PRODUCTION MANAGEMENT USING LEAN PRINCIPLE (OBEYA)

Submitted By

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Submitted To
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STATEMENT OF ORIGINALITY

I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other University or Institution.

Date	Hafiz Ahmad Bilal

DEDICATION

This thesis is dedicated to my parents, family members and my respected teachers!

ACKNOWLEDGEMENT

"*After asking Allah to guide you to the straight path, don't just stand there … start walking!"* ***– Albaz***

First and foremost I would like to thank Allah Almighty who always helped me throughout my life and to get through this research degree and thesis.

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ABSTRACT

Production assembly line is a very critical and important area of an industry as every product is unique and has distinctive manufacturing processes after the minor changes of difference in raw materials, work order machining, on floor bottleneck issues and others limitations. There are different production practices carried out by small and medium enterprises based on different production factors like Quality, Raw material shortage, Work order monitoring, Production time, and less revenue. Similarly, OBEYA is a lean engineering production technique pioneered by Toyota production system and later adopted in range of automotive industries. OBEYA; a Japanese word focuses on enhancement of production performance and tools along with feedback from the departments. In this research, an empirical study was conducted using a process control tool on an industry, prior to and after implementing OBEYA. On completion, the results were analysed and compared. The analysis of production was carried out using statistical process control (SPC) methodology. Statistical Process Control (SPC) is used to bind the variation between the permissible tolerances, as it is impossible to eliminate variation from any process. This Paper discusses planning and implementation of SPC with lean technique (OBEYA) so that it contributes to create unique production system and eliminate the perception of OBEYA to be purely origin as automotive industries. The results of the approach supports the methodology developed and implemented in a case industry producing ceiling fan.

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Chapter 1

Introduction

1.1. Background

Pakistan Electric Fan Manufacturing Association (PEFMA) encountered with some problems in their production side. PEFMA contacted SMME to find its solution by industry/academy collaboration. A team from university visited the industry to understand the problems. A research was then conducted. The purpose of the research was to study similar other cases and techniques used for such problems all around the globe and pick the best technique to provide cost-effective solutions of production practices for small and medium-sized enterprises (SMEs) that can be implemented easily. Production assembly line is very critical and important area of the industry. Most problems faced by case industry is in the lean production management , such as quality, resource shortage, control work orders, production time, the cost of the final product due to high stocks [1]. The proposed research subject is related to the development and identification of methods that can be used to facilitate the changes that can provide efficient manufacturing practices. The purpose of this study is to come up with a solution that qualifies for this particular industry. Lean manufacturing practice in comparison to other practices has been implemented in various sectors and is under development in other. For cost effective production and reduction of waste product different techniques in past 4 decades are used by developed countries products [2] the management of lean production have an important role in the production and processing [2].

Various manufacturing industries in the world use management techniques such as, Obeya, Value Stream Mapping, Kaizen, Total Productive Maintenance, Kanban, lean, etc. to survive in the market against competitive rival. Lean Activity, production optimization of product development, analysis and management of the value of work in controlled conditions can help [3].

The key role of lean manufacturing system is to offer the customer with what they want within the limitations of time, space and man power. Because of energy crisis and involvement of expensive food products, machinery and labour, value added production is very necessary [4]. Typical benefits of lean management are to reduce cycle time, waste product and rework and to adopt processes that are of higher financial savings [2]. Lean is not only a management technique but it also a progressive leaning tool. Lean production can be achieved by adopting simplified construction techniques and the highlighting the area in which necessary flexibility is required.

The Obeya is known as a method for Toyota Lean Product Development and structure. Obeya was also recognized as one of the sub-objectives [3]. To produce practical solutions to problems we carefully examine this Obeya, how it is used, its characteristics, and how it is mapped, figure 1 shows a meeting room for Obeya governing bodies.

By the collaborative effort of industry and academy focusing on manufacturing practices, the failure rate is much lower than the other lean techniques and principle that perform comparatively well on paper. This project is an attempt to analyze and optimize the production assembly line of ceiling fan industry.

After completion of the project, the case study will be planted with high efficiency and in return have a higher production with lower capacity and increased efficiency. Industrial unit will be able to identify problems and to make sure that right corrective measures are taken.

1.2. Basic Functions of Production Management

Manufacturing is an imperative process, not solitary for its own, it runs like a business companies that sell products to customers. Moreover in industries there are some companies whose primary business in to produce material and components rather than the assembled parts [6]. After that they supply it to other companies to convert them to assembled form. For effective manufacturing resources, concerned people and equipment to be used must be well-ordered. This whole well-ordered unit is called manufacturing system. Like any of the technical system Basic Goal of this system is to achieve maximum possible output.

Before the development of the plant system, in 18 century, there was no system for production control. Entrepreneurial manage store operations [7]. There were few consignments, known suppliers, and the employees follow a simple process to create simple products. Therefore, they didn't find it necessary to create a separate group that work solely for the management of the system, the idea of developing a management system for manufacturing businesses was evolved for the following reasons.

1. The development of the plant.
2. The development of large enterprises, and need to recruit employees to function the corporate

3. The services of the founders of scientific management, who were capable to prove the validity of methodologies developed by them. These methodologies facilitated in the improvement of performance and the incomes of the system.

Only manufacturing companies were using the earlier developments in management theories. However, nowadays, other companies are using these concepts as well. The Industrial Mutiny (1769) marks the beginning of the new era of production. Charles Babbage work on the science of production management can be seen in his book [16]. Afterwards major contribution to this field was by Fredrick W. Taylor also remembered as the father of scientific management [1]. He gave number of principles that improvise the impact of human factor on a company's success. Others, such as Henry L. Gantt produced different methodologies. One of his famous technique was the; Gantt chart which helped to manage and plan the activities in industries. In the reign of English industrial revolution, the concept of interchangeable parts was introduced by United State in 1801. Courtesy for this was given to Whitney In 1913, Henry Ford presented the assembly line. Which made it possible to produce complex parts massively [15],more technological developments were made in twentieth century that resulted in the automation of production.

1.3. Management of the processing industry

The Industrial Mutiny (1769) results the beginning of the modern era of production, the mutiny includes time and motion study, practice of industrial standards, incentive plans for labours and inception of systems for data collection

Nowadays manufacturing companies have more number of employees and complicated processes if we compare them with 'pre factory system' practiced in early eightieth century[5]. For hindrance free working of manufacturing activities coordination must be developed between them. For instance, the condition of shop floor, machine, employees and raw material must be up to date so any adverse situation like breakdown of machine can be handled. It is responsibility of management to take care of these activities. If a machine goes out of order, they are responsible for rescheduling the parts made at it and ensure the availability of machine that will be used as replacement[15].

Such measures are taken by management for more profitable manufacturing activities. Customer satisfaction is key to profitability. If the demands of costumer like specification and in time supply is fulfilled the customer is more likely to come back and give more orders. If company achieve the satisfaction of customer it practically needs no advertisement[8].

If we develop a hierarchy of the activities in manufacturing sector, receiving of order would be at first place. All other activities are the result of the motive of fulfilling or help in fulfilling this order. Order can be characterised as its quantity or quality required by the customer[10]. If multiple orders are to be completed in a day, then the priority of orders are decided by the management for example which order should be delivered first or if some activities are to be done simultaneously etc. Although today, almost every industry small or big produces wide range of goods and deliver them to different customers. Then the priority of these orders is decided by the management relative to the existing orders. This decision is usually not independent in nature. The management have to keep record of due dates, machine and worker availability and many other factor before taking any decision[9].

The second activity is MPS, MPS stands for Master Production Schedule; it consists of starting date of a task and estimated time duration for its completion. MPS is not an exact time table for people and machines involved in the task it is just an over view that may help in assurance of availability of raw material on time. CRP (Capacity Requirement planning)is then created, CRP decides the quantity of goods to be produced by plants[12]. Capacity of plant is referred to the amount of resources it has. Resources include the available machines, tools, people in plants, number of hours they work, and the amount of work they do. So, capacity can be measured by the amount of time a resource can be used and the material of specific type that is used by these resources. If according to the management the capacity of plant is not sufficient to meet demands and orders, then they decide to do contract with other industries. If right decisions are made while selecting factory for contract a plant can produce more deliverables then its capacity [19]

OBEYA room is a resource planning. It connects all departments, and allows providing the information to the right person at the right time, with guaranteed integrity immediately. It replaces the old standalone technique in finance, human resources, manufacturing and warehouse, and united them under one umbrella; source of information. Finance, manufacturing and the warehouse all still get their own production methods, except now the Obeya room is linked together so that someone can look into the warehouse chart to see if an order is shipped or not[11].

Shop Floor Control System is a module of an OBEYA system. Production management is involved in all areas of a company, and requires a OBEYA system to connect the activities within them and manage articles, however, it is usually associated with work in a factory. Previously it was developed to resolve the problems in the factory. The organizations that we see today were not the same in past[18]. There were numerous shops own by people they design and pack the products by themselves. There were fewer customers and products were not so complex for requirement of computerized machine. There were less order and plan was simple so the management of the business don't want to invest so much cost for its installation[13]. Again, while the use of OBAYA is the main module of the floor of the storage control, which manages the activities on the floor of the store. It also shows the status of the progress, the current location of materials, tools, etc. It is a system that effects all departments one way or another[20]. OBAYA not only keeps track of activities in a store, but also learn from the past experiences and try to improve everyday activities and create a functioning feedback system as well[14].

