CHAPTER-2

Literature Survey and observations at Company X

2.1 Waste elimination and Productivity

Productivity and waste elimination has very close relationship as when productivity is improved wastes are eliminated and when wastes are eliminated productivity is improved. Waste is anything that does not add value to process. There are main 7 categories of waste (Taiichi Ohno, 2009)

2.1.1.1 Defects

The simplest form of waste is components or products that do not meet the specification.

2.1.1.2 Over-Production

A key element of JIT was making only the quantity required of any component or product.

2.1.1.3 Waiting

Time not being used effectively is a waste - we are incurring the cost of wages and all the fixed costs of rent, rates, lighting and heating so we should use every minute of every day productively.

2.1.1.4 Transporting

Items being moved incur a cost, if it is only the energy needed to initiate the movement - such as the electricity absorbed by a fork lift truck.

2.1.1.5 Movement

On a related note, people spending time moving around the plant is equally wasteful.

2.1.1.6 Inappropriate Processing

When in fact such finishes served no purpose at inappropriate processing. A basic principle of the TPS is doing only what is appropriate.

2.1.1.7 Inventory

Extra inventory as well as lower inventory causes losses

2.1.2.1 Definition of Productivity

Productivity can be defined as the Rate of production at which a company produces goods or services, in relation to the amount of materials and number of employees needed. Productivity refers to metrics and measures of output from production processes, per unit of input. And also it can be introduced as the amount of output per unit of input (labor, equipment, and capital). Productivity is a measure relating a quantity or quality of output to the inputs required to produce goods and services

However, Productivity generates with efficiency along with effectiveness as it needs a higher rate of quality products and services.

2.1.2.2 Productivity improvement tools

2.1.2.2.1 Cleaner production

2.1.2.2.1.1 Definition

It is defined as a continuous application of an integrated preventative environmental strategy applied to processes, products and services to increase eco-efficiency and reduce risks to human and the environment. (Cleaner production consultancy training program manual,2008)

- Production processes - conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes.
- Products - reducing the negative impacts along the life cycle of a product, from raw material extraction to its ultimate disposal.
- Services - incorporating environmental concerns into designing and delivering services.

See annex A01

2.1.2.2.1.2 The main components of Cleaner Production are as follows:

- Waste reduction

CP aims for waste minimisation by utilisation of efficient input materials and recycling at source.

- Energy efficiency

Efficiency in energy use, whereby efficiency is determined by the highest ratio of energy consumption to product output achieved through energy balance assessments.

- Safe and healthy work environments

CP strives to minimize the risks of workers in order to make the workplace a cleaner, safer and healthier environment. In applying CP companies can go beyond compliance of regulations including safety standards through continuous reduction of toxins and waste products.

- Environmentally sound products

Health and environmental factors must be addressed at the earliest point of the product and process design and must be considered over the full product life cycle, from production through the use and disposal.

2.1.2.2.1.3 Cleaner Production comes with followings

- Change of attitudes: New approaches to the relationship between industry and environment (acknowledging the impact of industry on the receiving environment) and re-designing an industrial production process to ameliorate negative impacts.
- Applying know-how: Improving efficiency, better management techniques, changing housekeeping practices.
- Improving technology: Changing process technology, input materials, final product and reusing materials on-site.

2.1.2.2.1.4 Examples of CP opportunities

- Material substitution
- Good housekeeping
- Better process control
- Equipment modification
- Technology change
- On-site recovery and reuse
- Production of useful by-products
- Product modification

Cleaner Production can be achieved in any single, or combination of, the following ways: good housekeeping and operating procedures, materials substitution, technology changes, on-site recycling and product or service redesign. Pollution and risks to human health and safety are reduced at source, rather than the end of the production process, i.e. at the end-of-pipe stage. The adoption of Cleaner Production typically involves improving maintenance practices, upgrading or introducing new technology, changing production processes and modifying management and quality control procedures.

