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Application of Lean Manufacturing Principles in Gold Industry

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This paper presents the application of lean manufacturing to improve machine lead times, capacity, and quality. The fundamental goal of lean manufacturing is to give specialists at each division of the organization; the quality and utilization of good techniques to take out waste in plan and enhance work process and quality. A few techniques depict lean assembling frameworks as an effective arrangement, which can prompt shrewd, diligent employees. The paper sets a lean manufacturing framework to deal with discovering waste and other non-esteemed exercises to enhance machine lead times, limits, and quality. Basically, we are attempting to dispose of the exercise's clients are not willing to pay for by counting information accumulation and Total Productive Maintenance (TPM) for the selected department or manufacturing line. The essential idea of lean assembling is to give a quality item while that confirms the client required with the least expense. To start applying TPM concepts in the industrial facility support exercises, the whole work compel must be focused on the administrator. Finally, a step-by-step process is applied to a case study as proof of concept.

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I. INTRODUCTION

To increase profitability and competitiveness, leaders of many companies have chosen lean manufacturing to reduce or eliminate waste in their production systems. Leaders used lean principles for the automotive industry, which led to leaders instituting lean manufacturing principles as standard operating procedures in many industries today. When implemented with a good performance management system, lean principles have a proven record of success for the operation system, which converts into increased value to customers. Mass production was the original production system, while lean manufacturing focuses on eliminating waste in production systems; this process must be applied to understand the world market and compete.

The main objective of lean manufacturing is to give workers at every department of the company; the quality and use of good methods to eliminate waste in design and optimize workflow and quality. Several methods describe lean manufacturing systems as a successful plan, which can lead to smart, hard workers [1].

The widely adopted Japanese manufacturing concepts came to be known as “lean production.” The concept behind lean production spread to coordination, and from there, to the military, construction, and the service industry. Principles of lean thinking are universal and have been applied successfully to many disciplines [2].

Lean manufacturing management philosophy requires leaders to focus on reducing the seven waste streams (overproduction, waiting time, transportation, processing, inventory, motion, and scrap) in manufactured products. By eliminating waste, leaders can improve quality; production times, and costs. Lean tools include constant process analysis (*kaize*), pull production (*kanban*) [3], and mistake-proofing [4].

Lean Manufacturing is a system approach to finding waste and other non-valued activities to improve machine lead times, capacity, and quality. Essentially, we are trying to eliminate the activities customers are not willing to pay for. The fundamental concept of lean manufacturing is to provide a quality product while that verifies the customer needed with minimum cost.

Lean manufacturing is a performance-based process that leaders can use in manufacturing organizations to increase competitive advantages. The fundamentals of lean manufacturing employ

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continuous enhancement processes to focus on eradicating waste or non-value-added steps within an organization. The challenge that leaders of organizations utilizing lean manufacturing face involve creating a culture that will generate and sustain long-term commitment and support from top management through the entire workforce. If machine uptime is not forecasted and if process capability is not fixed, the factory cannot speed up the market. One way to think of total productive manufacturing (TPM) or total process management is referred to as lean thinking principles [3].

Lean thinking principles, discussed by Womack and Jones [6] and Tapping and Shuker [8], can be lean management enclosed by five fundamental principles, and therefore the fulfillment of those principles depends on worker involvement and management. The primary principle needs that a company leader sets a value from the customer's needs and calculates the process that often followed to attain customer's satisfaction. The next principle is that the company leader sets the chosen stream to identify the wastes, which might be eliminated. The chosen stream refers to the collection of activities that has got to be done to style, manufacture, and finish from fresh material to final product for a particular product, product teams, or services that request to decrease waste and optimize productivity to deliver the client desires [7].

The big seven wastes were determined by Womack and Jones as transportation, waiting, inventory, defects, movement, processing, and overproduction. The company leader should establish pull systems to maneuver works across the value stream, per the client demand. For the fourth one, the workers should be able and approved for constant improvement. For the fifth one, the corporate leader should maintain its weak work and go to verify perfection. The analysis of this case depends on these principles.

Mary and Tom Poppendieck were considered an early estimate of lean manufacturing ideas within the development method. Mary and Tom book on agile software development [5] offered a system of lean manufacturing thinking steps for system development. Then, Virgin and Tom Poppendieck [6] determined seven principles, which concentrate on people and communication during the setup process, together with technical leadership, building information, and decision-making. They additionally enclosed twenty-two tools for characteristic downside areas and discovering attainable solutions.

Womack, Jones, and Ross determined lean manufacturing and discussed it in detail regarding development companies. The calculation is based on a 5-year study of the worldwide automatic industry and provides insights on how lean manufacturing can improve quality and productivity. Quotes from this resource are used in the Purpose and Analysis of Data areas of this study to support the basic principles of lean thinking and benefits [9].

According to manufacturing mass productions due to flexible manufacturing and applying information technologies, increased customization requirements, and short production life cycles have steered the efforts of implementing mass customization. Mass customization deals with niche markets (Berman, 2002), making it difficult to calculate customer needs because the product is customizable. Mass customization requires the ability to evolve to verify demand [10].

The lean producer, the mix between the advantages of craft and mass production, is far from the high cost of the previous and the rigidity of the later. Lean manufacturing uses a minimum of everything instead of mass-producing items; lean manufacturing decreases the human effort in the factory, decreases the manufacturing space, decreases the machines and tools, and decreases the engineering hours to make a new product in minimum time. Additionally, lean manufacturing decreases the inventory on site, decreases many defects, and increases productivity with a high variety of products [11].

