Exploring the impact of Lean manufacturing and Green manufacturing in Steel industry

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Abstract : Lean manufacturing means manufacturing without waste. Anything else which are not adding any value to the product are considered as waste as per lean concept. Inventories of raw materials, work in process inventories, inventories of finished product, overproduction, waiting of equipment ,waiting of human resources, space occupied by unused equipment and materials, excess used of materials etc. are the waste as per lean concept. Green manufacturing means manufacturing means manufacturing without pollution and optimum use of natural resources. Hence if lean manufacturing concept are adopted by any industry, they automatically moves towards green manufacturing also and vice verse. Thus it is said that manufacturers can be green and highly profitable at the same time. Profits do not have to be sacrificed to environmental responsibility, or vice verse. The two strategies (lean and green) can be integrated and offered simultaneously that will reduce environmental pollution, optimum utilization of resources and improvement in productivity. While Lean Manufacturing (LM) focuses on minimization of wastes,Green Manufacturing (GM) emphasizes on achieving zero emissions. Little is known about the linkage between these two initiatives and their integration. Furthermore, it is also not clear whether these two initiatives can coexist in the same organization or not. Even without explicitly targeting environmental outcomes, lean efforts can yield substantial environmental benefits. However, because environmental wastes and pollution are not the primary focal points, these gains may not be maximized in the normal scheme of lean. The two strategies can be integrated and offered simultaneously. The approaches have similarities, in that they strive to eliminate non value-added components, assess baseline conditions and operations, capture the details of process inputs and outputs, and substrate to design and incorporate changes that will reduce environmental or productivity inefficiencies. As soon as your operations implement Lean you will become more capable of enabling increased capacity by freeing up underused resources

Index Terms **– Lean manufacturing. Green manufacturing, Steel industry.**

I. INTRODUCTION

During the end of the twentieth century and into the twenty-first century two types of manufacturing systems that emphasize waste minimization have gained in popularity. They are "Lean" manufacturing systems that reduce waste defined as non-value added activity, and "Green" manufacturing systems that reduce waste defined as having adverse environmental impact. Green manufacturing is an essential part of sustainable development. The concept of Lean Manufacturing was first seen in Japan particularly in Toyota Production System. Lean manufacturing was originally developed by the Toyota Motor Co. in Japan based on concepts given by Henry Ford. The concepts, tools and techniques had gone through a lot of testing before they were accepted. Lean manufacturing means manufacturing without waste. Waste can take many forms and can be found at any time and in any place. It may be found hidden in policies, procedures, processes and product designs, and in operations. Waste consumes resources but does not add any value to the product value.The aim of lean manufacturing should be to eliminate waste from their systems and operations and extract maximum output from minimum inputs. There are seven kinds of waste, that is addressed in the TPS are Waiting, improper Transport or Conveyance, Defects or Correction, Over-production, Unnecessary Motion , Unnecessary Inventory, Inappropriate processing. The ultimate goal is to have a minimum waste in the operations of the plant.

❖ LEAN

The history of lean began in early 1950s in Japanese's car maker factory, Toyota. Toyota was into textile manufacturing in the beginning, then they shifted to be a car manufacturing. In 1937 by the name of Toyota Motor Company they started manufacturing cars.The world was facing war and by the force of the military government they had to change their direction from car manufacturing to truck vehicle provider.And soon after the war they came back to their primary product and made themselves competitive in the car market. The problems that they faced were. By the time they returned variety of problems were waiting for them.

• A small Domestic market was demanding large variety.

• Employees powers were restricted and work union, work laws had gained strength.

• World War had weaken Japan economy, which restricted import of western technology to Japan.

So they soon realized, with current methods they cannot compete in international market. Taiichi Ohno,production manager of Toyota, found new methods which later became the fundamental of lean production.(Womack et al. 1990).One of the concepts that Ohno was going to change was the press machine

or in general machining. In mass production system, different parts was produced in huge numbers in one go. This used to involve many machines and manpower for all the time. These parts were stored in inventory and then they changed the setup of the machines to produce the other part. As changing dies or other setups was so time consuming and needed experts, this mass production approach was implemented.. Ohno applied his experience and observations to improved the process of changing the dies. He could reduced the setup up time for machines and used regular operator to make the production line more flexible. Doing this he made it possible to produce different parts with the same machine and the same day. By this improvement he reduced the number of machines needed for the production line, reduced the inventory and the cost of inventory and transportation and also improved the quality of the production line during the production process. The impact of this change was wide spread. It also reduced the rework as the defected part would be identified immediately and the failure reason would be repaired before making another defected batch.(Womack et al.1990) Liker in his book describes this achievement as when you make lead times short and focus on keeping production lines flexible,you actually get higher quality,better customer responsiveness,better productivity,and better utilization of equipment and space.By studying mass production Ohno realized that there are so many wastes in material, effort and time in the production system which enforced extra cost to the company and also its customers.

