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ANALYSIS AND IMPROVEMENT OF CURRENT MANUFACTURING FLOW AND CAPACITY OF TN ITALY PRODUCTION CHANNEL AA

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ABSTRACT

In this digital age, the company's competitiveness can be improved by optimizing production processes. However, successful introduction of new process adaption is difficult to achieve, the failure rate of new process is considerable, and it also involves high costs for the company. Therefore, the analysis and improvement of current production processes of steel ball bearing is necessary. Process engineering and planning is the determination of the manufacturing principles and operations required to produce a product on an industrial scale. In this paper, an approach for a clean and organized production line using pull system approach is presented. The steps include a needs demand analysis, a bottleneck analysis, and a time study using a representation of manual operations based on the development of SAP in the Manufacturing Execution System (MES). This study centred about the process engineering and scheduling optimization using theoretically available data and based on virtual methods are addressed in this work. Here, CHANNEL AA production line is considered and an attempt is made to apply various methods to improve the line.

Keywords: product and process design, demand and bottleneck analysis, SAP, time study, cost analysis

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CHAPTER 1 -INTRODUCTION

Thesis Objective and Structure

Most of the technological equipment that we use in our everyday life contain mechanical component like ball bearing, here the production of steel balls whose job is to reduce friction between components which have a relative movement and therefore reduce the energy needed for the movement. The industrial production of the ball, a rolling component that is very simple theory and that can be geometrically described by sole value of quality which is produced at the end.

The aim of this paper is to produce a study on the key principle of lean manufacturing with an emphasis on lean thinking approach. The paper systematically categories the related literature of various studies, analyses and finally reviews it methodologically. When it comes about the manufacturing, based lean strategies, similar numerous improvement approaches, can be a tool to support and create synergy for inducing a more competitive market among companies.

This paper presents practical steps to improve the quality of the work process in production, mainly focusing on pull system methods. At each step in the production process, in analysing the bottleneck conditions and in adapting to new system applications and products in data processing (SAP), the aim of the work was too deeply understanding the production process and the problem definition with the process to emphasize the need and changes that can be adapted.

The report is structured to give an insight into the knowledge on the topics of this work that summarises the main process aspects applied in each step of the new SAP and reflects on how each of these steps directly or indirectly affects the production process.

and later to explore the application of management of the production line that we have learned in our case study "Analysis and improvement of current production flow and capacity" in a production line.

CHAPTER 2 -THEORETICAL BACKGROUND

The introductory chapter provides knowledge of the concepts associated with the work. After a basic introduction to many aspects of product/process development, design for assembly and work measurement methods, the chapter also aims to explain the work and structure of this thesis.

The production had advantages and disadvantages on their own, the very main concern was that the production was completely filled with too many variants of same steel ball type. We would be able to see that the number of man power under going, simultaneously investing their time to plan and produce each variant were numerous and become a huge factor to handle the variant by the operators working on the production, kept on discussing about the variant to produce rather producing the perfect quality. The organising for each variant of same type was so relevant and can be eliminated using the proper approach using both pull system, i.e., analyse all the factors related to demand and bottleneck and dedicate machine for each variant was necessary and proposed SAP code without disturbing or losing the variants in the database. Of course, the reducing variants and managing the variants costs less and proven below in the study. Only the main concern was to build management of the production line and it is the main priority and concern of this project.

Product/Process Development

The key elements of steel ball bearing process engineering are process design, process control, process operations. Thus, designers must be able to communicate, visualize, analyze product behaviour, and develop tangible and viable products suitable for the industry 4.0 era.

The rapid development of science and technological department the following main obligation on a controlling and highly well-organized production, it must be ready and able to stop the production of its previous, well-known product at any time and without losses, and to switch to the production of any large batch of a new type of product within a short period of time.

Process Design of steel balls

In this phase the designer's study in detail the causes and investigates the consequence on the product, on the process and the context, afterwards, against an estimate focused on widespread on the basis of environmental, economic, and productive quality opportunities, it was possible to identify the design guide lines with the following experimental tests and corrections that are oriented at production.

Process Control of steel balls

In order to control the quality of production with automatic devices the ball has to be perfectly clean with a brilliant surface without any halo and obviously dry. The quality controls are done by an electrical that checks the superficial and structural qualities with an optical and inductive control.

The optical control that checks the superficial qualities is particularly critical, this test is done with spot laser that reflecting on the surface of ball, is returned to feeler, a discontinuity on surface causes a percentage drop of light reflected which determines the discarding of the ball. The check can be invalidated by the presence of impurities inside the area that is controlled by the spot laser.

Process Operations of steel balls

The production of the steel ball in plant is organised in channels each meant as a totally independent production in the plant. Each channel treats all the phases of production of specific kind of balls, the process is carried out in lots that are undivided during the process and until they are ready to be sold.

Pressing

The rod unrolled and introduced in the press where the undeveloped ball is born. The rod is sheared and cold-headed. The material, transformed in steel cylinder, is deformed by the caps of press-forging die that print a shape that is similar to ball This process uses whole mineral oil as auxiliary material for lubrication of press.

Grinding

Most of the allowance is removed during this phase thanks to pressure developed on each ball by the cast iron wheel. This operation is done with the help of lubricant and cooling liquid mainly composed by water by little quantities of emulsifying oils.

Heat Treatment

In this phase the ball is given its optimum hardness. The ball is washed in water and dried with air at 65 degree and then sent to main treatment consisting in two phases, the austenite phase in which the ball is heated at about 900 degrees in power supply oven and tempering in which the ball is rapidly cooled in paraffin mineral oil at 60 degrees. After a washing in water to remove the hardening oil and drying at 65 degrees, the ball is subject to a tempering at 160 degrees.

Peening

This operation is useful to define hardness of the ball. The balls are introduced in machine that creates with cyclic movement reciprocate collisions that confer a higher superficial hardness.

Prefinishing

The surface of the ball is smoothed by a bakelite wheel containing abrasive silindum, this phase whole mineral oil is used.

Pull System in the Production Line

Here complete production of steel ball bearings follows a Kanban controlled pull system, aims for the togetherness with other major conceptual changes in overall manufacturing strategy, have resulted in striking improvements for order points/ order quantity and base stock. Company tries targeting the areas in implementing and operating pull system on three aspects one the identification of flow line problems. Here the production process has to be comfortable stream-lined layout, that requires simultaneous consideration of all the resources like machine or transport and products, at the end it is achieve flow lines operating around product families with good level of utilization but with a minimal extra investment. Secondly, Flowline loading problem, which involves the allocation of viable amount of work to each flowline in periods of typically a shift, in order to avoid bottlenecks developing. Lastly, Operational control problem, which includes implementing the Kanban system to control the interaction between production and inventory level. The Kanban is used to signal the need for replacing or refilling materials necessary for production. There are a variety of ways that the signal can be sent. Actual cards, accompany goods though the production process can be used to keep track of current inventory. However, something as simple as the arrival of an empty container at an upstream processing station is a clear signal that the parts that were in the container have been used and more are needed. Kanban can be used in manufacturing systems where the product is manufactured to the pull of market demand. A Kanban card here used to identify production of part(s) to replenish in-house inventories, a withdrawal of product for shipment to a customer, or to signal the replacement of raw materials and components. The major aim is to determine the desirable number of Kanban's to be used in typical manufacturing systems which includes factors such as machine reliability and demand.

Pull system approves the release of work based on system status. A pull system releases a job only when a signal generated by a change in system status requires it. If an operator comes from a downstream process and retrieves work from an upstream process, but does so on an exogenous schedule, then it is a push process. If an operator from an upstream process delivers work to the downstream process, but does so in response to status changes in the downstream process, then it is a pull [2].

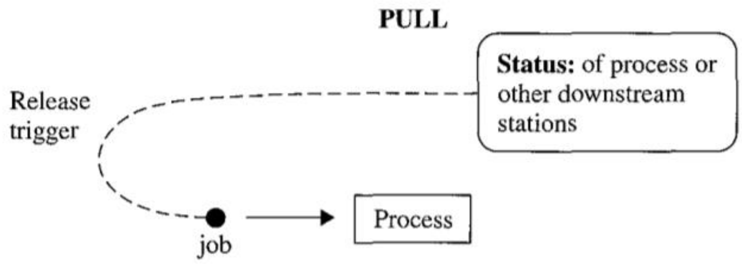


Figure 1, Release trigger in pull system

The success of several well-known Japanese companies in the 1980s was the result of a variety of practises ranging from arms reduction to quality control to rapid product introduction. Moreover, these companies operated in a cultural, geographic and economic environment very different from that in America [2].

At the micro level, this was achieved through an effective production control system that enabled low-cost production by promoting high throughput, low inventory and little rework. It promoted high external quality by producing high internal quality. It enabled good customer service by maintaining a steady, predictable flow of production. And it made it possible to respond to a changing demand profile by being flexible enough to accommodate changes in the product mix (as long as they were not too rapid or too pronounced).

