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STANDARDIZATION AND ITS EFFECT ON PRODUCT QUALITY AND PRODUCTION RATE

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Finally, no words can explain my appreciation, respect, greeting, pride, and gratitude for my parents for delivering me to such success and achieving important chapter of my life.
KARIM MOHAMED HUSSIEN, March 2020

Abstract

It's very important for any firm in any field to keep its place in the competition and defend it against competitors which requires continuous development and high efforts to overcome any default also to improve efficiency. The outcome of any production process will be different even for the same product this is due to variability of man, material, machine and method. Our focus will be on both how to control and develop the production process so standardization of the process will be the key word to achieve both high quality and high production rate not only that but also eliminate any assignable causes.

- The objective of the report is to create standardization process according to lean in order to perform tasks in optimal way. Using the case study and literature review will be able to answer the following:

1-How to standardize the production process?

2-what is the effect of standardization?

3-Does standardization always work?

-results have shown the requirements for standardization of production process, methods of standardizations and tools to be used.

CHAPTER ONE

INTRODUCTION

1.Introduction

1."If you think of standardization as the best that you know today, but which is to be improved tomorrow; you get somewhere." Said Henry Ford (Ford, (1926))

Companies now days working on lowering cost of production while enhancing product quality this is due to high competition and technological development so in order to achieve firm's target organization of the working environment is the key word as The general conditions of the working environment must be applied and taken in consideration.

1.1what are the main conditions of any working environment? starting from layout which plays important role in productivity and organization design, including allocation of different facilities also machine allocation as it boosts collaboration and ease access to the resources. (hussien, 2019)

Second includes Warehouse: considered one of the most important departments for any production facility which must be kept secure and clean for both raw material and products taking in consideration also warehouse stuff whom must be well trained and experienced. one of the strategies which highly used is the 5 S which will be discussed in detail in the following chapter. (hussien, 2019)

Third includes manpower: it can be classified to both operators and managers, for operators the focus can be financially by rewards - bonus and psychologically by sharing of rights to take decision and share their point of view. Managers focus is mainly financially to ensure the achievement of the targets and revenues. (hussien, 2019)

Forth includes Health and environmental considerations: working in healthy and safe environment is the key word for continuous development as the more comfort the employees feel the more productivity and creativity. (hussien, 2019)

Last is the Instruction of the working conditions which is the reference for all production facilities including general policy and instructions manuals which formalize both work and behavior. (hussien, 2019)

Working in different fields as main a vendor over 50 years is a great responsibility towards customers, markets and industry so using such concept Noubar have taken in consideration product quality and customer satisfaction as their priorities. Over hundreds of products with multiple specifications and different working conditions it is necessary to standardize the production process to ensure the lowest cost of production and optimum productivity. the link between productivity and quality is not that easy as it required high control over different production sequences starting from inspection of the raw material-raw material processing -warehouse and storage -production process (extrusion-mold) and packaging. (hussien, 2019)

1.2 Problem formulation

our case will focus on extruded products due to their importance as a wealthy product (big fish), due to cost of production and high specifications. Main problems related to such products is to meet the specification and to be within the control limits ,eliminating any assignable causes and reducing variability, taking into account process capability away from assignable causes .generally any production problem is related to man , machine ,material or method which in turn result defects or defective product causing waste in production cost and quality.

1.3 Aim

In order to achieve first type quality production standardization must take place in the production process to avoid such causes and in turn reduce cost, time, effort and assure high productivity and quality.

1.4Research main points?

-How to standardize production process?

- what is the effect of standardization on production rate and quality?

- **Case study**

The case study will be a specific organization as (Noubar firm), in which analysis and examinations takes place through qualitative and quantities research methods.

- **Data collection**

Primary data mainly are collected based on analysis and surveys of current state of the case study.

1.5The report will be composed of five chapters , starting with chapter one including introduction and general explanation of the working environment focusing on the production, then how to control the production process to reduce cost and effort .The aim is to use standardization as the mean to achieve high quality and productivity , then chapter two includes a brief description of the working environment , chapter three includes causes which make improvement necessary , simply as products with high specification require high production cost and effort not only that but also under some circumstances long time which affects the production rate causing delay regarding product delivery causing customer dissatisfaction . chapter four will focus on standardization of the production process as the tool to achieve both high quality (specification conditions) and high production rate to avoid late delivery. finally, chapter five will include the positive outcome after standardization and the enhancement of the production process also comparing before and after standardization.

1.6 History of lean production has been started in in 1980 by Toyota when Japanese's car was the best in the market due to its efficiency and quality, that is why it is optimal choice for many users due to its long life performance and reliability comparing to American cars with lower features. Toyota's engineering system was the keyword for its product and process consistency. operational excellency is the result of lean production which includes multiple standardization tools such as just in time, kaizen and one-piece flow. Lean production includes five main points: define the value, determine value stream, value flow, value pull by the market (customers) and target supremacy. Toyota production system composed of 4 main groups including 14 principles. The objective of lean production is to eliminate any kind of waste during production process as lean principles are mainly derived from avoiding nonvalue added activities either from consumer prospective or production prospective. (Liker J. K., 2006)

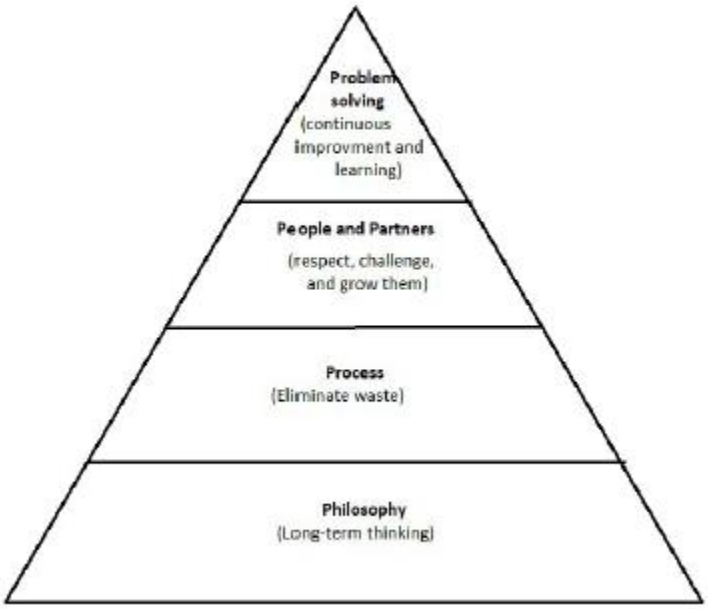


Figure (1) The 4P model

1.7 lean production objective is to minimize waste during production and maximize productivity. Just lean is an approach produced by Toyota production system and deployed other firms in different industries. lean production depends on multiple principles for example Kaizen (regular improvement methodology), in 1990 lean production took place in western world through a publication known as **The machine that changed the world,** such publication indicated the future of automobile industry under Toyota's lean system . The forecast of such publication was over five years , after 1990 the spread of lean production widely takes place due to its efficiency as a production methodology through which quality and productivity are guaranteed not only that but also it can be implemented in different industries such as software and healthcare .In a glance lean production reduces cost of production as it reduces lead time as the target for any firm is to reduce cost of capital and increase revenues. (searcherp.techtarget, n.d.)

1.8 lean production composed of five principles:

- Determine the value from customer's view: the value of a product or service is created by the producer but its evaluated and defined by the customer, so any company before production or development of product or service it must take in consideration customer's demand. utility and willingness to pay.
  -demand indicates the importance of such product or service from customer's point of view
  -utility is a function of customers' benefit from such product or service versus its price which is relate to customer's willingness to pay. (searcherp.techtarget, n.d.)

- Mapping of value stream: information and material flow related to specific product or service must be analyzed and evaluated to avoid any kind of waste and improve productivity. value stream is a detailed analysis of the product life cycle starting from raw material processing, production, distribution, usage and disposal so companies must eliminate nonvalue added activities within every stage.
- Create flow : optimal production system must flow smoothly by detecting any waste in either time or cost for example interruptions during production process as a result of man , machine or material which can cause huge losses , also lead time management must be considered to ensure continuous flow of activities.
- Creation of pull system: market demand must be the keyword for production which means that new production can only start for the sack of customer pull to ensure production related to demand and inventories efficiency.
- Continuous process improvement: continuous development is requited to achieve perfection which requires elimination of waste and determine its causes in order to achieve high quality. (searcherp.techtarget, n.d.)

- lean production focuses on waste elimination which can be included in the following forms:

1. Useless transportation
2. Over inventory
3. Useless motion of man and machine
4. Waiting
5. Over production
6. Over processing time
7. Defects

1.9 As it known that elimination of waste is the objective of lean production. waste elimination means to remove any non-added value activities from customer point of view or regarding his willingness to pay so following lean tools can be used to ensure that: (searcherp.techtarget, n.d.)