➢ **Lean manufacturing and traditional manufacturing**

The lean manufacturing techniques are conceptually different from the traditional process. For example, the traditional manufacturing work is based on inventory. But Lean Manufacturing questions the role of inventory and defines it as a waste and reflects the imperfections that the system has.Lean Manufacturing is in direct opposition with traditional manufacturing approaches characterized by use of economic order quantities, high capacity utilization, and high inventory.

In changing from a traditional environment to one of lean production, cultural issues will emerge quickly, as well as resistance to change. A managing change program is needed to accompany the effort. It has been established beyond doubt that the organizations that have mastered lean manufacturing methods have substantial cost and quality advantages over those which are still practicing traditional mass production**.**

➢ **Wastes**

Waste in any organization or process is referred to the misuse of resources, production not fit for sale or resources that tie up cash and inventory while providing little or no benefit to the organization or its consumers. These resources could be better used elsewhere in the organization invested in value creating operations or opportunities.The aim of lean manufacturing should be about eliminating waste from their systems and operations and extracting as much outputs as they can from minimal inputs.There are seven kinds of waste, that is addressed in the TPS are Waiting,Transport or Conveyance, Defects or Correction, Over-production,Unnecessary Motion or Movement, Unnecessary Inventory, Inappropriate processing.The ultimate goal is to have a minimum waste in the operations of the plant.

❖ **GREEN MANUFACTURING**

In the recent decades as a consequence of fast growth in the population, industrialization, usage of fossil fuel,growth in the economy and need of accelerated production, mankind has started a massive use of natural resources to meet its demand in a way that in some area it has passed the limitation of sustained trend of resources. On the other hand such a massive consumption has ended up in polluting the environment by the waste of its product and production. Thus there has been such pressure on the companies to minimize their emission and pollution of their activities from their supply chain to their product.

➢ **Green Manufacturing**

Green Manufacturing is a method of manufacturing that minimizes pollution and waste achieved through research and process design.It is also a method that supports and sustains a renewable way of producing products and/or services that do not harm us or the environment. Green Manufacturing goals are also to conserve natural resources for future generations. The benefit of Green Manufacturing is to saves useless cost, and promotes research and design.

The top ten environmental issues for organization to understand and consider the impact of are-

1. Climate change
2. Energy
3. Water
4. Biodiversity and land use
5. Chemicals and heavy metals
6. Air pollution
7. Waste management
8. Ozone layer depletion
9. Oceans and fisheries
10. Deforestation.

II. LITERATURE REVIEW

The literature on lean manufacturing is divided into three sections, namely lean philosophy, lean surveys.

❖ **Lean philosophy**

The definition of lean, its principles and main concepts,come under lean philosophy which is defined as a process that includes various steps: the first step is defining customer value, then defining value stream, making it 'flow',establish pull,and the last step is striving for excellence.lean manufacturing can be characterized by a collective set of key factors or key areas. These key factors are believed to be very

important for its implementation.In the 1980s, changing plant to lean production from mass production was considered to be very difficult.Workers did not take responsibility for the quality of the product.They responded only when they knew that management actually valued their skills. The quote 'do it right the first time',encourages workers to feel accountable for the products.Womack et al.(1990) explained how the movement of automobile manufacturing took place from craft production to mass production and then to lean production. The standardization of automobile parts and assembly techniques was done by Henry Ford. It takes a revolution, and as a result low skilled workers and specialized machines made the cars cheap for the people.Lean is viewed more as a philosophy than a strategy.Supplier involvement is a must if an organization is to reap the rewards of lean practices. Moreover, lean manufacturing should be considered as a continuous improvement process for better results.Continuous Improvement uses different methodologies to get better results in an organization. These methodologies include lean manufacturing, six-sigma, lean six-sigma and the balance score card.It is found that continuous improvement efforts are means to achieve high levels of pull production (production is based on actual daily demand) through eliminating variability in the system and thereby reducing defects in the organization. Clarity of the term waste must be understood. There are two types of waste, the first type is obvious waste and the second type is less obvious waste. Obvious wastes result from overproduction, waiting, transportation, inappropriate processing, excessive inventory, excess motion and defects.Less obvious wastes result from variability. Dhamija et al.(2011), in his publication stated lean organizations are those which utilize less material to create their work, less human efforts to perform the work, less time to design and develop less energy and space. Lean organizations focus on customer demand and thereby producing high quality products and services in most the effective and economical manner.Rose et al. (2011) purposed 17 lean practices which are considered to be best feasible and relevant to small and medium scale characteristics. They suggested that implementation of lean practices should be done in a consistent way. Inconsistency in the efforts may not lead any organization to avail full benefits from lean practices.