Cleaner Production is considered a management tool, as it involves rethinking and reorganizing the way activities are carried out inside an enterprise. For CP to be implemented successfully and sustainable the concept must have the support of middle and top management; this reinforces its function as a management tool.

CP is also an economic tool, because waste is considered a product with negative economic value. Each step is to reduce the consumption of raw materials and energy and prevent or reduce the generation of waste, can increase productivity and bring financial benefits to an enterprise. Since CP involves minimizing or eliminating waste before any potential pollutants are created, it can also help reduce the cost of the end-of-pipe treatment that may still, in many cases, be necessary, albeit for lower quantities of emissions. Obviously, CP is an environmental tool, given that it prevents the generation of pollution in the first place. The environmental advantage of Cleaner Production is that it solves the waste problem at its source, while conventional end-of-pipe treatment often simply moves pollutants from one environmental medium to another, the scrubbing of air emissions, for example, generates liquid waste streams, while waste water treatment produces significant quantities of harmful sludge. Finally, the systematic avoidance of waste and pollutants reduces process losses and increases process efficiency and product quality. The continuous attention and focus on the organization and management of activities in an enterprise brings the added benefit of an improvement in the quality of products, and a reduction in the rate of rejects.

All in all, Cleaner Production is more cost-effective than pollution control. By minimizing or preventing waste generation, the costs of waste treatment and disposal are reduced. The improved efficiency of processes and better quality control result in economic savings and contribute to enhanced competitiveness. Finally, by reducing emissions, CP protects the environment. This is why it is a win-win situation.

2.1.2.2.1.5 Benefits of CP

Why is CP beneficial for industry?

- Cost savings through reduced wastage both of energy and materials
- Improved operating efficiency of the plant
- Better product quality and consistency
- Recovery of some wasted materials
- Possibility to improve the working environment (health and safety)
- Improvement of the enterprise's image
- Better compliance with environmental regulations
- Cost savings on end-of-pipe waste treatment

2.1.2.2.1.6 CP Assessment Methodology

Steps involved in Conducting a Comprehensive CP Assessment Methodology.

Start

1. Getting Started
    - ❖ Designate CP team
    - ❖ List Process steps
    - ❖ Select Assessment focus

Analyze

2. Analyze process Steps
    - Prepare Cleaner Production Flow Charts
    - Make material and energy balances

- Assign costs to waste streams
- Review waste causes

3. Generate CP Opportunities

- Develop CP opportunities

Improve

4. Select CP opportunities

- Assess technical feasibility
- Assess financial viability
- Evaluate environmental aspects
- Select workable opportunities /solutions for implementation

5. Implement CP Solutions

- Prepare for implementation
- Execute CP implementation
- Monitor and evaluate results

Integrate

6. Sustain CP solutions

- Sustaining CP solutions
- select wasteful process steps

2.1.2.2. Other Tools

2.1.2.2.1 5S

5S Introduction

The 5S method is a structured program to implement workplace organisation and standardisation. 5S improves safety, work efficiency, improves productivity and establishes a sense of ownership. And a well organised workplace motivates people.

The programme is called 5S, since all steps start with an "S".