- Heijunka: continuous flow stream while production by avoiding interruptions.
- Kanban: creation of just in time delivery by either physical or electronic signals.
- Jidoka: methodology used to help man and machine to determine any abnormalities during work until its solved.
- Andon: visual indicators used to inform workers about a problem using flashing light.
- Poka-Yoka: it is an alarm against human error for example if the operator missed an activity while production, so the system will block the coming step until the previous one is finished.
- 5S: it is used for organization of the working environment also to ensure safety standards.
- Cycle time: it is the time required for production of one unite or the complete process.

❖ Lean versus six sigma:

They seem similar in the objective, which is to reduce waste, but both uses a different approach which is related to the causes. Lean production root causes based on identifying nonvalue added activities which are related to customer point of view, but Six sigma is based on elimination (process.st, n.d.) of waste related to process variation. (searcherp.techtarget, n.d.)

1.10 The role of successful leaders is to implement lean thinking within the organization for example experts inside Toyota use Kaizen in order to insure that lean standards are implemented by all the members not only that but also highly experienced members transfer their knowledge to less experienced members. Key performance indicators considered a method to determine the effect of lean on general performance, but such method will not be always used as indicator it may not reflect real performance accompanied by just intime approach. Comely used accounting systems for mass production un effective because lean accounting is more efficient also lean accounting align with lean approaches. After formalization of lean principles, in 2001 Toyota created lean management methodology which focuses on managerial behaviors and attitude in order to sustain long-term improvement. the core points of such methodology are elimination of waste in addition to customer engagement by continuous development. (wikipedia., n.d.)

1.11 As a multinational firm Toyota has to sustain (TPS) by problem solving system as Toyota has business behind borders in different countries all over the world so the issue now is to ensure that it is system is being followed inside all production plants not only that but also different problems arising from such plants so in order to solve such issue Toyota first focused on culture differences in order to determine people behavior and challenges facing them note that without behavior principles TPS efficiency will be lost . After determining different Joiners cultures Toyota stated with continuous development aspects which have been translated into the following principles: (wikipedia., n.d.)

- ✓ Challenges: determine challenges and capabilities required over the long term.
- ✓ Kaizen: operations must be continuously improved for the sake of innovation.
- ✓ Genchi genbutsu: target the source of information, take the right decision and quickly achieve the goal.
- ✓ Respect: taking stake holders problems in serious manner with high responsibility.
- ✓ Teamwork: individuals' development either in behavior or capability can take place within team through contribution to team performance.

1.12 Lean is considered by many firms as the product of TPS however there are differences between TPS and lean manufacturing including: (wikipedia., n.d.)

- Seeking profit: among the outcome of Toyota concepts is profit maximization by continuous cost reduction which is related to lean principles as flow and pull however the usage of curve analysis limits the effect of lean improvements to bottom line performance indicators.

- Tool orientation: tool used within lean such as standardized work , visual control and value mapping are used to figure out and avoid any problem but not for solving the problem, for example value stream mapping used for information and material flow not for man or method.
- Management technique versus agent change: according to Toyota managers and supervisors regularly follow training programs to develop their skills as Toyota rely on them to manage work performance rather than inserting new blood such phenomena considered as push implementation not pull according to lean.
- Lack of understanding: considered the main cause for lean failure in different projects as it known by romantic just in time such phenomena takes place when the belief in a method is highly considered than its understanding and outcome.

1.13 Lean principles have been deployed in several industries such as call centers in which lean was used to reduce handling time and variation in accent or agent. In healthcare industry lean hospital is used to provide high medical quality and cost reduction by implementing the concept of patient comes first. The usage of lean concepts in different industries has been used to determine its effect on working environment and its outcome. Lean is not used in other industries due to complexity of implementation and lack of translation of lean principles to support the context of such industry. (wikipedia., n.d.)

-Lean goals can be classified to internal focus (profit maximization) and external focus such as (customer satisfaction) in addition to the following:

- Quality improvement
- Waste elimination
- Time reduction
- Cost reduction

-Lean concepts also includes:

- Being lean (lean as fixed state)
- Becoming lean (lean as continuous process)
- Toolbox lean (lean as a tool)
- Lean thinking (lean philosophy) (wikipedia., n.d.)

1.14 Standardization is a process of setting standards to act as a guide for product or service production, the aim of standardization is to ensure quality of such product or service comparing to competitor's product or service. standardization also used to ensure safety and compatibility during production. There different parties acting in standardization process including customers, government, and organizations. (process.st, n.d.)

Goal of standardization is to ensure work process compatibility. standardization mainly focuses on production of good or service, business operations and used technology. multinational companies use standardization to ensure that policies and regulations are being followed in order to sustain product or service quality to meet specifications regardless of the geographical area. general benefits of standardization include: (process.st, n.d.)

- Process clarification: the process sequence is indicated in optimal way avoiding any kind of waste.
- Quality: assure product or service quality by formalization.
- Maximizing productivity: this is due to smooth stream of production.
- Avoid workers moral: using continuous improvement of expert workers skills and transfer of knowledge and capabilities to new ones.
- Optimal customer service: as standardization ensure quality which affects customer satisfaction and utility.

1.15 standardization avoid ambiguity in work , as teaching workers how to do their work requires time and effort in order to ensure work process efficiency however under some circumstances such training is not sufficient in the absence of standardization because workers may make defaults (human error) or lack of knowledge which result ambiguity in the work process as workers need one correct way to follow in order to avoid default behaviors. Using standardization workers are enforced to follow the instructions and even if they didn't flow it standardization tool will detect such behavior, so we can ensure sustainability of the work process. (process.st, n.d.)

- Standardization and quality: As production process for a product is characterized by high level of uncertainty due to man , machine or material so you cannot guarantee of the outcome for every production process in addition to production obstacles which may result waste in time and cost but using standardization we can ensure cost reduction due to elimination of non-added value activities due to to lead time management not only that but also we avoid duplication of efforts and safety. (process.st, n.d.)
- Standardization and productivity: cutting waste and optimal use of resources are highly promoted by standardization as production flow will follow smooth stream and default will be detected while production saving time and cost. standardization also ensures optimal allocation of resources for example human resources as each operator will be responsible for specific task. From a wider view firms include different departments each with specific objective so in order to avoid any kind of conflicts standardization is used. (process.st, n.d.)

CHAPTER TWO

WORKING-PRODUCTION CONDITIONS

2.NOUBAR History

For more than 50 years in custom parts market, Noubar has been a market leader in extruded and molded parts field. Using experience, research and development Noubar has developed and enhanced both supply products and services all over the region. (Noubar, n.d.)

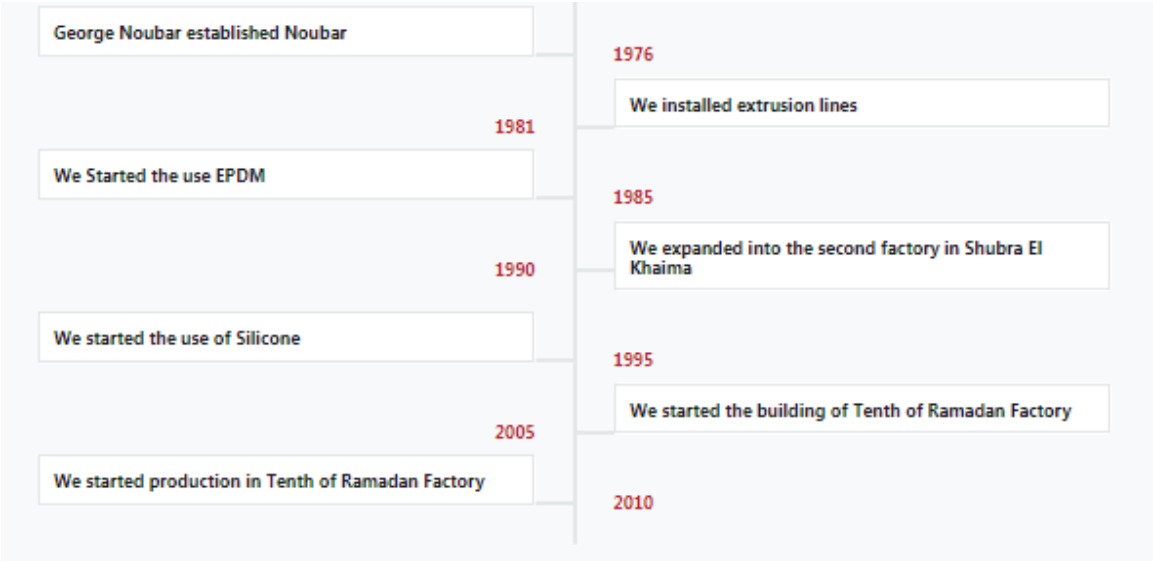


Figure (2) Noubar History chart

2.1 As a proactive entity Noubar has invaded rubber manufacturing field science 1980 and continuously acquired different segments with multiple market capacities and production diversity including the following industries: (Noubar, n.d.)