OVERVIEW OF PROCESS IN STEEL PLANT

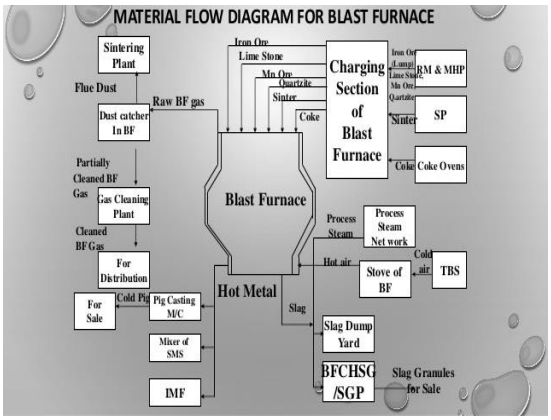

Figure: overview of steel plant

Manufacture of Steel

Methods for manufacturing steel have evolved significantly since industrial production began in the late 19th century. Modern methods, however, are still based around the Bessemer Process, namely, how to most efficiently use oxygen to lower the carbon content in iron.

Today, steel making comes from both recycled as well as from raw materials. Two processes:

- Basic Oxygen Steelmaking (BOS)/ Basic Oxygen Furnace (BOF) and

Electric Arc Furnace (EAF) account for virtually all steel production.

Primary steel production

Primary steelmaking methods differ between BOS and EAF methods. BOS methods add recycled scrap steel to the molten iron in a converter. At high temperatures, oxygen is blown through the metal, lowering silicon, manganese and phosphorous levels and lowering carbon content to between 0-1.5%. The addition of chemical cleaning agents called fluxes help to reduce the sulfur and phosphorous levels.

EAF methods, alternatively, derive from 90 -100% recycled steel scrap and passed high power electric arcs (temperatures up to 1650 °C) to melt the metal and convert it to high quality steel.

Secondary steel production

Secondary steelmaking involves treating the molten steel produced from both BOS and EAF routes to adjust the steel composition. This is done by adding or removing certain elements and/or manipulating the temperature and production environment.

Continuous Casting

The molten steel is cast into a cooled mould causing a thin steel shell to solidify. The shell strand is withdrawn using guided rolls and fully cooled and solidified. The strand is cut into desired lengths depending on application; slabs for flat products (**plate and strip**), blooms for sections (**beams**), billets for long products (**wires**) or thin strips.

Primary Forming

The steel that is cast is then formed into various shapes, often by hot rolling, a process that eliminates cast defects and achieves the required shape and surface quality. Hot rolled products are divided into flat products, long products, seamless tubes, and specialty products.

Manufacturing, Fabrication and Finishing

Finally, secondary forming techniques give the steel its final shape and properties. These techniques include:

- shaping (e.g. cold rolling)
- machining (e.g. drilling)
- joining (e.g. welding)
- coating (e.g. galvanising)
- heat treatment (e.g. tempering)
- surface treatment (e.g. carburising)

❖ **Types of Steel**

✓ Carbon Steels
✓ Alloy Steels
✓ Stainless Steels

Stainless steels can be divided into three groups based on their crystalline structure:

- **Austenitic**
- **Ferritic**
- **Martensitic**
- **Duplex Steels**

❖ **Types of coating**

- Zinc coated steel (galvanised)
- Aluminium-zinc alloy coated steel
- Organic coated: PVC plastisol
- Organic coated: Polyvinylidene difluoride (PVDF aka PVF2)

❖ **Recycling & Reuse**

Recycling

- 42% of crude steel produced is recycled material
- Re-melting proportion of steel scrap is constrained by availability. Availability can sometimes be defined as cost effective recovery.