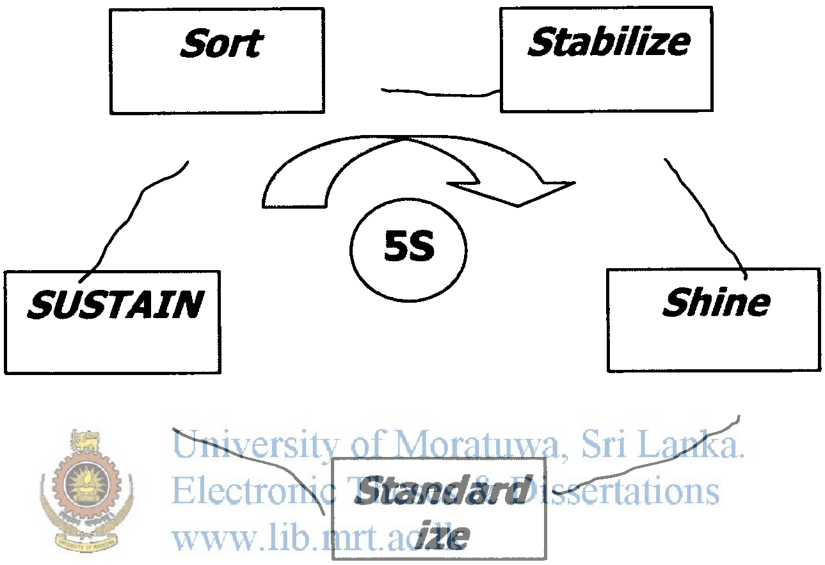

Fig 2.1: 5S Cycle

Sort deals with the contents of a workplace, and removes all items that are not needed there.

Set in Order refers to "a place for everything, and everything in its place" to enable easy access to needed items.

Shine refers not just to cleaning, but to "being proud" about the way the workplace is organized.

Standardize refers to having standards that everyone has to adhere to. Visual management is an important aspect to facilitate easy understanding of these standards.

Sustain refers to training of all employees and communication to all employees to ensure 5S application.

The 5S management program facilitates an excellent performance: see annex A02

2.1.2.2.2 KAIZEN

KAIZEN is a Japanese word meaning gradual and orderly, continuous improvement. The KAIZEN business strategy involves everyone in an organization working together to make improvements 'without large capital investments'.

KAIZEN is a culture of sustained continuous improvement focusing on eliminating waste in all systems and processes of an organization. The KAIZEN strategy begins and ends with people. With KAIZEN, an involved leadership guides people to continuously improve their ability to meet expectations of high quality, low cost, and on-time delivery. KAIZEN transforms companies into 'Superior Global Competitors'.

Two Elements of KAIZEN

There are two elements that construct KAIZEN, improvement/change for the better and ongoing/continuity. Lacking one of those elements would not be considered KAIZEN. For instance, the expression of "business as usual" contains the element of continuity without improvement. On the other hand, the expression of "breakthrough" contains the element of change or improvement without continuity. KAIZEN should contain both elements.

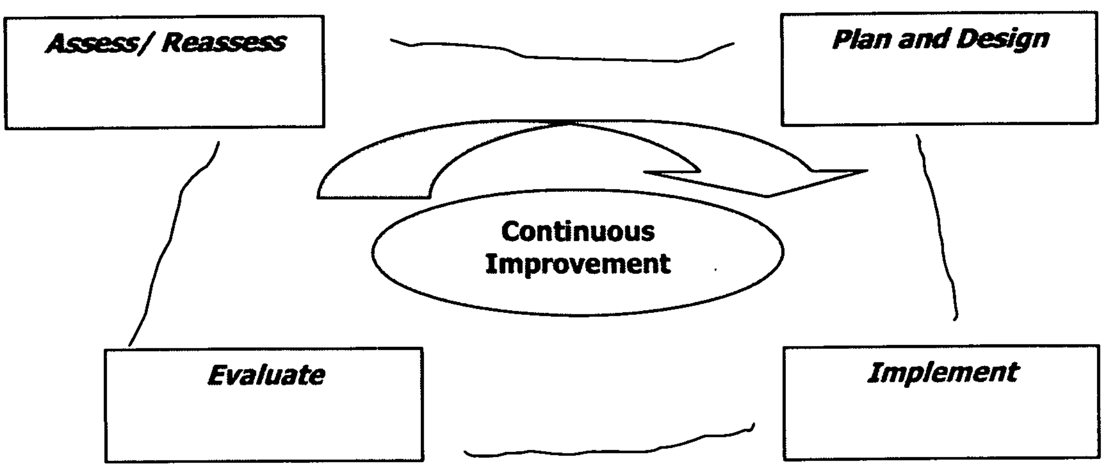

Fig 2.2 Kaizen Cycle

For further reading on Kaizen refer Annex A03

2.1.2.2.3 TQM

Total Quality Management

No two organizations have the same TQM implementation. There is no recipe for organization success; however, there are a number of great TQM models that organizations can use. These include the Deming Application Prize, the Malcolm Baldrige Criteria for Performance Excellence, the European Foundation for Quality Management, and the ISO quality management standards. Any organization that wants to improve its performance would be well served by selecting one of these models and conducting a self-assessment.

