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WASTE ELIMINATION AND PRODUCTIVITY IMPROVEMENT IN NUT & BOLT MANUFACTURING INDUSTRY IN SRI LANKA

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by

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Supervised by

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This thesis was submitted to the Department of Mechanical Engineering of the University of Moratuwa in partial fulfilment of the requirements for the Degree of Master of Engineering in Manufacturing Systems Engineering

Universith of Moratuwa

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Department of Mechanical Engineering
University of Moratuwa
Sri Lanka

December 2009

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DECLARATION

This Dissertation paper contains no material which has been accepted for the award of any other degree or diploma in any University or equivalent institution in Sri Lanka or abroad, and that to the best of my knowledge and belief, contains no material previously published or written by any other person, except where due reference is made in the text of this Dissertation.

I carried out the work described in this Dissertation under the supervision of Dr. S.M. Piyasena

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Abstract

This Project provides the possible ways to sustain the Hexagonal Nut and Bolt manufacturing Industry in Sri Lanka.

When the London Metal Exchange figures and graphs are analyzed it is clearly shown that the steel prices are in a hike. And also China and India are trying to acquire Sri Lankan market. Hence, the steel manufacturers have been facing many difficulties with the price competition and the rising costs. Therefore, waste elimination and productivity improvement methods needed to be introduced to the Hexagonal Nut and Bolt manufacturing Industries in Sri Lanka. This report contains a successful case study carried out at Company X Ltd which represents this industry and shows how to apply these methods to other factories for their future protection.

This also contains a literature survey carried out regarding waste elimination, productivity improvement and Nut and Bolts and their manufacturing.

Interviews were carried out at Company X Ltd and found out the major problems to the organization which relevant to the industry. Then wastes and losses were found out with the support of Cleaner production Techniques. After that made a suitable questionnaire and got the details from the other companies. Then found the most important problems to be solved and solutions given with the technical knowledge and with the help of external expertise.

Appreciable results were obtained as an overall improvement of 33% while reducing the damaging the cold forging dies of the heading machine by 33%;reducing the rework at lubrication process by 60%; reducing the water consumption at the lubrication process by 50%; reducing the electricity consumption in the lubrication process by 25%; reducing the scrap iron collection by 20%; reducing the consumption of chaser dies by 33%; reducing the buffer stocks in the process by 10% and reducing the labour idling by 30%

As the other Hexagonal Nut and Bolt manufacturing companies in Sri Lanka showed the similar issues in their processes they can use this methodology to solve their issues and face the critical situation successfully.

With the success of this Hexagonal Nut and bolt manufacturing industries, all hardware manufacturing industries and also industries other than hardware manufacturing can follow this with the necessary further studies

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Acknowledgement

Words are insufficient to express my sincere gratitude to Dr. S. Piyasena who guided me to carryout this literature survey and complete the report. It is a great pleasure to convey my heartiest gratitude and respect to my external supervisor Eng. Sena Peiris, Director of NCPC who consulted me on carrying out the practical activities.

I acknowledge all those who assisted me for the Getting the observations at USS Engineering (Pvt) ltd. specially, Managing Director, Former Factory Manager, Production Manager as well as the Senior Technical Officer. And also I must thank the members of the other organizations who answered my questionnaire.

Special thank should go to the officers in the Department of Mechanical Engineering, University of Moratuwa, Sri Lanka Standards Institute and National Cleaner Production Center for the assistance corporation and the guidance provided through out.

Finally, I should thank many individuals, including my parents, wife, relatives, friends and colleagues in making this process a success. May be I could not have made it without your supports.

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Notation

ASTM	-	American Society for Testing Materials
°C	-	Degree Celsius
CEB	-	Ceylon Electricity Board
CP	-	Cleaner Production
Fig	-	Figure
LECO	-	Lanka Electricity Company Limited
LME	-	London Metal Exchange
MEng	-	Master of engineering
MT	-	Metric Ton
$NaNO_2$	-	Sodium Nitrite
NCPC	-	National Cleaner Production Center
PG	-	Post Graduate
SLR	-	Sri Lankan Rupees
SLT	-	Sri Lanka Telecom
TPM	-	Total Productive Maintenance
TQM	-	Total Quality Management
UNEP	-	United Nation's Environment Programme
UNIDO	-	United Nations Industrial Development Organization
USD	-	Dollar of United States America
Zn	-	Zinc

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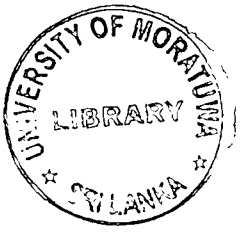

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CHAPTER 1

Introduction to the Project

1 Introduction

There are various types of Nuts and Bolts such as wood screws, carriage bolts, hexagonal bolts, Eye bolts, U bolts, etc. used in world for many applications. From all these types Hexagonal Nuts and Bolts have one of the major usages in Sri Lankan market. When considering the Hexagonal Nut and bolt market major customers are; some bulk purchasing institutes like CEB, SLT, LECO, and the retail market. Main suppliers of this Hexagonal Nut and Bolt to CEB, LECO, SLT is USS Engineering (Pvt) ltd. And also Janahitha Nut and Bolts also have a good share in the market. Other than that Keselwatta marketing, Tradesman Lanka, Best Tec (pvt) ltd, and some other companies do the business.

Due to the price fluctuation of the raw materials and technical faults, some major suppliers stopped catering the Sri Lankan Market such as St. Anthony's Industries which had a good share in the market with a manufacturing plant but now not operating. When the London Metal Exchange figures and graphs are analyzed it is clearly shown that the steel prices are in a hike. And also China and India tries to acquire the Sri Lankan market. Hence, the manufacturers have been facing many difficulties with the price competition and the rising costs.

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1.1.1 Prevailing main issues in the industry

In the market in Sri Lanka there is a big competition for these hexagonal nuts and bolts. On the other hand the main problem lies with the manufacturers is rising of steel prices According to the London Metal Exchange it shows the steel prices are increasing. Although the manufacturers also able to increase the prices accordingly, it affects the market share. Therefore, to face these situations and to have a good future in the Nut and Bolt manufacturing industry we need to find a possible way to do this. On the other hand imported Nut and Bolts are also coming to capture the market. To face this threat Sri Lankan industry needed to be improved by waste elimination and productivity improvement.

Following are the main threats and weaknesses in the Industry.

1.1.1.1 Market competition

The bulk purchasing is done with tendering process. Due to the high competition between the suppliers the bidding prices are reducing gradually. When the order winning prices at the institute Y are compared within the year of 2009 this can be clearly seen.