Time study and methods of work measurement

The study of methods at the ball bearing firm consists of examining the systems used or usable to perform a particular task in order to find the best way to perform the task. The main objectives of the study of methods are: to find the simplest solution and improve productivity, to achieve the same result at a lower cost or to improve the result at the same cost. The study requires a systematic and precise application according to general and specific procedures for each individual reality, company, technology and product. The ways to achieve these objectives can be traced back as follows:

1. Improve product design
2. use the factors of production more effectively
3. making full use of technical capabilities
4. Improving the layout of departments and workplaces

Eliminating unnecessary steps to make work easier and less tiring, developing better physical working conditions.

The measurement of work consists to determining the time required for carrying out a given job with an adequate level of efficiency, by an employee who has passed the training phase for the job and the specific activity.

The two areas, study of the methods working times, are closely connected: the study of methods concerns the search for the optimal content of work in an operation, the study of times concerns the determination of the standard time to perform the operation on the basis of the content established through the study of the method. A correct analysis of the work foresees in succession the study of the method and the consequent measurement of the predetermined working times under predetermined conditions. The techniques used are mainly of two types:

1. **Direct survey:** field assessment of the organizational situation with timekeeping or the use of normalized elements such as Predetermined

Standard Times techniques (MTM, TMC, MTM2, TMC 2, UAS etc.).

2. **Estimation:** forecast of the organizational situation of the reference work for new products or for situations not yet implemented with the most suitable techniques (company tables, estimates, micro-movements of predetermined standard times, etc.)

In the operational application it is necessary to use one of the work measurement techniques in order to proceed with an organic study of the methods. For example:

1. a study of importance analysis of the single methodological operations cannot ignore the analysis of the phases with greater content with potential greater opportunities;
2. a comparison study for alternative methods cannot fail to analyze the different time of each single phase.

CHAPTER 3 - DEMAND ANALYSIS

The effectiveness of any production control system is largely determined by the environment in which it operates. A simple assembly line can work well with very simple planning tools, while a complex job shop can be a management nightmare even with very sophisticated tools.

Needs assessment is important in two ways:

1. it provides a framework for analysing prices and other influences on sales of the company's products, and
2. it provides a basis for pricing products and marketing in general, and for predicting and influencing demand.

The ultimate purpose of a manufacturing plant is not to make life easy for managers, but to make money by satisfying customers. As customers change their minds, ask for favours, etc., the reality in almost every production environment is that sometimes emergencies arise and therefore some orders need to be treated specially.

This means that customer orders cannot be passed on to the factory in the random order in which they are received. Rather, they must be collected and grouped in such a way that the factory's workload remains reasonably constant. The challenge of the demand management module is to balance the concern for factory stability with the desire for reliable customer service and short, competitive due date quotes is the challenge of the demand management module.

The principal goal of performing demand analysis in an organisation is to foreknown the future of the production quantity and for inventory management in order to balance the conflict of not wanting to hold too much stock thereby tie up capital and the desire to make items or goods available when and where required as to avert the cost of not meeting such requirement [5].

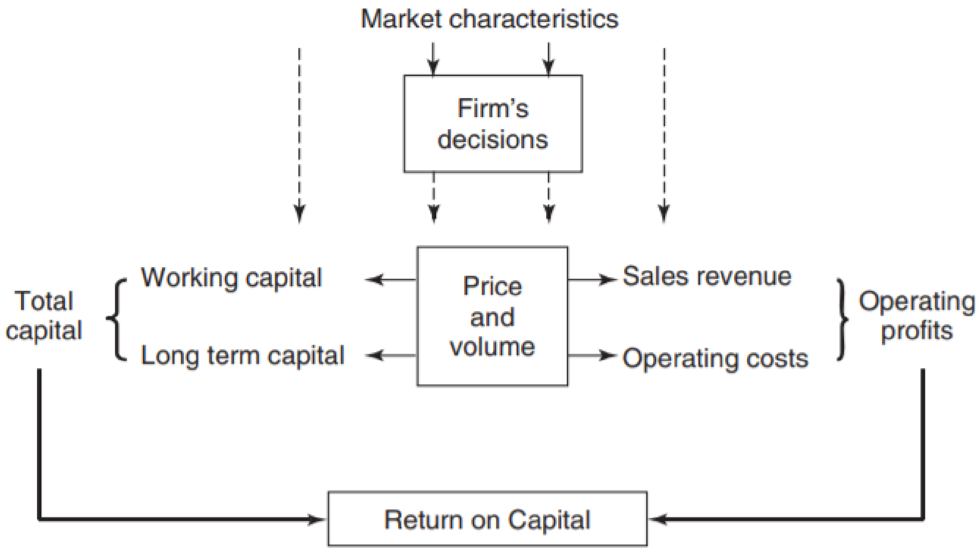


Figure 2, Demand management module

Forecasting ensures that the problems of over production or under production of quantity of goods in an industry at right time will be handled and eliminated of forecasting can cause business failure [4].

Furthermore, the application of demand study is very essential for effective management and can make significant contribution to a business profit as well as increase its return on total assets. It is thus the management of the future production at right time and the right proportion. The reason for greater attention to forecasting it helps industry to understand whether the future is profitable or not, and also the appropriate quantity of goods necessary to produce or stock over future time. Fundamentally, it coordinates the activities of production planning and control in manufacturing industry.

The literature review shows that there are about 30 basic methos that help to predict future sales, many of them with subtypes [6]. The purpose of demand planning is to improve decisions that affect demand accuracy [7]. Its main task is calculated future demand, and it comprises the selection of a specific forecasting method and its parameters [9].

The Research method, used in this work is a quantitative research approach, data collection and analysis, the gathered data on the bases on below mentioned categories are the daily record of steel balls production over the years. The method used was time series technique to model for the quantity of steel (which variant sizes) to be produced in the industry using predictive tools namely: excel tool for development of the model and forecasting of the results. Here the data analysis, some groups of data were analysed using the forecasting model to predict the actual quantity needed to be produced in each of the variants of steel balls over the month in the manufacturing industry.

Selection of the Type of Production

The concept of dedicating machine for particular variant of product can be done through perma and flexi, which should be implied in the factory in order to optimise the work in a proper way and keep the line in balance. Perma means to dedicate the whole line to produce single variant, usually selected the highest demand target we have on the forecast, where Flexi means production line can produce or then one variant on the line and be for flexible to work with, combination of all minimum requirement on the forecast.

It is not mandatory that a product unit where we decide to produce a high-volume product type is a PERMA production unit. However, it is not forbidden to combine a high-volume product type with several low volume product types to create a FLEXI product unit THEN, TO DO THIS CHOOSE, YOU NEED TO HAVE UNDER CONTROLS THE DRAFT OUTPUT OF EACH MACHINES IN EACH OPERATION so that we have an idea of how our future product unit will be approximately composed.

Product Type

The production of steel balls in the factory is organised in channels, each of which represents a completely independent production in the factory. Each channel handles all phases of the production of a specific type of balls like steel ball sizes of 5.5mm, 5.556mm, 5.953mm, 6mm, 6.35mm, 6.5mm, 6.747mm, 7mm, 7.144mm and 7.5mm. The process is carried out in batches that are not subdivided during the process and until they are ready for sale.

Annual And Daily Demand

Demand forecasting should have a clear purpose. At its core, it is about predicting what, how much and when customers will buy. Choose your time period, the specific product or general category you are looking at, and whether you are forecasting demand for everyone or just a specific group of people. Daily customer demand is considered for the entire 240 working days, which corresponds to a normal operating setting. The maximum daily demand is always calculated taking into account 20 per cent peaks.

Make sure that your financial planners, product marketing, logistics and operations teams can assume this without bias. You need to be clear about what your objectives are in planning demand capacity properly so that you can use decision forecasts to better understand consumer behaviour.

Finish Good Equivalent

The storage point at the end of a routing is either a storage location (i.e., a temporary storage facility) or a finished goods storage facility. Temporary storage is used to collect various parts within the plant before further processing or assembly. For example, a gear manufacturing routing may be fed from several stocks containing gears, housings, crankshafts and so on. The finished goods warehouse is where the final products are stored before being shipped to the customer.