The simplest model of TQM is shown in this TQM diagram. The model begins with understanding customer needs. TQM organizations have processes that continuously collect, analyze, and act on customer information. Activities are often extended to understanding competitor's customers. Developing an intimate understanding of customer needs allows TQM organizations to predict future customer behavior. TQM organizations integrate customer knowledge with other information and use the planning process to orchestrate action throughout the organization to manage day to day activities and achieve future goals. Plans are reviewed at periodic intervals and adjusted as necessary. The planning process is the glue that holds together all TQM activity.

TQM organizations understand that customers will only be satisfied if they consistently receive products and services that meet their needs, are delivered when expected, and are priced for value. TQM organizations use the techniques of process management to develop cost-controlled processes that are stable and capable of meeting customer expectations.

TQM organizations also understand that exceptional performance today may be unacceptable performance in the future so they use the concepts of process improvement to achieve both breakthrough gains and incremental continuous improvement. Process improvement is even applied to the TQM system itself!

The final element of the TQM model is total participation. TQM organizations understand that all work is performed through people. This begins with leadership. In TQM organizations, top management takes personal responsibility for implementing, nurturing, and refining all TQM activities. They make sure people are properly trained, capable, and actively participate in achieving organizational success. Management and employees work together to create an empowered environment where people are valued.

All of the TQM model's elements work together to achieve results

Total Quality Management Model

TQM is a collection of principles, techniques, processes, and best practices that over time have been proven effective. Most all world-class organizations exhibit the majority of behaviors that are typically identified with TQM.