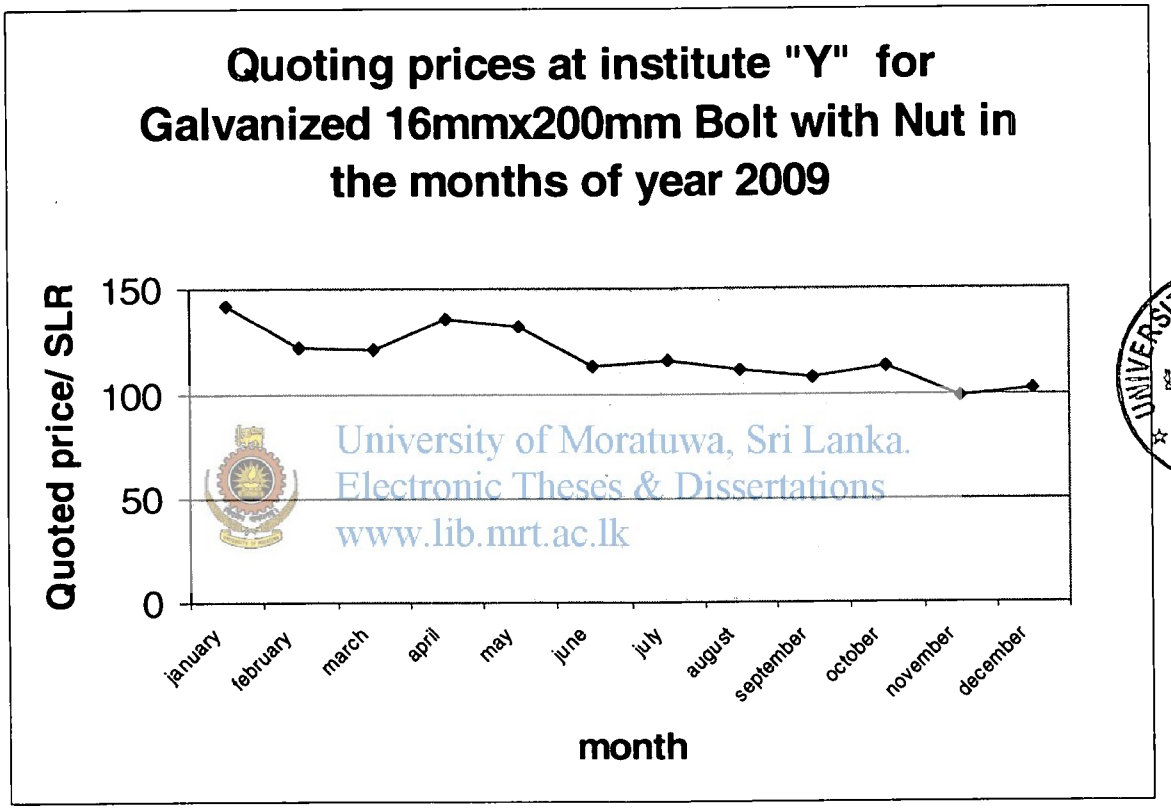

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Figure 1.1: Quoted price for Bolts and Nuts for the year 2009

This is a threat to keep the profits of the companies

1.1.1.2 Increasing raw material price (www.lme.com, 2009.11.06)

London metal market shows a rapid increment in steel as well as Zinc prices. This reflects the future increase in steel prices. Hence, the costs of the products will increase accordingly. Therefore, this is also a threat to keep the profits as well as survive the companies.

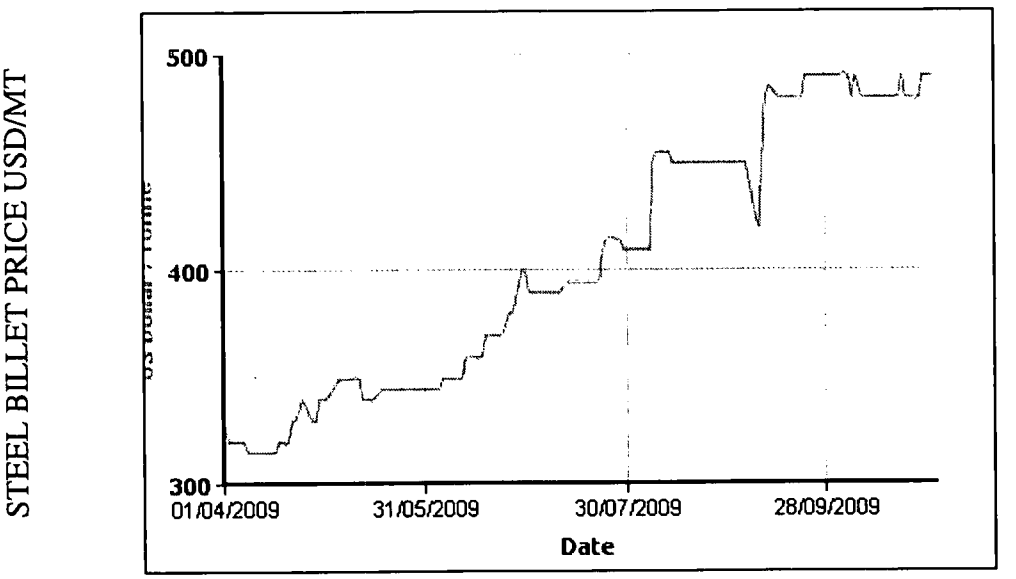

Figure 1.2: LME Steel Billet prices in year 2009

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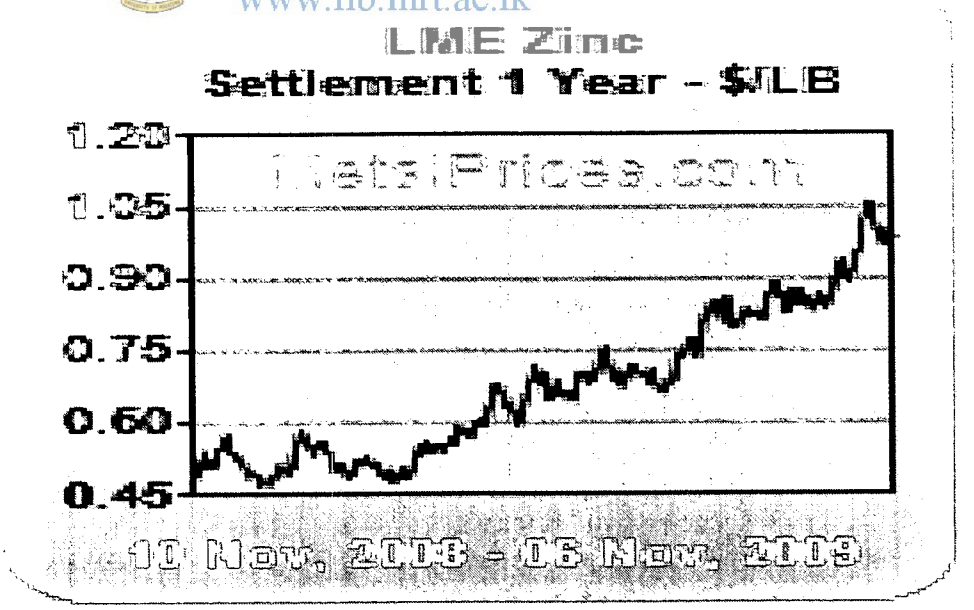

Figure 1.3: LME Zinc prices in year 2009

1.1.1.3 Unnecessary losses

This is the weakness the companies should get corrected to reduce the costs and face the other increment of other costs and market competition. First we have to identify the wastes and then should provide solutions. For that purpose waste elimination and Productivity improvement methods should be applied.

It is necessary to look at the available waste elimination methods and productivity improvement tools which can be implemented to the Nut & Bolt manufacturing industry. Initially, needs to identify the wastes i.e. where are wastes generated? Why are wastes generated? And how can these causes be eliminated? This can be carried out by the described methodology which uses the techniques of Cleaner Production Assessment, Kaizen, etc. Initially, Interviews were carried out at X ltd which is one of the major manufacturers in the industry, and found out the major problems to the organization which relevant to the industry. Then wastes and losses were found out with the support of Cleaner production Techniques. After that made a suitable questionnaire and got the details from the other companies. Then found the most important problems to be solved and solutions given. Appreciable results were obtained and further area for study is proposed for other industries.