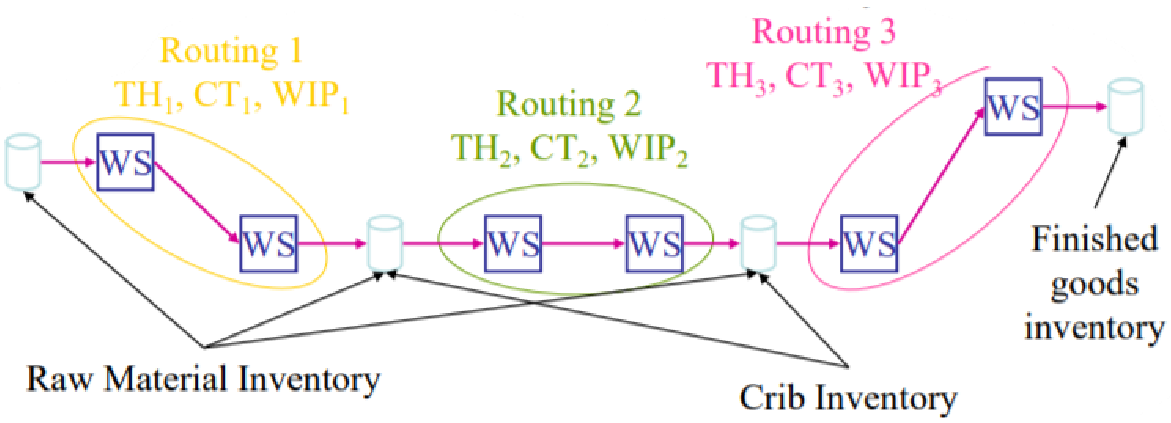


Figure 3, Inventory management

CHAPTER 4 - BOTTLENECK ANALYSIS

Production rate of the work station with the highest utilization. The bottleneck rate of the line, is the rate (parts per unit time or orders per unit time) of the workstation with the highest long-term utilization. By long-term, we mean that stoppages due to machine breakdowns, operator breaks, quality problems, etc. are averaged over the time horizon under consideration. This means that the correct treatment of breakdowns depends on the planning frequency.

For lines consisting of a single work schedule, where each station is visited exactly once and there is no yield failure, the arrival rate at each work station is the same. Therefore, the workstation with the highest load is the one with the lowest long-term capacity (i.e., with the slowest effective rate). However, for lines with more complicated routings or yield losses, the bottleneck may not be at the slowest workstation. A faster workstation that has a higher arrival rate may have a higher load.

Bottle neck problems from time – to time slow down and occasionally stop the entire manufacturing process thereby limiting the manufacturing capacity [11], asserted that all manufacturing systems are constrained by one more bottleneck problem signifying that irrespective of how well a manufacturing system is designed it cannot be bottleneck- free including the digital manufacturing system or industry 4.0 revolution.

Identification of manufacturing bottleneck element together with the corresponding variable factors that turn the element into bottleneck prioritizes process improvement [10]. Variables composing bottleneck problems in the manufacturing platform are enormous and therefore complex the improvement decision occasioned by a lack of direction from addressing the problem.

Hence, the challenge is how to identify the principal variables among the numerous variables causing the problem to sharpen process improvement focus and minimize manufacturing losses [12] and [13] argued that any element of production can turn into a bottleneck by causing overcrowding, slow down or stop the manufacturing process. According to [14], bottleneck is unescapable when there are differences in job arrival and processing rates. The significance of bottleneck problem on manufacturing system is loss of economic value because it describes the volume of manufacturing outputs [15][16].

Detecting a bottleneck in a production system is not minor task. The understanding of the current situation in the company was really important. Current bottleneck detection methos used here is analytical approach. A special formation of bottleneck detection has been developed on evaluation of the real time data from the manufacturing system in this work.

For the analytical method, the system performances mentioned below are assumed to describe it by statistical distribution. Where an analytical methos is more suitable for lone term prediction [17].

Machine Time

The duration of the phase of the operation performed by the automatically operating machine depends solely on the technical performance of the machine. This is purely the machine time per batch.

Efficiency

Considerable effort has been made to develop analytical and computerized tools to assess the efficiency of assembly operations. It provides a basis for comparing designs and objectively selecting design features that facilitate assembly. To assess assembly efficiency, each component of an assembly is evaluated in terms of its characteristics, which can affect both the assembly itself and the estimated base time for installing the part into the assembly. Note that assembly efficiency can also be measured for existing products. The assembly efficiency is given by $\eta = Nt / t_{tot}$, where N is the number of parts, ttot is the total assembly time and t is the ideal assembly time for a small part that has no difficulty in handling, alignment or assembly.

Cycle Time

The average cycle time at a station is made up of the following components:

Cycle time = shift time + queue time + setup time +process-time + wait- to batch + Wait time + wait-in- batch time+ wait-to-match time

Shift time is the time it takes for jobs to be shifted from the previous workstation. Queue time is the time a job waits to be processed at the station or to move to the next station. Setup time is the time a job spends waiting for the station to be set up. In this case, it may even be shorter than the station setup time if the setup is partially completed while the job is still being brought to the station. The processing time is the time during which the orders are actually processed at the station. As we have already discussed in the context of batch processing, waiting time is the time orders spend waiting to form a batch for (parallel) processing or transport, and batch waiting time is the average time a part spends in a (process) batch waiting for its place at a machine. Finally, waiting time occurs at assembly stations when components wait for their counterparts so that the assembly process can be carried out.

Production Lot

In the production system, each production unit of an assembly that is planned and produced is assigned a number, and this production lot number is each work breakdown structure that the system creates that lists the number.

When the production process of an assembly changes, we create a new production lot number each time and perform the planning, production and planned and actual cost calculation with the new number. In this way, you can determine the costs of the different manufacturing processes separately and compare them with each other.

Batch Weight

The batch size refers to the quantity of an item ordered for delivery on a specific date or produced in a single production run. In other words, batch size here usually refers total between 270 kg to 300 kg of product ordered for production.

Production Unit Capacity

Production unit capacity is the maximum output of a production system.

Production unit capacity = 24/ (cycle time/real machines) x lot size unit

Calculations For Bottleneck

Bottleneck rate (rb): production rate of the workstation with the highest utilization.

Raw process time (T0): sum of the mean effective process times of the workstation in a line.

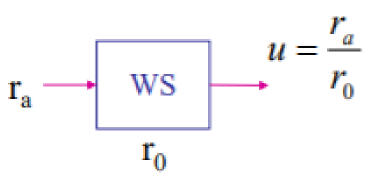
Throughput (TH): average quantity of non-defective parts produced per unit time.

Cycle time (CT): mean time a part spends in the routing.

Work in process (WIP): inventory in the routing.

Utilization(u): fraction of time a workstation is not idle for lack of parts

Equation 1, Utilization



Raw Material Inventory (RMI): inventory at the beginning of the routing.

Benchmarking: evaluation of line performances (TH, WIP e CT) based on data gathered inside or outside the line.

Critical WIP (W0=rb ·T0): level of WIP providing the maximum throughput and the minimum cycle time in a line without variability.

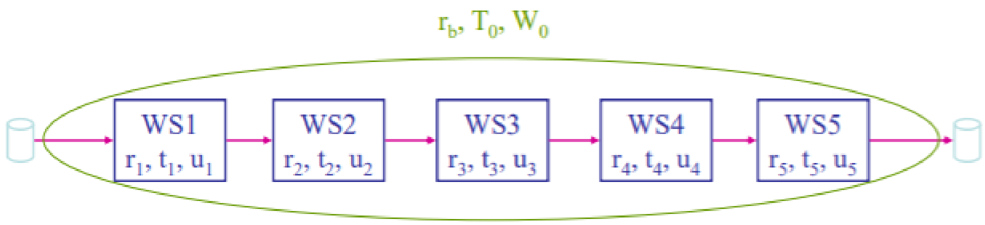


Figure 4, Layout of operations in the production line

Fig 4: Layout of operations in the production line

Here in the production as mentioned before nine production operations included to adopt the bottleneck for right operation.

Cycle time= 19.95 hours

WIP= CT×TH = 0.83125 × 5010 = 4158.3 Kg/day

U= $r_a/r_o = (r_a \times t_o)/ m$, r_a is the arrival rate

Workstation1(heading) = u_1 = 3.571ra

Workstation2(Flashing) = u_2 = 4.3ra -**BOTTLENECK**

Common operation for all ball variants in production unit- Workstation3(heat Treatment) = u_3 = 14.5ra, which is not be considered

Workstation4(Scouring) = u_4 = 2.3ra

Workstation5(Hard grinding) = u_5 = 2.1ra

Workstation6(Prefinishing) = u_6 = 2.3ra

Workstation 7(lapping) = u_7 = 2.06ra

Workstation8(Inspection) = u_8 = 0.95ra

Workstation 9(Final lapping) = u_9 = 2.1ra

Bottleneck For Respective Production Unit

The environment allows consist of discrete event data and MS Excel user allowing setup of input data of the model and observing analysis results this methos according to its criterion. The analysis is based on the simulation statistics about the resource utilization, starvation, blocking, waiting for labour, set-up and breakdown features and on the assessment of relationships between the downstream and upstream activities. According to [17], comparison of simulation statistics of the starvation and blocking of the adjacent workplaces is able to evaluate multiple bottlenecks in the production unit and the bottleneck of the largest severity is the workplace with the maximum value of specific index.

