calibration. In any case, the manager's objective is to correct, prepare or equip the worker, facility or equipment to be more productive for an increased output.

Proactive managers are the ones who want to be productive. Such managers are eager to take corrective actions that will lead their departments and companies to a progressive and productive end, as they meticulously monitor, measure and correct different elements of their workplace. They are the ones who understand the slang which says that a stitch in time saves nine.

Areas To Control in Manufacturing Systems

Modern manufacturing systems, now embodied in computer integrated manufacturing (CIM) systems, have many modules or subsystems. These

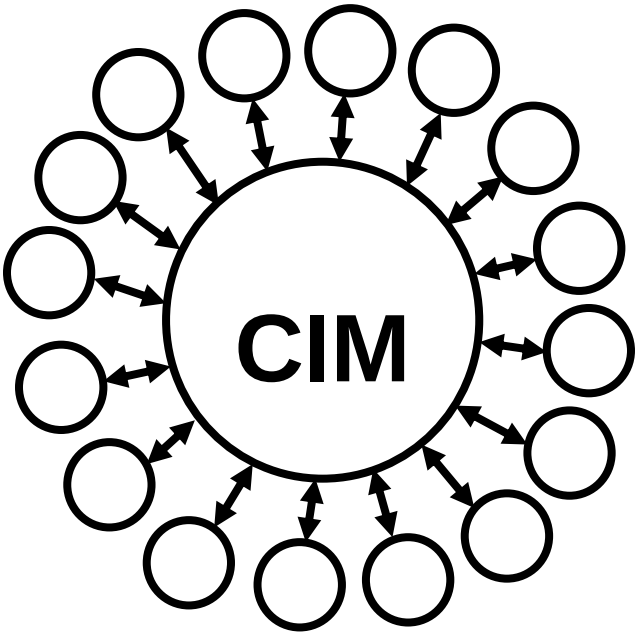

Figure 3: Computer Integrated Manufacturing Subsystems

subsystems are shown in figure 3. Each of the outer circles in the figure represents a module of CIM such as materials, personnel, quality or facilities. In addition, each has its own peculiar constituent elements and issues that have to be managed or controlled. As a result of these inherent differences, each subsystem demands a different type of control to ensure that the expectations of managers are realized.

Numerous books and articles have been written on different elements of manufacturing management. Some notable examples include Besterfield's (2007) Quality Control, Material management by Arnold, Chapman and Clive (2003), Personnel or Human Resource Management by Ivancevich and Ivancevich (2004), Facility Management by Rondeau, Brown, and Lapides (2006), Process Control by Marlin (2000), Process Control: Modeling, Design and Simulation by Bequette, (2002), Production and Inventory Control by Greene (1997), New Product Management by Crawford and DiBenedetto (2006), and Successful Product Management by Morse (1998) to name a few. Note that each one of these various titles reflects the specific area of manufacturing systems that is being managed or controlled. This section will briefly discuss the nature of control normally undertaken in selected components of manufacturing systems.

Personnel Management

Workers or people who work for a manufacturing organization are the most valuable resource in the arsenal of the company. Sometimes referred to as the human element, workers must be conditioned to be fully functioning so as to

maximize productivity for the company. To accomplish this, they must be reviewed, evaluated and improved (trained) in the knowledge, skill or competency areas where they are lacking. Moreover, workers must be treated fairly, respectfully, encouraged and rewarded.

Competent employees must also be sought, hired, and trained. Training of employees is a major control task in many companies today. Training can be technical, social, ethical, managerial or business. However, most of the personnel issues facing manufacturing organizations today are in the area of integrity or ethics. For example, a study of 81,000 people on integrity, work attitude and drug use by Orion PE System (1999) found that 24.9% of them admitted to stealing from previous employers, 28.5% admitted to some drug use, 24.0% admitted they had problems with absences in previous jobs, while 30.0% admitted tardiness in previous jobs. Clearly, no employer who intends to be on a competitive edge would want to hire such employees. These employees must be changed through proper training in order to be productive.

The more productive manufacturing companies are those that hire and train their workers in key areas that the companies know will positively affect their business. Competent, responsible, and knowledgeable employees with manufacturing background should be trained on a continuous basis. Kelley (1998) recommended that such employees must also be flexible so as to perform multiple functions, and will need to be trained to perform other manufacturing disciplines. The multiplicity of today’s manufacturing tasks makes training a must for companies who want to be on a competitive edge.

Quality Control

While quality is innate excellence of a product or service, it is also the major determinant of whether a manufacturing company will survive or not. Products must perform the functions they are manufactured to accomplish. They must conform to what the manufacturer stated about them. They should not disappoint the user for no clear reason. Some of the quality characteristics that make an excellent product include performance, extra features, conformance, reliability, durability, availability, aesthetics, and reputation. These descriptive terms, which join forces in meeting customers' satisfaction, must be measured and controlled.