1.4. Purpose of the Study

The modern production environment is fierce and sophisticated so competition is very high. It is characterized by short product life cycles, the wide variety of products and customer demands with excellent quality and fast delivery[25]. Current research focuses on developing a finely tuned process to meet the cost. Constraints, quality, variety, and the time constraints imposed by the market. The main objectives include the production lead time off to be as short as possible and to achieve a high level of process control[16][17]. The advantages of such a system would have a greater flexibility and responsiveness, better use of resources, reducing inventory and recording it. Quick turn around on customer orders advanced information technology brings these goals at hand. Without the application of Lean technology in management of production operations, it is impossible to produce sustainable and effective strategy in the workplace there is a need for a well-defined and constant architecture, which describes the environment in which only by integrating the capabilities of the production staff, production process and information technology can continue to contribute to the competitiveness of enterprises .This research focuses on the increased need for a Lean management system for the production company. It is also designed to remove the complexity of existing techniques[18].

Chapter 2

Case Industry

2.1 Sample Industry Overview

With the mission "To satisfy the customers in a broad network through manufacturing and delivering the newer, better, efficient, unique and cost effective products of international quality and through best after sale services" [20]. The case industry took an initiate its fan manufacturing industry in 1987. The key product (ceiling fan) of case Industry that is proficiently engaged in manufacturing and delivering a wide range of reliable, durable and consumable product in industrial and residential buildings. They export their products to regions in Middle East, Africa and Asia. It is the outcome of devotion and loyalty of our highly professional engineers and employees with quality that their products are certified and recognized by the Pakistan Standards and Quality Control Authority (PSQCA) and also by international authorities like European Conformity (CE Certification) and ISO 9001:2008. Aforementioned large integrated ceiling fan industry is used to implement Obeya (Lean technique)[22]. Since some of the information is confidential, the company is referred to as case industry throughout this paper.

2.2 Sample Industry Concerns

With certified products, strong and broad customers' service and dealers' network but the case industry has also faces some issues regardingmicro-management & production tracking issues,parts handling issues, lack of ergonomically designed work benches, shop floor inventory management[30].

2.2.1 Micro-Management & Production Tracking Issues

There were following micro management and production tracking issues faced by case industry:

- Work order monitoring
- Micromanagement of all issues required
- Check on progress of production schedule
- Bottlenecks during production process
- Quality problems
- Defect percentage for parts
- Maintenance issues
- Raw material shortage … to name a few

2.2.2 Parts Handling Issues

In case industry, Lots of problems founds at assembled or packaging stage due to improper parts handling e.g., Copper coil wiring is damage by stacking.

Figure 1: Parts Handling Issue

2.2.3. Lack of Ergonomically Designed Workbenches

There were not properly workbenches designed in industry and its illustrate in the following picture:

Figure 2: Ergonomically workbench

2.2.4. Shop Floor Inventory Management

There was no management regarding inventory in case industry. If we do not know the quantity of inventory which we have, we cannot calculate the blocking price.