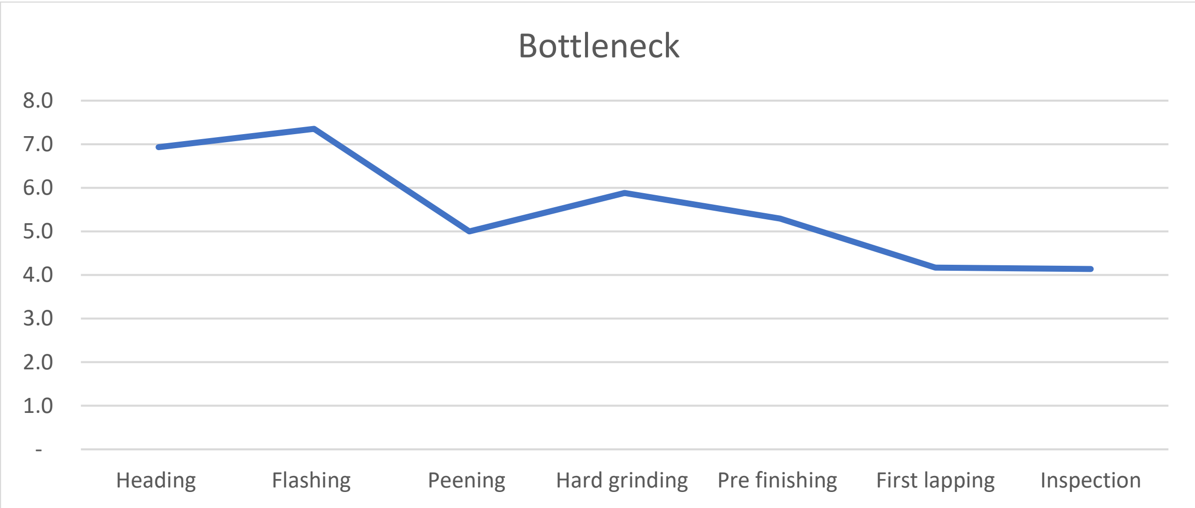


Figure 5, Bottleneck for Perma -6.35mm production unit

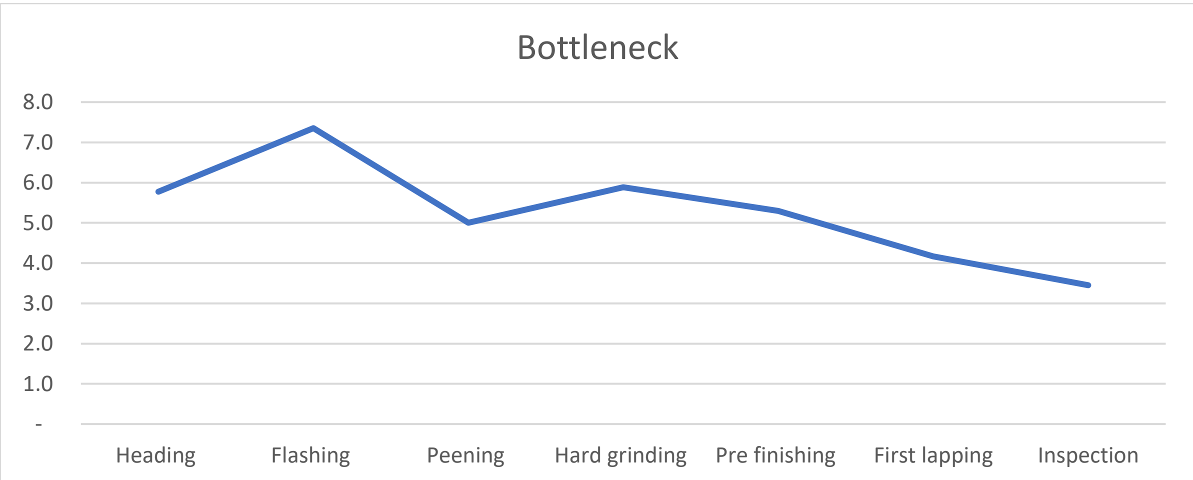


Figure 6, Bottleneck for Perma – 6.747mm production unit

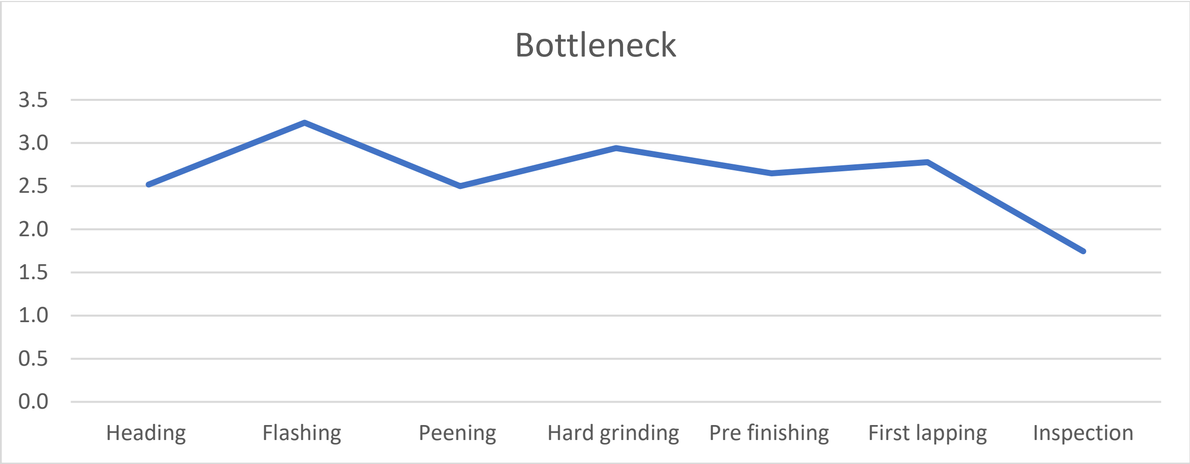


Figure 7, Bottleneck for Perma 7.144mm production unit

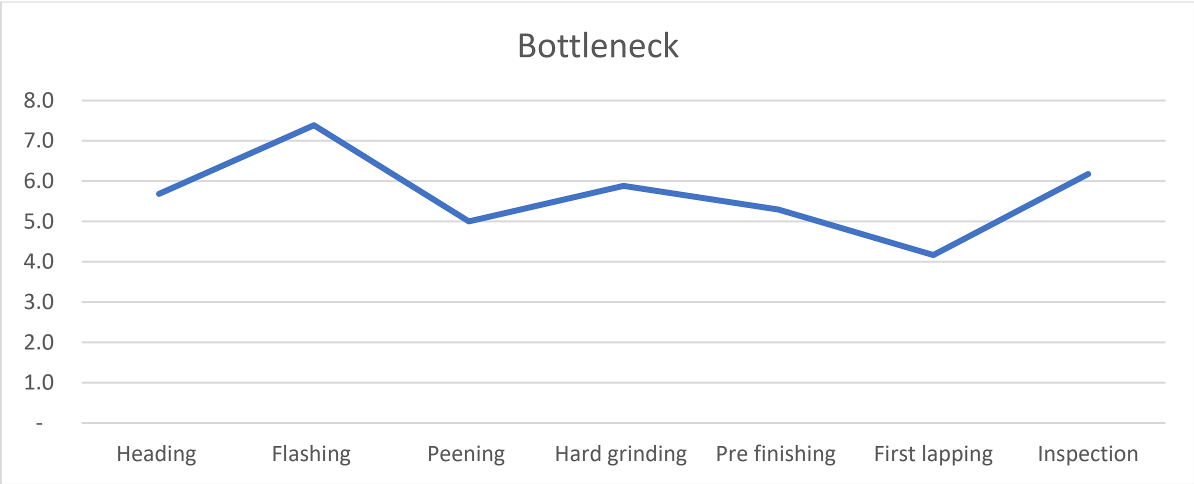


Figure 8, Bottleneck for Flexi 6.000mm &7.000 mm production unit

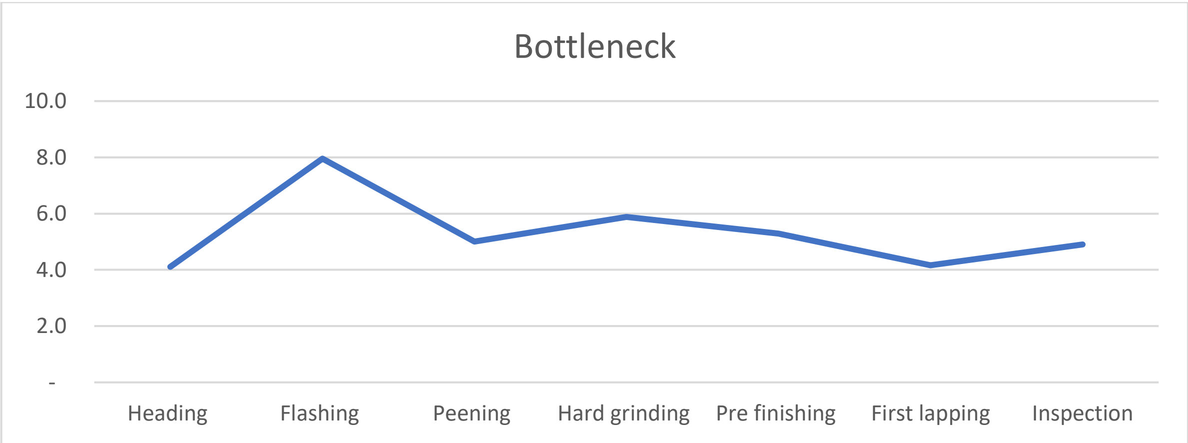


Figure 9, Bottleneck for Flexi 5.5mm, 5.556mm, 5.953mm, 6.500mm & 7.500mm production unit

The bottleneck analysis involves locating the source of bottleneck and. Here operation flashing is the bottleneck on the production line, to balance other operations, setting bottleneck is an optimum point so that we have good buffer unit to maintain by the operators.