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1.2 Objectives.

The main objective is to protect the sustainability of the Sri Lankan Hexagonal Nut and Bolt manufacturing Industries by identifying eliminating wastes and improving productivity. To achieve that objective following objectives are set.

1.2.1. To find out the major issues in Hexagonal Nut and Bolt Industry.

1.2.2 To find out the causes for the above issues

1.2.3 To find out the possible ways to eliminate the above issues by providing solutions to the causes

1.2.4 To introduce a methodology to carry out the above

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1.3 Methodology

1.3.1 Select the Industry which delivers the product or service.

If there is any specific requirement in a selected area; select it. Otherwise find out a requirement in the industry and select it.

1.3.2 Select one organization for the case study which delivers the product or service.

In selection of the organization for the case study it is better to find a place which delivers the selected product or service. Get the authority to carry out a study freely by explaining the advantage of the study to the organization.

1.3.2 Carry out interviews and find out the major issues in the organization

This should be carried out relevant to the selected product/ service. These results may not much Accurate with the numerical values. However, by these answers a rough view could be obtained and it will help the future activities.

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1.3.4 Use Cleaner production Techniques and find out the wastes and losses.

Designation of the team should be done initially. Then list the Process steps and draw the CP flow charts. Use the Cleaner production techniques to find the wastes. Material balance and energy balance methods will help to identify the wastes easily. And also assign costs to the wastes.

1.3.5 Make a questionnaire and get the details from the other companies.

Make a questionnaire which is appropriate to understand the situation of the other companies in the industry. When making the questionnaire other possible losses and wastes which didn't find at the case study also should be considered.

1.3.6 Find the most important issues to be corrected.

Analyze data to understand the most important problems.

1.3.7 Analyze the Causes for the wastes and losses.

Use the technical knowledge to find out causes. And also carry out Brain Storming sessions. Then finalize the rout causes

1.3.8 Give solutions to the Causes found.

1.3.9 Analyse the results

1.3.10 Follow the applications to the other similar factories.

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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.

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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)

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- 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.

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- 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.

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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

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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

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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".

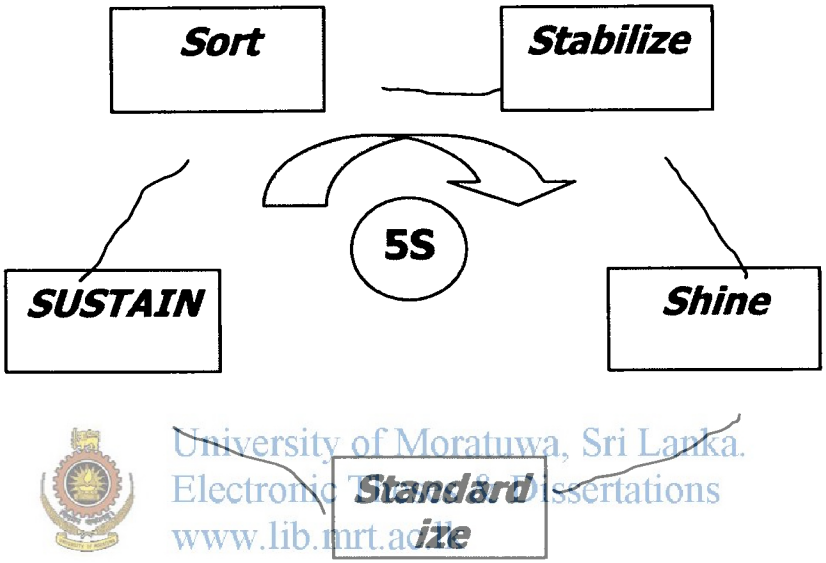

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Fig 2.1: 5S Cycle

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.

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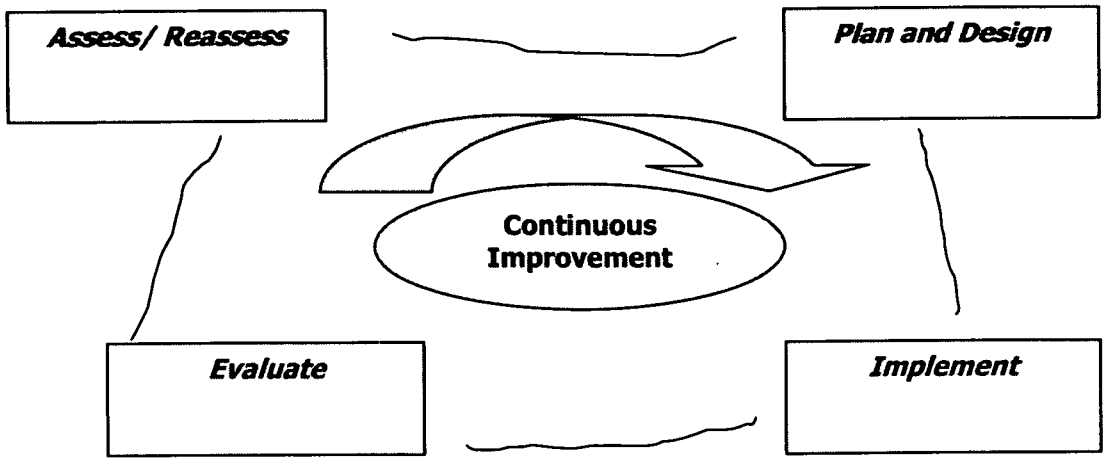

Fig 2.2 Kaizen Cycle

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.

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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.