Figure 3: Inventory Management

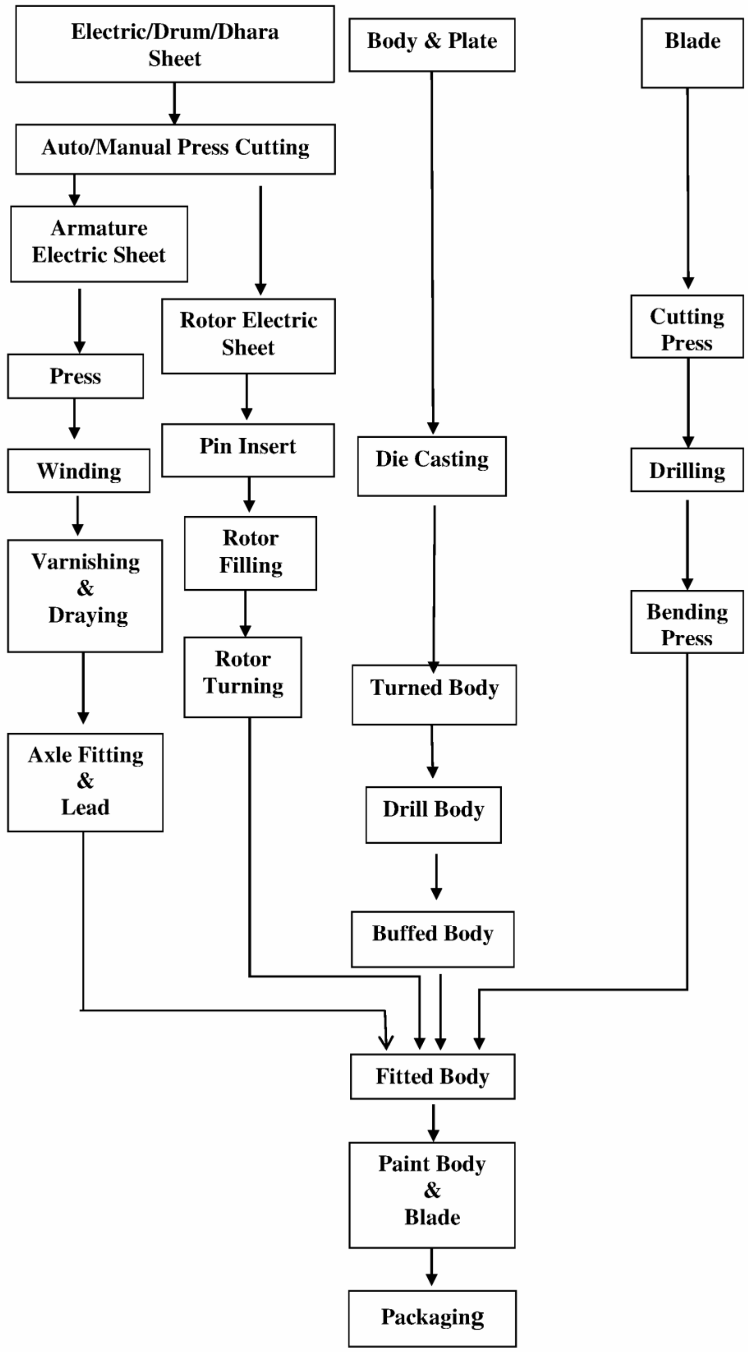

Figure 4: Case Industry Production Flow Chart

2.4 Departmental Layout

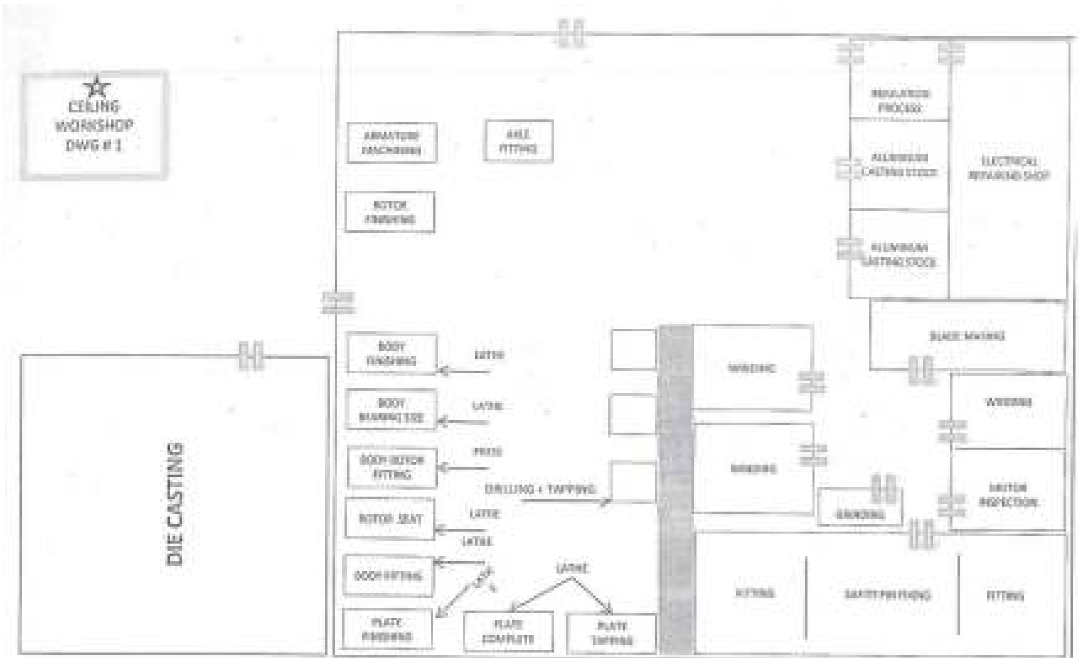

Figure 5: Departmental Layout

2.4.1 Layout Work Flow Direction

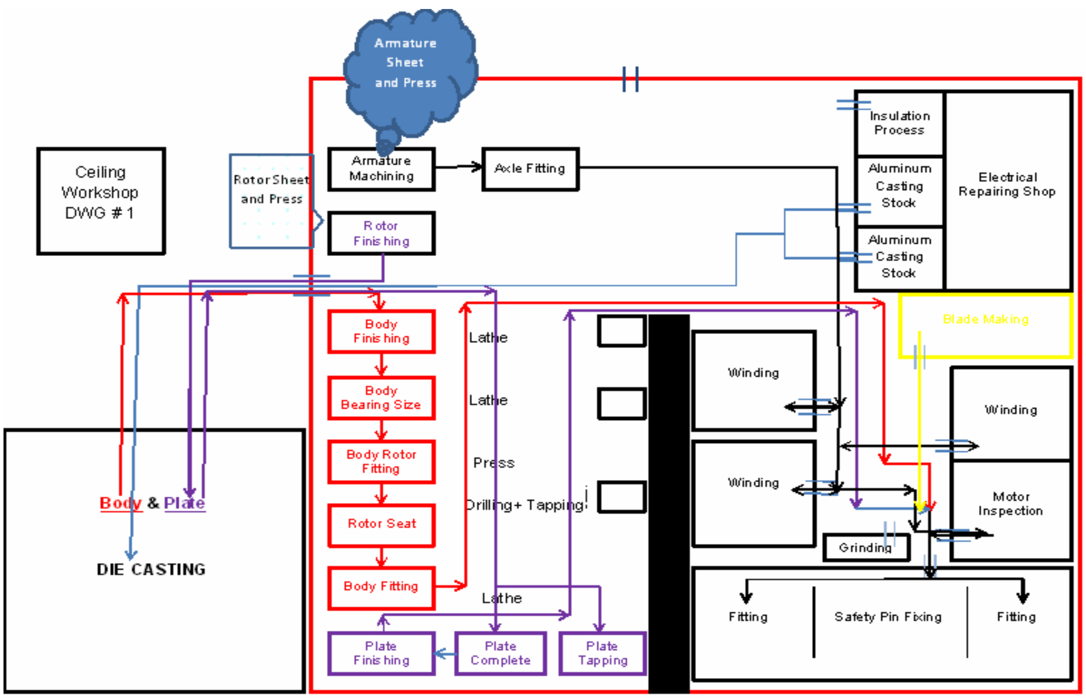

Figure 6: Directional Work Flow

Chapter 3

Lean Principles (Shop Floor Control Systems)

3.1 Introduction

Lean manufacturing technique is adopted by many manufacturing companies to survive and establish in global market. Lean techniques are used to diminish the non-value added activities to reduce cost. Using lean techniques we can develop reasonable scheme to direct manufacturing companies for uninterrupted production [4], [5], [18] [22]. When such lean manufacturing tool are efficiently utilized, it can also help in reduction of waste material, better control of inventory, improvement in quality of product and to get improved general operational and financial control [23]. Starting from Toyota Production System, many different lean manufacturing methods have been applied in discrete manner i.e. total productive maintenance, production smoothing, single-minute exchange of dies, just-in-time (JIT)and cellular manufacturing and Obeya. Above mentioned techniques are explained below.

3.2 Mass Production

Long run production of quality goods for mass market is called Mass production. In the start of 20th century it was introduced in united state [18]. Henry Ford was the first industrialist to use this system, for this reason on his name this system is known as Fordism. This can be elaborated as "mass production of quality goods by means of appropriate machines and assembly lines, semi-skilled and unskilled labors equally spread in different jobs along with skilled labors and tight discipline in bigger industries" [18].

Mass production development mutates the work of organization in two ways. Firstly, different tasks are shared between un-skilled and semi-skilled workers, as they can learn it on machine. Secondly, a team consists of supervisors and managers are needed [4]. The major disadvantage of mass production is its inflexibility to change in product as well as production system. There were huge investment and high demand of the product was needed. Due to these major disadvantage the lean manufacturing system replaced mass production system [19].

3.3 Lean Manufacturing

Lean manufacturing is a sequence of techniques for recognizing and removing waste (actions that add no worth to final products) and constantly improving the stream of product. Lean manufacturing is better suited for present environment of varied parts manufacturing. The market is described by short product life cycles, high product variety, and demand of customers for excellent quality as well as in time delivery. Lean manufacturing is competent of accomplishing these challenges, and can give real competitive benefits for today's business. [20]

There is a lead- time between the order placement and finished goods delivery to customers. Generally in manufacturing companies this lead time exceed surprisingly from the actual time of processing and manufacturing. The reason is simple: lack of coordination between manufacturing department and sales department. To resolve this issue lean manufacturing make use o f techniques like Planning of Manufacturing Resources, Just-in-time and optimization of Production Quality etc.

Every system has pros and cons. For a successful business, hybrid techniques of all good traits from each of them are applied but this is not helpful unless proper modifications are done and adequately implemented.

3.4 Overview of Lean Manufacturing and tools

Japanese manufacturer faced deficiency of material, human and financial resources after World War ll. These circumstances are responsible for originating the concept of "Lean" manufacturing [32].At that time president of Toyota Motor Company Kiichiro Toyota, acknowledged that in American automaker of that period were producing ten times more Japanese counterpart. In early days Japanese industrial leaders including Toyoda, Shigeo Shingo and Taiichi Ohno counter acted by formulating a new disciplined, process-oriented system, today we know that system as “Toyota Production System" or "Lean Manufacturing System". The purpose of that system was to highlight the key sources of waste. Common lean tools are briefly described below [24], [25], [29].

3.4.1 Cellular Manufacturing

Processes required for specific or similar products are organized into a group or cell that include all machines, operator and equipments necessary for it. All resources in a cell arranged in order to facilitate each operation.

3.4.2 Just - in-time (JIT)

The name of this approach "Just in time (JIS)" is self-explaining that this is an uncomplicated goal to approach targeted quantity and quality of product in the specified time limit [26]. It includes a constant dedication to the pursuit of brilliance in all segments of manufacturing systems operation and design. The JIT philosophy is a set of primary manufacturing approaches as below

Demand and Supply Compatibility: Industries must scrutinize their market vigilantly and decide the suitable manufacturing approach in terms of product quality, product range, and product cost. It is extremely possible to present a wide range of products in market but it exponentially increases the budget. Increasing flexibility of a system means expensive manufacturing system and consequently, the product [11]. One of the solutions is Modular design and it can be attained by understand the product design, by investigative the similarity of components and sub-assemblies in entire product range with a goal to boost these similar features to the maximum possible level. This would help in reduced production costs due to less manufacturing set-ups, lesser items in stock, and lesser compliment drawings [16].

Defining families of Product: JIT look to endorse product based factory plan. The root of product-based plan is the definition of families of products; Products that share same design and manufacturing characteristics and as a result can be manufactured in one cells [5]. A general approach for the classification of product families and the subsequent growth of flow based manufacturing systems is group technology. Group technology helps in design process and to minimize avoidable duplication in Product design [5]. Secondly, JIT defines families of products and components, which can be developed in distinct manufacturing cells. Manufacturing cells produces simplified material flow model in a plant, and allow liability and possession for a component to rest with one group of operators and their supervisor [27].

Timely deliveries of raw materials by good relationships with suppliers: JIT strongly suggests that manufacturing companies should set up strong and long lasting relationships with competent suppliers [5]. Companies must share their ideas about possible future order patterns, changes in design and other related information with selective qualified suppliers; in a way, support them to make their efforts to be helpful and trusted.

Summary of JIT, techniques and approaches: [27]

1. Product design easy to manufacture and assembly

2. Manufacturing arrangement planning

3. Methodologies to ease the use of simple but sophisticated manufacturing control Systems like Kanban

4. Appropriate use of manufacturing resources

5. Guarantee for quality control and quality procedures

3.4.3. Kanbans

Kanban is a Japanese word meaning card, shop floor control and production - control element activity JIT. This technique is limited to recurring manufacturing environment, where it is used to harmonize the amount of materials used on the last assembly line. There is no place for periodic variation in Kanban system so it is sort of an inflexible system this is an indicating system for the implementation of the production of JIT

3.4.4 Total Preventive Maintenance (TPM)

To detect any variation, equipments periodically calibrated by the workers. Wisely said that “Precaution is better than cure" so pretension to avoid any breakdown before it happens.

Regular maintenance is carried out periodically by workers to detect if there is any anomaly. As prevention before breakdown avoids addition waste cost so the focus is now changed accordingly. Operators are part of system as they are closest to machines, so while maintenance and monitoring activities one cannot ignore them so require warnings and preventions are made against malfunctions [32].

3.4.5 Reduce installation time

Constant Efforts are made to minimize the machine setup time.

3.4.6 Total Quality Management (TQM)

A feedback system from the customers for improvement of product called perspective management is developed. The major components are involvement of employees and their training, team for problem solving, statistical quality control methods, long –term planning, identifying that wistfulness is in the system and not in employees [7].

3.4.7 5S

5S emphases on operative work place organization and consistent work procedures.

3.5 Overview of Value Stream Viewpoint (VSM)

All actions (value-added as well as non-value-added) need to get a product or a whole cell (having different product of same protocol) are collectively called Value Steam from the main stream, that begins with the raw material and ends with the customer [28].

These measures consider the stream of both information and resources within the general supply chain. The actual goal of VSM is to recognize all types of discarded resources in the value stream and take measurements to reduce this waste [28]. In the supply chain researchers have developed different strategies to optimize each operation. These strategies lack in connecting and visualizing the materials nature and facts to propagate in the entire supply chain of company. Using VSM complies to work on big picture. VSM makes a joint basis for the production process, thus enabling more rational decisions to develop the value stream [24]. VSM make use of pencil and paper that use predefined icons to form a product or set of product for the sake of improvement. After that a state map is drawn which is a snapshot covering the things that are done so far. Next step in VSM is development of future state map; it is basically a snapshot showing the future picture of the system after removal of inefficiencies. A questionnaire is answered about the efficiency of the system and implementation relevant to the lean tools uses to create a future map. This map then helps in for the future amendments in system. [28].