The production should be clearly understanding the importance of the bottleneck and start managing the buffer unit at a initially stage to have a proper balanced production line.

Through the analysis the bottleneck in the production, the main idea was to up bring whether the process step exceeding 100% utilization and capacity dropping below or equalling demand.

It was been noticed that the bottleneck was limiting the capacity and hold back inventory through the production system, and it was important for us to identify the areas where bottleneck found in manufacturing facilities. All manufacturing facilities and industries are looking to uptime, reduce operational costa and aims at having an effective operation. So, bottlenecks are by far one of the most frequently acquiring reasons why projects were getting delayed at the company. This is why it was essential to start diving into why our operation is unpredictable and not able to fulfil customer orders on time. Through this we understood there was delay in the production, low customer satisfaction and very important was stress on the employees. To take approach on the production line, a proper bottleneck targeting was necessary.

CHAPTER 5- PRODUCTION UNIT LAYOUT

Objective

Clear vision to organize the production process. To analysis continuous flow line tracing the path of an item or activity through a process. Plant layout is a very serious part of running an efficient and cost-effective business. All work zones, production line, material storage facilities, etc., should be designed to perform to the highest rate and corresponding shortest cycle time.

Plant Layout is physical arrangement of equipment and facilities within a plant. i.e., the grouping of equipment and operations in a factory for the greatest degree of efficiency. According to [19], the plant layout can be indicated on the floor plan showing the distances between different features of plant. Optimizing the layout of a plant can improve productivity, safety and quality of products. Unnecessary efforts of materials handling can be avoided when the plant layout is optimized, as used in the work.

Methodology Followed for The Analysis

Raw Material Requirement

Total raw material of each variant is divided according to their demand and this data is used for layout designing analysis. From this we understand the importance of each type of variant that goes into the production line. The data is very helpful to decide the variant priority.

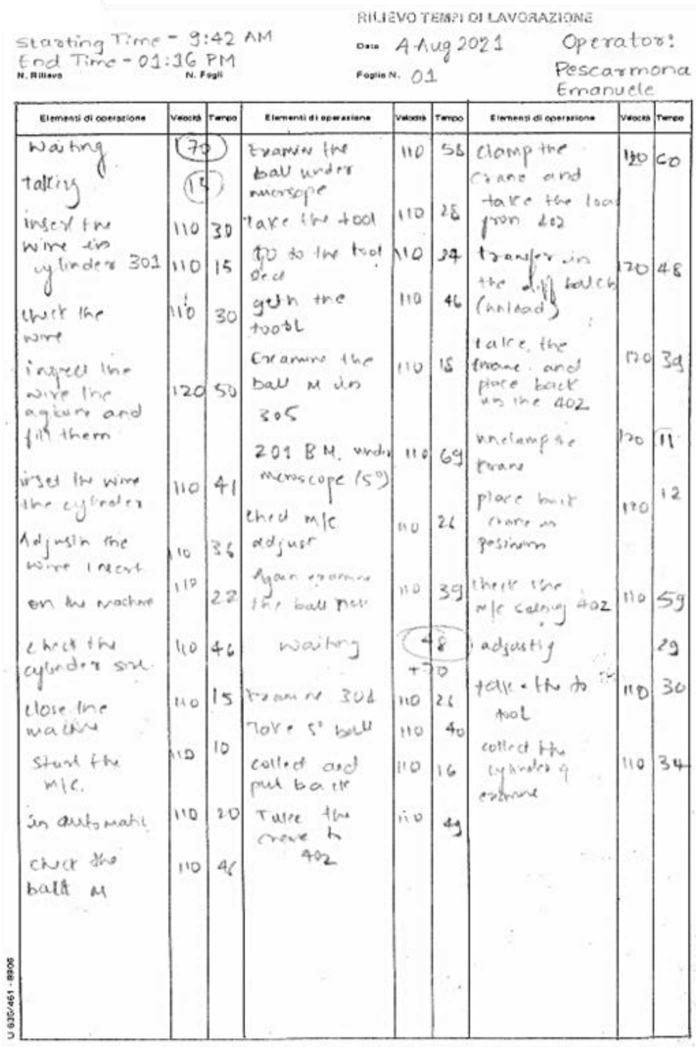
Understanding Of Existing Process Sequence

Designing an efficient plant layout identification of process sequence is necessary. For these the existing manufacturing processes are studied in sequence. The acute operations in each process are observed careful. This helps us in redesigning the process sequence

Time Study

The time study has been carried out to each processing stage. It is done manually using the stop watch and reading are noted in the time sheet shown below in the figure. The time study helps finding out the time required for each process in the sequence. This date will be useful in deciding the capacity planning for a new lant. Basically, from the time study we additionally know about the bottleneck stage in detail.

Figure 10, Time study in the workshop



Elementi di operazione	Velocità	Tempo	Elementi di operazione	Velocità	Tempo	Elementi di operazione	Velocità	Tempo
Waiting		(70)	Examin the ball under microscope	110	58	clamp the crane and take the load from 402	120	60
talking		(15)	take the tool	110	28	transfer in the [illegible] batch (unload)	120	48
insert the wire in	110	30	go to the tool desk	110	24	take the frame and place back in the 402	120	34
cylinder 301	110	15	get the tool	110	46	unclamp the frame	120	11
check the wire	110	30	Examine the ball M in 305	110	15	place back crane in position	120	12
inspect the wire the [illegible] and fill them	120	50	201 B M. under microscope (5°)	110	69	check the m/c calling 402	110	59
insert the wire the cylinder	110	41	check m/c adjust	110	26	adjusting		29
Adjustin the wire [illegible]	110	36	Again examine the ball now	110	39	take the tool	110	30
on the machine	110	22	waiting		48 +70	collect the cylinder [illegible]	110	34
check the cylinder [illegible]	110	46	Examine 304	110	26			
close the machine	110	15	Move 5° ball	110	40			
Start the m/c.	110	10	collect and put back	110	16			
in automatic	110	20	Take the crane to 402	110	49			
check the ball M	110	41						

Figure 11, Template to insert the observation of each operation on production line

Layout Construction

According to [18], most plant layouts are designed properly for initial conditions of the business. Those are basically based on the demand and bottleneck analysis, project of location machines, utility systems, auxiliary services, people and materials used to draw plant layout definition in overall. However, these layouts provide many bottlenecks during growth period, usually adapts internal and external changes for which re- layout are necessary.

Usually, the optimization of facility is situation-based requirement of the industry as must in the plant.

The indicators that allow the need for re-layout is situation are blocking and bad utilization of space excess in the process at the facility, bottleneck at workstations, idle time of facilities and work, labour anxiety and discomfort, accidents and difficulty in controlling operations.

The channel AA design concerns the design and implantation of optimal arrangement of industrial equipment, including human resources, machines, inventory, high material handling distances, auxiliary services.

The color helps to define the production line and which type of variant is ready to go into the production at a time. It includes the design of most suitable facility to host and protect such systems.

Layout Design Mission

1. Simplifying the production process (utilization, production delays, stock, maintenance).
2. Minimizing material handling costs.
3. Minimizing production stock and quantity of stored materials. Using the available space in the most effective way.
4. Offering employees, a satisfactory work environment.
5. Avoiding unnecessary capital investment.
6. Effective use of labour.

Figure 12, Layout design with the specific dedicating machine for each variant

CHAPTER 6 – SAP SYSTEM LITERATURE REVIEW

Nowadays, the requirement of business has been quickly altered after the introduction of globalization. Under such circumstance, the needful challenges associated with the country are joined with the global economic conditions [22][23][24]. A well – structured enterprise resource planning tool along with SAP is framed by seamless data and dataflow denuded industry [26].

Accordingly, the SAP also takes major role financial accounting which is a greater condition in this work, alone with management accounting and financial supply chain management that belongs to the modules of integrated business process.

The study [20] shows that SAP suggests a wide range of software solutions to support the factory in terms of end-to-end engineering across the entire value chain.

The SAP has been able to cover almost the business drivers that meet certain extent what company requirements are. It mainly defined in its roadmap that need to invest time and resources to develop innovative solutions in emerging sectors and technologies as additive manufacturing, virtual reality, augmented reality, machine learning and human machine interactions.

According to [21], module-based software is the core, that automates business activities of functional area within organization. Such software attributes include product planning, parts purchasing, inventory control, product distribution, order tracking, finance, accounting and human resources aspects of the whole organization.