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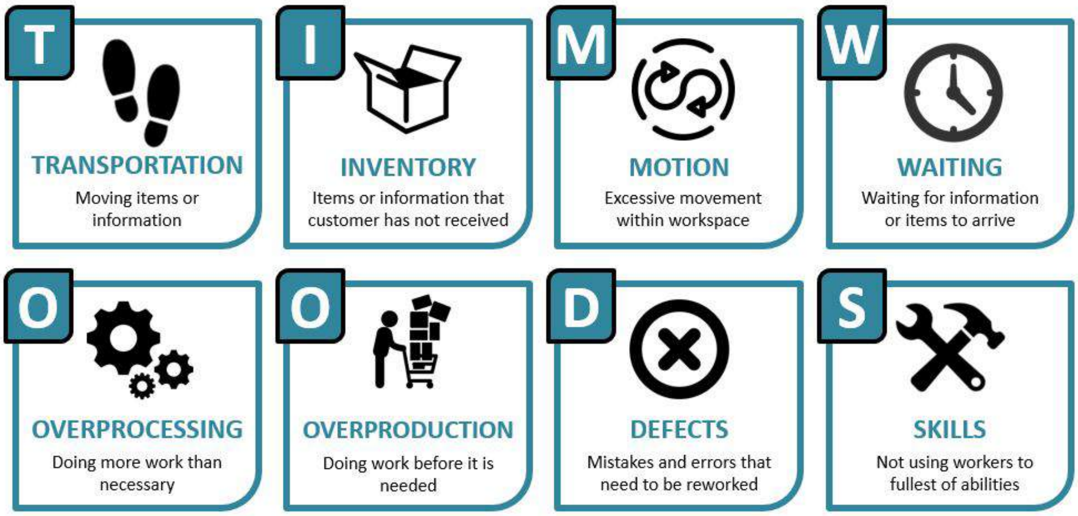

Figure 1: Lean Systems Standard Work Continuous Improvement

II. BACKGROUND

Constructing TPM for AbdulGhani Gold Company through lean manufacturing for its manual production line, its automated production line, and casting production line will provide a new means for waste minimization but will not sacrifice the productivity required for each department to maintain company profit. With lean manufacturing adding value through reducing those wasteful processes, company leaders can have a new set of tools to both identify and eliminate those wasteful procedures recognized as problematic or nonessential. The set of tools that are suggested for application of lean manufacturing in any TPM application include the SMED, the value stream mapping, the 5-S, a pull system known as *Kanban*, and the error-proofing measures called *poka-yoke* [17]. Lean manufacturers also consider TPM as part of a mixed model processing, multi-process manufacturing material handling, and controlled charting methods as foundational processes for successful implementation.

Current literature regarding implementing lean manufacturing and the use of TPM typically focuses on the manufacturing industry; however, in the past few decades, leaders in other industries, such as healthcare, advertising, and retail, have used these cost-cutting methods [7]. The current study's examination of such literature indicated current themes related to lean manufacturing process overview [15] [16], competitive benchmarking [2], cycle time reductions [8], bottleneck removal [10], and self-directed work teams [6].

Researchers have examined the process of lean manufacturing in multiple industries. Mass production systems in the manufacturing industry need streamlining to create efficiency and increase profits. To do this process, lean manufacturing implementation has shown significant levels of success [4]. School of Mechanical and Industrial Engineering Expert, Thakur, reviewed these processes associated with lean manufacturing as implemented successfully in many industries [15]. The author aimed to determine at what extreme were lean management processes put into practice and, if so, at what level did these achieve an outcome of success. The author structured this study on an overview of current literature; in doing so, the author observed several themes with a frequency of similar opinions related to lean manufacturing as a management skill.

Thakur's review of lean implementation was exampled through many expert studies as a complex and contrasting ideology of lean manufacturing process implementations based on (a) the industry, (b) the number of employees involved in the process, and (c) the education and experience of the management team [13]. The author found that the bottleneck process, value stream mapping, takt time, u-line manufacturing, line balancing, flow manufacturing, quick changeover, and Kanban were all related to a successful implementation of lean manufacturing processes. However, the data indicated specific forces supporting and resisting lean manufacturing outside the manufacturing floor, such as finances, customers, and quality perceptions [13]. The author concluded for lean manufacturing to have concrete success, the implementation must increase its value regarding those stakeholders indirectly involved with the process [13].

The lean producer mixes between the advantages of craft and mass production, while far from the high cost of the previous and the rigidity of the later. Lean manufacturing uses a minimum of everything, unlike mass production. Lean manufacturers decrease the human effect in the factory, manufacturing space, machines and tools, and engineering hours that it may take to make a new product in minimum time. Additionally, lean manufacturing decreases the inventory on site, resulting in decreasing many defects, thereby increasing productivity [18]. Lean thinking principles, discussed by experts Womack and Jones and authors Tapping and Shuker, was produced from lean manufacturing practices to practice continuous improvements [tapping] [18]. The authors explained how lean management was covered by five basic principles and offered predictions of success dependent on management and employee involvement [14] [18]. Womack and Jones also determined there were seven big wastes: overproduction, inventory, waiting, defects, processing, movement, and transportation [18]. The principles included requiring an organization to define value from the customer's viewpoint and calculate which processes followed the viewpoint to achieve customer satisfaction. These principles indicated a company exampled the selected value stream and determined the wastes, which could be eliminated.