3.6 Production Management using Lean Principles

It is process that hybridize and evolve different resources involve in the subsystems of production of operation in a system into controlled value added product/services according to the organizations policies. Hence this part of organization is responsible for the evolution of all inputs to make them more useful [31] and better in quality.

The characteristics of production system are:

1- There must be an objective for every production system because it is an organized activity.
2- Useful outputs can be obtained by transforming different inputs
3- Any system of organization cannot isolate itself from other

For continuous improvement in system a feedback system is required about the activities.

3.7 Production Management

It is a process that involves organizing, planning, controlling and directing the production activities. It make use of combination and transformation of different resources in subsystems within an organization into value added products according to the organizations policies in controlled environment [31].

3.7.1 Basic Aims of Production Management

The goal of Production management is to provide good services to their customers with required quantity and quality in specified time but in relatively less cost.

1. HIGH QUALITY

   Quality is a relative term; it depends upon the need of customer. The major misconception about quality is that high quality is always right quality, it is not the case. It is an optimization between cost and technical characteristics best suited for particular requirement [13]

2. HIGH QUANTITY

   Quantity is a critical variable because it is necessary to produce products according to the demand as excess production can lead to create load on the capital and inventory will be filled with wasteful products and producing less goods will lead to the shortage of products and delay in fulfilling the consignment [28].

3. LESS TIME

   Production department can easily be judged by a very important parameter i.e. timeliness of delivery. So it is the responsibility of a production department to optimize the use of resources so this objective can be achieved.

4. LESS MANUFACTURING COST

   The estimation of cost is done prior to the actual manufacturing. Estimated cost is set goal and efforts are made to produce goods within it or at least to minimize the difference if it exceeds [31].

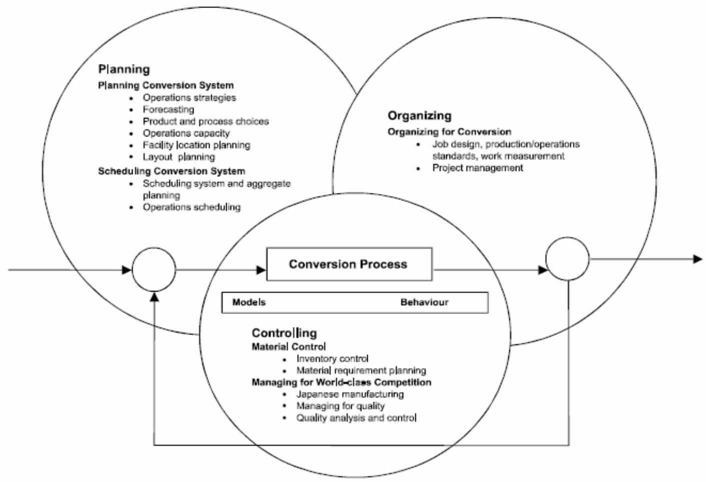

Figure 7: Basic Tasks

3.7.2 Basic Tasks of Lean Principles

Lean Principle is one of the general management function. The main concern of operation mangers are to plan, organize and control the actions that are responsible for human behavior [18].

1. PLANNING

   Planning is the set of actions and guide for making decision in future. To achieve this objective the operations managers identify the objective of every subsystem within organization and formulate rule and protocols.

   This phase comprises clarifying the function and focus of operations in the overall strategy of organizations. Facility designing, Product planning and using the conversion process are also part of this strategy [18].

2. ORGANIZING

It is one of the duties of Operation Manager to establish a role structure and information flow in subsystems of organization. All the activities required for the achievement of goal is determined by them they also assign responsibilities amongst workers [9].

3. CONTROLLING

The efficiency of the system can be judged by comparing the actual output of system with the planned or expected output to ensure that the objectives are accomplished and the systems are operational. The main parameters for comparison are; quality, quantity cost and timeliness. [18].

4. BEHAVIOUR

The concern of operation mangers is the effectiveness of planning, organizing and controlling on the behavior of human. This is also there concern that how these attributes of manager can be affected by the subordinates behavior which facilitate them for future decision making.

5. MODELS

Operation manager has to face many problems while making plans and controlling conversion process. They can get help by using appropriate planning models to investigate and conclude that; in short-terms how the existing capacity can be used more effectively. Different tools can be used e.g. break even volumes, break even analysis, computer simulation and linear programming, decision trees for long term analysis. For determination of best location simple median model can also be used. [9].

6. RESOURCE UTILIZATION

An additional key objective of operating systems is to make use of means for the fulfillment of customer requirements efficiently, i.e., customer service must be offered along with the accomplishment of efficient operations through proficient use of resources, improper use of means or inappropriate customer service results in commercial collapse of an operating system [18].

Operational manager is focused primarily on the consumption of resources and methodologies that can reduce the waste products. The resources includes, time, space and money involved in that process. The measure indicates the maximum capability of resources. This is called the resource utilization objective. [10].

Another concern of operations management is the attainment of satisfactory customer service as well as resource utilization. Advancement in one usually give rise to declination in the other. Generally both of them are not likely maximized so an optimal performance is required in both goals. While doing all activities the operational manger must concentrate on these two objectives. If any conflict occurred the operation manager has to face many problems. So efforts must be made to balance these objectives.[10].

Table 1.3 sums up the parallel objectives of operations management. This kind of equality developed between and inside these essential objectives will be affected by market concerns, competition, the flaws and potential of the organization, etc. Hence, contribution must be made by the operations managers these objectives are set.

3.8 Benefits of Lean principles:

Lean manufacturing is a mind set to improve the production assembly which has developed many years ago[38]. It is a method to focus on the actual requirements of the customer to ensure that waste is not merged into your system. Several benefits of lean manufacturing are briefly discussed below.

1. Enhance customer service; provide the customers exactly what they want.

2. Improvement in productivity; Add per person. Improved flow and value

3. Quality improvement; Pre -manufacturing preventions to reduce errors and rework.

4. Innovation; totally implicated in order to improved spirit and contribution in society staff

5. Fewer waste; less travel, transport, waiting and physical waste.

6. Better delivery; faster Business and configurations, lesser delays.

7. Greater wind stock; less inventories and work in progress reducing fund requirements.

1.1

Chapter 4

Proposed Current lean technique (Obeya)

4.1 Introduction (Why Obeya Needs)

Development the Value Chain Analysis and lean principle (Obeya) of production management lead optimize to the manufacturing industries. After that, the industries easily utilized production capacity, inventories diversification, less dependency on raw material due to proper inventories levels and compete with the international manufacturers [34].

This removes the barriers that have been created with the time, in a certain way Obeya can be understood as a team spirit empowerment tool at an administrative level. During the product and process development, all individuals involved with the planning gather in a 'Large Room' to achieve fastest communication and shortest decision-making processes for Micro-management & production tracking issues [35]. The main issues facing and resolve by Obeya in production management are:

- Work order monitoring
- Micromanagement of all issues required
- Check on progress of production schedule
- Bottlenecks during production process
- Quality problems
- Defect percentage for parts
- Maintenance issues
- Raw material shortage … to name a few

4.2 Implementation Obeya in the case industry

Due to competition with internationally developed industries and global market, manufacturing and process Industries in developing countries are facing increasing competition. Small and medium industries sector has become much more vulnerable due to the pace of development. Similarly, the case-study industry had faced challenges. Major challenges faced by the industry include, but not limited to, Using old techniques, Quality problems, Raw material shortage, Work order monitoring, Longer Production time, Cost tied up on the factory floor, and less productivity. In the past 10 years, a number of small and medium fan industries have faced closure due to a number of reasons, in which thousands of their workers were made redundant [36]. Despite the fact, that many governments and non-governments organizations are active in addressing the issues faced by the industry, there is little tangible benefit achieved as most of the research only focuses on identifying the problem without providing the solution in a comprehensive manner. After that, PEFMA (Pakistan Electric Fan Manufacturers Association) invited us for apprising them about issues being confronted by the fan industry so that these issues could be resolved through academia-industry collaboration [36], [37].

For resolving production assembly issues, we implement Obeya in the sample industry, we set a room as the OBEYA room with Green board, coloured pins and threads mandatory but no chairs and tables are required. The concerning Supervisors / Managers of different departments meet once every week before two to three minutes of meeting fixed time at the OBEYA room and filled their departmental charts displayed in the green board by using the coloured pins.

4.3 Design Case industry sample Obeya Charts

For the sample ceiling fan industry, we developed the Obeya chart presented in table 2 according to their different departments like, finance, sales production planning and control, die casting, winding, armature and rotor, fitting, painting, packaging section and machining section. All Supervisors / Managers display their targets on the basis of their departmental charts.

The departmental charts are:

Four-Week Action Plan (OBEYA)										
(Supervisor Name) Department										
WEEKS	DAYS		Production Targets			Deficiencies				
							Issue 2			
			Proposed	Actual	Pending/Defective	Issue 1	Sub Issue 1	Sub Issue 2	Issue 3	Issue 4
Week 1	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 2	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 3	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 4	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								

Table 1: General Obeya Chart Format.