SAP have been created a set of databases for all the applications running in an organisation. Research develops creative ideas for assisting manufacturing operations. Key projects at this time address a variety of topics including:

1. Real-world integration: continuous real time incorporation of business management systems with physical devices and processes in the real world.

2. Adaptive manufacturing software: Extremely configurable software frame for building process detailed solutions for manufacturing operations management.
3. Innovative user interaction: Technology and infrastructure for building highly instinctual user interface for shop floor workers, foremen and plant managers

Finished Good Analysis and Packaged Lot Size Analysis

With the hope of future growth, plant have implemented SAP. The overall growth of any company is based on the growth of market as well as the eagerness of the industrial to capitalize the opportunity [25].

The SAP adaptation the company is been analysed using the software and the differentiate the direct orders and indirect orders are noted down

The excel sheet included all the variation of balls to be manufactured and database of the material, lost size production, grade, maximum and minimum stock.

14.06.2021 — EG - Livelli stock (min, medio, max) e stock tot x materiale

EG - Livelli stock (min, medio, max) e stock tot x materiale

	ReSch	GS	Materiale	dia+grade+var	Lotto minimo	Liv.max.stock	Lotto massimo	Minimum level KG	Average Level KG	Maximum Level KG	Stock Disponibile KG	Stock Disponibile	Sales1 KG/Day	Sales2 KG/Day	Sales3 KG/Day
		41	005500G005CTTN0066	005500G005CTT				0,000	0,000	0,000	0,000	497.000,000	2,215	2,442	2,089
*				005500G005CTT				0,000	0,000	0,000	0,000	497.000,000	2,215	2,442	2,089
	C69	41	005500G005SEAM0431	005500G005SEA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G005SEAN0031	005500G005SEA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G005SEAP0431	005500G005SEA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
*				005500G005SEA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G010INAM0131	005500G010INA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,544
	C69	40	005500G010INAM0138	005500G010INA	2.787.750,000	5.177.250,000	7.566.750,000	1.890,856	3.511,589	5.132,322	0,000	0,000	185,542	191,772	169,599
	C69	41	005500G010INAM0231	005500G010INA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,539
	C69	40	005500G010INAM0238	005500G010INA	796.500,000	1.393.875,000	1.991.250,000	540,244	945,428	1.350,611	1.744,659	1.744.659,000	22,949	18,611	28,930
	C69	41	005500G010INAM0331	005500G010INA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,531
	C69	41	005500G010INAM0431	005500G010INA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	1,679
	C69	40	005500G010INAM0438	005500G010INA				0,000	0,000	0,000	36,000	36.000,000	0,000	0,000	3,745
	C69	41	005500G010INAM0531	005500G010INA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,541
	C69	41	005500G010INAM0631	005500G010INA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	2,173
	C69	40	005500G010INAM0638	005500G010INA				0,000	0,000	0,000	0,000	0,000	2,217	1,109	1,750
	C69	41	005500G010INAN0031	005500G010INA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	1,114
	C69	40	005500G010INAN0038	005500G010INA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
*				005500G010INA	3.584.250,000	6.571.125,000	9.558.000,000	2.431,100	4.457,017	6.482,933	1.780,659	1.780.659,000	210,708	211,492	211,145
	C69	41	005500G010STAM0131	005500G010STA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G010STAM0231	005500G010STA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G010STAM0331	005500G010STA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G010STAM0431	005500G010STA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G010STAM0531	005500G010STA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G010STAM0631	005500G010STA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G010STAN0031	005500G010STA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
*				005500G010STA				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	C69	41	005500G028KGZN0031	005500G028KGZ				0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Figure 13, SAP database formation according to industry

CHAPTER 7- INDUSTRY APPLICATION

The whole project is been discrete into two main parts, one being production unit and packaging unit.

The idea is posing the SAP code in the package unit and reduce the items up to 50% in the production unit. Note that the operator on the machine has to be more focused on the production part rather overthinking of what has to deliver at the end.

The quality is never point to be composed here, rather be focused on the grade to produce from the initial stage i.e., Header operation until the lapping operation.

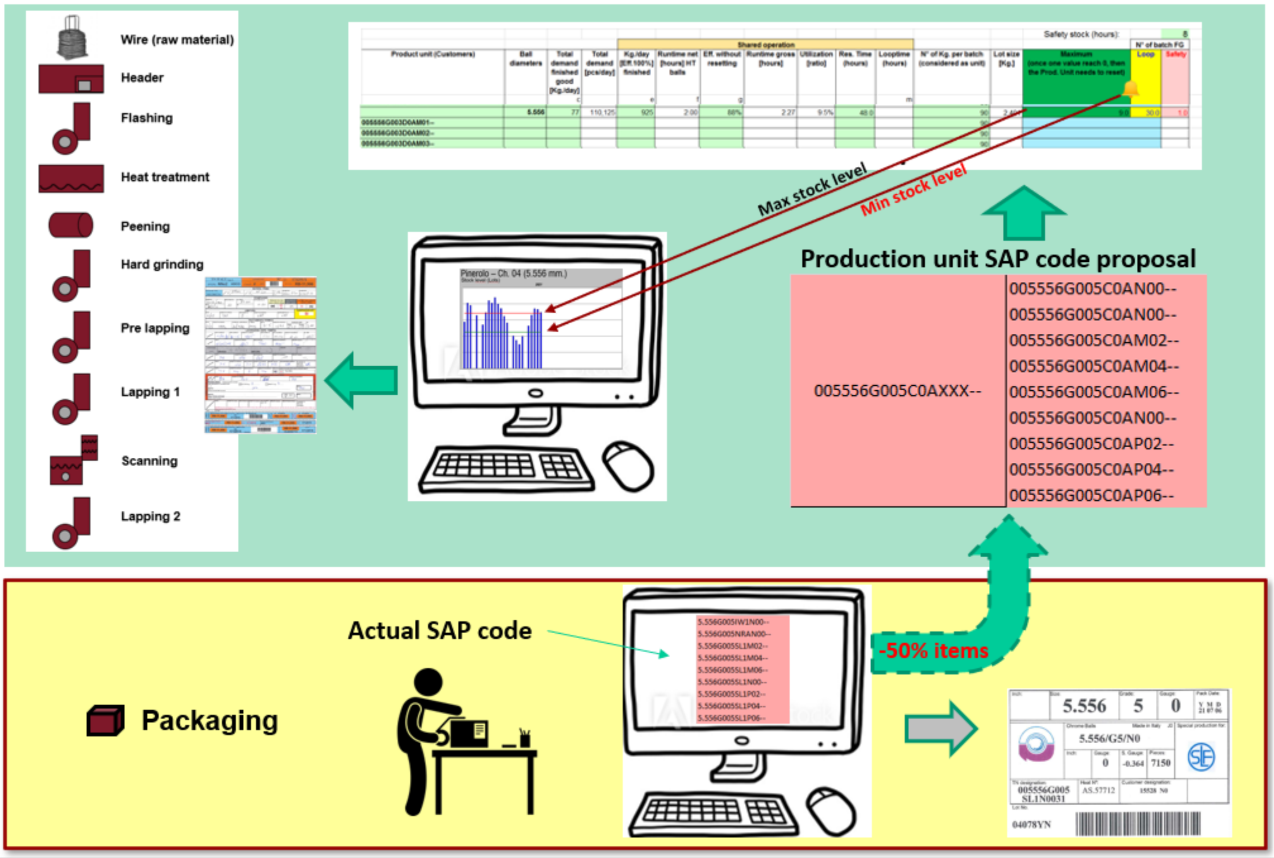


Figure 14, Explanation of SAP code in the industry

Here the SAP offers various benefits to mechanical component manufacturing whish are strategic and operational in nature

1. Strategic adaption: By integration within the business process, adaptability, unique solution features, country specific solutions, industry specific solutions, pre-configured solutions and reliable product support
2. Operational adaption: These are the outbound and inbound supply chain optimization, optimization in planning process such material planning, production order planning, capacity planning, streamlined financial processes, single point data entry those are the data entered

Product Variants Formation

Company produces certain variants on the production line. Usually, the product variants are noted on bases of the process quality, raw material and product type classification.

Table 1, Raw material nomenclature

Raw Material	
A- Ascometal	B- Kobe

Table 2, Process type and their quality grades

Process type	Quality grade
A	HBQ (First lapping)
B	INQ (First lapping)
C	ESQ (Lapped)
D	EMQ (Lapped)
E	G100 &>
F	EMQ (Lapped)
Blanks	Blanks

Actual Finished Product Codification Vs Proposal – Process

The proposed nomenclature describes the quality accordingly with the variant that as to be produced rather mixing the different variants with same quality process.