In the gold and jewelry industry, the transaction cycle of any gold factory is understood as being a loss based on wasteful processes. With using competitive benchmarking, companies' leaders evaluate driving factors from quality measures to customer satisfaction. Alosani et al. investigated using competitive benchmarking and if its processes correlated to best practices in organizational performances [2]. Contributing to the existing body of knowledge, the authors explored the underpinning theory of a resource-based view (RBV). The authors observed that benchmarking was advantageous when encompassed from the foundations of competitive advantages [2]. Following the recognized idea that continuous improvements were standardized practices of lean systems, the authors suggested adding a competitive benchmarking process through RBV as part of lean manufacturing to show TPM as a successful endeavor. The authors suggested that companies' leaders should examine the potential of competitive benchmarking using RBV for continuous improvements [2].

The current literature survey examined multiple expert examinations of lean manufacturing and those facets that made it successful in its enterprise with TPM. Many experts found that the impacts of lean manufacturing based on industry type and industry standards [13], while others claimed such elements as competitive benchmarking [2], cycle time reduction [8], and bottleneck removal [10] were fundamental for success. The gathered data from the reviewed literature did show a recognized important part in self-directed work teams related to the successful implementation of lean manufacturing. The conclusion from many experts [4] [5] [6] [17] expressed that self-directed work teams were the vital element to make lean manufacturing work in most industries.

III. METHODOLOGY

Chapter III presents an introduction about the company that is the study site and the department under observation in this study. Chapter III also presents the groundwork of this study, including data collection and Total Productive Maintenance (TPM) for the selected department.

- An Introduction to the AbdelGhani Jewelry Factory

One of the largest industrial factories in Saudi is a branch from AbdulGhani Gold Company. It is located at the Makkah city in the field of Gold Industry sector. This factory includes three production lines:

• Manual production line.
• Automated production line.
• Casting production line.

These plants produce a large number of products at an increase of more than 3000 products. The production in this factory works according to orders from customers. According to the tour in the factory around the department, problems were mainly in the availability of data and which department this researcher should select for the purpose of this study. Several possibilities were explored until this researcher finally made the choice of production lines.

At AbdelGhani Jeweler's manufacturing unit, this researcher believed that quality means customer satisfaction. Jewelry manufacturing to achieve customer satisfaction must be according to the following procedures discussed in the next subsections.

1-Designing Step

To produce a brand-new special product, the primary step is to make a design. this is often the purpose from wherever the production first happens. The designer develops a thought for the look, evaluates the concept, and interprets it into reality.

2-Computer Aided Design Process

Leaders will use Computer Aided Design code to extend the productivity of the designer, improve the standard and dimensional accuracy of style, and build information for producing. Once the jeweler designer conceptualizes a design, they draw it on paper, so into the system. This method of constructing a style into the system is expedited through Computer Aided Design technology by exploitation the Rhino Gold program.

3-Rapid Prototype Process

Once the Computer Aided Design style file is prepared, it'll convert the data into the 3D rapid prototype system. this method works on the principle of direct light projection technology where the resin model is formed employing a 3D rapid prototyping system (RPT), and that is totally useful.

4-Model Making Step

Pitch yield from CAM is then modified over into silver model by utilizing the casting method. The silver model could be the main style that's traced to form several similar itemsof jewelry. The silver model is employed to make the rubber mold from that all subsequent items are created.

5-Rubber Mold Process

Mold creating is an integral part of the production process. It helps in making multiple items of jewelry of the identical style. These styles stay protected and embedded within the mold forever, and it's potential to make replicas of the identical in the future. There are different types of materials used for mold creating, like natural rubber, and metal.

6-Waxing Process

In this step, designers are manufacturing wax items from rubber molds made up of the silver or rubber materials. The rubber mold is placed on the wax contraption machine. liquefied wax is pressure injected into the mold cavity to make wax models for casting.

The process of bonding the wax items on a wax stem is termed "treeing." Tropical sprue is hooked up to every piece, that is hooked up with the stem. The tropical sprue creates an angle of roughly forty-five degrees with the stem. The tree is specified the heavier parts are at the underside of the tree and therefore the lighter ones are at the highest.

7-Casting Process

Casting could be an advanced method and needs special consummate and knowledgeable casters for the specified final product. The waxing process is placed in steel flasks, that are then occupied with a suspension of chemical powder, that solidifies in an hour. The flask is then heated in an electrical chamber, that melts the wax, dropping the cavity of wax. liquefied metal is poured into the flasks, allowed the temperature to cool, then disassembled to expose the jewelry in casting shape.

8-Grinding Process

After the fresh casting is removed from the casting tree, it's a little nub left at an area wherever the gold piece was hooked up to the tropical sprue. The polisher tool grinds off this nub by motorized grinding machine, that acts as an abrasive to smooth the surface of the gold piece/jewelry. A final sprucing is then completed by holding the piece against a spinning wheel to realize a smooth surface.

9-Filing and Assembly Process

The filing could be a technique that helps in removing excess material or solder from an item that's being worked. The casting layer will be removed by different tools, such as burrs and files. These tools give a smoother look to the piece. Then, Assembly happens once 2 or additional elements of the identical style are articulated with the assistance of solder or laser-cut device.

10-Polishing Process

Polishing provides a straight finish and enhances the worth of an item. Polishing contains three steps, pre-polishing, tumbling, and ultra-cleaning. jewelry items with diamonds need pre-polishing before the diamond is placed. Once the diamonds are placed, the part below the diamond piece cannot be polished and will affect the shine of the diamond.

11-Metal Setting Step

Diamond and stone setting considered the art of firmly setting or placing gemstones within the jewelry. Several types of settings will be used to produce many designs. Also, combining two settings can be employed to form an item look appealing. The various styles of settings embrace projection, plate projection, pave, channel, bead, invisible, bezel, flush, miracle, fishtail, plate, and pressure.