Four Week Action Plan (OBEYA)			
Department: Machining Department			
Deficiencies/Issues			
Men Power	***Raw Material***		***Maintenance***
	Quality	**Inventory**	

Table 2: Sample Obeya Colour Pins

There are three colors of pin can be used for filling the Obeya chart and the above coloured pin pivoted by the explanation in the chart, what are the deficiencies so that can't get the desired production. The Red colour shows that men powers is delayed & require extra time to achieve, yellow colour represents delayed but can be achieved within scheduled time and White colour illustrate the production as per schedule.

4.3.1 Machining Workshop

OBEYA										
(Mr. ABC) Machining Workshop										
WEEKS	DAYS		Production Targets			Deficiencies				
						Men Power	Raw Material		Maintenance	Electric Shortfall
			Proposed	Actual	Pending/Defective		Quality	Inventory		
Week 1	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 2	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 3	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 4	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								

Table 3: Machining department Obeya chart

4.3.2 Armature & Rotor Press Section

OBEYA									
(Mr. ABC) ARMATURE & ROTOR PRESS SECTION									
WEEKS	DAYS	Production Targets			Deficiencies				
		Proposed	Actual	Pending	Men Power	Raw Material Quality	Raw Material Inventory	Maintenance	Electric Shortfall
Week 1	Saturday								
	Monday								
	Wednesday								
Week 2	Saturday								
	Monday								
	Wednesday								
Week 3	Saturday								
	Monday								
	Wednesday								
Week 4	Saturday								
	Monday								
	Wednesday								

Table 4: Armature and rotor press department Obeya chart

4.3.3 Winding Section

OBEYA										
(Mr. ABC) WINDING SECTION										
WEEKS	DAYS		Production Targets			Deficiencies				
			Proposed	Actual	Pending/Defective	Men Power	Raw Material Quality	Raw Material Inventory	Mainten ance	Electric Shortfall
Week 1	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 2	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 3	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 4	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								

Table 5: Winding Department Obeya Chart

4.3.4 Motor Inspection Section

OBEYA										
(Mr. ABC) Motor Inspection Section										
WEEKS	DAYS	Production Targets			Deficiencies					
					Bearing Noise		Motor Watts		Not Switch on	
		Proposed	Actual	Pending	Low Quality	Unbalanse	Up	Short		
Week 1	Saturday									
	Monday									
	Wednesday									
Week 2	Saturday									
	Monday									
	Wednesday									
Week 3	Saturday									
	Monday									
	Wednesday									
Week 4	Saturday									
	Monday									
	Wednesday									

Table 6: Motor Inspection Department Obeya Chart.

4.3.5 Fitting Section

OBEYA																
(Mr. ABC) FITTING SECTION																
WEEKS	DAYS		Production Targets			Deficiencies										
						Body			Plate			Armature			Rottor	
			Proposed	Actual	Pending	Weight	Crack	Sizes not Properly	Weight	Crack	Sizes not Properly	Quantity	Short Circuit	Lead Connection	Angel	Unbalanse
Week 1	Saturday	Line 1														
		Line 2														
	Monday	Line 1														
		Line 2														
	Wednesday	Line 1														
		Line 2														
Week 2	Saturday	Line 1														
		Line 2														
	Monday	Line 1														
		Line 2														
	Wednesday	Line 1														
		Line 2														
Week 3	Saturday	Line 1														
		Line 2														
	Monday	Line 1														
		Line 2														
	Wednesday	Line 1														
		Line 2														
Week 4	Saturday	Line 1														
		Line 2														
	Monday	Line 1														
		Line 2														
	Wednesday	Line 1														
		Line 2														

Table 7: Fitting Department Obeya Chart.

4.3.6 Painting Section

OBEYA									
(Mr. ABC) Painting Section									
WEEKS	DAYS		Production Targets			Deficiencies			
			Proposed	Actual	Pending/Defective	Not Properly Dry	Men Power	Not Properly Paint	Maintenance
Week 1	Saturday	Body							
		Blade							
		Rod							
	Monday	Body							
		Blade							
		Rod							
	Wednesday	Body							
		Blade							
		Rod							
Week 2	Saturday	Body							
		Blade							
		Rod							
	Monday	Body							
		Blade							
		Rod							
	Wednesday	Body							
		Blade							
		Rod							
Week 3	Saturday	Body							
		Blade							
		Rod							
	Monday	Body							
		Blade							
		Rod							
	Wednesday	Body							
		Blade							
		Rod							
Week 4	Saturday	Body							
		Blade							
		Rod							
	Monday	Body							
		Blade							
		Rod							
	Wednesday	Body							
		Blade							
		Rod							

Table 8: Painting Section Obeya Chart.

4.3.7 Packing Department

OBEYA											
(Mr. ABC) Packing Section											
WEEKS	DAYS	Production Targets			Deficiencies						
		Proposed	Actual	Pending	Raw Material	Not Properly Paint	Watt	Thermopol	Packing Meterial Defective	Manpower
Week 1	Saturday									
	Monday									
	Wednesday									
Week 2	Saturday									
	Monday									
	Wednesday									
Week 3	Saturday									
	Monday									
	Wednesday									
Week 4	Saturday									
	Monday									
	Wednesday									

Table 9: Packing Department Obeya Chart.

4.3.8 Die Casting Department

OBEYA											
(Mr. ABC) DIE CASTING SECTION											
WEEKS	DAYS		Production Targets			Deficiencies					
						Men Power	Raw Material		Mainten ance	Electric/Gas Shortfall
			Proposed	Actual	Pending		Quality	Inventory		
Week 1	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 2	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 3	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								
Week 4	Saturday	Line 1								
		Line 2								
	Monday	Line 1								
		Line 2								
	Wednesday	Line 1								
		Line 2								

Table 10: Die Casting Department Obey Chart.

4.3.9 Production Plan & Control Department

OBEYA							
(Mr. ABC) PRODUCTION PLAN CONTROL SECTION							
WEEKS	DAYS	Production Targets			Deficiencies		
		Proposed	Actual	Pending	Store Department	Procurement Department	Engineering Depatment
Week 1	Saturday						
	Monday						
	Wednesday						
Week 2	Saturday						
	Monday						
	Wednesday						
Week 3	Saturday						
	Monday						
	Wednesday						
Week 4	Saturday						
	Monday						
	Wednesday						

Table 11: Production Plan & Control Department Obeya Chart

4.3.10 Sale Department

OBEYA								
(Mr. ABC) SALES SECTION								
WEEKS	DAYS	Sales/Production Targets			Deficiencies			
		Proposed	Actual	Pending	Availble Finish Product	Incomplete Product Parts	Return Defective Products	Order Cancil/change
Week 1	Saturday							
	Monday							
	Wednesday							
Week 2	Saturday							
	Monday							
	Wednesday							
Week 3	Saturday							
	Monday							
	Wednesday							
Week 4	Saturday							
	Monday							
	Wednesday							

Table 12: Sale Department Obeya Chart.

4.3.11 Finance Department

OBEYA										
(Mr. ABC) Finanace Department										
WEEKS	DAYS	Finanace Department								
		A/c Payables						A/c Reciveables		
		Daily Wages	Salaries	Petty Cash	Transportation Cost	Utility Bills	Miscellaneous Purchases	Dealer 1	Dealer 2	Dealer 3
Week 1	Saturday									
	Monday									
	Wednesday									
Week 2	Saturday									
	Monday									
	Wednesday									
Week 3	Saturday									
	Monday									
	Wednesday									
Week 4	Saturday									
	Monday									
	Wednesday									

Table 13: Finance Department Obeya Chart.

4.3.12 Case Industry Combine Departments

Four-Week Action Plan (OBEYA)																													
WEEKS	DAYS	Production Targets			Departments																								
					Machining Workshop				Fitting Section							Motor Inspection Section					Painting Section				Packing Section				
					Deficiencies				Deficiencies							Deficiencies					deficiencies				Deficiencies				
					Men Power	Raw Material		Maintenance	Body		Plate		Armature		Rottor	Bearing Noise		Motor Watts		Not Switch on	Not Properly Dry	Men Power	Not Properly Paint	Maintenance	Connector	Not Properly Paint	Capacitor	Thermopol	Packing Damage
		Proposed	Actual	Pending		Quality	Inventory		Crack	Sizes not Properly	Crack	Sizes not Properly	Short Circuit	Lead Connection	Unbalanse	Low Quality	Unbalanse	Up	Down										
Week 1	Sunday																												
	Tuesday																												
	Thursday																												
Week 2	Sunday																												
	Tuesday																												
	Thursday																												
Week 3	Sunday																												
	Tuesday																												
	Thursday																												
Week 4	Saturday																												
	Monday																												
	Wednesday																												

Table 14: Ceiling Fan Departments Obeya Chart.

Chapter 5

Statistical process Control

5.1 Introduction

Statistical process Control (SPC) is a widely used method to measure and control manufacturing processes. SPC is defined as "the application of statistical technique to control a process. "SPC is sub-area of Statistical Quality Control (SQC), it refers to the use of statistical methods in the monitoring and maintaining of the quality of products and services [31].

5.1.2 Why SPC is used?

In earlier years of the century, inspection was the only method to check the quality of products. Inspection was done by checking final product or service quality. But this method was not reliable and efficient in terms of time and money. Furthermore, this type of quality control is reactive[31]. It means that faulty products are manufactured before it is found and so increase scrapping and reworking cost. Hiring people and importing equipment just to separate good and bad ones is not a good idea it engages company time and add no value to productivity. Inspection neither tells the cause of error nor any remedy for that. To resolve this problem, some measures must be taken in order to prevent errors to go in production phase rather they must be detected at operational phase so the product of desirable quality can be achieved. Such method based on statistical method (known as SPC). This method is used to check, control, examine and perk up performance by sequentially remove assignable variation in process.