-Transportation industries (Bellows -Bumpers-Convoluted Boots-Diaphragms)

-Infrastructure (Extruded Profiles-Valves-Connector Seals)

- Petrochemical (Connector Seals)

-Construction (Parking Finders-Rubber Profiles-Insulators)

-Food (Pipes junction-fluid seals)

-Pharmaceuticals (Pipes Junctions-Machinery couplings)

-Industrial Safety (Pressure Valves-Coated metal rods-Solid tires)

-Lighting (Lamp Gaskets-Profile for boards-Transformer Base)

-Automotive (Foot mats -Bumpers-Filters oil seal)

2.2As it known quality is the key word for customer satisfaction which is critical when its business to business, so material quality and formulation are highly considered by Noubar including: (Noubar, n.d.)

-NBR (Nitrile butadiene rubber which is highly resistant to heat, oil and minerals)

-NR (Natural Rubber highly used for metal abrasion)

-SBR (Styrene Butadiene Rubber mainly used for it low price and high stability and wear resistance

-EPDM (Ethylene Propylene Diene Monomer used for fire proofing due to its high resistance to heat

-Silicone (Silicone rubber highly recommend to temperature -55 °C to +300 °C.)

-Viton®(Fluoroelastomer polymer provides high resistance to both heat and corrosion)

Figure (3) Extruded and molded products

2.3Over 50 years Noubar has proved to be a market leader by continuous development, technological progress and creativity. Simply they operate in both molded and extruded products each requires different production facilities and production process. (Noubar, n.d.)

- The production process first started with incoming inspection of the pure raw material which may be composed of (Natural Rubber-NR - Styrene Butadiene Rubber-SBR- Ethylene Propylene EPDM- Silicone rubber Silicone-Fluoroelastomer polymer Viton®) which is recorded in raw material sheet including type and quantity ,then raw material goes under processing combining them with some chemicals-oils to be used for production , which in turn also goes under intermediate inspection such process which must be recorded in the daily production sheet including type of material and quantity also comments in case there are defects . (Noubar, n.d.)

2.3.1The best in Noubar is the know-how as they used the pure raw material to make raw rubber instead of buying it from supplier which give them privilege of lower production cost and vertical integration to avoid fluctuation prices of the market and the barging power of the supplier. Step two after raw rubber is mixed with the chemicals and oils according to the specification of the product to be produced it is delivered by the operator either over a jolly trolley or delivery line to the production facility where the both operators sign on the daily production sheet including the type of the material and quantity to be used and the prospective product . (Noubar, n.d.)

- The layout actually plays important role in such daily collaboration and ease access to resources as the there are two rubber mixers between both extraction department and molded department linked to each department with delivery line by the end of each line there are two operators which inspect the material then record in the daily production sheet then deliver to the production operators . (Noubar, n.d.)

2.3.2Each product depending on its type as molded or extruded has specific production time and temperature for example for molded product , raw rubber is inserted inside the mold then mold inserted inside the autoclave under a specific temperature and time, a different production technique used for injection mold products where the raw material is transferred to the machine through delivery line then using a nozzle inside the machine raw rubber is injected inside the mold which mainly including 100 samples (such technique used for tiny and small products) (Noubar, n.d.)

2.3.3Both first and second production batches are inspected by both production and quality engineer (snapshot approach) then the following batches are randomly checked.

In case there is a problem during production as product is not within specification then the operator will stop production , informing the production engineer which in turn has to determine the causes related to such failure in production as it can be from the material, machine or the operator, such incidence is recorded in a sheet known as production failure. (Noubar, n.d.).

In case the production is going well, final quality check takes place while packaging.

2.3.4Noubar warehouse is composed of raw material section and products section each has a specific storage conditions , Noubar has implemented (wms) ware house management system which has improved their inventory accuracy , save effort and time , reduce labor cost and enhanced productivity .Each item either raw material or product is listed with full detail including : type , quantity , supplier , storage conditions , enter and exist time.in the mean time ware house operators are trained in order to use such software. (Noubar, n.d.)

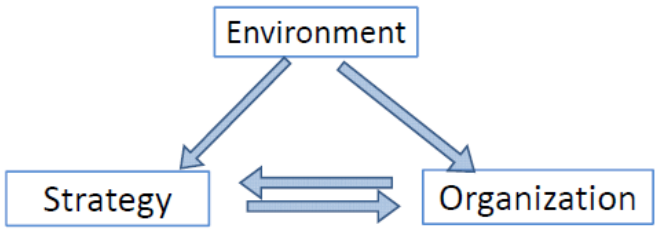


Figure (4) relation between organizational structure, strategy and environment

2.3.5Best thing in any working environment is to be one family which means each one has rights and duties. inside Noubar operators, employees, engineers and managers all are the same each has his own rights and duties but within limits the organization structure of Noubar is operational as the decisions are decentralized (which means each actor has a space to take decision) following bottom up approach (which means that operators drive the flow of work not only the managers) driven by operational concerns and productivity (cost -time and quality). (Noubar, n.d.)

In any organization there is three core issues first the technological issue which is how to use technology to shape , enhance and substitute work of individuals and in Noubar production work is both technological as under some condition technology only used , in other man is only used or both may be used. Second bureaucratic issues which means how many roles and norms formalize working behavior also inside Noubar each activity either production, administration or managerial is formalized. Any organization has two perspectives the managerial which focuses on revenue and firm's target and sociological perspective which focuses on individuals and what drives their motivation.

Finally in Noubar they use the output control as the product output is controlled however the tasks not all programmed, take in consideration that job specialization is horizontal as it's a set of repetitive tasks also position design is vertical decentralized which means each actor has limits of taking decisions and the general structure of Noubar is functional structure. (Noubar, n.d.)

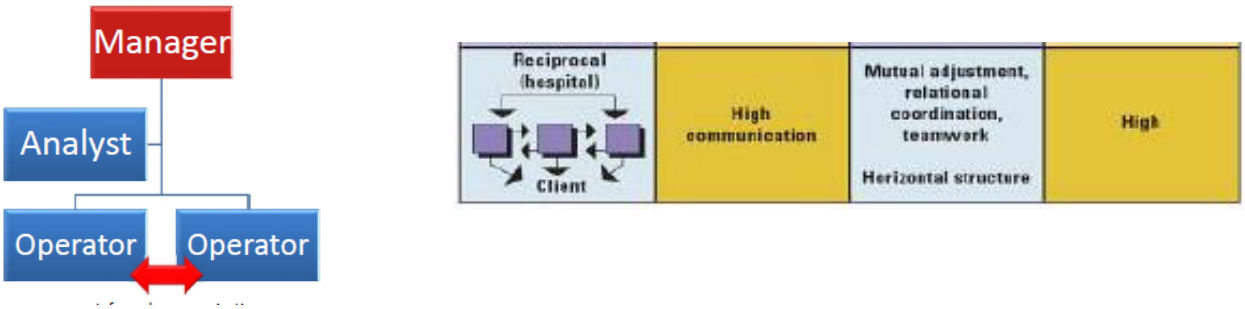


Figure (5) mutual adjustment organizational structure

2.3.6Healthy working environment has a great effect on employees and their productivity inside Noubar such considerations highly followed starting from sufficient space between working facilities and optimum allocation machines to assure safety and avoid traffic also work stations are well organized and equipped as each station includes a seat giving the operator full flexibility and comfortability while working in addition to fire and electrical control system, note that each work station is numbered. Temperature control affects operator's productivity as productivity dropped by 4 percent for each degree above 27 degree using this concept Noubar used to control high temperature accompanied by machines, mixers, capacity of the working place, lighting and emissions of carbon dioxides. (Noubar, n.d.)

CHAPTER THREE

CAUSES WHICH MAKE THE IMPROVEMENT NESSESARY

3.Cost leadership and differentiation considered today's target to be a competitive firm and to defend your market leadership , but combining both is difficult specially in industries of durable products , therefore the focus on both cost and quality requires to take in consideration all the parameters of the production process not only that but also eliminating any production problems which will cause loss of time, production cost and customer dissatisfaction. The question now is, what are the causes of production problems and what are the consequences? basically, production problems are related either to man, material or machine. (hussien, 2019)

3.1 Following the daily production sequence inside Noubar most of the time there is no sampling check after raw material processing is finished, as the processing operator supposed to follow the processing sheet. Noubar used to make their raw material for different types of rubber as they have the know how so they just get pure rubber then using chemical compositions and oil they transform it to (**NBR-SBR—NR, …) ,** then using the delivery line the raw materials is transported into the machine and the operator starts production, According to daily production routine both first and second batches of production are tested and checked using snapshot approach but for the following batches they make random check which in most of the cases is accompanied by defect (product with serious failure to meet the specifications) or defective samples (product with low specification which may be repaired) in both cases we loss cost and time as the production stopped (from five up to fifteen minutes) as both quality and production engineer try to determine the cause which in this case is due to material and man either because of poor mixing while processing or even wrong composition of the materials used , note that under some circumstances a whole batch of raw material can be disposed of and start the process from the beginning. (hussien, 2019)

3.2In addition in case raw material batch is defective they try to enhance and re produce it but itis not first time quality (first time quality is a measure of number of scrapes versus total number of production the aim is to achieve highest quality with lowest production cost not only that but also to make production alarm and recovery plan) which as result produces lower quality product that can be sold at a lower affordable price or even the customer can ignore it ,which doubling the cost of production in order to produce new one. (downjy, n.d.)