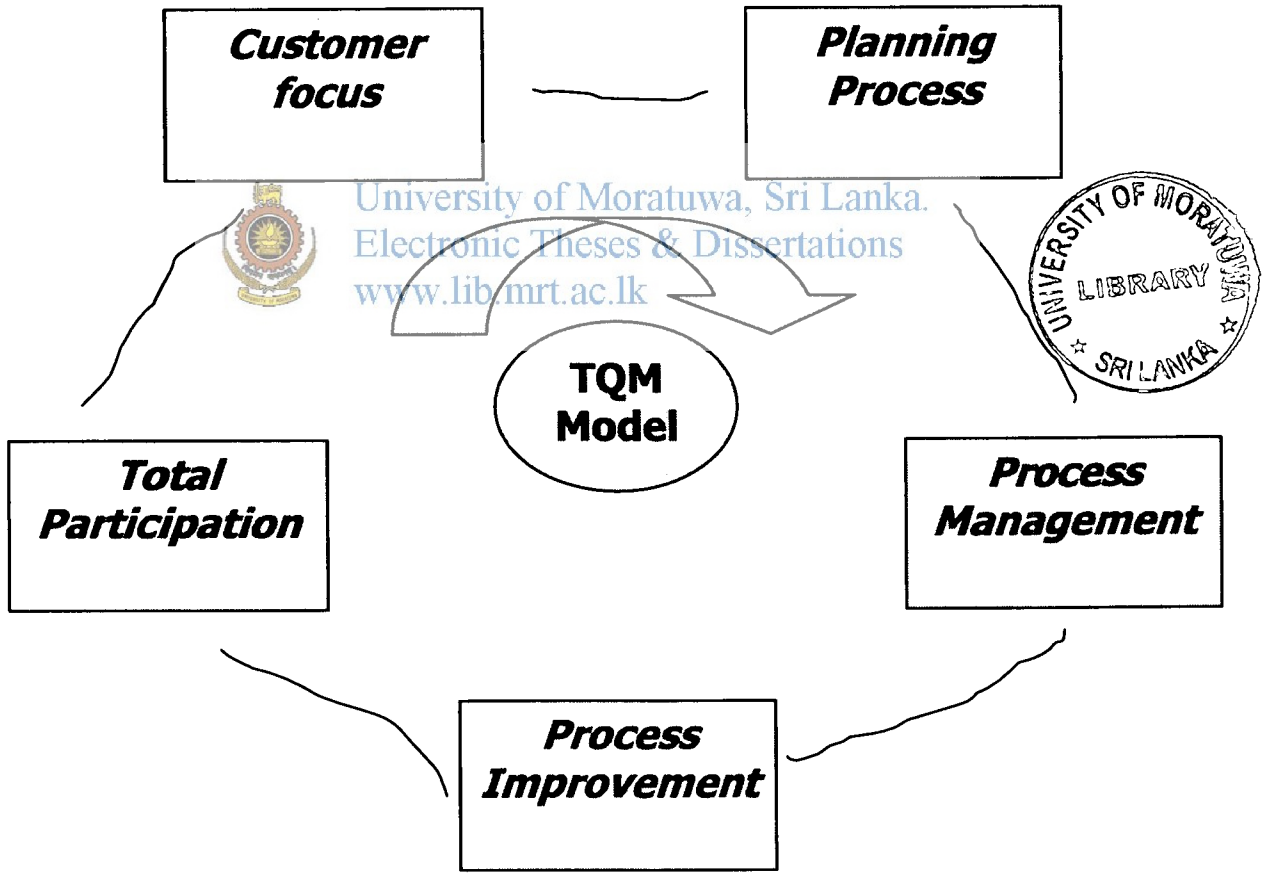

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Fig 2.3 TQM Cycle

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:

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- Availability
- Performance
- Yield (Quality Rate)

See Annex A05

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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

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- 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.

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- Hanger Bolts

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

- Shoulder Bolts

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

- Sex Bolts

  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.

- Mating Screws

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

- Hex Bolts

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

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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.

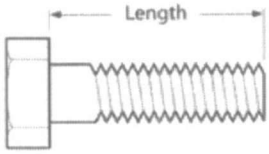

Fig 2.5 measuring Hex bolt

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

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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 NaNO2 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

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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

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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.

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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.

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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.

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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

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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

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CHAPTER 3

Implementation of the introduced methodology in Company X

3.1 Issue Finding

Industry was Selected which delivers the product or service as follows. There is special requirement in the Hexagonal Nut and Bolt Manufacturing Industry as its future is very uncertain with the market competition and lower margins. Therefore, it is selected as the industry for this study in Sri Lanka. Then one organization was selected for the case study which delivers the product or service. Company X is selected as the organization due to easy access to obtain data and carry out activities with the permission form the ownership. And also it has both hot forging and cold forging Nut and Bolt manufacturing processes.

Thereafter, interviews were carried out major issues were listed in the organization. The following information found at the initial interview with the Chairman, former Factory Manager, Finance Manager, HR Manager, Commercial Manager, Production Manager, Senior Technical Officer and 5 workers.

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- The Profit margin was decreasing. (23% in 2008/2009 but 2009 first quarter 12.4%) Therefore the future of the business was uncertain.
- There was no productive inventory control system to minimize the costs.
- At raw material Purchasing and delivery of the finished goods transport supply was not utilized productively. Capacity of the vehicles were not considered at delivery plan
- Large amount of scrap was generated frequently.
- Production reworks were very high.
- Dies of the machines were broken very frequently.
- Machine break downs were not frequent.
- Galvanizing Plant had been temporarily closed.
- Delay charges were paying due to the late deliveries to the customers. Although customers satisfied with the quality of the products they were not satisfied with the delivery.

- Labour Productivity at certain sections were very low

Then Cleaner Production Techniques were used and found the wastes and losses as follows

❖ Designated the project team

Initially the project team was designated as follows

1. Factory Manager
2. Production Manager
3. Senior Technical Officer
4. Finance Manager
5. Chief Commercial Manager
6. Quality executive
7. Purchasing Executive
8. Production assistant
9. A Machine operator
10. External experts

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❖ Listed Process steps

The steps of the process of manufacturing cold forging hexagonal nuts & bolts were 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

The steps of the process of manufacturing hot forging hexagonal nuts & bolts were 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

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❖ Assessment focus was selected as follows.

Table 01: Level of difficulties at each step in Cold Forged Nut & Bolt Manufacturing Process

Process step	High	Moderate	Low
Raw Material Receiving		X	
Cutting			X
Lubricating	X		
Wire Drawing			X
Wire cutting and Heading	X		
Trimming			X
Threading			X
Galvanizing	X		
Re-tapping			X
Packing		X	
Other Processes			
Tendering	X		
Purchasing with cash payment	X		
Cash collection with Invoicing			X
Transport		X	
Documentation			X
Quality assurance		X	
Inventory control		X	