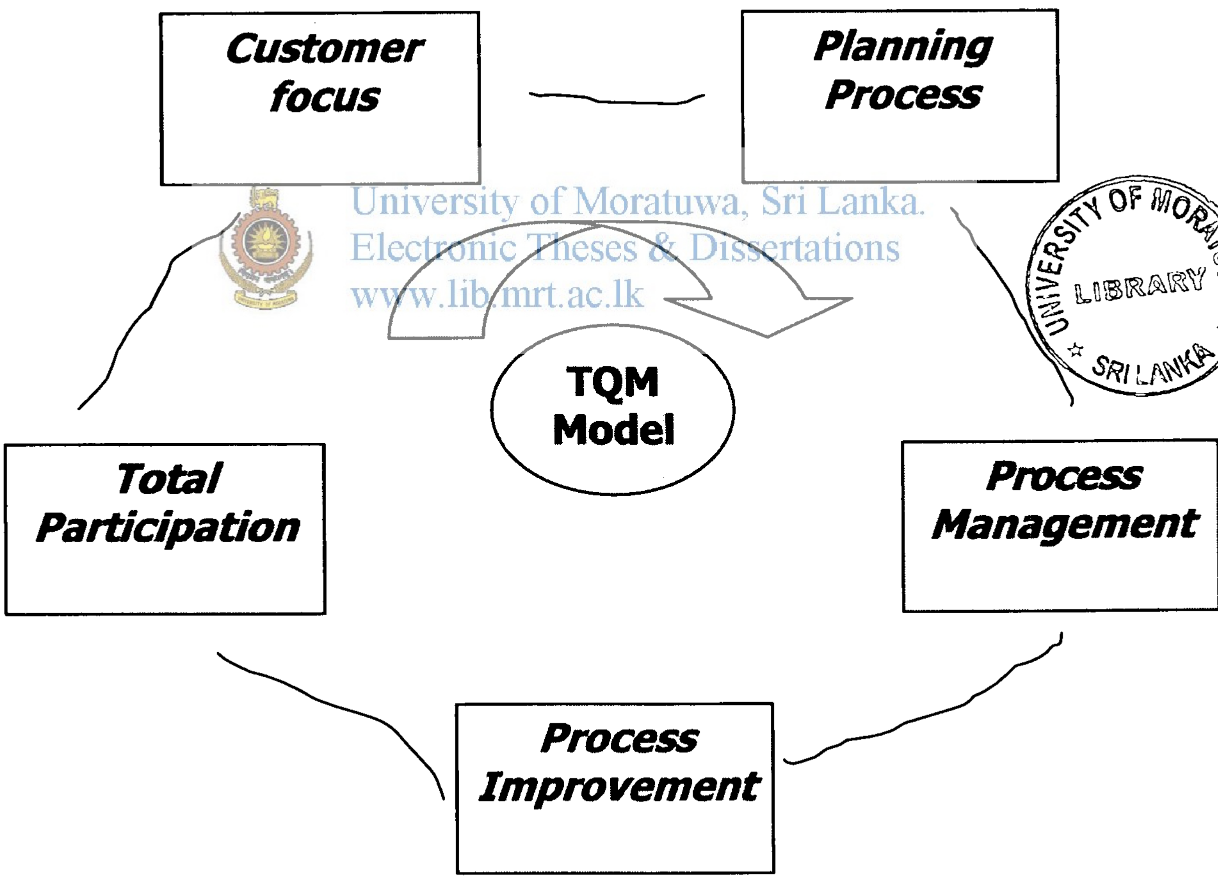

Fig 2.3 TQM Cycle

For further reading on TQM see Annex A04

2.1.2.2.4 TPM (Total Productive Maintenance)

When we realize that in many factories, the valuable operating time is less than 50% of the gross available hours per year, it is obvious that our assets are not sweating. Part of this is caused by scheduled downtime, which includes holidays, no production planned due to limited load, spare capacity to cope with volume flexibility etc. The other part is caused by the fact that we do not produce fully efficiently. The reasons for this can be categorized into six big losses. These losses can be influenced during development and production.

Why TPM?

TPM is becoming an industrial standard and it is an approach to optimize the effectiveness of production means in a structured manner.

TPM focuses on improving the Planned Loading Time. The gap (losses) between 100% and actual efficiency can be categorized into 3 categories:

- Availability
- Performance
- Yield (Quality Rate)

See Annex A05

2.2 Hexagonal Nut and Bolt Manufacturing

2.2.1 Types of Nut and Bolts and Screws

- Wood Screws

Screws with a smooth shank and tapered point for use in wood. Abbreviated WS

- Machine Screws

  Screws with threads for use with a nut or tapped hole. Abbreviated MS

- Sheet Metal Screws

  Fully threaded screws with a point for use in sheet metal. Abbreviated SMS

- Self Drilling SMS

  A Sheet metal screw with a self drilling point.

- Carriage Bolts

  Bolts with a smooth rounded head that has a small square section underneath.

- Lag Bolts

  Bolts with a wood thread and pointed tip. Abbreviated Lag

- Set Screws

  Machine screws with no head for screwing all the way into threaded holes.

- Socket Screws

  Socket screws, also known as Allen head are fastened with a hex Allen wrench

- Eye Bolts

  A bolt with a circular ring on the head end. Used for attaching rope or chain.

- Eye Lags

  Similar to an eye bolt but with wood threads instead of machine thread.

- U-Bolts

  Bolts in U shape for attaching to pipe or other round surfaces. Also available with a square bend.

- J-Bolts

  J shaped bolts are used for tie-downs or as an open eye bolt.

- <u>Hanger Bolts</u>

  Hanger bolts have wood thread on one end and machine thread on the other end.