To ensure that these important quality attributes are achieved, each manufacturing company has a department or area assigned to do the job. Variously known as quality control, quality assurance or inspection, this department works to ensure that the products that are produced by the company meet or exceed customers’ quality expectations. Any product that does not meet the specified requirements is failed while those that pass are shipped to customers. The failed products indicate that a process, machine, employee, material or other condition needs to be checked and/or corrected.

The control tasks of quality control extends to inspecting other elements that the company uses in manufacturing its products, including materials, instruments, processes and machines. The importance and increasing need for quality control has resulted in the field expanding to include practices like quality circle and total quality management (TQM) in many companies. Quality circles

are small groups of workers from different departments who meet regularly to find and solve quality problems. TQM, on the other hand, is a practice of involving everyone inside the organization in quality management of all aspects of the company's operations.

Facility Management

By definition, manufacturing facilities consist of things that provide services, including buildings, factories (plants), equipment, people, processing machines, tooling, vehicles, instruments, materials, material moving/ handling equipment, storage devices, aisles, offices, restrooms, receiving & shipping docks, parking lots, drive ways, and other things that provide services to manufacturing personnel. (Meyers & Stephens, 2005). Related managerial functions include planning, construction and maintenance of physical facilities and equipment as related to plant layout and design, regulatory and environmental compliance, safety or security, energy conservation, process improvement and production line planning activities.

In addition to plant layout and design tasks, a plant manager will be expected to produce and manage a complete plant's organizational chart including personnel and ideal schedules for efficient and smooth operation of the plant, daily operations schedules for personnel and workstations, shipping schedules for raw materials and finished goods, tooling schedule, meeting and downtime schedules etc. The plant manager is also expected to produce maintenance schedules for servicing the plant, machines and other equipment

located in it, monitor and manage other areas such as safety schedules for items like fire extinguishers, employee safety and health maintenance as specified by the Occupational Safety and Health Administration (OSHA).

It is clear from the above tasks that the plant or facility manager has a lot of areas to control in a manufacturing company. This person works with all the supervisors under him or her to ensure that these facilities-related tasks are accomplished as planned. Also, by working closely with other managers at his or her level, the manager strives to ensure that all activities are coordinated so that the expected results are realized for the company.

Inventory Management

For a typical manufacturing enterprise, manufacturing resources would normally consist of distinct entities such as materials, tools, machines and human beings employed in the production of goods and services. Often, these resource items are not only too varied but also too numerous to count and manage. This is best illustrated by the case of an automobile manufacturer who not only has to deal with the issue of vehicle types, models and years, but also with the thousands of assembled vehicles, thousands of different parts, not to mention the thousands of the different tools, equipment, hardware and other resources employed in production.

As a result, the tasks of an inventory manager involve a lot of management or control of inventory list items for each category of resources, such as products, tools, instruments, machines, equipment, materials and parts.

Each category of inventory requires a special monitoring of the way the items are expended so that the manager would know when to replenish them as needed. Using special software, the task of inventory management has been mostly automated and includes some aspects of modern manufacturing techniques as evidenced in material requirement planning (MRP) and just-in-time (JIT) manufacturing. In each case, the idea is to help the inventory manager not only to know when resources are needed, how many that are needed and when to replenish them, but also to manage them in such a manner that the productivity of the company is increased.

Implications for Manufacturing and Technology education

This paper has dealt with the topic of control or management, a topic of much interest to many practicing and to-be manufacturing managers in today's manufacturing industry. Manufacturing systems programs are designed to equip their graduates with the tools that will make them competent managers in the workplace. Therefore, the implications of this topic to technology education and manufacturing professionals cannot be overemphasized.

Perhaps, the most important lesson from this paper is the need for exposing manufacturing majors into the world of manufacturing control with all its definitions and ramifications. While still in school, manufacturing students should be challenged with as many manufacturing managerial tasks as possible in as many projects. Such an exposure and consistent follow-up will, without doubt, aid in the development of these young minds into managerial types and enforce our

united resolve to equip this nation with the right tools for the competition facing it. Projects may be structured in such a way that every manufacturing major in the program would experience manufacturing management in different areas of manufacturing, including materials, facilities, personnel, financial, quality, production etc. In fact, the more areas of exposure they can get, the better.

With the need for exposure comes the challenge to reinvigorate the curriculum. A program's content is an indicator of how successful it can go toward helping manufacturing students learn key managerial skills. Professors and teachers are encouraged to examine their courses and curriculum to ensure that adequate managerial courses and materials are included to ensure that students are getting the necessary managerial skills from them. In trying to address this issue, the National Association of Industrial Technology (NAIT) is requiring that, to be accredited, manufacturing programs must have at least 15 credit units of course work within their degree program from business management. This is a very wise step because it will foster the development of management-minded graduates in the field of manufacturing.

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