12-Final Polishing

This is the last polish of the jewelry pieces. The concept is to feature shine to the complete piece of jewelry. Polishing is finished when setting stones, and it can be done by machine or hand. If the jewelry is polished by hand, then the designer uses tools, like solid buff, hair buff, soft buff, coin buff, a line ball buff, Pt sprucing rouse, green rouse for shine, black luster for removing casting and filling layers, red rose to impart shine, and white luster to get rid of roughness.

13-Rhodium Plating Process

Rhodium considers a shiny white colored valuable item. once a piece of jewelry is Rhodium-plated, it provides a white reflective look and gives the piece of jewelry higher resistance to tarnish and scratches. Rhodium-plating on gold ought to add white to the gold; as a result whiteness for it isn't white in its original pure type.

14-Quality Control Step

Quality control is a step or set of steps supposed to make sure that a factory-made product or the performed piece adheres to a constraint set of quality criteria or meets the necessities of the consumer. There are three strategies of quality control check: visual examination, activity, and mechanical inspection. The transaction cycle for the gold factory in the following flow chart:

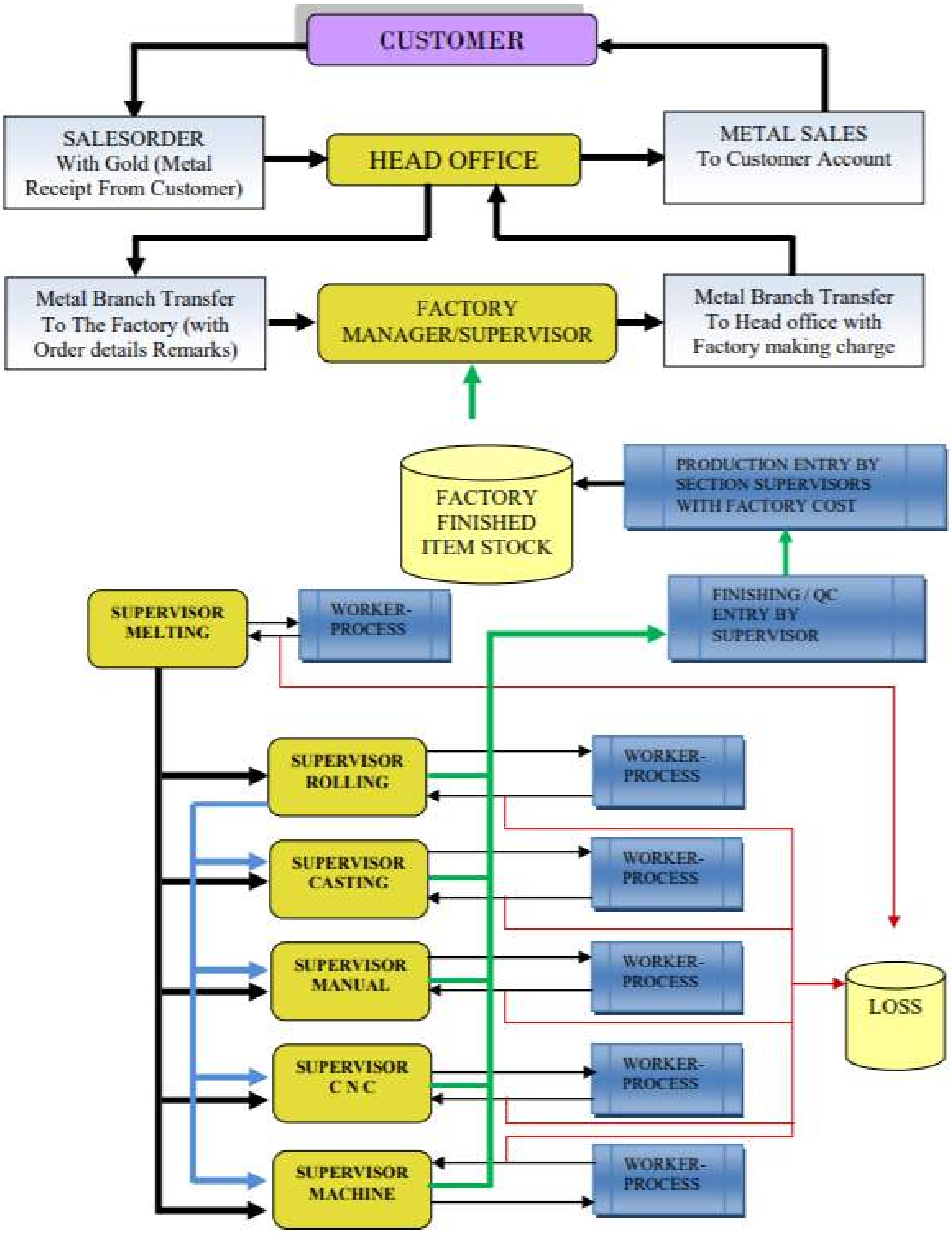

Figure 3.1 Production cycle in gold factory.

The stages of this production line are as follows:
1. The furnace to melt the gold
2. Lab to check the Karat for gold specifications
3. The rolling station according to the dimension's specifications
4. Prepare the rings in dimensions according to orders of production
5. Welding the rings
6. Buffing the place of welding
7. The working on CNC machine
8. The quality control on the product
9. Bar code and backing

The following flow chart shows the procedures of manufacturing for this production line:

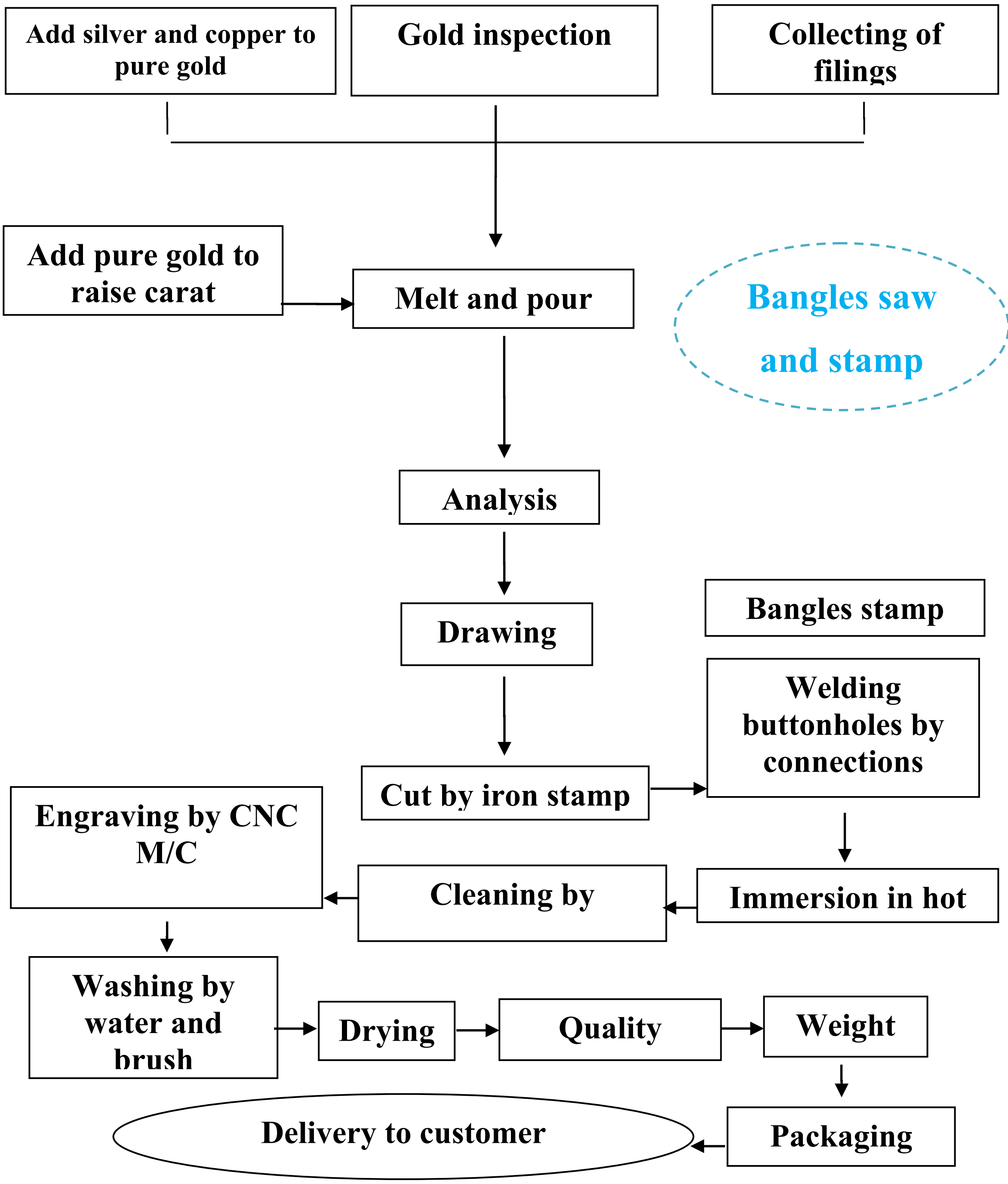

Figure 3.2: Procedures for manufacturing.

IV. BUILDING A TPM OF THE EXISTING PRACTICE

As discussed in Chapter II, TPM may be the most important part of the operational stability foundation of building the Lean House of Excellence. TPM is the starting point for many quality and cost improvements. From the information gathered, this researcher created overall equipment effectiveness (OEE) for all operations that occurred in the production line, which was performed by workers in each step, according to process sheets and work orders.

OEE is a simple but clever calculation that focuses on individual items of process or manufacturing equipment at a finite level and allows the 'effectiveness' to be measured individually or in groups (i.e., with other equipment items). The OEE calculation is based on the ratio of the three key production parameters: availability, performance, and quality with time (e.g., planned shift time/s).

V. THE COMPONENTS OF THE OEE DESIGN

1. Accessibility (A) is the constraint that considers the time period. once a machine isn't running because of a fault, one is losing planned production time (PT): A = operational Time / PT.
2. Performance (P)is the model cycle time (CT), which is the highest speed that the machine will run, presented as a part of cycle time. In some cases, it is called the name plate cycle time. Performance is topped at a hundred percent to make sure that if cycle time is minimum, the performance character won't ruin the calculation: P = (CT * items Produced)/Operating Time.
3. Quality (Q) is a wastage because of poor quality: Q = sensible Pieces/Pieces made. the typical for overall instrumentation efficiency/effectiveness in producing plants is between forty-five percent and sixtieth percent. To realize "world class" producing standing, the grade of eighty-five percent or higher ought to be targeted. Each plant and producing processes are
4. completely different. If one operates a policy of Six-Sigma, then quality levels of 96.5 percent would be unacceptable; but, 99.99% would be a more robust target to get.
5. Calculation refers to leaders scheming every step within the line. As shown within the flow chart for the assembly line, some operations are neglected within the calculations as a result of these don't have an additional impact in the calculations. These operations embrace bangles stamp, immersion in hot acid, and, drying.

VI. TOTAL PRODUCTIVE MANUFACTURING

To begin applying TPM concepts in the factory maintenance activities, the entire work force must be committed to the manager. The next step is to coordinate TPM applications by a coordinator. The coordinator must sell the TPM concepts to the workforce through a training program. To do a thorough job of educating and convincing the work force that TPM is just not another "program of the month" will take time, perhaps a year or more.