As previously stated SPC is used to check and control variation. Variation is the enemy of quality. Variation can be of two types i.e. "Common Cause" and "Assignable Cause". Every product is unique because of minor difference in materials, worker, tools and other factors. These are called random or common source of variation. We cannot identify and avoid such type variations. Common cause variation can be defined as “Variation due to minute difference in processing and inherent in process itself". In a process if only this type of variation exists then the process is statistically controlled[30].

The other type of variation that can be encountered is when the cause is identifiable and removable. These are termed as "Assignable Cause" of variation. These types of variations are caused by substandard row material, a worker need to be trained or equipment needs to be repaired. In short “the variation in a process that might be identified and removed is called assignable cause of variation". If in a process this type of variation exists the process is out of control.

There are numerous reasons why companies use SPC. Usually company’s starts employ control charts and other SPC techniques to decrease variation and to enhance manufacturing processes. Occasionally companies employ SPC to satisfy customer demand or to meet certification requirements[31].

5.1.3 Where SPC is used?

SPC can be used when there is mass production of similar items. It is not the purpose of SPC to eliminate variations as it is impossible to eliminate variation from any process. The core purpose of using this process is to bind the variation between the permissible tolerances. If we take an example of paint manufacturing company when the paint is filled in the bucket it is not possible to fill every bucket with exactly same amount of paint but on the other hand too much paint in a bucket is uneconomical and too little paint will leads to customer complaint at this stage SPC plays its role it warns when process mean has moved away from the target. Another purpose is to give warning when object variability has increased [30].

5.2 Statistical Process Control

Statistical Process Control is a methodical decision making tool that lets you observe when a process is running properly and when it is not. Variation is present in every process. To make a decision when the variation is natural and when it requires correction is the key to quality control. For Consistent quality characteristics, specification limits are usually used. If an item falls in these specification limits it is considered as 'OK' otherwise 'NOT OK' debatably control chart is the most successful tool for SPC, Control Chart was developed by Walter Shewhart in the early 1920s.

5.2.1. Six Sigma

It is a set of methodologies and tools for process improvement, While using six sigma, goal of process are set in PPM (parts per million) in all sectors of production process. If an organization is tend to achieve it, simply means that they are striving to attain near perfection in their production. To achieve six sigma, there must not be more than 3.4 defected PPM. It has following two methodologies:

- **DMAIC:** is an abbreviation of define measure, analyze, improve and control is a data-driven quality technique to improve processes. This scheme is used to enhance an existing process.
- **DMADV:** is an abbreviation of Define, Measure, Analyze, Design, Verify is a data-driven quality technique to design products & processes. This scheme is used to develop new product or process designs to make its performance more predictable, established and free of defect.

The six sigma quality process depends majorly on statistical analysis and statistical process control (SPC) for quality improvement. Six sigma can be measured through control charts process capability index and process performance index.

5.2.2 Control Chart

In all manufacturing processes, we need to know that up to which level the products meet the required specifications. There are two "enemies" of product quality:

- divergences from target specifications
- too much variability around target specifications

Control Charts are used to periodically monitor the quality. Control chart is basically a graph that represents data and its variation with time. There are several types of control charts. An X-bar (average chart) is a chart used to confirm that if a process is stable and in control.

Average Chart

The X-bar chart represents data and its variation with respect to time. Average chart consists of a centre line that represents the average value, upper and lower specification limits line, upper and lower control limit line and data line [31].

Average Line

In a set of data average represents the middle value. More specifically it is mode median or most commonly mean of the data. Mean can easily be calculated by summing up all the values and then by dividing it by the number of values. Line representing this mean value is called average line.

Specification Limits

Specification limits are external limits usually given by the costumers. Products falling outside of this specification are rejected. It can also be referred as the tolerance. It is job of manufacturer to come up with process that can meet these specification limits. Specifications define the allowable deviation from target or nominal. Specification limits are bilateral limits[31].

Control Limits

Unlike specification limits control limits depend on the distribution of data. Control limits are affected by the past performance. It tells us about process variability produced in past, with an alert of unusual change in order to adjust the process in desired manner. Control limits are narrow limits but still it is possible that a process is in control while not be able to meet specification. Control limits demonstrate the capability of a process (voice of process) while specification limits tell the required behaviour of the process (voice of costumer).

$$UCL = CL + 3\sigma$$

$$LCL = CL - 3\sigma$$

Mean: Mean is the average value of a set of numbers

$$X = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Standard Deviation (σ): A quantity representing the extent to which the members of a group diverge from the mean value for the group.

$$\sigma = \sqrt{\frac{\Sigma(X - \bar{X})^2}{(n-1)}}$$

Range (R)

The difference between the smallest and largest value in a set of data

$R = Max(A) - Min(A)$

Example:

We take the average percentile productions 48.2, 47.6, 47, 46.6, 47.4, 46.4, 48 and 47.6 of eight days and Ranges are 2, 4, 2, 3, 2, 3, 2, 1. Find mean, Range Bar, standard deviation, upper control limit and lower control limit.

$$\textbf{Mean} = X = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{1}{8}(48.2 + 47.6 + 47 + 46.6 + 47.4 + 46.4 + 48 + 47.6)$$
$$= 47.35$$

$\textbf{Mean} = \textbf{47.35}$

Standard deviation:

$\text{standard deviation} = \sigma = \sqrt{\frac{\Sigma(X-\bar{X})^2}{(n-1)}} = 0.6392$

Range Bar

$$\bar{R} = \frac{\sum_{i=1}^{n} R_i}{n}$$

$$\bar{R} = \frac{2 + 4 + 2 + 3 + 2 + 3 + 2 + 1}{8}$$

$\bar{\boldsymbol{R}} = \textbf{2.375}$

Upper Control Limit

$UCL = CL + 3\sigma = \bar{\bar{X}} + A_2 \times \bar{R} = 47.35 + (0.577)2.375 = 48.72$

$\textbf{UCL} = \textbf{48.72}$

Lower Control Limit

$LCL = CL - 3\sigma = \overline{X} - A_2 \times \overline{R} = 47.35 - (0.577)2.375 = 45.98$

$\mathbf{LCL = 45.98}$

5.3 SPC Methodology

Following flow chart represents the step by step procedures involved in SPC

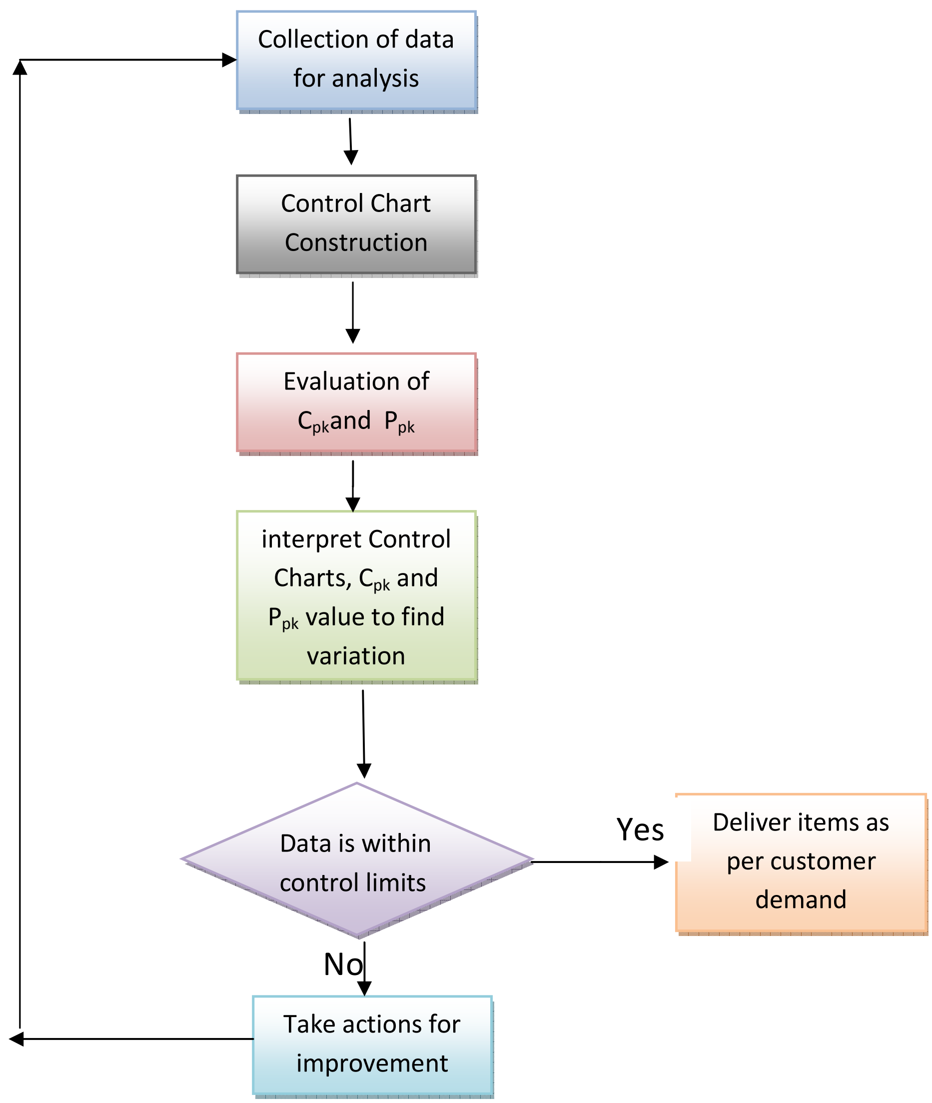

Figure 8: SPC Methodology

Chapter 6

Implementations Obeya &SPC

6.1 Implementing Obeya

For the sample ceiling fan industry, we developed the OBEYA chart presented in table 2 according to their different departments like, Finance, Sales Production Planning and Control, Die Casting, Winding, Armature and Rotor, Fitting, Painting, Packaging Section and machining section. One of the departments' deficiencies were highlighted in table 3. After Obeya implementation in the sample industry we reach to the findings and Targets shown in table 4.