Nomenclature new SAP code proposal							
SAP code (without gauge)	Comlpete SAP code	Process type (quality)	Raw material (type)	Gauges	Packaging	Current SAP code	Stock type
005500G010B0AXXX10	005500G010B0A M01 10 005500G010B0AM0110	B	A	M01	1	5.5G010INA	2
	005500G010B0A M02 10 005500G010B0AM0210	B	A	M02	1	5.5G010INA	2
	005500G010B0A M03 10 005500G010B0AM0310	B	A	M03	1	5.5G010INA	2
	005500G010B0A M04 10 005500G010B0AM0410	B	A	M04	1	5.5G010INA	2
	005500G010B0A M05 10 005500G010B0AM0510	B	A	M05	1	5.5G010INA	2
	005500G010B0A M06 10 005500G010B0AM0610	B	A	M06	1	5.5G010INA	2
	005500G010B0A N00 10 005500G010B0AN0010	B	A	N00	1	5.5G010INA	2
005556G003D0AXXX10	005556G003D0A M01 10 005556G003D0AM0110	D	A	M01	1	5.556G003Q01	2
	005556G003D0A M02 10 005556G003D0AM0210	D	A	M02	1	5.556G003Q01	2
	005556G003D0A M03 10 005556G003D0AM0310	D	A	M03	1	5.556G003Q01	2
	005556G003D0A M04 10 005556G003D0AM0410	D	A	M04	1	5.556G003Q01	2
	005556G003D0A M05 10 005556G003D0AM0510	D	A	M05	1	5.556G003Q01	2
	005556G003D0A N00 10 005556G003D0AN0010	D	A	N00	1	5.556G003Q01	2
	005556G003D0A P01 10 005556G003D0AP0110	D	A	P01	1	5.556G003Q01	2
	005556G003D0A P02 10 005556G003D0AP0210	D	A	P02	1	5.556G003Q01	2
	005556G003D0A P03 10 005556G003D0AP0310	D	A	P03	1	5.556G003Q01	2
	005556G003D0A P04 10 005556G003D0AP0410	D	A	P04	1	5.556G003Q01	2
	005556G003D0A P05 10 005556G003D0AP0510	D	A	P05	1	5.556G003Q01	2
	005556G003D0A P10 10 005556G003D0AP1010	D	A	P10	1	5.556G003Q01	2

Figure 15, Actual finished product codification Vs Proposal according to process

Actual Finished Product Codification Vs Proposal – Raw Material

The proposed nomenclature describes the material accordingly with the variant that as to be produced rather mixing the different variants with same raw material.

Nomenclature new SAP code proposal							
SAP code (without gauge)	Comlpete SAP code	Process type (quality)	Raw material (type)	Gauges	Packaging	Current SAP code	Stock type
006350G010B0AXXX50	006350G010B0A N00 50 006350G010B0AN0050	B	A	N00	5	6.35G010S01	1
	006350G010B0A M03 50 006350G010B0AM0350	B	A	M03	5	6.35G010S01	2
	006350G010B0A M06 50 006350G010B0AM0650	B	A	M06	5	6.35G010S01	2
	006350G010B0A M09 50 006350G010B0AM0950	B	A	M09	5	6.35G010S01	2
	006350G010B0A P01 50 006350G010B0AP0150	B	A	P01	5	6.35G010S01	2
	006350G010B0A P02 50 006350G010B0AP0250	B	A	P02	5	6.35G010S01	2
	006350G010B0A P03 50 006350G010B0AP0350	B	A	P03	5	6.35G010S01	2
	006350G010B0A P04 50 006350G010B0AP0450	B	A	P04	5	6.35G010S01	2
	006350G010B0A P05 50 006350G010B0AP0550	B	A	P05	5	6.35G010S01	2
	006350G010B0A P06 50 006350G010B0AP0650	B	A	P06	5	6.35G010S01	2
	006350G010B0A P09 50 006350G010B0AP0950	B	A	P09	5	6.35G010S01	2
	006350G010B0A M02 50 006350G010B0AM0250	B	A	M02	5	6.35G010S11	2
	006350G010B0A M04 50 006350G010B0AM0450	B	A	M04	5	6.35G010S11	2
	006350G010B0A N00 50 006350G010B0AN0050	B	A	N00	5	6.35G010S11	2
	006350G010B0A P02 50 006350G010B0AP0250	B	A	P02	5	6.35G010S11	2
	006350G010B0A P04 50 006350G010B0AP0450	B	A	P04	5	6.35G010S11	2
006350G010B0BXXX50	006350G010B0B M03 50 006350G010B0BM0350	B	B	M03	5	6.35G010S03	2
	006350G010B0B M06 50 006350G010B0BM0650	B	B	M06	5	6.35G010S03	2
	006350G010B0B M09 50 006350G010B0BM0950	B	B	M09	5	6.35G010S03	2
	006350G010B0B N00 50 006350G010B0BN0050	B	B	N00	5	6.35G010S03	2
	006350G010B0B P03 50 006350G010B0BP0350	B	B	P03	5	6.35G010S03	2
	006350G010B0B P06 50 006350G010B0BP0650	B	B	P06	5	6.35G010S03	2
	006350G010B0B P09 50 006350G010B0BP0950	B	B	P09	5	6.35G010S03	2

Figure 16, Actual finished product codification Vs Proposal according to process

Sap System Code Proposal

Company ensures to have a proper dedicated code to produce a certain variant. Without disturbing the existing number characters of code on the channel, here we tried to sum up a nomenclature which includes the ball diameter, type of process, grade information, raw material and given the gauge. The main intension of proposing this code was not to disturb the variants which are produced according to customer requirements. Quality is the main factor we are focused on and sum by all the variants which have the common grade, gauge, process and raw material. There are many such variants now in the database which have all the commonality, but have a different variant code and it keeps on making mix-up at the stock level to management.

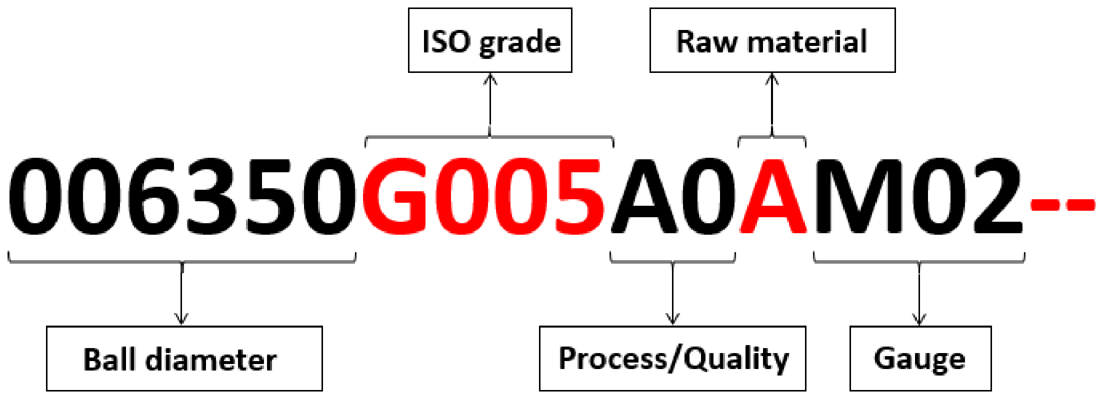


Figure 17, Proposed SAP nomenclature

CHAPTER 8 – COST DETAILS INVOLVED TO PRODUCE ON PRODUCTION LINE AND IMPROVED TOTAL COMPANY SAVING

The maintenance of the less variants is a good option for any company in terms of investment at production level. Similarly, here in this case producing steel ball and managing the product involves of direct labour and the major considerations where on the basis of bellow mentioned factors, i.e.,

1. Lot size
2. Customer demand
3. Annual freq to restore the max. stock
4. Possible no. of variants
5. Man-time spent to plan, to produce each variant
6. Average hourly cost of labour

On the basis of this knowledge, we have focus on the value that is usually defined as a process of systematic review that is applied to existing product design in order to compare the function of product require by customer to meet their requirements at lowest cost consistent with the specified performance and reliability needed [26]. The approach aimed to attribute the proper cost at product in compliance with the desired performances.

The cost is the monetary value of goods, resources and services consumed by the company's activity to produce and sell products/services. It is then necessary to track, on a monetary base, all the factors consumed and transformed by the company: the result is an economic cost of the product and the monetary value of factor consumed is calculated as its unit cost and its required quantity [1].

To be more precise the direct labour is one of the important attributes for the considerations and we need necessary cost configuration details for our work. So, cost is the variable that should be controlled in order to maximize the profit at same competitor's price or to be more competitive with same competitor's profit Controlling the cost allows to have conscious product development process. Controlling the cost since the early stage of the concept and continuously thinking of how to optimize it during the whole lifetime of the product.