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❖ Analyzed process Steps

- Part Flow Charts were Prepared

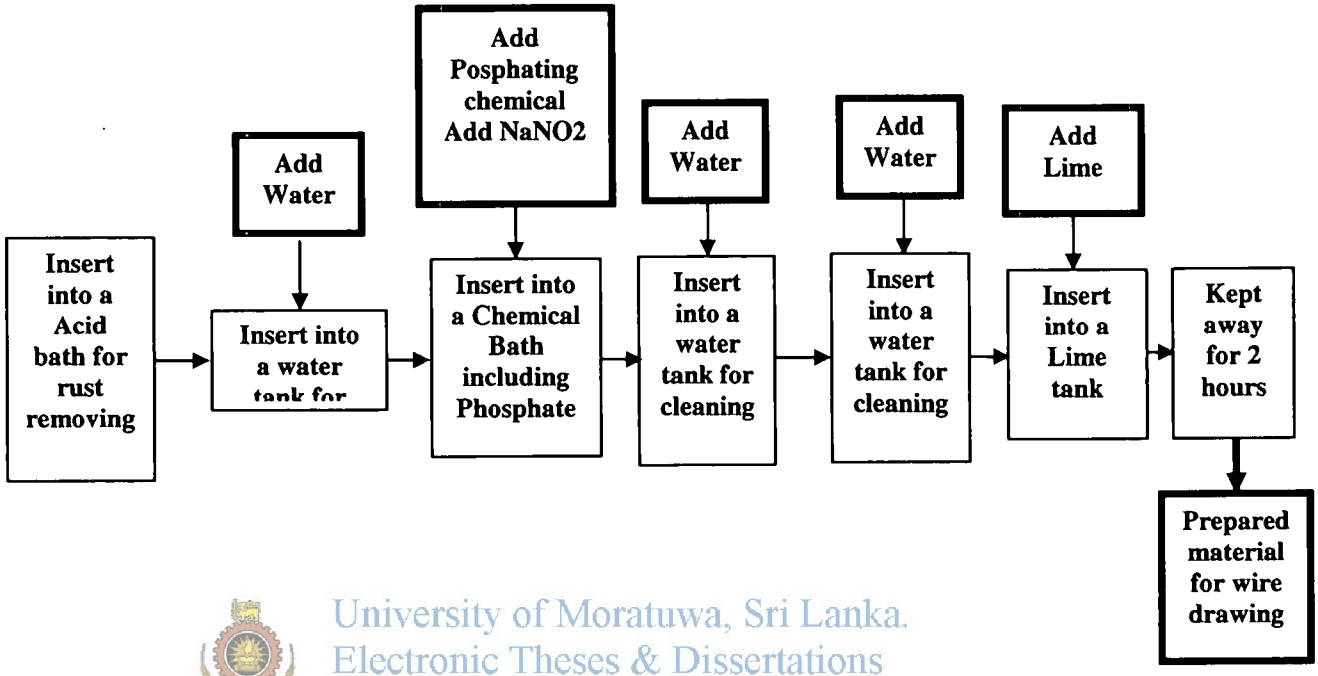

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Fig 3.1 The lubrication process of Cold Forging Nut & Bolt Manufacturing Process.

- Make material and Energy Balances

Material Balance:

Incoming Material + Generated Material = Outgoing Material + Consumed Material

Energy Balance:

E.g. heat energy at lubrication process

Heat in - Heat out = heat losses in the process

Findings through the material balance and process study

- Dies of Heading machine are damaged more frequently Average of 1 die/ 50MT
- Lubricated and drawn wires are frequently rejected and lubricated repeated average 20%

- 2000 Litres of Water is consumed in each week
- Large amount of Electricity is consumed 1248 units per week
- No. of threads cut by one chaser die is only a maximum of 1200 No's
- Chaser die teeth are broken frequently. Average of 1 die/ 3days
- Large amount of scrap iron is collected each week. Average of 5MT / week

Make a questionnaire and get the details from the other companies. (See Annex C01, Annex C02, Annex C03)

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The Percentages of answers Received for the questions are summarized as follows.

Table 02: The Percentages of answers Received for the questionnaire for Cold Forging Nut and Bolts

Index	Question	High	Moderate	Low
1.1	What is the Average No of dies damaged in the Heading machine?	100%	0%	0%
1.2	What is the frequency of rework at Lubrication?	100%	0%	0%
1.3	What is the water consumption per each week?	100%	0%	0%
1.4	What is the Electricity consumption at the lubrication process?	100%	0%	0%
1.5	What is the machine breakdown frequency?	50%	0%	50%
1.6	What is the amount of scrap iron collected weekly?	0%	0%	100%
1.7	What is the amount of reworks at Galvanizing?	0%	0%	0%

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Table 03: The Percentages of answers Received for the questionnaire for Hot Forging Nut and Bolts

Index	Question	High	Moderate	Low
2.1	What is the frequency of breaking chaser dies?	60%	40%	0%
2.2	What is the amount of scrap iron collected each week?	100%	0%	0%
2.3	Are there machine hours idling?	20%	60%	20%
2.4	Are there labour idling hours?	40%	60%	
2.5	What is the frequency machine breakdown?	40%	40%	20%
2.6	Are there Buffer stocks in the process?	60%	40%	0%
2.7	What is the amount of reworks at Galvanizing?	0%	0%	0%

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Table 04: The Percentages of answers Received for the questionnaire for Common Questions

3.1	Does the profit margin becoming a issue for you?	100%	0%	0%
3.2	Are there documentation system issues?	40%	40%	20%
3.3	Are there issues in optimum utilization of transport resource?	60%	20%	20%
3.4	Do you fail to optimize the financial facilities and minimize the finance cost	80%	20%	0%

Find the most important issues to be solved.

Find the weighted average by giving marks as follows

High - 3 marks

Moderate - 2 marks

Low - 1 mark

Calculation of Weighted Average

Weighted average = 3 x "High" Percentage + 2 x "Moderate" Percentage +
1 x "Low" Percentage

For the Percentages of answers Received for the questionnaire with weighted average for Cold Forging Nut and Bolts see Annex C04, Annex C05 and Annex C06

Rearrange the tables with descending order of the weighted average

See Annex C07, Annex C08, Annex C09

Major issues are taken as the weighted average value more than 2.25 (which is the 75% of maximum weighted average: 3)

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When considering the cold forging manufacturing industries the following problems are major problems

- Damaging the dies of the Heading machine
- Rework at lubrication process
- High amount of water consumption at the lubrication process
- High amount of Electricity is consumed in the lubrication process.

According to the table when considering the hot forging manufacturing industries the following problems are key factors

- High amount of scrap iron collected each week
- High frequency of breaking chaser dies
- High amount of Buffer stocks in the process
- There is poor labour efficiency

According to the table when considering the common factors in manufacturing industries the following problems are key factors

- Profit margin is decreasing
- Financial resources are not utilized effectively
- Transport resources are not utilized effectively

In this study Assessments are focused on the manufacturing of cold forging and hot forging Nuts and Bolts. Common problems which are apart from the manufacturing process will be forwarded for the assessment in future

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3.2 Cause Analysis and Solutions

Analyzing Causes for the wastes and losses.

Causes are analyzed using the Technical knowledge as well as holding Brain storming sessions

Table 05: Causes for the wastes and losses for Cold Forging Nut and Bolts

Index	Issue	Possible Causes
1.1	Damaging the dies of the Heading machine	1. Ineffectiveness's in Lubrication Process 2. Poor raw material Quality 3. design of the dies 4. Improper way it carried out
1.2	Rework at lubrication process	1. Ineffectiveness's in Lubrication Process
1.3	High amount of water consumption at the lubrication process	1. Ineffectiveness's in Lubrication Process set up at waste water management
1.4	High amount of Electricity is consumed in the lubrication process.	1. Ineffectiveness's in Lubrication Process set up at insulation 2. inefficiencies in Heaters

Table 06: Causes for the wastes and losses for Hot Forging Nut and Bolts

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Index	Issue	Possible Causes
2.1	High amount of scrap iron collected each week	1. Poor Raw material procument system 2. defective items
2.2	High frequency of breaking chaser dies	1. Poor Raw material Quality 2. Poor design and manufacture of chaser dies 3. Human errors
2.3	High amount of Buffer stocks in the process	1. Poor layout planning 2. Labour inefficiencies
2.4	There is high labour idling	1. Unorganized labour handling 2. lack of knowledge 3. Inadequacies in skills 4. Poor Attitudes

Then the possible causes were analyzed deeply even with the external experts and finally exact causes were identified.

1. Lubrication process was not carried out properly. Correct steps were not followed with the required testing at each step. And also dipping of the coil was done by a fork lift. There is a threat of touching the bottom of the tank. After some time there is a deposition of chemicals in the Phosphate bath. Quality defects will be arisen when the coil touches these chemicals.

2. At the lubrication process Waste water management was not done effectively.

3. At the lubrication process Insulation was not done properly. Therefore large amount of heat was dissipated to atmosphere. This resulted not only higher electricity consumption but also poor quality of the lubrication process

4. Hot forging Nut and Bolt manufacturing raw material was not ordered by considering the wasting material. For example when a 1000mm round iron pieces needed, if purchased 5.8m bar from the market 800mm will be wasted

5. Chaser dies are broken due to the improper sharpening. Period as well as the way of doing. And also the operators defects also affect this

6. High amount of buffer stocks is caused by poor layout planning as well as labour inefficiencies.

7. Labour inefficiencies mainly caused by the attitude. There are some points the knowledge and skill of the labour also affected.