Next, action teams are formed. These teams usually consist of people who have a direct impact on the problem being addressed. Operators, maintenance personnel, shift supervisors, schedulers, and upper management may all be included on a team. Each person becomes a "stakeholder" in the process and is encouraged to do his or her best to contribute to the success of the team effort. Usually, the TPM coordinator heads the teams until others become familiar with the process and natural team leaders emerge.

TPM has five basic components as following:

1 . Autonomous maintenance.
2. Effective Training
3. Over all equipment
4. Planned maintenance
5. Early Equipment.

VII. AUTONOMOUS MAINTENANCE

Autonomous maintenance is a critical first step of TPM, and operators must be trained to close the gap between them and the maintenance staff, making it easier for both to work as one team. Therefore, the operators should work closely together with maintenance people in the following three ways:

- They can alert maintenance people.
- They can provide excellent information.
- They can perform routinemaintenance.

The purpose of autonomous maintenance is to teach operators how to maintain their equipment by performing:

- Daily checks
- Lubrication
- Replacement of parts
- Repairs
- Precision checks
- Early detection of abnormal conditions. [16]

1. There are Seven Steps in Autonomous Maintenance:
2. Initial cleaning.

3. Eliminate sources of contamination and inaccessible areas.
4. Creation of a checklist for cleaning and lubrication standards
5. General inspection
6. Autonomous Inspection
7. Organization and housekeeping.
8. Full Implementation Continuity. [16]

Leaders of maintenance departments make all TPM equipment check sheets and schedules for all equipment. Their historical knowledge of break downs and the types of checks required to highlight potential problems before terminal failure place them as the only department within the facility to own this documentation. Then, all equipment check sheets are placed in relevant standardized work folders kept in the work area. Supervisor/team leaders train operators about what is required to carry out each check to the required standard. Operators then carry out checks at the desired frequency, as stated on the TPM check schedule. They fill in TPM check schedules to confirm equipment condition using the following parameters:

• Green=OK
• Yellow= potential problem
• Oranges=Equipment failure.

Operators find a problem while carrying out their TPM equipment checks. Operators pull the cord to call team leaders. Team leaders then discuss problems with operators and agree whether the issue is a potential failure. Team leaders then complete a TPM equipment tag. They tie equipment tags to areas of equipment with concerns. Team leaders then post another half of the tags to maintenance post boxes.

Maintenance empties post boxes at the start of each shift. Then, they sort cards into closed/urgent and open/potential failure. Open/potential failures tags are placed onto flip cardboards for maintenance. Each tag is placed against a technician with the relevant skills required to carry out the tasks.

Maintenance technicians pick urgent work before planned task cards. Technicians then speak to team leaders about concerns. Maintenance technicians carry out tasks to prevent potential breakdowns — technicians input issue data into a predictive maintenance database. Then, maintenance technicians staple both halves of equipment tags together when completed. When the equipment tag is closed, it is placed here. A lack of tooling or spares is placed here.

Repeatable equipment issues are recorded via the problem and countermeasure boards for the area. This process will ensure a permanent countermeasure is developed between the production team and the supporting functions. Finally, each production area is reviewed by the maintenance supervisor daily. All ongoing and new issues are discussed daily between team leaders and maintenance supervision. [20]

VIII. AN EFFECTIVE TRAINING PROGRAM

For An effective training program, three fundamental features are required:

1. Compatibility.
2. Instruction.
3. Improvement.

Compatibility suggests that the training program should work inside the command's outline and schedule. Leaders should make sure the style of coaching needed can match into the long run schedule of their command.

Instruction involves the particular coaching of personnel. Leaders should guarantee instructors ability for conducting the coaching or singing qualification are well-informed and capable of clearly connected to the topic matter. Analysis checks the progress of every person and therefore the ability of division personnel to perform along with safety and efficiency as a team. Leaders should measure the instruction to make sure personnel are being correctly trained.

The improvement involves detecting groups and individual performances. Leaders should compare results with standard criteria. Improvements involve of steps needed to create training more effective. [21]

IX. TPM TRAINING

The maintenance department conducts training in technical aspects of maintenance. They train each operator in the equipment checks and relevant frequencies. They also focus on the importance of recording all potential and actual failures as these occur and escalating those concerns to the maintenance department. [20]

Overall Equipment Effectiveness (OEE)

Overall equipment is a measure of how well lines or equipment are utilized in relation to full potential. The calculation will target three main production losses:

1. *Availability* shows the relationship between planned production time less any unplanned stoppage. These stoppages will be major breakdowns that can be readily identified.
2. *Performance* shows the relationship between the units that should have been produced and those actual produced. The losses are usually due to speed losses (machines running too slowly) and minor stoppages (events that happen quickly and cannot be easily captured).
3. *Quality* shows the relationship between good pieces produced and rejected parts. It is effectively a "first-time right figure". Six Sigma Methodology can be used with OEE to reduce waste. [19]

Availability:
Total scheduled time= 600 min
(Including over time)

Required down time = 60+60 = 120 min
(60 min for lunch+
60 min for breaks)

Net available time= 720-120 = 600 min
All other down time= 45+45 = 90 min
(Machine down time
And pray)

Operating time= 600-90 = 510 min

Availability= 510/600 = 85%

Performance efficiency:

Mean Ideal cycle time = 8 minutes/part
Total parts run = 60
Operating time = 510 min

Performance Efficiency = 8*60/510=94.12%

Quality Rate:

Total parts run = 60

Rework = 5

Scrap = 0

Quality Rate = (60 – (5+0))/60 = 91.67 %

Overall Equipment Effectiveness:

Availability = 85%

performance Efficiency = 94.12%

Quality Rate= 91.67%

OEE= 0.85*0.9412*0.9167

OEE = 73.3%

Figure 4: OEE calculation example.