3.3Lag and lead time

Cost and time are corresponding , that is why lag time and lead time are taken in consideration , each production process must be timed in order to be under control and to manage the production chain but mainly this is not applied as the operator asked for a specific quantity of batches regardless of the time required for each batch or even for each product which in turn leave the total flexibility to him but negatively as he may use more time or less time while production. I mean during inspection we can find a sample with fracture or spots which means that it has taken longer time or it can be with low shore (shore used to determine hardness and resistance of products) or different weigh which means it has taken lower time . All the previous affects the lead time of the operation (required time for production) which in turn affects productivity and quality not only that but also lag time affecting the following production operations which can be quality inspection and packaging causing delay for all the process. (hussien, 2019)

3.4Disorganization

Loss or lack of Fixturing equipment and tools also affects lead time as in most of the cases operators lost them during production as the operator leaves the production station or stop production to search or ask for a tool , such process wastes from (five to seven minutes). Finally, I would say that this is the responsibility of both the operators and the managers. (hussien, 2019)

3.5Organizational structure

According to Noubar their organizational structure is mutual adjustment in hierarchy there is a manager then an analyst who determines the best production process then the operators with high degree of decentralization which means they have high flexibility of decision making such structure has positive side which drives the motivation of the employees as they feel responsible and trusted however there is a negative side which is lack of specialization , job formalization and behavior control. For example under some circumstances operators may try to fix a machine in case of lagging during production although this is not their job and they are not specialized (not technical) such action goes beyond safety and security standards .Second point is job formalization which means job boundaries including rules and responsibilities, inside Noubar itis flexible as they can leave their work station during production to ask or do anything even not related to their duties. (hussien, 2019)

3.6Waste

- **over production**

Over production or in another meaning stock production takes place for frequent orders , to make it more clear inside Noubar they try to make the product ready before the purchasing order took place which causing delay for official purchasing orders and excess usage of material , usage of inventory and excess transportation cost. (Liker J. K., 2004)

- **waiting time**

Simply the operator can waste time doing nothing while watching the automated machine or because of a stock out or even the machine downtime. (Liker J. K., 2004)

- **unnecessary transportation**

When finished products or materials are moved within different process in unpractical way causing longer work in progress. (Liker J. K., 2004)

- **Over processing**

When poor equipment is used, or useless procedures took place during production

- **Excess inventory**

This is mainly due to defect products and late deliveries causing an increase in transportation cost and lead time. (Liker J. K., 2004)

- **Defects and defective products**

Both cases considered waste as defects will double the production cost and efforts, also defectives will waste time and effort to be repaired. (Liker J. K., 2004)

Figure (6) wastes of production

3.7Quality costs

In order to focus more on the previous indicators, we need to figure out quality costs which considered as a methodology to determine costs associated with quality to determine the width of resources and efforts used to avoid poor quality. Quality costs can be classified to:(quality-resource, n.d.)

- **Apprasail costs** which is the evaluation cost of the product to determine the degree of conformance not only that but also cost of monitoring the associated activities such cost includes:

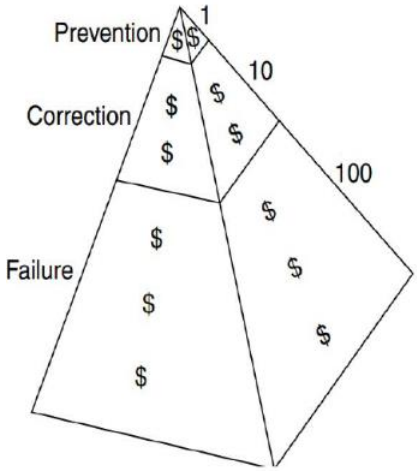


Figure (7) Quality costs

- **Verification cost** which is used to determine conformity of the incoming material and process set up. (cost-of-quality, n.d.)

-quality audits which is the cost of monitoring quality system functionality

-last cost is the supplier rating which used to assess suppliers of products and services

- **Internal failure cost** is the cost when defects or defective products are discovered while production before the product are delivered to the customer such cost includes: (cost-of-quality, n.d.)

-scraps costs (defects costs) products characterized by serious failure (out of specification) that cannot be repaired.

-rework (repair costs): costs of defective products correction

-failure analysis: costs of activities to determine the causes of such failure

3.7.1External failure cost : is the cost of defects products after they have been delivered to the customer , such cost considered the highest cost comparing to all the previous costs as it costs the firm double cost of production not only that but also affects customer satisfaction and firm's reputation . it includes the following: (researchgate, n.d.)

-reproduction cost

-return cost includes investigation and handling costs in addition to transportation cost

-warranty claims: cost of affording products or services under guarantee

3.7.2Prevention cost is the cost to avoid problems related to quality including quality management system which composed of process , procedures and responsibilities to achieve quality objectives not only that but also organization and coordination among activities .The aim of such system is to improve process capability , reduction of waste and time finally staff management . (cost-of-quality, n.d.)

Back to prevention cost which includes:

-product requirements including specifications of the raw material or product

-quality planning: is to create plans for controlling - assuring production operations and inspections

-quality assurance: is the frequent maintenance of quality systems

CHAPTER FOUR

STANDARDIZATION OF WORK (PRODUCTION) PROCESS

4.Standardization of the work process first started and implemented during world war two by the American military such methodology has been created to provide support to the allied force by increasing production. Standardization mainly based on corporation between operators and supervisor. latter standardization has been transferred to Japanese business for example Toyota. (Liker, 2004)

4.1The main objective of standardization is to reduce scraps and improve both product and process quality , in case defects products were found during production according to standardization methodology first we need to ask the operators about the cause then we need to monitor the operator while production to determine if he is following the standardized work sheet in case yes then we need to focus on the standardized process which may require change. (Liker, 2004)

4.2what is standardization? Simply itis is a system used to improve and enhance process running and its output, using documentation for every single step. The main source of standardization is the principle from industrial engineering which includes:

1-there is only one optimum way to accomplish the job

2-specialization must take place for example operators are not involved in neither designing nor improving the production process.

3- only experts are authorized to make any change

- There is a main difference between Taylorism and standardization .Taylorism is a pure bureaucratic system through which operators must follow the standards blindly but standardization is more flexible and practical . (Whitmore, 2008)

4.3 The aim of Lean production is to ensure consistency of the production process also reduction of waste in time, cost and effort. Waste reduction requires elimination of any assignable causes which can be controlled by detailed description and understanding of the process procedures using documentation and visualization technique also quick adjustment to ensure performance consistency . (Whitmore, 2008)

Standardized work also eliminates unnecessary movements using standardization work sheet, such technique improves productivity and reduce traffic.

4.4 Generally using Standardization we will ensure the following: (Martin, 2007)

-process stability and consistency

-control of lead time and lag time using clear start and stop timing

-Knowledge will be preserved using standardization as in case an expert leaves the working environment will not be affected which enhance the organizational structure.

-standardization affords inspection of job elements, monitoring of process steps, evaluation of production, finally defining and solving problems which improves control and audits.

-the best outcome of standardization is that operators are involved in the production process not only by following the orders but also improving it.

Standardization of the production process must follow specific procedures **first** we need to study production process in details , **second** breaking it in to small tasks , **third** determine the optimum arranging order, **forth** ensure communication and coordination along the organizational structure. (Martin, 2007)

In order to correctly implement the previous guide lines we need to start with the optimum allocation of machines and layout to reduce waste in time and effort also to ensure production consistency not only that but also analyzing of job procedures and timing using diagrams over the working stations to be followed by the operators.