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Solutions to the Causes found- for waste elimination and better productivity.

Although solutions proposed in high capital investments to initiate the improvement the project is carried out with small Kaizen activities.

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1. An expertise Engineer was brought from the chemical supplier from India to refresh the technology of the lubrication process and knowledge and skill was given to the workers by holding a workshop. Check list was given to the workers and a team leader was appointed to look after the carrying out of the duties.

   A new hoist system was proposed but initially not carried out as it is a capital investment.

   A six inch height wire mesh was made to avoid the coil touching the ground with chemical deposition as a Kaizen activity

   And it was scheduled to clean the deposits every week

2. Two water tanks had been refreshed paralleled. Therefore, it wasted much water. Therefore, more polluted tank's water is removed and water is replaced by the better tank. Then the better tank is filled with new water. This saved 50% of water.

3. For the insulation better tanks are needed. As an initiative a cover made of wood is used to cover the tanks. On the other hand a good quality regulator was used to control the current.

4. Discussions were held directly with the suppliers and purchased the raw material according to the actual requirement. When a 1000mm round iron pieces needed, if purchased 5.8m bar from the market 800mm will be wasted (13.79%). Purchasing at SLR 100.00 and sold as scrap at SLR 45.00 otherwise needed to be kept aside until an order comes in usable size.

SLR saving with the reduction of scrap iron.

(According to the prices in 2009 September)

Value of one MT of a mild steel wire	=	110,000.00
Value can be obtained from scrap	=	45,000.00
Saving with reduction of 1MT of scrap iron	=	65,000.00

Let us compare the generated scrap in two ways for the requirement of 100,000 No's each from 665 mm length and 930 mm length

Two sizes of rods needed for manufacturing products

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665mm, 930mm

Z - Waste of the rod

$Z = L - (665X + 930Y)$

$665X + 930Y < 5800$

$X > 0, Y > 0$

At $Y=0$, $665X < 5800$

$X < 8.72$

At $=0$, $930Y < 5800$

$Y < 6.24$

To find the minimum scrap value for both situations

$Z_{ij} = (aX_i - bY_j)$

Minimum of [Mode of $(aX_i - bY_j)$]

Where a = 665

b = 930

X_i = Number of parts of X cut by a length (X_i= 1,2...8)

Y_j = Number of parts of Y cut by a length (Y_j = 1,2...6)

Table 07: Scrap value of the bar in mm

X_i / Y_j	1	2	3	4	5	6	7	8
1	-265	400	1065	1730	2395	3060	3725	4390
2	-1195	-530	135	800	1465	2130	2795	3460
3	-2125	-1460	-795	-130	535	1200	1865	2530
4	-3055	-2390	-1725	-1060	-395	270	935	1600
5	-3985	-3320	-2655	-1990	-1325	-660	5	670
6	-4915	-4250	-3585	-2920	-2255	-1590	-925	-260

Minimum of [Mode of $(aX_i - bY_j)$] = 5

This occurs at X_i = 7 and

Y_j = 5

Required lengths = maximum of [7*665, 5*930]

= 4655 mm

Let us compare the generated scrap in two ways for the requirement of 100,000 No's each from 665 mm length and 930 mm length

Weight of a 5.8 m 16mm diameter MS bar = $\pi D^2/4*5.8*$density of MS

= $\pi*(0.016)^2/4*5.8*7850$

= 9.158 kg

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No of 665 sizes getting from 5.8 length = integer of (5800/665)

= 8 pieces

No of 5.8 lengths required for 100,000Nos of 665 lengths = 100,000/8

= 12,500 bars

Waste as scrap from each 5.8 length = 5800-665*8

= 480 mm

Total waste for 100,000 No's of 665 pieces With 5.8m lengths = $480*12500*\pi*(0.016)^2/4*7850$

= 9473.83 kg

Like wise

Total waste for 100,000 No's of 930 pieces With 5.8m lengths = 5789.68

Total waste for 100,000 No's of 665 pieces

Total waste for 665 and 930 items with 5.8 length = 15263.51 kg

	=	5.71%
With 4.655 m lengths	=	0
Total waste for 100,000 No's of 930 pieces		
With 4.655 m lengths	=	157.9 kg
Total waste for 665 and 930 items with 4.655m length	=	157.9 kg
	=	0.06%

Therefore,

Generated scrap with new size = 0.06/5.71

= 1%

Prevented scrap generation fro this production = 15263.51-157.9

= 15105.61 kg

Saving in SLR = 15105.61/1000*65000

= 981864.59

5. Holding device was used for the sharpening of chaser die with a surface grinding machine. And the frequency of the sharpening was changed from two days to 1 day. A technician is appointed to sharp the dies everyday in the evening.

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6. An incentive was given to the workers on their performances. And the change was done to the workers to work at optimum places.

Attitude change was occurred with the incentive and training opportunities were given to the workers as well as the production management team. **Motivational Schemes**

To maintain the labour productivity it is very important to develop knowledge, skill, attitudes. For the developing of Attitudes Motivational schemes play a very important role.

3.3 Results

Results Obtained

Table 08: Results obtained for Cold Forging Nut and Bolts

Index	Issue	Value before improvement	Value after improvement	improvement
1.1	Damaging the dies of the Heading machine	3 dies/ month	2die/ month	33%
1.2	Rework at lubrication process	5 times/ month	2 time per month	60%
1.3	High amount of water consumption at the lubrication process	2000 liters/ week	1000 liters/ week	50%
1.4	High amount of Electricity is consumed in the lubrication process.	1248 units/ week	936 units/ week	25%

Table 09: Results obtained for Hot Forging Nut and Bolts

Index	Issue	Improvement		
2.1	High amount of scrap iron collected each week	5MT/ week	4MT/ week	20%
2.2	High frequency of breaking chaser dies	3dies/ week	2 die/week	33%
2.3	High amount of Buffer stocks in the process	Average of 50 MT	45 MT	10%
2.4	There is high labor idling	Average of 10%	7%	30%

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3.4 Discussion

This plant is one of the two main Cold forging Hexagonal Nut and Bolt manufacturing plants in Sri Lanka who provides Nut and Bolts to the consumer market. Therefore, any effect to the machine will affect the Nut and Bolt market in Sri Lanka.

The average output of the machine per day was found to be 5MT. According to the Manufacturer of the dies the average usage of one heading dies should be 150MT. And at the time of investigations it was only 50 MT. On the other hand there was a reworking process at the lubrication process 5 times a month in average. However with the implementation of this methodology root causes were identified and with the solutions given the average usage of heading die has increased to 125MT with a percentage increase of 250%. And also the rework of the lubrication process reduced to 1 rework per month and it is an 80% reduction in rework process.And also more improvement is expected with the proposed hoist system which is to be implemented in the next stage. Water consumption had been 2000 liters per week and with the introduction of counter current washing system one tank of water could be saved per week as an improvement of reducing the water consumption by 50%. Electricity consumption had been 1248 units per week and it reduced to 936 units per week and it is a saving of 25% of the electricity bill. And also when hot forging is concerned, weekly collected scrap iron amount reduced by 20%. However, each Metric tone of scrap irons saving saves more than 65,000.00 SLR. Identified correct period of sharpening the chaser dies improved the life time of them by 66.7%. On the other hand, amount of buffer stocks could be reduces by 10% identifying the bottlenecks and improving the resource utilization. Labor idling could be reduced from 10% to 7% with the introduction of the incentive scheme. Altogether with the introduced methodology considering all factors there is a n average improvement of 33%. This will help the organization to withstand the critical situation of the market. And also as the other Sri Lankan companies also gave similar answers at the issue findings, they can apply this methodology to face the critical situations successfully.