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X. PLANNED MAINTENANCE

Failure to record breakdown frequencies by mode and machine type prevents the ability to determine when key equipment checks should be carried out. Failure to plan key equipment checks and maintenance activities result in surprise breakdowns. Surprise breakdowns result in a lack of productivity or poor-quality products being produced. All the above equates to poor customer satisfaction, reduced profit, and loss of competitive advantages. [20]

For planned maintenance, the flip card process is used. Each card represents a task that has a defined frequency; this frequency is set to reduce the risk of failure prior to reaching a known point. The flip card system is card based and uses color to show the status of tasks. This follows the basic principles of visual management, makes abnormalities stand out, and enables rapid management of situations before becoming a problem. The red field card refers to the following:

- Task description.
- Card no.
- Frequency.
- Spares required.
- Tooling required.
- Repair manual location.

The green field card refers to the following:

- Task description.
- Card no.
- Frequency.
- Date next check required, written by a technician from the frequency date.

At the end of the production week, all cards in that week now must be green. Maintenance supervisors then move all cards to the next frequency slot and turn these to red. [20]

XI. ADAPTING LEAN MANUFACTURING PRINCIPLES TO THE GOLD INDUSTRY

This section was conducted to calculate which lean principles are suitable and applicable in the gold industry. Lean manufacturing involves many principles and techniques, all of which have the same main goal: to eliminate waste and non-value-added activities at every production or service process in order to give the most satisfaction to the customer. To stay competitive, many gold manufacturers have sought to improve their manufacturing processes so that they can be more readily compete with overseas manufacturers. This study identifies the different tools and principles of lean. A model for implementing lean tools and principles in a gold factory environment was developed.

XII. OVERVIEW OF THE LEAN PRODUCTION SYSTEM

The wastes noted above are commonly referred to as non-valued-added activities and are known to Lean practitioners as the Eight Wastes. These account for up to 95% of all costs in non-Lean manufacturing environments. These wastes are:

1- Overproduction – Producing more than the customer demands. The corresponding Lean principle is to manufacture based upon a pull system or producing products just as customers order them. In our gold factory there is no this type of west because we make a production according order.

2- Waiting – This includes waiting for material, information, equipment, tools, etc. Lean demands that all resources are provided on a just-in-time (JIT) basis – not too soon, not too late.

Wait time results in lost capacity and efficiency and it increases the lead time to the customer while failing to add any value.

In response, Lean organizations:

- Design processes to have a continuous flow with minimal or no buffers between steps.
- Implement Standard Work to make sure that a consistent method is used for each activity.
- In the first two steps (furnace melting gold and rolling) the waiting in rolling operation depends on the types of orders and measuring of all dimensions and specification of all orders. In the average about half hour after melting and inspection of karat in gold. The following data for one week 6 days working:

Table 5.1: Wait Time for four weeks

Day	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
Average Quantity (gm)	3500	1960	2000	2200	1700	2800
Waiting time1_st week	45	29	32	34	28	40
Waiting time 2_nd W	42	31	30	28	30	38
Waiting time th_nd W	40	28	33	36	28	36
Waiting time fh_nd W	43	30	35	32	23	33

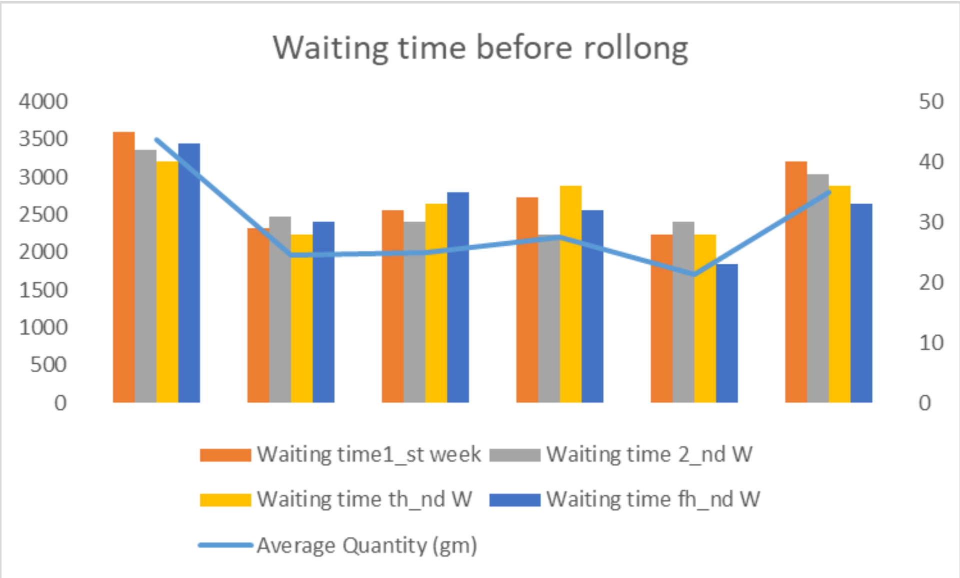

Figure 5.1: Wait time for workers

From chart it shows that the loss in worker hours leads to take decision that the workers in these two stations (melting and rolling) must start two hours prior all other worker in the factory. This point will save in labor cost about 17,200 SR/month.