- <u>Shoulder Bolts</u>

  Shoulder bolts (also known as stripper bolts) are used to create a pivot point

- <u>Sex Bolts</u>

  Sex bolts (a.k.a. barrel nuts or Chicago bolts) have a female thread and are used for through bolting applications where a head is desired on both sides of the joint.

- <u>Mating Screws</u>

  Mating screws have a shoulder that matches the diameter of the sex bolts they are used with.

- <u>Hex Bolts</u>

  Bolts with a hexagonal head with threads for use with a nut or tapped hole. Abbreviated HHMB or HXBT

Fig 2.4 Hex Bolt

A standard bolt has a hex head and a smooth shoulder area beyond the standard amount of threading. Shorter lengths are fully threaded.

For more details about the grades of hexagonal bolts and Nuts see Annex B01

2.2.2 Measuring Bolt Length

Hex Bolts

Hex bolts are measured from under the head to the tip of the bolt.

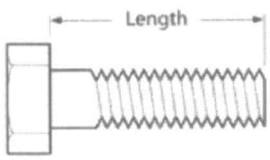

Fig 2.5 measuring Hex bolt

For the measuring methods for other bolts and nuts see Annex B02

2.2.3 Manufacturing Types and Processes of Hexagonal Nut and Bolts

There are three Main types of manufacturing Hexagonal Nuts and Bolts.

a) Cold Forging

b) Hot Forging

c) Worm Forging

2.2.3.1 Cold Forging

The steps of the process of manufacturing cold forging hexagonal nuts & bolts are as follows

1. Raw material receiving
2. cutting
3. Lubricating (Pospating)
4. Wire Drawing
5. Wire cutting and Heading
6. Trimming
7. Threading
8. Galvanizing
9. Re-tapping
10. Packing

1. Raw material receiving

   - Raw material is received in the coil form. Mild Steel coils are used in making MS Nuts & Bolts.

2. Cutting

   - The coils are in the batch size of 2MT. for the easiness of handling the coils are cut in to 500 kg coils

3. Lubricating

   - Insert into a Acid bath for rust removing

- insert into a water tank for cleaning
- Insert into a Chemical Bath including Phosphate
    - Add Phosphating chemical to satisfy the test of finding the pointage of the solution with NaOH
    - add $NaNO_2$ to satisfy the test of starch Iodide paper colour change [becoming dark blue
    - keep the temperature at 60 degrees Celsius
- insert into a water tank for cleaning
- Insert into a Lime tank
- Kept away for 2 hours

4. Wire Drawing
    - Wire is drawn to the required diameter using a wire drawing machine

5. Wire cutting and Heading
    - The wire is cut into the required length and the round shaped head is forged by the cold forging machine.
6. Trimming
    - Round shaped head is trimmed to get the hexagonal shape
7. Threading
    - Thread rolling dies are used to form the thread of the bolt
8. Galvanizing

There are number of methods of applying zinc coatings and each will determine the coating thickness and its ultimate durability in a specific environments. The most commonly encountered types of zinc coatings are;

1. Zinc electroplating – involves immersion of the items to be coated in a solution containing zinc ions and applying an electric current to uniformly coat the surface.
2. Mechanical plating – involves tumbling the items to be coated in zinc powder with glass beads and special reducing agents to bond the zinc particles to the steel surface.