Finally, we can say that lean production (standardized production) can be composed of three main points: (Liker, 2004)

1-timimg for each task

2-process sequences to ensure optimum efficiency during production

3-stock on hand which means to ensure enough inventory to secure production consistency

4.5 there are types of standards that must be included in the standardization process , according to Meier and Liker as shown in figure (6) .the objective of such standards is to determine the best possible way to run the job not only that but also improving operators knowledge and skills by providing detailed information . we have to know that standardization work sheet will not contain all the required standards as it will include only the methods and tools to achieve them , on the other hand we can find the detailed information in the instruction documents. (Liker J. K., 2006)

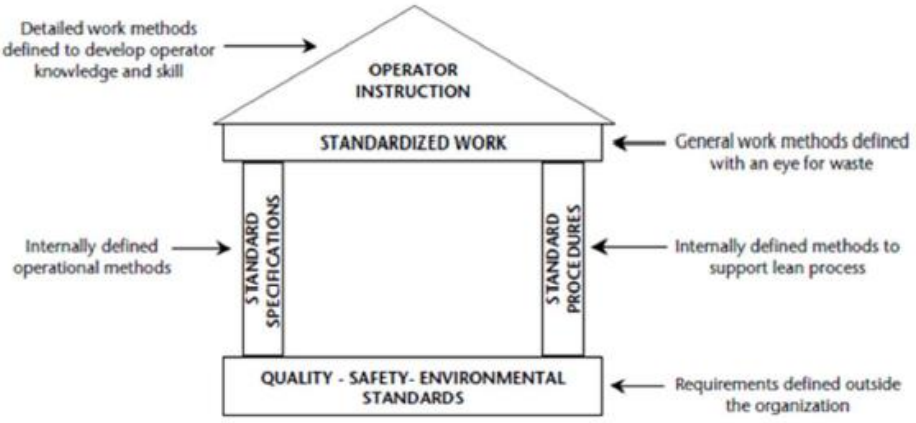


Figure (8) standards relationship and objectives

4.6. Quality and safety standards

Product or service quality specifications depend on quality design which is related to customer requirement for example surface quality, dimensions and gaps. As we said such detailed information will be found in the instruction sheet so the operator will use such standards to determine if the product fill or lack the specifications .under some circumstances (a boundary sample) may be used as a guide to target product. (Liker J. K., 2006)

Environmental and safety standards are designed by specific engineering department according to regulations and laws , so the operator using standardized work will be responsible to achieve safety and environmental standards. (Liker J. K., 2006)

4.6.1 Standards specifications

Either manufacturing or industrial engineer will provide such specifications which includes technical tools and process to be used for production. In details specifications includes timing, temperature, tolerance and dimensions. In addition to all the previous regular inspection must be taken in consideration to evaluate production and quick adjustment in case of failure. Simply the operator must know that standardized work is the method to achieve the standards of the product or service. (Liker J. K., 2006)

- Standard procedures

Such procedures may include 5S, WIP work in progress, Kanban or color coding. Note that such techniques are not documented but will be explained and identified in the job floor. (Liker J. K., 2006)

- Standardization keywords

In order to ensure optimum implementation of standardized work the following key words must be taken in consideration:

1-repeation of the task is the key word to assure standardization

2- assure consistency and stability of the production line as standardization depends on low rate of interruption.

3-assure low level of defects or defective products (low level of quality) as such products will waste time, cost and effort either for repair or disposal which in turn affects standardization. (Liker J. K., 2006)

- Standardization documents includes:

1-standardized work chart

2-standadized work combination table

3-production capacity sheet

4.7 standardized work chart includes work sequences, timing for each task, work movements and layout. The main objective is to reduce waste in time by removing unnecessary movements and improve process efficiency, so in order to achieve standardization we need to determine the sequences of work elements, then timing of each task, finally make the required improvement. If the improvement has been achieved such chart latter will be posted in the job floor to be followed. (Liker J. K., 2006)

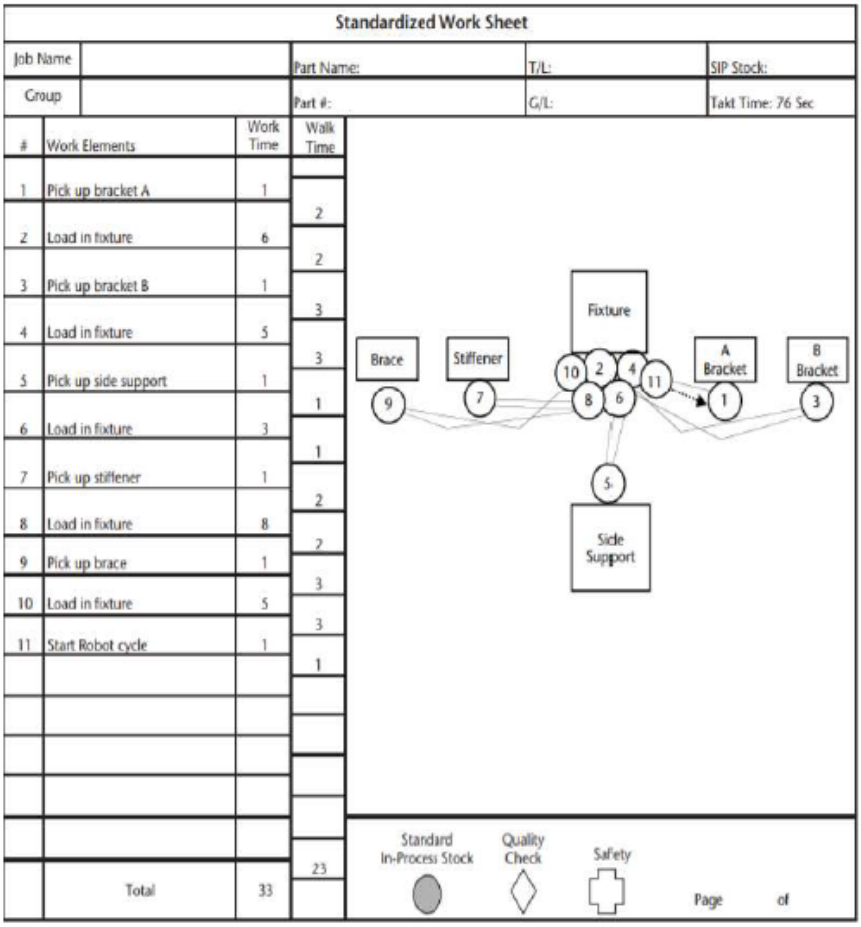


Figure (9) standardized work sheet

4.7.1 Standardized work combination table is used for jobs combining both automated and manual activities, the main objective is to understand and determine the relation between machine and operator in term of time. Operators can waste time just waiting for the machine to finish production or due to machine lagging , so it will be more practical if such time can be used instead of be to be wasted. (Liker J. K., 2006)

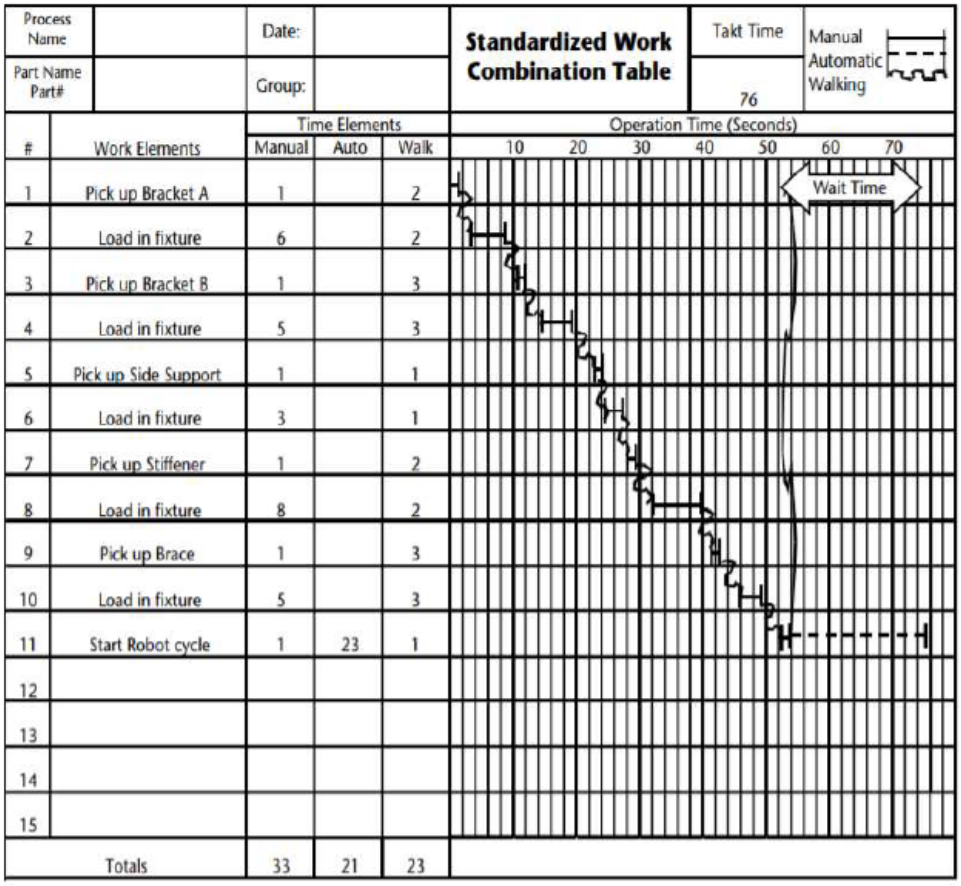


Figure (10) Standardized work combination table

4.7.2 Production capacity sheet

It's used to determine if the capacity of machines meets the production capacity also to determine bottleneck operations. Especially for operations associated with tool changes. such sheet includes timing for machine running, changing time and manual time. Continuous evaluation of the production line requires management to identify any problems during production not only that but also auditing is required to make prevention actions in case of any deviation from standards. Visual control also is required in order to assure standardization work and detect any abnormalities, see figure (9-10) to determine the difference between visual control or lack of it. (Liker J. K., 2006)