Iron and steel are the world's most recycled materials, and among the easiest materials to reprocess, as they can be separated magnetically from the waste stream. Recycling is via a steelworks: scrap is either re-melted in an electric arc furnace (90-100% scrap), or used as part of the charge in a Basic Oxygen Furnace (around 25% scrap). Any grade of steel can be recycled to top quality new metal, with no 'downgrading' from prime to lower quality materials as steel is recycled repeatedly.

Recovery and reuse in construction

Globally around 85% of construction steel is currently recovered from demolition (sourceWSA) (UK 96% source steelconstruction.info)

Re-use of structural steel

Steel reuse is any process where end-of-life steel is not re-melted but rather enters a new product use phase.
Steel buildings and products are intrinsically demountable. Easily re-usable components include:

- Piles (sheet and bearing piles)
- Structural members including hollow sections
- Light gauge products such as purlins and rails.

❖ **Design for reuse**

To facilitate greater reuse it is important that designers not only use steel but also do what they can to optimize future reuse. Steps that the designer can take to maximize the opportunity for reusing structural steel include:

- End plate beam to column and beam to beam connections
- Use bolted connections in preference to welded joints to allow the structure to be dismantled during deconstruction
- Use standard connection details including bolt sizes and the spacing of holes
- Identify the origin and properties of the component for example by bar-coding or e-tagging or stamping and keep an inventory of products
- Use long-span beams as they are more likely to allow flexibility of use and to be reusable by cutting the beam to a new length. (source: SteelConstruction.info)

❖ **TOOLS FOR ELIMINATION OF WASTE**

There are various tools which are effectively used for elimination of wastes in the organization. These tools include just-in-time, value stream mapping (VSM), kaizen, material requirement planning, kanban, 5s, etc.

(a) Just-In-Time (JIT)

It is a tool of lean manufacturing that stands on the pillars of successful planning and the execution of events necessary to produce a final product.It is stated that each event and process should be processed in the right form, in the right necessity to produce goods and with the right timing. The ultimate objective is to provide every process with one part at a time, exactly

when there is a need for that part,which is the principle of JIT. Reducing lot sizes,reducing buffer sizes and reducing order lead times are the important components of JIT. Size of the plant, age of plant and status inside the unions are three important factors of JIT. The implementation of JIT in a small scale industry in Taiwan had been carried out by Gunasekaran and Lyu (1997). They started their journey by training the workers,and then the 5S tool (Seiri (Sorting), Seito (Set in Order),Seize (Shine), Seiketsu (Standardize) and Shitsuke (Sustain)) was implemented to improve security in the workplace, the quality of products and the production of the company. Worker training was given in the preventive maintenance of their equipment and machines.The largest barrier to implementing JIT was the lack of bargaining power of the SME with the outside world.

(b) Kaizen

Kaizen is a Japanese term which is used for continuous improvement; the continuing involvement of everyone –whether managers or employees. Finding, targeting and removing waste in machinery, labor or production methods refers to kaizen in manufacturing companies. The JIT approach can be further molded in an approach that is called the continuous improvement or kaizen approach.Kai stands for change and Zen stands for the better, so kaizen means 'to change continuously for the better involving every single person in the company'. he various benefits experienced by them after implementing kaizen were the complete elimination of wastes such as lack of quality, rejects, reworking of products and a considerable amount of expenditure was saved.

(c) Value Stream Mapping (VSM)

VSM is a world-famous graphical tool which helps to enlighten and analyse the work-flow and to find the value added and non-value-added activities contributing to the final product. Lean concepts and techniques are used collectively in VSM.They have discussed VSM in which analyses of the current state of the value stream of a product are carried out. After this redesign, an improved future state of the value stream of the product is developed which is mainly focused on the reduction of wastes, the decrease in lead times, and improvement in the material-flow. Only one map is required to show the flow of both material and information, which are found to be important characteristics of VSM when comparison is made with other such types of technique. The current layout showed that there was a separate station for ram assembly and the cylinder greasing operation. The layout was modified and the idea of a single modular trolley was introduced for the elimination of this problem.

(d) Material Requirement Planning (MRP)

MRP is a powerful tool that converts the requirements for end products into a detailed schedule of raw materials Inaccuracies in material planning create many problems,including a decrease in productivity, the production of non-required inventories and frustration. MRP helps to estimate correctly the requirements for inventories and raw materials and to decrease the chances of making unattainable manufacturing plans.