3. Sheardising – involves heating the article to be coated in zinc powder to approximately 400 °C at which temperature diffusion bonding of the zinc with the steel occurs.
4. Continuously galvanized sheet – involves passing coil steel through a bath of molten zinc in a controlled reducing atmosphere at high speed (180m/min)
5. Continuously galvanized wire – is produced by passing cleaned steel wire through a lead/ zinc bath at high speed (180m/min)
6. Galvanized pipe and tube – is produced by two methods; one is semi continuous where stock lengths of tube are cleaned and passed continuously through a bath of molten zinc at 450 °C . The other method is continuous where strip is formed in to tube from coil and the tube then passed through a bath of molten zinc at 450 °C. This second method coats the exterior of the tube only.
7. General or hot dip galvanizing – involves preparing work by acid pickling in batches or on jigs and then dipping the work into a bath of molten zinc.
8. Zinc metal spraying

Hot dip galvanizing is an old and well known process of applying zinc coating to iron or steel surface for protection against corrosion. The zinc coating firstly protects the base metal by acting as an impervious shield between the metal and the atmosphere and secondly affords sacrificial protection even when moderately sized areas of the base metal surface are exposed.

When an article is immersed in a galvanizing bath, the metal surface reacts with molten zinc to form a zinc-iron alloy. As the article is withdrawn from the bath, it picks up pure zinc which solidifies on cooling and forms the outer layer. The intermediate alloy layer provides a strong bond between the ferrous base material and the pure zinc and also resists corrosion and abrasion in the event of the pure zinc layer being removed.

The galvanizing process can be grouped under two broad categories, namely wet process and the dry process depending on the method of application of the flux coating. In the wet process, a layer of flux (flux blanket) of a few centimetres thickness floats on the surface of the zinc bath and articles are dipped through the layer of flux. In the dry process, a thin layer of flux is applied on to the article by dipping in an aqueous flux solution followed by drying. The flux coated article is then immersed in a bath of clear molten zinc. The choice of the exact method is dependent on a number of factors, such as the type of work to be galvanized, pre treatment procedures, drying facilities, rate of through put etc.

The most important advantage of the dry galvanizing process is a lower production of dross and cleaner working atmosphere. The wet process on the other hand gives a greater latitude of working conditions and requires relatively less expensive plant installations. Besides these, there are a number of other minor advantages in each of the processes and very often a combination of the two processes is followed to suit individual plant requirements.

Hot dip galvanizing is an immersion process where steel sections and fabrication undergo the following operations

- Hot caustic degreasing – removal of oil, organic materials, mill primers and paint.
- Hydrochloric acid pickling – removal of rust and mill scale
- Rinsing – removal of pickling acid residues
- Prefluxing in zinc ammonium chloride solution – surface conditioning
- Hot dip galvanizing – at 450~460 °C
- Centrifuging to remove unnecessary Zn from threaded parts
- After checking the quality of the product regalvanize the item if needed
- Chromate quenching – passivation of the zinc surface to prevent early oxidation.

There are number of factors in the nature of steel work presented for galvanizing that impact on the galvanizer's ability to provide a quality product and service. These are;

1. Surface condition of the steel: rusty, painted, previously galvanized
2. Type of product; castings, old wrought iron work, soldered or riveted work
3. Steel metallurgy
4. Surface profile.
5. Weld quality
6. Dimensions

1. Surface condition of the steel: rusty, painted, previously galvanized

Steel that is badly corroded will be slow to pickle and removal of heavy rust on part of the surface may remain on the surface to cause galvanize defects. Badly rusted steel should be abrasive blasted too remove heavy rust areas prior to delivery for galvanizing.

Steel coated with old paint may not be able to be cleaned effectively in the caustic pre-treatment. Paint remaining on the surface will prevent the acid pickling the surface and galvanizing defects will result.

Previously galvanized steel requires complete stripping prior to galvanizing. While this can be done effectively, there is a cost in additional handling and acid consumption that will add to processing cost.

2. Type of product; castings, old wrought iron work, soldered or riveted work

Old wrought ironwork may be porous and allow moisture into voids in the castings. Abrasive blasting is the preferred method of surface preparation for this material to minimize immersion in process chemicals. Soldered items must not be galvanized. The solder will melt out at galvanizing temperatures.

Steel and iron castings must be sound and free of moulding sand. Any sand that is burned onto the surface will prevent the galvanized coating from forming.