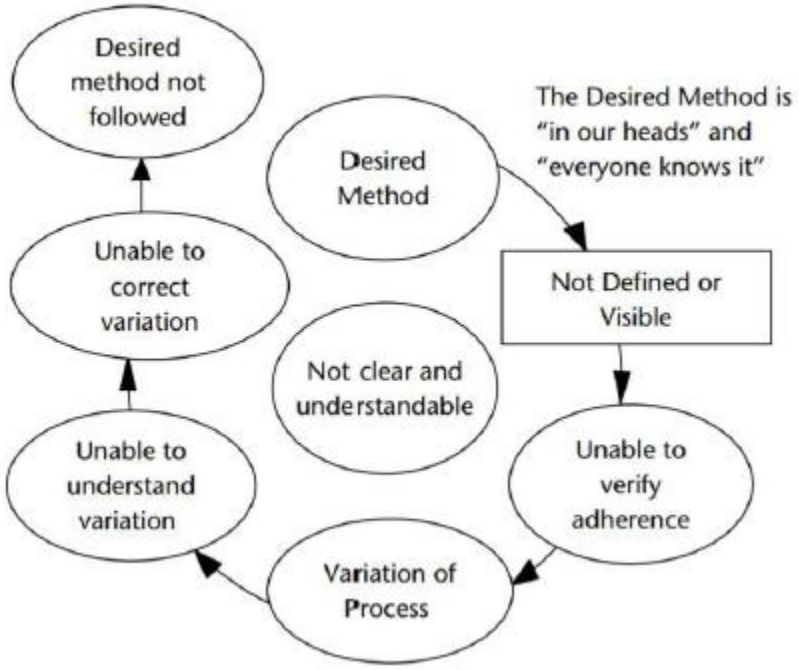


figure (11) lack of visual control

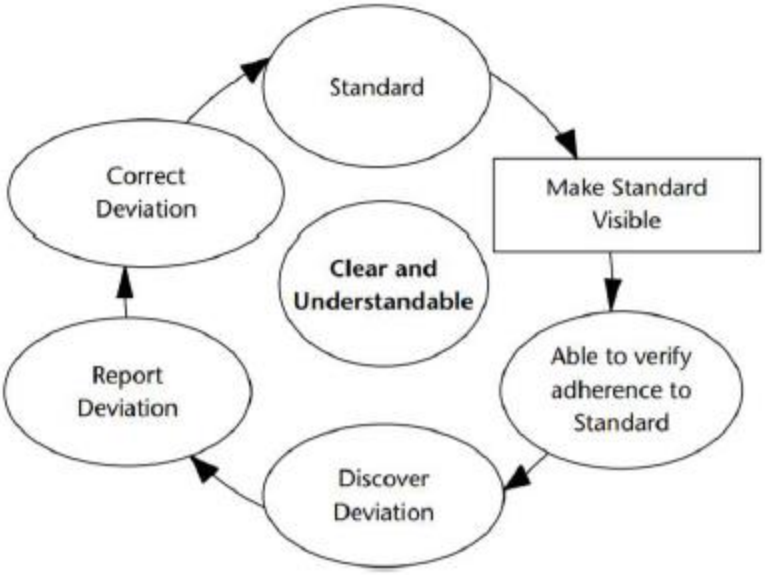


Figure (12) visual control

4.8Training

Although standardization as a methodology will help the operator to perform the job correctly but it will not be sufficient , as it did not provide detailed information , so operators training is required to be fully aware of the job instead of trying to learn by their own way and perform tasks less practically. (Liker J. K., 2006)

- training techniques:

-skin or swim: simply as a child your parents may throw you in the pool while watching how you will survive. this is the same as operators must learn the job by hard way.

-Give time to learn as operators have to discover and determine how to run the task by themselves but you have to accept their poor performance (deviation from the standards).

-Microwave method: training will be by giving instructions (do that or do not do that)

-Follow the best employee: ask new operators to follow, watch and learn best operators and learn from them. (Liker J. K., 2006)

- Job instruction training:

It was first implemented by USA military during world war two , the main concept is to train quickly and practically unskilled or new employees as they will be nominated for jobs of skilled employees who were nominated for active duties then such technique was transferred to Japanese and currently used by Toyota and other Japanese companies. Job instruction training includes the following procedures: (Liker J. K., 2006)

4.9 Breaking Down the job:

1-first analyze the job and determine most important steps, then insert it in job break down sheet along with key points and reasons for key points. Note that such sheet is built on standardization and training so that standardized task will be divided to smaller training steps which facilitate the training process not only that but also operators can easily understand how things work. such technique will help the trainer to observe if the trainee was facing any difficulties in order to adjust the training method. (Liker J. K., 2006)

Step two after breaking the job is to determine the key points (the objective of training) which are the critical aspects of job , including (technical, cost, time, and quality) finally determine the reasons of such key points. (Liker J. K., 2006)

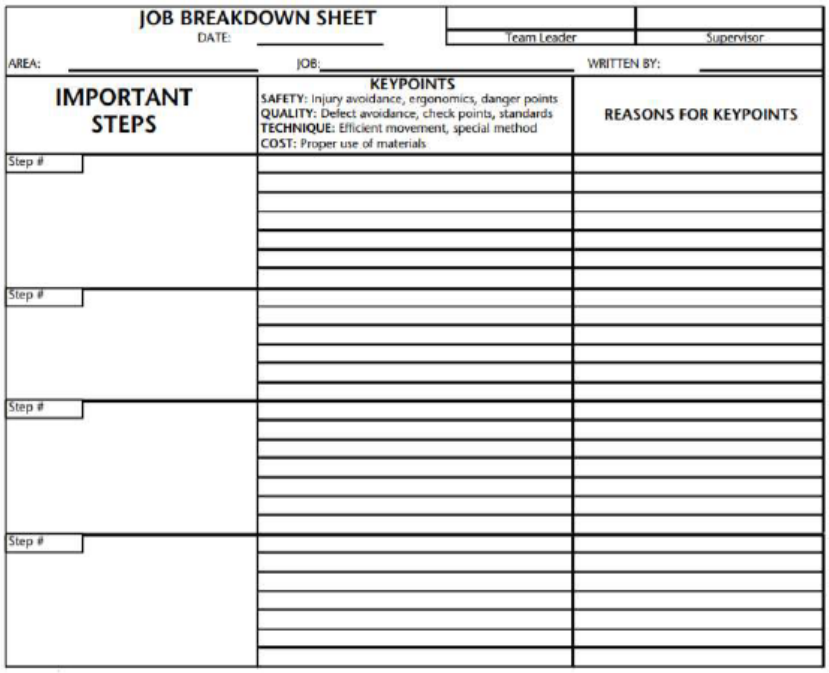


Figure (13) job break down sheet

4.10. In order to provide optimum presentation for job operations we need to take in consideration good organization of work and tools selection in addition to sufficient training time. all the previous are key points which can arise or diminish employees' expectations about the job. it is important to provide top quality work therefore the training process will be composed of two stages: (Liker J. K., 2006)

-the first step is to explain to employees what must be done using job break down sheet, informing them about the important steps in the job without going in details.

-the second step is to explain how the work is done by clarifying the reasons (key points) also continuous repetition of work steps.

- Try out performance is the third step through which the trainee will be nominated to do the activities themselves in order to develop their capabilities not only that but also the trainer will be able to evaluate their performance and correct any abnormalities. (Liker J. K., 2006)

4.10.1Put in work and watch

Trainee (new employees) will be put to normal working conditions with some support from trainer not that this is the critical phase in any job. Under work pressure and lack of experience the work performance will be slow which considered as limitation, so trainer must watch and instruct according to quality and safety standards not only that but also continuous performance improvement.

4.11 under the current situation the production process of extrusion products follows the following sequences including both manual and automated activities. (initial description of the production process)

1-the processed rubber is transferred using jolly trolley from the mixer to the extrusion machine by either operator from production or mixing team.

2-production operator loads the processed rubber inside machine 's hopper

3-production operator run the machine

4-it is an automated activity as the rotating screw and the conveyer push the rubber towards the die after the rubber passed through the die, it will take the shape of the required product passing through the other side of the extruder.

5-post processing or secondary processing activity such as Vulcanization or dusting (processes used to provide strength to the product).

Figure (14) Extrusion machine

4.11.1 under the current situation there are many points to be taken in consideration, first there is no standardization as the operators depend on past training and daily production routine to be followed. I mean there is no real and documented reference to be followed including process organization chart, figures and list of procedures. Second there is a lack of control even visual control in case of defects. Third there is no specialization or duties niceties as transferring of the processed rubber is not officially assigned to either mixing or production operators. Forth under the current situation there are two operators assigned to run the machine. the first operator feeds the machine while the second runs the machine without any effective duty as he must be assigned to monitor the production in case of defects and corporate with the production engineer. Finally, in case of multi products production the operators must change both type of the die and rubber used in addition to careful cleaning of the machine from inside, even this process waste lot of time up to 15 minutes due to absence of standardization.