3- Transportation – Material should be delivered to its point of use. Pure or used gold from vendors or our branches being collected and shipped from the vendor to a receiving location in the factory every day with the order from each to make our production, processed, moved into a warehouse, and then transported to the assembly line, Lean demands that the material be shipped directly from the vendor to the location in the assembly line where it will be used. The Lean term for this technique is called point-of-use-storage (POUS). This point divided into two stages , transportation from vendors to factory and internal transportation between production stations and machines. The first one it is done smoothly and not increase in cost of production directly. The second one is the most complicated in movement from machine to another and make a losses in gold in each station. In average, we work in each station to decrease the movement in each location to decrease losses in continuous improvement until now. The average saving is about 0.5 gram in each kg means 3 gm instead of 3.5 gram. These make save about (0.5 * 2200 kg annual production) means save 1100 gm yearly about 154,000 SR yearly.

• Non-Value-Added-Processing – Some of the more common examples of this are reworking (the product or service should have been done correctly the first time), deburring (parts should have been produced without burrs, with properly designed and maintained tooling), and inspecting (parts should have been produced using statistical process control techniques to eliminate or minimize the amount of inspection required). A technique called Value Stream Mapping is frequently used to help identify non-valued-added steps in the process (for both manufacturers and service organizations).

• Excess Inventory – Related to balance of pure gold which related to factory (owner) this is stand by to cover the decrease in the raw material input in production processes to make all order complete at the end of the day.

• Defects – Production defects and service errors waste resources in four ways. First, materials are consumed. Second, the labor used to produce the part (or provide the service) the first time cannot be recovered before two months because we make our recycle every two months and not obtain all losses and lost about 3 gm from all kgs we produced. Third, labor is required to rework the product (or redo the service). Fourth, labor is required to address any forthcoming customer complaints.

• Excess Motion – Unnecessary motion is caused by poor workflow, poor layout, housekeeping, and inconsistent or undocumented work methods. Value Stream Mapping (see above) is also used to identify this type of waste.

-Underutilized People– This includes under - utilization of mental, creative, and physical skills and abilities, where non-Lean environments only recognize underutilization of physical attributes. Some of the more common causes for this waste include – poor workflow, organizational culture, inadequate hiring practices, poor or non-existent training, and high employee turnover.

- Operational Improvements

Abdul Ghani gold company recently surveyed forty of their clients who had worked with it. Typical improvements were reported as follows:

• Lead Time (Cycle Time) reduced by 90%
• Productivity increased by 50%
• Work-In-Process Inventory reduced by 100%
• Quality improved by 95%
• Space Utilization reduced by 75%

-Administrative Improvements

A small sample of specific improvements in administrative functions is (based upon personal experiences):

-Reduction in order processing errors

Streamlining of customer service functions so that customers are no longer placed on hold Reduction of paperwork in office areas to achieve zero by using Information technology system.

Reduced staffing working in the factory. Documentation and streamlining of processing steps enables the out-sourcing of non-critical functions, allowing the company to focus their efforts on customers' needs Reduction of turnover and the resulting attrition costs make implementation of job standards and pre-employment profiling ensures the hiring of only "above average" performers – envision the benefit to the factory.

-Strategic Improvements

Our company implement Lean to do adequately take advantage of the improvements. Highly successful happen learned us how to market these new benefits and turn them into increased market share. In order to capitalize upon the improvements, the company began a marketing campaign, advertising that customers would receive the product in the same day, or the cost of the order would be decrease. Sales orders increased by 15% almost immediately. After making the appropriate improvements to handle the new demand, the company initiated another marketing campaign; for only a 10% premium, they would ship to another sites in KSA like Reyad. The end result was that the company increased revenues by almost 35% with no increase in labor or overhead costs. Another key benefit was that the company was able to invoice customers in the same day with no lateness than before, greatly improving cash flow.

Barriers to Successful Implementation of the company that attempt to implement Lean experience difficulties and/or are not able to achieve the anticipated benefits. Some of our own observations in this area include:

- Lean radically impacts every person in every function of the company, and literally changes the organizational culture. The change causes discomfort, and many departments are not able to cope with this magnitude of change.
- It takes long time to fully understand and implement lean throughout our company; frequently. One manager decided to implement lean, just to have his successor scrap the program.
- Finally, many of the concepts we learn in Lean are different from managers, accountants, and other decision makers were taught. Some of the more interesting ones that we've encountered (and, address in our own lean implementations) include:

Table 2: Comparison before and after the implementation of lean Manufacturing

Concept	Before lean implementation	After lean implementation
Inventory	An asset, as planned from old management system	No waste and increase process lead time
Economic order quantity	Large to make up for process downtime	Reduce down time to zero
People utilization	All people must be busy at all time	Because working based on customer demand, people might not be busy
Process utilization	Run all machines all the time	Designed processes to keep up with demand
Work scheduling	Build product to forecast	Build products to demand
Labor costs	variable	fixed
Work groups	Traditional (functional) departments	Cross-functional teams
accounting	Traditional guidelines	"through-put" accounting
quality	Check work at end of process to make sure we find all errors.	Process, product, and services are designed to eliminate errors.

XIII. CONCLUSION

The concept of lean manufacturing was advanced for take full advantage of the resource use through reducing the waste. Due to rapidly changing business environment the organizations are forced to face challenges and complexities. Any association in the case of assembling or administration arranged to endure may at last rely upon its capacity to deliberately and consistently react to these progressions for improving the item esteem. Consequently worth adding procedure is important to accomplish this flawlessness; henceforth executing a lean assembling framework is turning into a center competency for an associations to support.

In this paper, an endeavor has been made to build up a lean course map for the gold industry association to execute the lean assembling framework. Examinations of the exploratory study results are abridged in this paper to outline the execution succession of lean components in gold industry business condition and the finding of this audit was blended to build up a bound together hypothesis for usage of lean components.

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