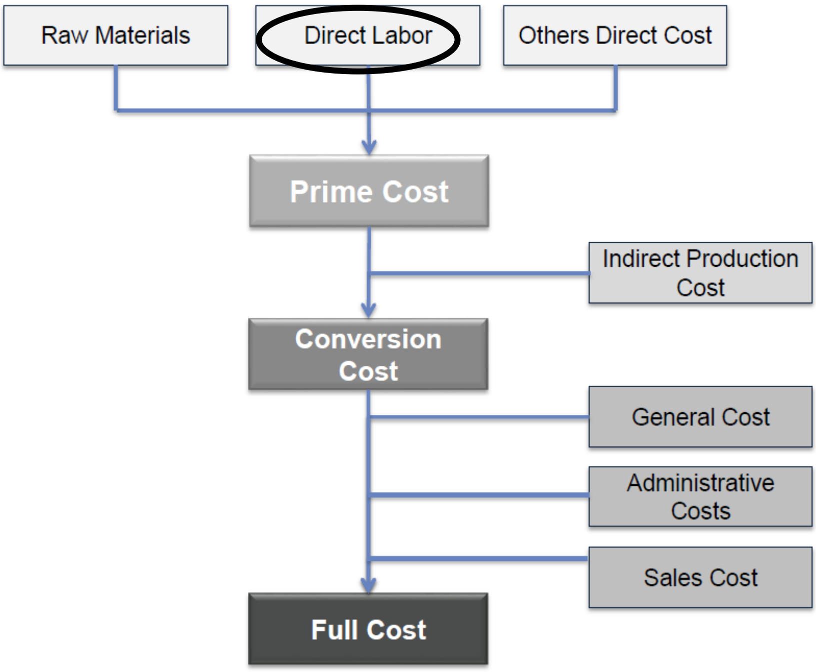


Figure 18, Cost configuration

Prime cost: useful when we compare two different products as a first level of information about cost, in terms of raw material labour and others direct cost. It is used to make a first approximation estimated on product cost and quickly cost comparison btw different products.

Conversion cost consist of the other indirect costs to transform the direct material in final product. These are attributed according to assumptions and criteria (do not reflect the proper industrial scenario). This includes the material handling time cost. To that we have to sum the general cost, administrative cost and sales costs to find the **full cost** of our product.

If we use always the same cost configuration (so the same aggregate classification) we can compare different solution to find what is more competitive or what we have to improve in terms of cost related to the product. If we do not do this operation, we are not able to say that our product is capable to create margin. Full cost includes R&D, marketing, training and general administrative cost. Full Cost + the Profit = **SELLING PRICE**

Let's discuss one example of actual and proposed labour cost of the perma and flexi production unit and their factors effecting the whole production cost of the channel AA.

Actual cost in production unit perma 7.144 mm steel ball size

1. Lot size: 144 lots to be produced from minimum to restore maximum stock = 144 x 90 Kg. lot = 12960 Kg.
2. Customer demand: 480000 Kg./year
3. Possibile N° of current variants to be produced in this lot size: **6** (considered only half)
4. Average production lot size for each variant: 12960 : 6 = 2160 Kg.
5. Yearly number of times to put in production of all variants: 480000 : 2160 = **222**
6. Man time spent to plan and put in production each variant to be produced: **1** hour
7. Average hourly cost of labour: **31.9** Euro/hour
8. Cost spent to produce a new ball variant = Number of times times variants are out on prodcution annually x man time spent plan and put in production x average hourly cost of labour = 222 x 1 x 31.9 = **7081 €/year**

Proposed cost in production unit perma 7.144 mm steel ball size

1. Lot size: 144 lots to be produced from minimum to restore maximum stock = 144 x 90 Kg. lot = 12960 Kg.
2. Customer demand: 480000 Kg./year

3. Possibile N° of current variants to be produced in this lot size: **4** (considered only half)
4. Average production lot size for each variant: 12960 : 4 = 3240 Kg.
5. Yearly number of times to put in production of all variants: 480000 : 3240 = **148**
6. Man time spent to plan and put in production each variant to be produced: **1** hour
7. Average hourly cost of labour: **31.9** Euro/hour
8. Cost spent to produce a new ball variant = Number of times times variants are out on prodcution annually x man time spent plan and put in production x average hourly cost of labour = 148 x 1 x 31.9 = **4721 €/year**

Actual cost in production unit Flexi 5.500 mm steel ball size

1. Lot size: 72 lots to be produced from minimum to restore maximum stock = 72 x 90 Kg. lot = 6480 Kg
2. Customer demand: 80160 Kg./year
3. Annual frequency to restore the maximum stock (N° of resettings) = hours in year : looptime hours =
4. = 24 x 240 : 1025 = **6**
5. Possibile N° of current variants to be produced in this lot size: **2**
6. Annual frequency to recover maximum stock level increased by the number of variants: c x d = 6 x 2 = **12**
7. Man time spent to plan and put in production each variant to be produced: **1** hour
8. Average hourly cost of labour: **31.9** Euro/hour
9. Cost spent to produce a new ball variant = Number of times times variants are out on prodcution annually x man time spent plan and put in production x average hourly cost of labour = 12 x 1 x 31.9 = **382 €/year**

Proposed cost in production unit perma 5.550 mm steel ball size

1. Lot size: 72 lots to be produced from minimum to restore maximum stock = 72 x 90 Kg. lot = 6480 Kg.
2. Customer demand: 80160 Kg./year
3. Annual frequency to restore the maximum stock (N° of resettings) = hours in year : looptime hours =
4. = 24 x 240 : 1025 = **6**
5. Possibile N° of current variants to be produced in this lot size: **1**
6. Annual frequency to recover maximum stock level increased by the number of variants: c x d = 6 x 1 = **6**
7. Man time spent to plan and put in production each variant to be produced: **1** hour
8. Average hourly cost of labour: **31.9** Euro/hour
9. Cost spent to produce a new ball variant = Number of times times variants are out on prodcution annually x man time spent plan and put in production x average hourly cost of labour = 6 x 1 x 31.9 = **191 €/year**

Similarly, all the steel ball size labour cost involved to put on the production are mentioned below.

Table 3, Actual vs proposal labour cost in Perma production

Ball size-->	7.144	
Consideration	**Actual**	**Proposal**
Lot size	144	144
Customer demand (Kg.)	480000	480000
Possible N° of current variants to be produced in this lot size (considered only half)	6	4
Average production lot size for each variant (Kg.)	2160	3240
Yearly number of times to put in production of all variants	222	148
Man time spent to plan and put in production each variant to be produced (hours)	1	1
Average hourly cost of labour (€/hour)	31.9	31.9
Cost spent to produce a new ball variant (€/year)	**7081**	**4721**

Table 4, Actual vs proposal labour cost in Flexi production

Ball size-->	**5.500**		**5.556**		**5.953**		**6.500**		**7.500**	
Consideration	**Actual**	**Proposal**	**Actual**	**Proposal**	**Actual**	**Proposal**	**Actual**	**Proposal**	**Actual**	**Proposal**
Lot size	72	72	9	9	8	8	5	5	5	5
Customer demand (Kg.)	80160	80160	1840	1840	14400	14400	9600	9600	10080	10080
Annual frequency to restore the maximum stock (N° of resetting)	6	6	6	6	6	6	6	6	6	6
Possible N° of current variants to be produced in this lot size	2	1	5	2	1	1	1	1	5	3
Annual frequency to recover maximum stock level increased by the number of variants	12	6	30	12	6	6	6	6	30	18
Man time spent to plan and put in production each variant to be produced (hours)	1	1	1	1	1	1	1	1	1	1
Average hourly cost of labour (€/hour)	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9	31.9
Cost spent to produce a new ball variant (€/year)	**382**	**191**	**957**	**382**	**191**	**191**	**191**	**191**	**957**	**574**

Total Saving of Manufacturing Plant

1. Labour saving in production unit 3 PERMA = 2360 €/year
2. Labour saving in production unit 5 FLEXI = 1149 €/year
3. Labour saving in production unit 1-2-3 PERMA = 2360 x 3 = 7080 €/year
4. Labour saving in production unit 4-5 FLEXI = 1149 x 2 = 2298 €/year
5. Total saving of production units 1-2-3-4-5 (1176 Tn/year) = 9378 €/year
6. Total demand of Pinerolo plant = 14300 Tn/anno
7. Saving = 114035 €

CHAPTER 9- CONCULSION

Improvement Observed

1. Dedicate and organize the production units

   a) Too many steel ball sizes present in the operations to handle.

   b) The bottleneck is not defined and emphasized as it should be.

   c) The concept and operation of the FLEXI line is not clear.

2. Man time reduction to put the product in production.
3. High number of variants to be managed in the production unit.
4. Reduce direct orders (they are currently ~ 33%).

Steps For Approach

1. Involvement of people who clearly understand the necessary changes to made the production system in accordance with the new product management process.
2. Implementing SAP in packaging operation, it would be necessary to establish the software modification to set SAP in this direction.
3. Operators involved from header to lapping should not know the final customers but only focused on balls quality.

Note that by planning instead of adopting a visual method to produce, the specifications required by stock management are lost because by requesting manual orders too often you create a disturbance to the system that goes against the pull system.

As a result of the reduction in the number of variants, the management of the stock offers the possibility of further reducing it compared to the current condition in the order of 15% based on our experience.

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