4.12 our case study will be standardization of production process for extrusion products as production of extrusion product includes high uncertainty comparing to production of molded product. in molded production the operator or automated machine insert raw rubber inside the mold then flow it towards the autoclave to be cooked under certain pressure and temperature but in extrusion products higher uncertainty takes place resulting more defects or defective products due to human error , process complexity and sensitivity specially in rubber industry and in our case study the machine extrude the product and the operator drag it.

Figure (15) production of extrusion product

4.13 simply the production process can be classified into pre-production activities, main production activities and post-production activities. Our case will focus on main production activities as the focal point through which raw material transformed into real product not only that but also due to high degree of uncertainty which can take place and require full control in order to avoid any kind of defects that is why standardization of production process must take place to assure optimum production standards including both high quality and low wastage in other words the aim is to establish standards to sustain and improve quality , quantity and performance.

- Pre -production activities include:
  -raw material selection
  -raw material check
  -raw rubber processing (mixing with chemical additives to produce rubber product with certain strength, stress, elongation, and shore) note that such characteristics depend on the product to be produced.

- Post -production activities include:
  -random check of the produced batch (didn't take place in all product cases)
  -packaging

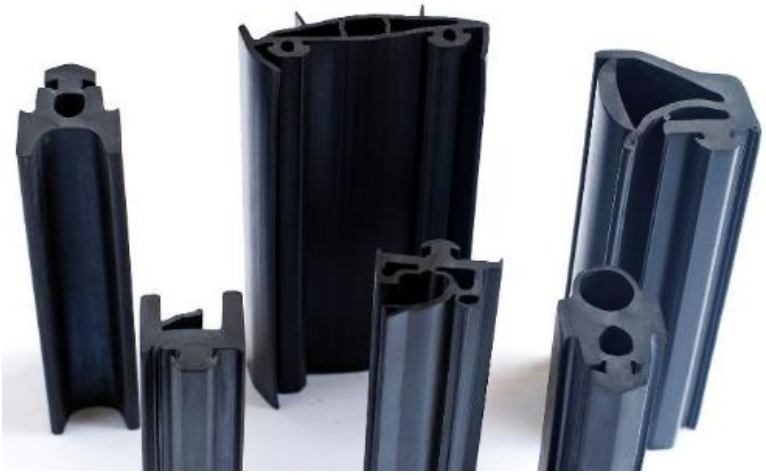


Figure (16) rubber extrusion products

- Main production activities (under standardization)
  -transfer the processed rubber to the extrusion machine
  -load the processed rubber inside machine hopper
  -run the machine
  -vaculization and cutting
  -transfer the product to the autoclave
  -run the autoclave

- All the activities may include manual – automated or both activities. timing of each activity is in minutes, in our case customer demand is 1200 unit per week which can be produced over 5 working days as 240 unit per day.
- **Takt time** is the total time production within which customer order must be finished in other words it's the average of time between the start of production of one unit and the start of production for the next unit.

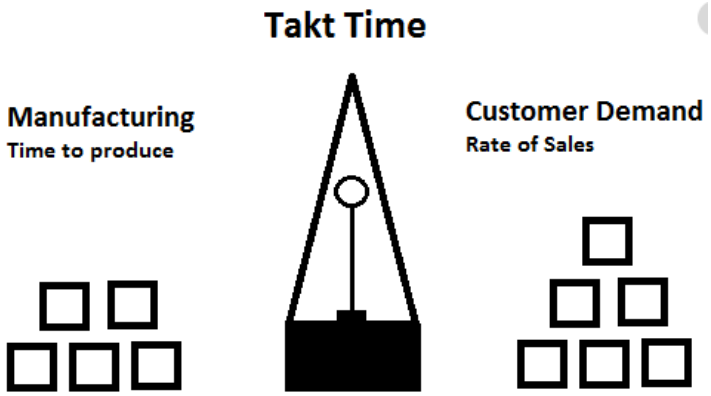
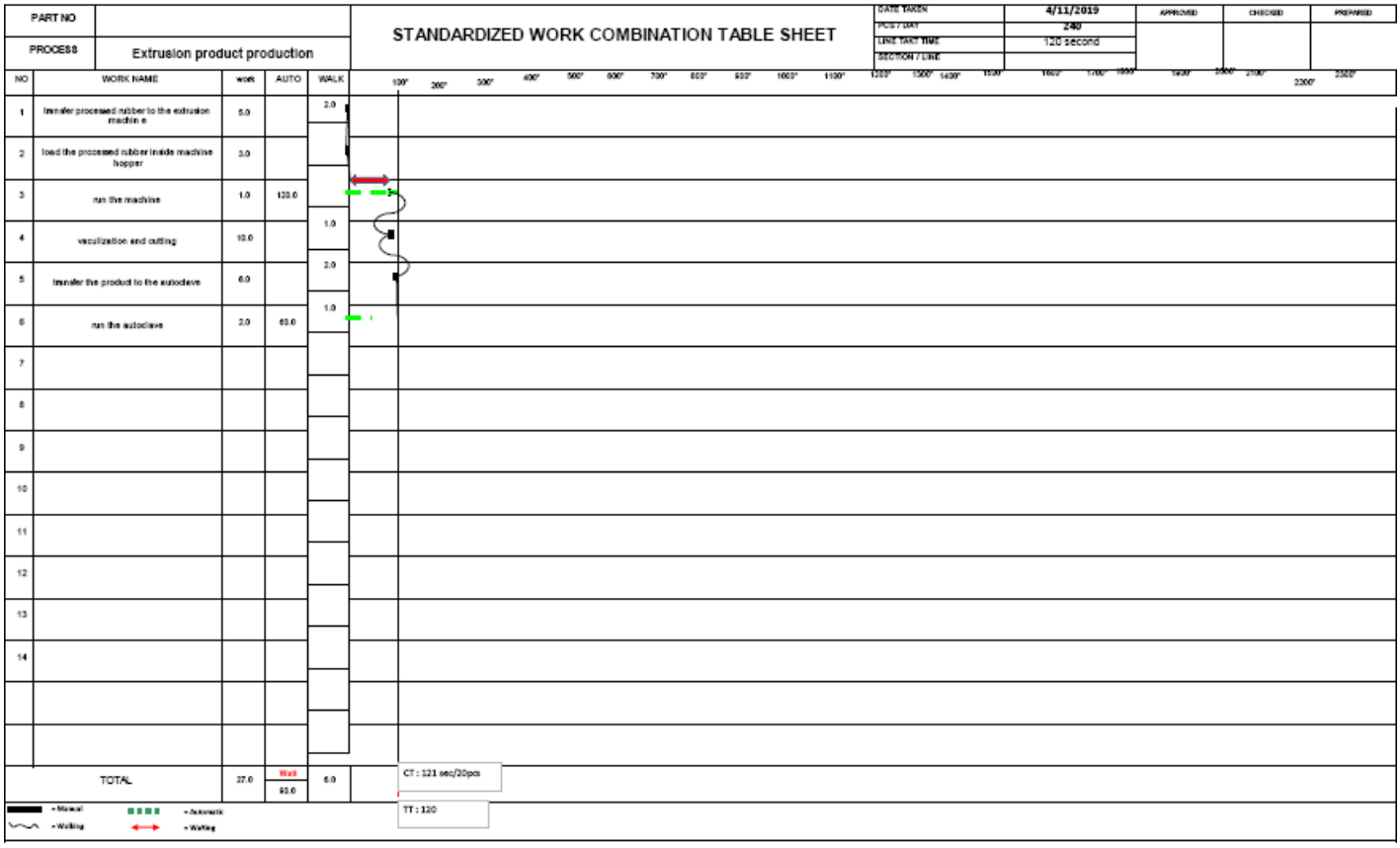


Figure (17) takt time

-benefits of takt time include:

1. Determine service delivery process
2. Sustain productivity
3. Standardization of production process
4. Improve efficiency
5. Reduce overtime and error
6. Improve quality
7. Set realistic production target
    - **Cycle time** is the time interval between two finished products

4.14 in order to standardize a production process we need to set standards according to production environments including employees power , machine power and required production performance so according to our case we have concluded the following standardized work sheet through which we can sustain optimum production performance by deploying optimal timing (manual and automated) , production sequences , resources allocation and takt time .