Table 15: Findings and Targets

6.2 SPC Implementations

Nowadays purchaser market is experiencing increasing demand for better products and services more than ever before. Customers are looking forward for constantly improved quality products and services even when they pay less for them than the earlier purchase prices. Quality is therefore a significant aspect for any company to uphold competitiveness. In the last half-century, quality and its management have grown to what is now known as total quality management (TQM). Following are the few examples of the implementation of SPC [31].

1. Doctors and nurses depend on monitors to record heart beat, oxygen, and other factor in their patients. These monitors give alarm when the gauge reading fall below or above specific levels. Similarly, statistical process control (SPC) can monitor the state of patient's health [31].
2. SPC can be used to maintain the quality of products where consistent quantities have to be maintained throughout productions for example, automotive parts manufacturing company, electrical appliances like fan, air conditioner, mobile phones etc manufacturing company [31].
3. Statistical process control can help stakeholders of diverse businesses like restaurant, hospitals, banks etc. to manage or change system for improvement of service. The data for SPC can be obtained by getting feedback from costumer [31].

Following are the advantages of using SPC

- Minimize the waste of effort and cost
- Improvement in process
- increase efficiency and effectiveness
- Consistent output
- Assist operator for taking any action
- Avoid unpredictable scenario
- No need to learn special language to interpret the results of SPC
- Special and common cause variation can be distinguished using control charts
- Reduce variation, quality costs and effort for inspection, scraping and reworking
- Reduce customer complaints and improve the reputation of the company.

Organizations take advantages from statistical process control by getting an organized method to monitor and evaluate the variation of process. Usually, the problem is not identified by in charge before going in production phase or in customer's hand. SPC helps in identification of potential problem and evaluation of the outcomes of process in order to improve the process control. In this way organizations can make use of their time, money and attention more efficiently[31].

(SPC) statistical process control is a technique to control variation. This technique is applied on a fan producing company to identify the improvement caused by OBEYA by comparing daily production of fans of different models before and after application of OBAYA lean technique. We collected Targeted and actual production data of 5 different models (fan brands) for implementing SPC. The data is in percentage. The fan brands denotes as A, B, C, D and E

Days		1	2	3	4	5	6	7	8
Models (Fan Brands)	A	47	46	48	45	48	45	47	48
	B	49	48	46	46	48	47	49	48
	C	48	47	48	47	47	46	48	48
	D	49	50	46	48	46	48	49	47
	E	48	47	47	47	48	46	47	47

Table 16: SPC before Implementing Obeya

X-bar (average) and R (range) chart is couple of control charts used to confirm that if a process is stable and in control. Different parameters are required to produce average chart and range chart:

Days		1	2	3	4	5	6	7	8
Models	A	47	46	48	45	48	45	47	48
	B	49	48	46	46	48	47	49	48
	C	48	47	48	47	47	46	48	48
	D	49	50	46	48	46	48	49	47
	E	48	47	47	47	48	46	47	47
SUM		241	238	235	233	237	232	240	238
AVG		48.2	47.6	47	46.6	47.4	46.4	48	47.6
RANGE		2	4	2	3	2	3	2	1

Table 17: SPC After Implementing Obeya

Chapter 7

Results and Discussions

7.1 Results Analysis

After one month Obeya implementation, we can easily figure out departmental deficiencies and bottlenecks points. The extended problematic areas are illustrated in red circles and intermediate problems defined as yellow circles. The first week production targets are going to pending phase due to machining workshop. Machining workshop has less production because it faced twice manpower issues and once maintenance problem. Similarly by studying Obeya chart, we developed a comparison deficiencies chart by calculating extended departmental deficiencies. Departments have a competitive edge by increasing production efficiency through identification and elimination of departmental deficiencies. 26 to 30 percent of production increases as illustrate in SPC charts.

7.1.1 SPC Results

These parameters are evaluated using their formulas.

MEAN	47.35	$\bar{\bar{R}}$	2.375	USL	50	LSL	45

UCL	48.72038	LCL	45.97963	UCLr	5.02075

Using these values control and range chars are produced

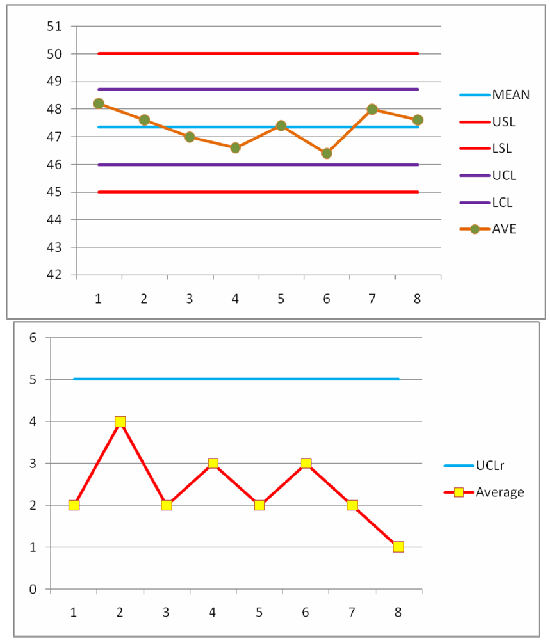

Figure 9: Obeya Charts Before Implementing Obeya

Two other parameters can also be calculated from these values i.e. CP_k and Pp_k

Cpk	0.767172	Ppk	1.225498

C_P/C_{Pk}: Process capability (C_P) simply refers to the capability of a process. Process capability index (C_{Pk}) is an index or a number that tells the degree to which a process meets the specification limits

$P_p/P_{pk:}$ Process Performance (Pp) indicates the performance of the process. Process performance index (P_{pk}) is adjustment of Pp for the effect of non cantered distribution.

Similarly we apply SPC on the same fan manufacturing company after implementation of OBAYA and get the following results:

Cpk	1.192821	Ppk	1.94878

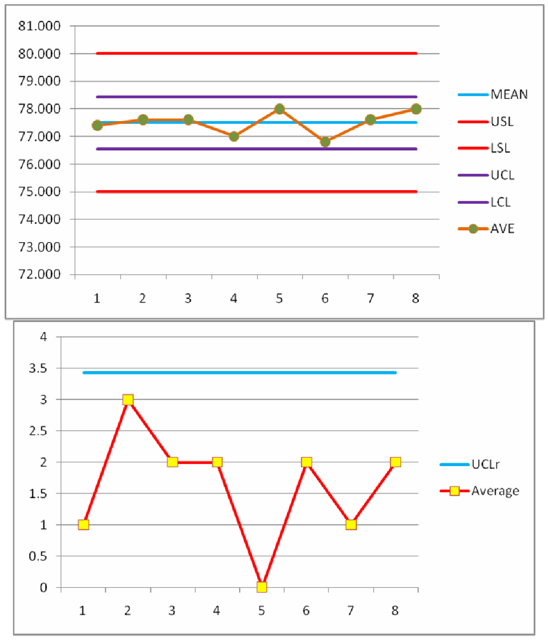

Figure 10: Obeya Charts After Implementing Obeya

These results show how OBEYA incredibly improved the performance of an industry.

1- At first place we notice that after the implementation of OBEYA the industry is capable of producing more parts.
2- Graphs are more converged it shows that now the system is controlled.
3- After using OBEYA the range of graph is decreased: now the system has less variation.