(e) Kanban

Kanban is a simple parts-movement system in which material movement between workstations in a production line is based on cards. A supplier should only deliver parts to the production line as and when they are required, so that there is no storage of parts in the production area, which is the basic need of the kanban system. VSM along with the kanban system was used to implement lean manufacturing on an assembly line. A current state map was prepared and analysed in order to note down the cycle time of various activities involved in the production of the component. It had been clearly highlighted that a push system was usually adopted on manufacturing lines, which was a big problem for the assembly line process. A kanban system was generated to replace the push system with a pull system.Large amount of the work in process inventories, lower value added time were major weaknesses which had been visualized during analysis. The kanban system played a vital role in making a better product flow.

(f) 5S

5S is a methodology for sorting, organizing, cleaning, standardizing and sustaining a productive work environment. Increase in safety levels, cleaning of workspace, enhanced productivity and preventive maintenance are some of the results of a 5S program. 5S has been implemented by a small Taiwan company that produces a variety of automobile lamps. They have found large lead times ,low quality and low efficiency to be big problems in scale industries. 5S is the basic starting tool used to make companies neat and standardized. Bottlenecks can be found by the line balancing tool.

(g) Waste elimination

A target of lean manufacturing is the total elimination of waste. From a customer's point of view, anything that does not add any value to the final product is termed a waste.These wastes can be identified and reduced/eliminated by using lean tools and methods.We have successfully implemented the lean philosophy in a north Indian company. In its earlier stages, the lean manufacturing approach was considered appropriate only in medium size industries. Flow process charts were used to analyse product flows.

❖ GREEN MANUFACTURING

The first stage in environmental production system (like other management systems) is top management engagement. An Environmental Management System (EMS) is a good frame work for the whole organization which should be established from the top level management. ―The EMS defines the corporate environmental policies and procedures that assure good environmental performance.EMS, itself does not reduce the environmental impact of the production but it makes the whole system proper for being more resource saver and makes the suitable environment for performing the practical solutions for being green.One of the well known standards for EMS is ISO 14001 which is widely used in the industries and also service companies nowadays. Three disciplines which are helping reduce the resource and energy usage in a manufacturing process are as follows:

- **Design for Environment**: it has an engineering perspective in to a production process and the scope is the whole life cycle. ―The premise of Design for the Environment is to design a product with minimum impact on the environment.It is during the design phase that almost all potential environmental effects of the product are determined.

- **Total Cost Accounting.**

- **Industrial Ecology**

Overall looking to the literature and researches beside the best practices in green lean, we can conclude that there exist strong similarities between lean system and green system and in fact they seem to go a parallel path through the manufacturing system.These two systems mainly act complimentary to each other. Some aspects of lean like; inventory minimization, work system and human resource practices can end up with the environmental resource inventory reduction, environmental improvement due to the personnel continues improvement and can make the whole organization and people more amendable for the further environmental training.A statistical survey shows that ―plants with Lean systems yield higher Green Results.It seems that having lean system will act as catalyst to implement environmental best practices.However lean and green seem so complimentary to each other but sometimes some conflict may occur. For instance the quality technology which might be used in lean system may not satisfy properly the environmental expectation. Or some other aspects such as JIT and one peace flow, while they can reduce the in-process inventory, they may cause over transportation, more packaging and handling which are not so convenient from environmental point of view.It appears that lean and green combined system is not intuitively considered as win-win situation for plants however these firms can use innovative technology or solution to overcome these conflicts like using reasonable batch size or reusable packages.

Figure: Green manufacturing

❖ Tools and Techniques to Go Green from Lean

A range of tools and techniques mentioned below can make the path smoother towards Lean and further to Greening the company.

- Draw a Value Stream Map of the material conversion processes or water usage.
- Undertake a Mass Balance of all energy and materials into and out of a process.
- Conduct a material waste assessment of your organization.
- Develop a Waste Reduction Action Plan (WRAP).
- Assess requirements and prepare for Waste wise accreditation.

❖ ROLE OF GREEN MANUFACTURING IN STEEL INDUSTRIES

- Green Manufacturing is all about using process improvement to maximize the yield and to help minimize the waste that is produced.
- GHG reduction in Iron & Steel Industries and Providing a cleaner source of energy though new technology.
- Decreasing energy consumption in process by using Energy saving technologies & Productive efficiency.
- Environmental regulation and production structure for the iron and steel industry.
- Increase iron resource efficiency in the steel manufacturing process.
- Emission Mitigation of CO2 by CO2 captures technologies.
- Converting pollutants and wastes into byproducts and promote their utilization and recycling along with the use of the product.
- Finally making the process much better for the environment and better use of the materials that are being used.