Riveted components containing Aluminium pop rivets should not be processed. The Aluminium will rapidly dissolve in both the caustic tank through sodium hydroxide attack or in the zinc bath.

3. Steel metallurgy

The galvanized coating is formed by the steel reacting with the zinc at galvanizing temperatures. The metallurgy of the steel combined with its surface condition will affect the appearance and the thickness of the galvanizing coating.

Steel composition: most structural steels have low levels of alloying elements that are typically Carbon, Phosphorous, Manganese, Silicon, and Sulphur which total around 1% of the constituents. The balance is iron.

4. Surface profile

The rate of reaction between steel and zinc is also affected by the surface profile. Very smooth surfaces such as those found on cold rolled sheet and tube products will have a relatively low rate reaction of and may not produce galvanized coatings. Hot rolled sections have a natural surface profile arising from the presence of mill scale during rolling. The mill scale is removed by pickling during the galvanizing process leaving a steel surface that will generally produce galvanized coatings in excess of the thickness required by standards.

5. Weld quality

Weld quality can have a direct impact on galvanizing quality in both the design of the weld and its execution. Most welding wire is high in silicon and this will cause the weld metal to react more vigorously with the zinc than the parent metal, resulting in thicker coatings on the weld metal. If weld aesthetics are important and welds are required to be flush finished after galvanizing, low silicon welding wire or rods of similar metallurgy to the parent metal should be used.

Weld design will be a function of weld location and extent. Unsealed welds will allow preparation chemicals to penetrate joints. Entrapped liquids will boil out and cause surface defects during galvanizing defects. Residual flux crystals left in joints will absorb atmospheric moisture and cause staining and corrosion problems after galvanizing. Fully sealed welds offer the best performance for galvanizing and in service.

Slag lefts on welds will prevent the preparation chemicals conditioning the surface and will also prevent the zinc reacting with the weld metal. The galvanized coating will not form on these areas and these defects are beyond the control of the galvanizer.

6. Dimensions

Dimensioning fabrications to best suit available galvanizing bath dimensions will ensure that;

a. The item can be hot dipped galvanized at the lowest cost and without delay.
b. The item can be presented to the molten zinc in a way that optimizes venting and draining to produce the best possible surface finish.
c. The item that can be loaded efficiently in to the dipping jigs and produce a better quality product.

9. Re-tapping

- Nut is retapped to remove the unnecessary Zn

10. Packing

Packing is done according to the customer requirement and standards

2.2.3.2 Hot Forging

The steps of the process of manufacturing hot forging hexagonal nuts & bolts are as follows.

1. Raw material receiving
2. Drawing
3. Cutting
4. Heating
5. Heading
6. Trimming
7. Grinding
8. Thread Cutting
9. Galvanizing
10. Re-tapping
11. Packing

2.3 Washing Methods

There are many washing methods can be found in industrial washing

1. Overflow washing
2. Alternate washing
3. Counter-current Washing

Counter Current washing

This measure is employed frequently on continuous preparation and dye ranges for water and energy savings. Clean water enters at the final wash box and flows counter to the movement of the fabric through the wash boxes. Thus, the cleanest water contacts the cleanest fabric, and the more contaminated wash water contacts the fabric immediately as it enters the actual process. This method of water reuse is opposed to the traditional washing method of supplying clean water at every stage of the washing. Water and energy savings are related to the number of boxes provided with counter flow. Counter-current washing can be applied at desize washers, scour washers, mercerizing washers, bleach washers, dye ranges and printhouse soaper ranges.

It is also easy to implement in existing mills where there is a synchronous processing operation. In a non-synchronized processing system, the use of a counter-current flow principle for washing from the following washing machine to the preceding one may become more difficult. In such a case, the reusable water could be collected in a common sump and then the water from the sump could be pumped to appropriate washing machines used on earlier cycles. It has been found that apart from savings in fresh water consumption, there are additional benefits of effluent blending to yield neutralization and equalization effects