Fitting section faced extended problems 8 times; painting section 7, machining section 5,

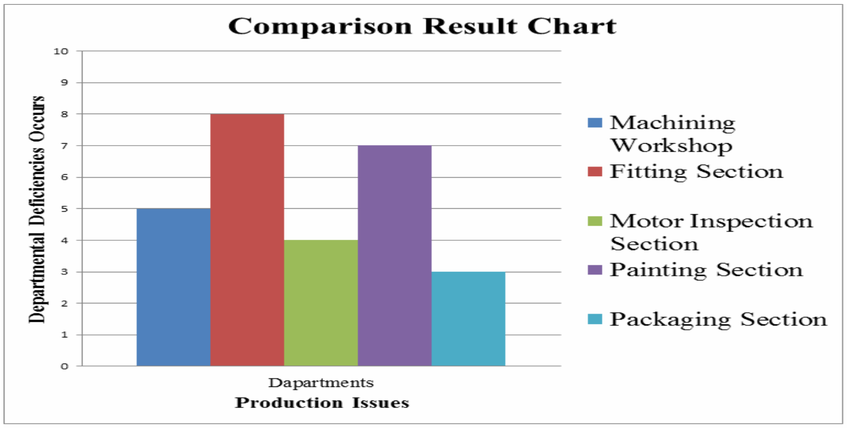

Figure 11: Comparison Result Chart

Motor inspection section 4 and packaging section faced least extensive problems i.e. 3, which can be seen in figure 4

First day proposed production target was 400 parts, out of which 324 were actually produced while 76 were pending and accumulated in the production plan for the next day. The first day Production efficiency was, therefore, 81%. Actual Production efficiency steadily increased over the month and pending production targets gradually decreased. On the last day of the month, proposed production target was set for 465 fans, out of which 421 were produced, leaving only 44 fans pending for the next working day at an efficiency of 90%. Previously low production efficiency i.e. 81% was recorded mainly due to high rejection rates, bottleneck points and lack of storage utilization in work process. Work in process storage utilization have controlled efficiently in the manufacturing industry by using the Lean management technique [12]. After one month of Obeya implementation the production efficiency increased to 90% through rectification of aforementioned problems; illustrated in figure 5. The chart below highlights changes in various criteria for measuring production efficiency through implementation of Obeya.

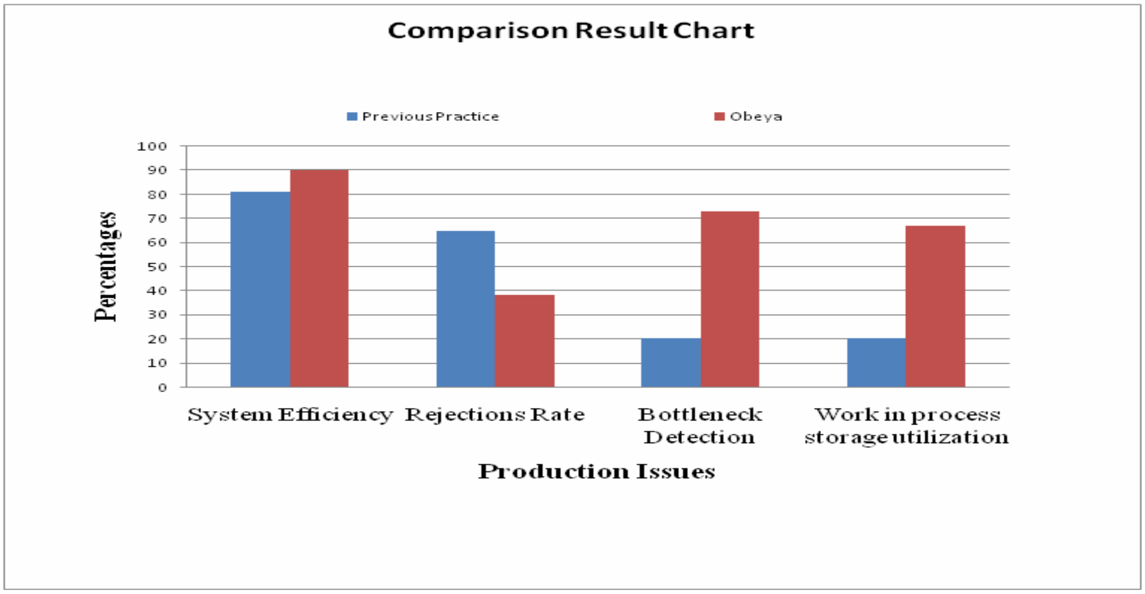

Figure 12: Comparison Chart After implementing OBEYA

Chapter 8

Conclusion

OBEYA is a very simple tool with considerable benefits for SMEs. Industrial growth leads to a stage where micro-management of production processes directly becomes impossible for managers. This is mostly due to time spent on coordinating growing departments on inter-dependent projects or processes. OBEYA offers a simple solution to detailed meetings every day. Production process management is simplified by quick identification of problem areas on the production floor and rapid decision making to address the issues. The implementation of OBEYA in the case study organization has resulted in excellent results. The practice can be adopted across small and medium industries with slight modifications offering similar outcomes. Production costs in the case study organization were brought down by 9% after one month of OBEYA implementation. The improvement was a result of bottleneck processes management and reduction in waiting times.

Chapter 9

Future Recommendations

OBEYA has been implemented in some industries in a digitalized manner hence increasing its capabilities even further. This modification has been coined as OBEYA. PSA Peugeot Citron has implemented iOBEYA to some of its operations with excellent results. Further studies can be conducted on customizing the techniques for implementation in SMEs. Smart iOBEYA would enable enhanced flexibility and visualization of production floor activities hence further simplifying decision making process with focuses on problem identification.

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Appendices

Appendix A: Tabular Values

Tabular values for X-bar and range charts

Subgroup Size	A_2	d_2	D_3	D_4
2	1.880	1.128	-----	3.268
3	1.023	1.693	-----	2.574
4	0.729	2.059	-----	2.282
5	0.577	2.326	-----	2.114
6	0.483	2.534	-----	2.004
7	0.419	2.704	0.076	1.924
8	0.373	2.847	0.136	1.864
9	0.337	2.970	0.184	1.816
10	0.308	3.078	0.223	1.777
11	0.285	3.173	0.256	1.744
12	0.266	3.258	0.283	1.717
13	0.249	3.336	0.307	1.693
14	0.235	3.407	0.328	1.672
15	0.223	3.472	0.347	1.653

X-bar

$$\bar{X} = \frac{\sum (X_1 \ldots X_n)}{n}$$

n is the number of observations

$$\bar{\bar{X}} = \frac{\sum (\bar{X}_1 \ldots \bar{X}_k)}{k}$$

k is the number of subgroups

Upper control limit:

$$UCL_x = \bar{\bar{X}} + A_2 * \bar{R}$$

Lower control limit:

$$LCL_x = \bar{\bar{X}} - A_2 * \bar{R}$$

Appendix B: Constants used in the design of control charts for mean

Sample size (n)	Hartley's Constant ($(d)_n$ or d_2)	Constants for mean charts using					
		Sample standard deviation		Sample range		Average sample standard deviation	
		A_1	$2/3 A_1$	A_2	$2/3 A_2$	A_3	$2/3 A_3$
2	1.128	2.12	1.41	1.88	1.25	2.66	1.77
3	1.693	1.73	1.15	1.02	0.68	1.95	1.30
4	2.059	1.50	1.00	0.73	0.49	1.63	1.09
5	2.326	1.34	0.89	0.58	0.39	1.43	0.95
6	2.534	1.20	0.82	0.48	0.32	1.29	0.86
7	2.704	1.13	0.76	0.42	0.28	1.18	0.79
8	2.847	1.06	0.71	0.37	0.25	1.10	0.73
9	2.970	1.00	0.67	0.34	0.20	1.03	0.69
10	3.078	0.95	0.63	0.31	0.21	0.98	0.65
11	3.173	0.90	0.60	0.29	0.19	0.93	0.62
12	3.258	0.87	0.58	0.27	0.18	0.89	0.59

Formulae

$$\sigma = \sqrt{\frac{\Sigma(X - \bar{X})^2}{(n-1)}}$$

Appendix C: Constants used in design of control charts for median and range

Sample size (n)	Constants for median charts A_4	$2/3\ A_4$	Constants for range charts $D^{m}_{.001}$	$D^{m}_{.025}$
2	2.22	1.48	3.98	2.53
3	1.27	0.84	2.83	1.79
4	0.83	0.55	2.45	1.55
5	0.71	0.47	2.24	1.42
6	0.56	0.37	2.12	1.34
7	0.52	0.35	2.03	1.29
8	0.44	0.29	1.96	1.24
9	0.42	0.28	1.91	1.21
10	0.37	0.25	1.88	1.18

Appendix D: Sampling sizes

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TABLE I — Sample size code letters

TABLE II-A — Single sampling plans for normal inspection (Master table)

Lot or batch size	General inspection levels I	Level Normally Used II	III	Sample size code letter	Sample size	Acceptable Quality Levels (normal inspection) 0.010 Ac Re	0.015 Ac Re	0.025 Ac Re	0.040 Ac Re	0.065 Ac Re	0.10 Ac Re	0.15 Ac Re	0.25 Ac Re	0.40 Ac Re	0.65 Ac Re	1.0 Ac Re	1.5 Ac Re	2.5 Ac Re	4.0 Ac Re	6.5 Ac Re	10 Ac Re	15 Ac Re	25 Ac Re
2 to 8	A	A	B	A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2
9 to 15	A	B	C	B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3
16 to 25	B	C	D	C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4
26 to 50	C	D	E	D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6
51 to 90	C	E	F	E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8
91 to 150	D	F	G	F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11
151 to 280	E	G	H	G	32	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15
281 to 500	F	H	J	H	50	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22
501 to 1200	G	J	K	J	80	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑
1201 to 3200	H	K	L	K	125	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑
3201 to 10000	J	L	M	L	200	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑
10001 to 35000	K	M	N	M	315	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑
35001 to 150000	L	N	P	N	500	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑
150001 to 500000	M	P	Q	P	800	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑
500001 and over	N	Q	R	Q	1250	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑
				R	2000	↑	↑	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑

Ac — Acceptance number.
Re — Rejection number.

↓ Use first sampling plan below arrow. If sample size equals, or exceeds, lot or batch size, do 100 percent inspection.

↑ Use first sampling plan above arrow.