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CHAPTER 4

Conclusion

4.1 Further Study

Further study should be carried out to ensure the sustainability of the solutions given. Capital investment can be done for a hoist system after necessary appraisals for the cold forging Nut and Bolt's lubrication process.

Other than in manufacturing side in following areas improvements can be done

- Optimizing the financial facilities
- Optimizing the transport resources
- Systemization of the documentation

However further studies can be carried out on how these methods can be implemented to other Hardware manufacturing Industries and finally to Industries other than Hardware items manufacturing

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4.2 Conclusion

According to the market situation it is a must to reduce wastes and improve productivity in Hexagonal Nut and Bolt Manufacturing Industry in Sri Lanka. By applying the methodology described, Company X achieved an overall improvement of 33% while reducing the damaging the cold forging dies of the heading machine by 33%;reducing the rework at lubrication process by 60%; reducing the water consumption at the lubrication process by 50%; reducing the electricity consumption in the lubrication process by 25%; reducing the scrap iron collection by 20%; reducing the consumption of chaser dies by 33%; reducing the buffer stocks in the process by 10% and reducing the labour idling by 30%

And the other Hexagonal Nut and Bolt manufacturing companies in Sri Lanka showed the similar issues in their processes they can use this methodology to solve their issues and face the critical situation successfully.

And also other than the Nut and Bolt Industry the companies can use this methodology with the relevant changes and further study.

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ANNEXURE

Annex A01

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CP for production processes

For production processes, CP aims:

(a) To reduce the consumption of raw materials and energy used in the production of one unit of product;

(b) To eliminate as far as possible the use of toxic and dangerous materials;

(c) To reduce at source the quantity and toxicity of all emissions and wastes generated and released.

CP for products

For products, Cleaner Production aims to reduce the environmental, health and safety impacts of products:

• Over their entire life cycles

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• From raw materials extraction, through manufacturing and use, to the ultimate disposal of the product.

CP for services

For services, Cleaner Production implies incorporating environmental concerns into the design and delivery of services.

The design of a service is crucial: not just, "Are we doing things right?" but rather, "Are we doing the right things?" and, "Are we doing them the right way?"

Annex A02

The 5S management program facilitates an excellent performance:

Safety: a well organized and orderly workplace is a safer workplace. 5S activities remove clutter, visual indicators alarm people for hazardous situations.

Improving production efficiency: 5S supports a smooth production process in various ways. Searching for tools is eliminated, flow principles are applied, and tools storage is done where they are needed most. Location indicators visualize how things have been organized, and non conformities are seen at once.

Quality improvement: Daily activities like inspection help to keep the production process in the right condition. Defects are prevented, because deviations are spotted before they result into defects.

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Controlling your workplace: 5S helps to control the workplace by:

- determining what is needed, and where it is needed.
- defining the appropriate location for tools and other materials.

maintaining these standards.

Annex 03

KAIZEN Concept in Our Individual Life

KAIZEN, as you could learn from the definition, is a common word and very natural to individual, continuous improvement in personal life, home life, social life and working life. Everybody deserves to and should be willing to improve himself/herself for the better continually. "If a man has not been seen for three days, his friends should take a good look at him to see what changes have befallen him" quoted from the old Japanese saying, describes how natural KAIZEN is.

Maintenance, Innovation, and KAIZEN

In our concepts, three functions should happen simultaneously within any organizations: Maintenance, Innovation, and KAIZEN. By maintenance, we refer to maintaining the current status, the procedures are set and the standards are implemented. People in the lower level of organization mostly do that, they maintain their standards.

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By Innovation, we refer to breakthrough activities initiated by top management, buying new machines, new equipment, developing new markets, directing R&D, change of strategy etc.

In the middle there is KAIZEN, small steps but continuing improvement. KAIZEN should be implemented by the lower/middle management and the workers, with the encouragement and direction of the top. The top management responsibility is to cultivate a KAIZEN working climates and cultures in the organization.

KAIZEN Attitude

The kaizen attitude makes our firm so adept at exploiting new technology, even when we are not its originator. Kaizen-driven firms do not suffer from "not invented here" syndrome. Ideas are not the exclusive preserve of R&D, corporate planning, or market research; every new idea is welcomed and "channels" are forsaken.

Kaizen Technologies, Inc is built on the above concept and "Kaizen" is part of our name, heart, work and is clearly reflected in our solution deliverables.

Annex 04

TQM Process Thinking

TQM requires a new process thinking mindset. We must realize that everything we do is part of a process. Our focus shifts from managing outcomes to managing and improving processes; from what to do to how to do the processes better. Quality performance expands to include how well each part of the process works and the relationship of each part to the process. Also, process improvement focuses on continuously achieving the greatest potential benefit for our customers.

Annex A05

Availability losses:

Breakdowns and changeovers indicate situations where the line is not running while it should be.

Performance losses:

Speed losses and small stops/idling/empty positions indicate the line is running, but is not providing the quantity it should.

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Yield losses:

Additionally, when the line producing products, there are losses due to rejects and start-up quality losses.

These losses lead to the Overall Equipment Effectiveness (OEE) indicator, which tells you how efficiently you produce when you have planned to produce. TPM helps you to improve your OEE by providing a structure to quantify these losses, and by subsequently giving priority to the most important ones. TPM provides concepts and tools to achieve both short and longer term improvements.

Annex B01

Hex Head Cap Screws-Bolts Grade 5 Coarse

Fig B.1 Hex Head Cap Screws-Bolts Grade 5 Coarse

Hex Head Cap Screws-Bolts Grade 8 Coarse

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Fig B.2 Hex Head Cap Screws-Bolts Grade 8 Coarse

Hex Head Cap Screws-Bolts Grade 8 Fine

Fig B.3 Hex Head Cap Screws-Bolts Grade 8 Fine

Steel grade 2

Zinc plated low carbon steel. Best for general hardware use where high strength is not required.

Steel grade 5

Made from medium carbon steel, tempered and zinc plated. Best for automotive use and other areas where higher strength is desired.

Steel grade 8

Made from medium carbon alloy steel, tempered, and zinc plated. Best suited for applications where high strength and hardness is required.

Stainless steel 18-8

Stainless steel 18-8 is an alloy of steel with high corrosion resistance. Stainless has become the material of choice for exterior and most marine applications.

Silicon Bronze

Bronze is an alloy of copper with greater strength and corrosion resistance than brass. Most commonly used in wood boat building and restoration.