PART NO		STANDARDIZED WORK COMBINATION TABLE SHEET	DATE TAKEN	4/11/2019	APPROVED	CHECKED	PREPARED
PROCESS	Extrusion product production		PCS / DAY	240			
			LINE TAKT TIME	120 second			
			SECTION / LINE				

NO	WORK NAME	work	AUTO	WALK
1	transfer processed rubber to the extrusion machin e	5.0		2.0
2	load the processed rubber inside machine hopper	3.0		
3	run the machine	1.0	120.0	
4	vaculization and cutting	10.0		1.0
5	transfer the product to the autoclave	6.0		2.0
6	run the autoclave	2.0	60.0	1.0
7				
8				
9				
10				
11				
12				
13				
14				
	TOTAL	27.0	Wait 93.0	6.0

CT : 121 sec/20pcs

TT : 120

= Manual = Automatic = Walking = Walking

Table (1) standardized work combination table

-As it shown that the takt time = 2 minutes in order to fulfill 1200 unit over 5 working days , also we can conclude that according to the sheet our production limit is within takt time but also we need to figure that there is waiting time about 90 seconds between step two and three.

-we can also conclude that the cycle time is 121 sec for each unit

4.15 production capacity sheet is used to determine the production capacity related to each machine also to eliminate the bottle neck during production in order to sustain productivity

Standard Work Production Capacity Sheet

Part Name	extrusion	Part Nr.	240	Date		Manager		Section	

Sequence	Process Name	Machine Nr.	Manual Time Min.	Manual Time Sec.	Machine Time Min.	Machine Time Sec.	Total Time Min.	Total Time Sec.	Lot Size	Change Over Time Min.	Change Over Time Sec.	Process Capacity 8 hours	Comments
1	transfer processed rubber to the extrusion machine		7	0	0	0	7	0	240	0	0	69	
2	load the processed rubber inside machine hopper		3	0	0	0	3	0	240	0	0	160	
3	run the machine	EX1	1	0	120	0	121	0	240	0	0	4	
4	vaculization and cutting		11	0	0	0	11	0	240	0	0	44	
5	transfer the product to the autoclave		8	0	0	0	8	0	240	0	0	60	
6	run the autoclave	auto1	3	0	60	0	63	0	240	0	0	8	
7													
8													
9													
10													
11													
12													
		Total	33	0									

Table (2) production capacity sheet

-from the chart we can determine that the bottle neck is step 3 as it takes the longest time during production. we can only produce 4 lots of size 240 unit comparing to number of lots in other steps.

4.16 standardized work chart used to show operators movements regarding machine allocation, and it is also used to determine process layout. In order to fill the chart, we need the takt time, process sequences and standard work and standard in process stock which is the minimum number of parts in hand of the operator in order to process operations or sub operations required for production.

Standardized Work Chart Process Name: Author (Date): econoshift.com

Step #	Step Name
1	ransfer processed rubber to the extrusion machine
2	load the processed rubber inside machine hopper
3	run the machine
4	vaculization and cutting
5	transfer the product to the autoclave
6	run the autoclave
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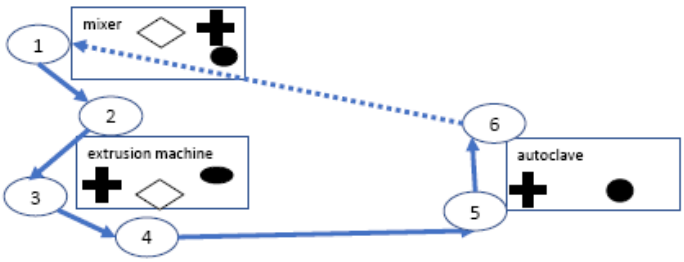

Quality Check	Safety Caution	Std. WIP	# of Std. WIP	Takt Time
◇	✚	●	2	120 sec

Table (3) standardized work sheet

CHAPTER FIVE CONCLUSION

5. resources from multiple studies have showed similar results of standardization. As the importance of standardization for any type of industry has been increased over the past years, due to it is effectiveness on rate of production and product quality by using standardization, we can assure continuous flow of production and frequent output not only that but also elimination of any kind of waste (time, effort, cost). simply it provides detailed documentation for job completion. (Liker J. K., 2004)

5.1 According to (Liker J. K., 2004) standardization ensures continuous development of work, effective use of resources and preserves knowledge within the organization. standardized production process of extrusion product has been established using first the production capacity sheet through which we indicate sequence of steps, timing for each step (manual – automated), required lot size and operating hours. The aim is to determine the bottleneck activity which may affect the production flow causing delay. Second step is implementation of standardized combination table indicating both takt time and cycle time in addition to production process sequence. Third step is implementation of standardized work chart through which we indicate allocation of equipment, sequence of steps along with operators movements , stock in hand which is supporting tool to allow operators to process operations finally we need to indicate the sensitivity of each activity regarding quality check , safety and stock in hand.

5.2 using standardization for production process includes a sequence of procedures in order to create continuous flow and optimum use of resources. According to the results time required for extrusion product of a lot size (240 unit) is (210 minute) which is enough to determine how many lots to be produced not only that but also assure delivery in time. In order to standardize production process, the following documents are required including process capacity sheet, standardized combination table, standardized work chart, and work instruction sheet not only that, but also visual control and boundary samples are required. finally, I would say that using standardization in the production process has enhanced and developed productivity also assures full control and eliminate waste.

5.3 outcome of literature study has been used within the case study to be tested. Our case study id based on actual problem which is lack of standardization and its consequences on quality, production and customer. the firm has been working on implementation of standardization in order to ensure quality and productivity by eliminating of non-add value activities and working on cost reduction to maximize profit. The firm seeks to enhance both internal and external considerations, external regarding its reputation in the market and among the competitors not only that but also regarding customer point of view. internally firm focused on defaults as duplication of efforts, waste of time, production cost , productivity , poor quality and defaults related to man – machine and material, so elimination of waste is the key word for lean using standardization tools which in turn is related to all the previous considerations. Comparing firm performance before and after standardization we can say that the firm is on the right track.

5.4 How to standardize the production process?

Standardization of the production process requires to set one correct way to deploy production activities, in addition to elimination of non-value add activities which in turn reduces time waste, increase productivity and improve cost reduction which affects profit maximization. In order to implement standardization, we need to use three main sheets. first production capacity sheet through which we can determine production capacity of each production activity so we can determine the bottleneck to avoid any delay in the production process. second, we use standardization combination table through which we can include accurate timing for each activity (manual – auto and walk) also we use takt time to determine optimal time for production to ensure delivery of the product in time. Cycle time is also required to determine the time required between production of two products. finally, we use standardization table to determine allocation of equipment, movements of operators and sensitivity of the activities regarding quality, safety and stock in hand.

- what is the effect of standardization?

Standardization affects firm's performance by ensuring high productivity and quality due to elimination of waste, avoiding any kind of default, formalization of behavior and attitude not only that but also reduction of production cost and profit maximization.

- -Does standardization always work?

According to results derived from literature studies and case study Standardization has been used in different industries due to its efficiency as the mean by which any firm in any industry can achieve optimal performance.

5.5 results have shown that in order to achieve standardization the following points must be considered including:

1-takt time: the time required to complete the time within the deadline line

2-sequence of procedures

3-stock on hand: ensures required amount of inventory to secure standardization.

5.6 The aim of standardizing a process is to establish the base for future improvement, so standardized work must be regularly improved, and standardized work sheets must be continuously updated. Regular audit is required to monitor operator's behavior to determine if they are following the standardized work process or not, in case not then what is the reason? Note that this check must be at least every two hours. workers should be encouraged to suggest any change over standardization process in order to improve it. finally, in case standardization process is followed but the are problems while production so we need to change visualization control or standardization of the process.

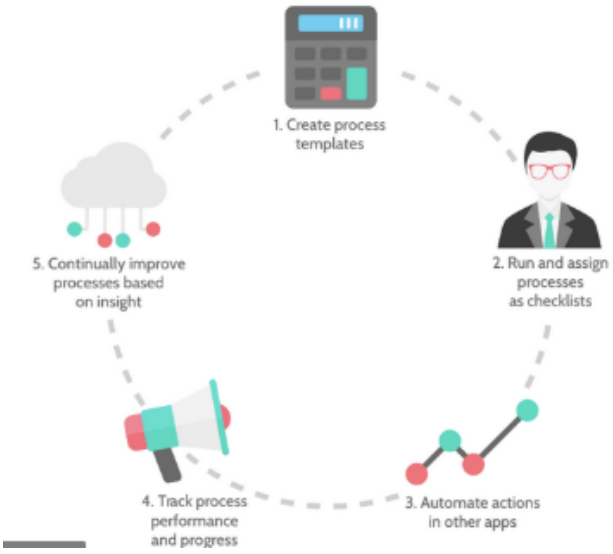

Figure (18) standardized process cycle

5.7 Recommendations

Standardization process indicated in this report considered the beginning towards complete standardization as 5s, color coding (used to eliminate poor activities) and visual control are required to implement full standardization. the previous methods are not included in standardized work sheets but they are visually determined on job floor .the aim of these methods is to quickly observe any variation from the standard state .furthermore we can draw marks on the floor to identify materials location not only that but also we can color fixture s to easily identify and distinguish them . finally, training is required for operators to improve their capabilities and knowledge.

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