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Hot dipped galvanized

Hot dipped galvanized fasteners are much more corrosion resistant than zinc plated fasteners. Due to the thickness of the galvanized coating, galvanized bolts will only work with galvanized nuts. For exterior and coastal area use. (ASTM A153)

Grade 5 chrome

A grade 5 fastener with a bright mirror-like finish providing sharp looks for a variety of applications

Annex B02

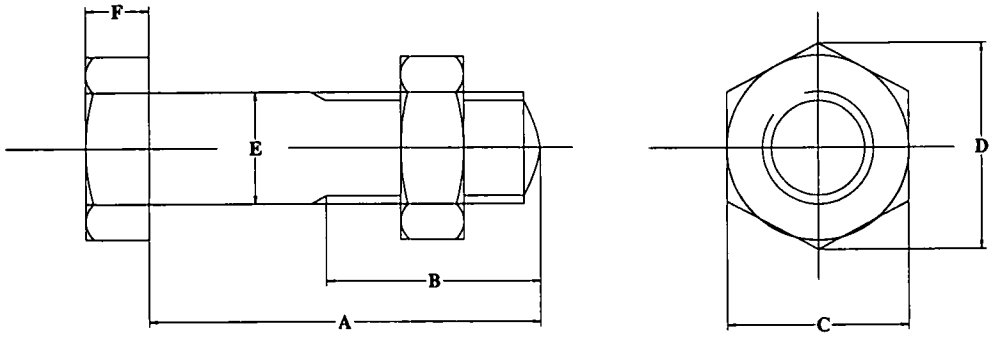

Fig B4: Measurements of the Hexagonal Bolts and Nuts

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A - Length of the Bolt

B - Thread Length

C - Width across Flats

D - Width across Corners

E - Shank Diameter

F - Height of the Head

Annex C01

Table 10: The questionnaire for Cold Forging Nut and Bolts

Index	Question	High	Moderate	Low
1.1	What is the Average No of dies damaged in the Heading machine?	100%	0%	0%
1.2	What is the frequency of rework at Lubrication?	100%	0%	0%
1.3	What is the water consumption per each week?	100%	0%	0%
1.4	What is the Electricity consumption at the lubrication process?	100%	0%	0%
1.5	What is the machine breakdown frequency?	50%	0%	50%
1.6	What is the amount of scrap iron collected weekly?	0%	0%	100%
1.7	What is the amount of reworks at Galvanizing?	0%	0%	0%

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Annex C02

Table 11: The Percentages of answers Received for the questionnaire for Hot Forging Nut and Bolts

Index	Question	High	Moderate	Low
2.1	What is the frequency of breaking chaser dies?	60%	40%	0%
2.2	What is the amount of scrap iron collected each week?	100%	0%	0%
2.3	Are there machine hours idling?	20%	60%	20%
2.4	Are there labor idling hours?	40%	60%	
2.5	What is the frequency machine breakdown?	40%	40%	20%
2.6	Are there Buffer stocks in the process?	60%	40%	0%
2.7	What is the amount of reworks at Galvanizing?	0%	0%	0%

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Annex C03

Table 12: The Percentages of answers Received for the questionnaire for Common Questions

3.1	Does the profit margin becoming a problem for you?	100%	0%	0%
3.2	Are there documentation system problems?	40%	40%	20%
3.3	Are there problems in optimum utilization of transport resource?	60%	20%	20%
3.4	Do you fail to optimize the financial facilities and minimize the finance cost	80%	20%	0%

Annex C04

Table 13: The Percentages of answers Received for the questionnaire with weighted average for Cold Forging Nut and Bolts

Index	Question	High	Moderate	Low	Weighted average
1.1	What is the Average No of dies damaged in the Heading machine?	100%	0%	0%	3
1.2	What is the frequency of rework at Lubrication?	100%	0%	0%	3
1.3	What is the water consumption per each week?	100%	0%	0%	3
1.4	What is the Electricity consumption at the lubrication process?	100%	0%	0%	3
1.5	What is the machine breakdown frequency?	50%	0%	50%	2
1.6	What is the amount of scrap iron collected weekly?	0%	0%	100%	1
1.7	What is the amount of reworks at Galvanizing?	0%	0%	0%	0

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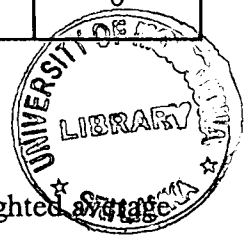

Annex C05

Table 14: The Percentages of answers Received for the questionnaire with weighted average for Hot Forging Nut and Bolts

Index	Question	High	Moderate	Low	Weighted average
2.1	What is the frequency of breaking chaser dies?	60%	40%	0%	2.6
2.2	What is the amount of scrap iron collected each week?	100%	0%	0%	3
2.3	Are there machine hours idling?	20%	60%	20%	2
2.4	Are there labor idling hours?	40%	60%		2.4
2.5	What is the frequency machine breakdown?	40%	40%	20%	2.2
2.6	Are there Buffer stocks in the process?	60%	40%	0%	2.6
2.7	What is the amount of reworks at Galvanizing?	0%	0%	0%	0

Annex C06

Table 15: The Percentages of answers Received for the questionnaire with weighted average for Common Questions

Index	Question	High	Moderate	Low	Weighted average
3.1	Does the profit margin becoming a problem for you?	100%	0%	0%	3
3.2	Are there documentation system problems?	40%	40%	20%	2.2
3.3	Are there problems in optimum utilization of transport resource?	60%	20%	20%	2.4
3.4	Do you fail to optimize the financial facilities and minimize the finance cost	80%	20%	0%	2.8

Annex C07

Table 16: The Percentages of answers Received for the questionnaire with sorted weighted average for Cold Forging Nut and Bolts

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Index	Question	High	Moderate	Low	Weighted average
1.1	What is the Average No of dies damaged in the Heading machine?	100%	0%	0%	3
1.2	What is the frequency of rework at Lubrication?	100%	0%	0%	3
1.3	What is the water consumption per each week?	100%	0%	0%	3
1.4	What is the Electricity consumption at the lubrication process?	100%	0%	0%	3
1.5	What is the machine breakdown frequency?	50%	0%	50%	2
1.6	What is the amount of scrap iron collected weekly?	0%	0%	100%	1
1.7	What is the amount of reworks at Galvanizing?	0%	0%	0%	0

Annex C08

Table 17: The Percentages of answers Received for the questionnaire with weighted average for Hot Forging Nut and Bolts

Index	Question	High	Moderate	Low	Weighted average
2.2	What is the amount of scrap iron collected each week?	100%	0%	0%	3
2.1	What is the frequency of breaking chaser dies?	60%	40%	0%	2.6
2.6	Are there Buffer stocks in the process?	60%	40%	0%	2.6
2.4	Are there labor idling hours?	40%	60%		2.4
2.5	What is the frequency machine breakdown?	40%	40%	20%	2.2
2.3	Are there machine hours idling?	20%	60%	20%	2
2.7	What is the amount of reworks at Galvanizing?	0%	0%	0%	0

Annex C09

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Table 18: The Percentages of answers Received for the questionnaire with weighted average for Common Questions

Index	Question	High	Moderate	Low	Weighted average
3.1	Does the profit margin becoming a problem for you?	100%	0%	0%	3
3.4	Do you fail to optimize the financial facilities and minimize the finance cost	80%	20%	0%	2.8
3.3	Are there problems in optimum utilization of transport resource?	60%	20%	20%	2.4
3.2	Are there documentation system problems?	40%	40%	20%	2.2