III. RESEARCH METHODOLOGY

The study assume a descriptive and observational study approach.To explain research approach, research methodology and data collection methods
Research involves various methods used in this process which are as follows :

- **INDUCTIVE METHOD;** Inductive method starts with gathering data and then coming up with conclusions.
- **QUANTITATIVE METHOD:** Quantitative method involves analyzing numeric data and commonly gathered by questionnaires and includes graphs and statistics.
- **QUALITATIVE METHOD:** Qualitative method uses non-numerical data and commonly obtain by interviews. It allows to research deeply the question, especially when where is a very specific question and company

The research contains both ways of data collection: Primary and Secondary. We have to do our project in two direction which are as follows:

PRIMARY DATA

This study used the questionnaires and interview guides in collecting the primary data to obtain the information about the operations of the company.

SECONDARY DATA

The secondary data involves written sources such as published books and electronic sources such as as articles,journals and statistics.

❖ RESEARCH APPROACH

The initial step in this research is to systematically study and define the history of the lean and Green manufacturing concept and its different tools and techniques. This will be followed by a literature review of the Steel industry and a study of the findings regarding applications of lean concepts to Steel manufacturing, and the steel industry in particular.To study the effect of lean tools in the process sector the steel industry is used to illustrate the procedures of implementing lean tools.

❖ METHOD OF DATA COLLECTION

A total of 100 questionnaires each were prepared and randomly administered among management, employees and vendors.
One of the procedures used for data collection in this research work was through the use of questionnaires since it is an effective and systematic way of asking questions under scientific control.The interviews were performed to gain a deeper knowledge of the results received by the questionnaire respondents. The interviews were structured in order to ensure the objectivity of the research, and open-ended questions were used. Quantitative and qualitative aspects may also be combined in the same study.

IV. CASE STUDY

There are basically seven types of wastes which can be eliminated with help of Lean principles, then the major waste is found which is more prone in steel plant. After getting the information from the plant with help of questionnaires, the major type of waste found out to be rework.

Case Study:
The objectives of the industry are:
1. To train technical and non-technical personnel.
2. To Reduce Rejection in Production.
3. To Reduce Production cycle time.
4. To reduce Product delivery lead-time.
5. To conduct research in the respective fields.

Once the team has defined the main wastes, the next step has been to propose the future state value. So the team have tried to eliminate the main wastes defined in the before step and improve inefficient processes, moreover targets set by the company have been used to propose the future map. The targets about inventory and productivity are shown respectively.

INVENTORY TARGETS

Invetory.	**Current level (ton)**	**Targets (ton)**
Raw material stock	544 (26 days)	313 (15 days)
Finished product stock	158 (7,6 days)	62 (3 days)
Work in process	20 (1 day)	18 (0,9 day)
Total inventory	**722 (34,6 days)**	**393 (18,9 days)**

On these targets, the team has proposed the future. One can notice that all processes have remained on the new process because all of them are important to the customers and cannot be eliminated. So to achieve the goals set by the company the processes

has needed to improve. This has been the next challenge to be overcome by team.

PRODUCTIVITY TARGETS

Processes	Current productivity (kg/h)	Targets (kg/h)
Production	28	32
Binding	1318	1318
Expedition	162	162
Total Productivity	28	32

Once set the future state, the next step was propose action plans to reach this state. There unto the factory team have tried to propose simple plans linked to lean fundamentals. This unit cannot invest much money therefore the most part of plans was linked to management.

All action plans have been implemented but the factory team have found some difficulties to implement plans linked to discipline. Even after trained, the staff continued breaking standards. Order to curb this bad behavior, leadership acted rigid way. The results of implementation are shown in the next topic.

❖ IMPLEMENTATION OF GREEN MANUFACTURING

Analysis of Green Manufacturing implementation

we can learn that, the implementation of Green Manufacturing has been paid great attention to by experts and scholars, where some measures have been taken into effect. Though literature on Green Manufacturing are theoretically focused on key issues including the implementation mechanism as well as the information support system, and empirically delivered quantitative researchers on some data in surveys, when it comes to status qua all over the world, there are still plenty of difficulties in Green Manufacturing.

Awareness of Green Manufacturing

It is of great importance for the society to be aware of the significance of Green Manufacturing in order to realize it. There is no denying that Green Manufacturing can be easily accepted and supported by the populace, the government, and non-profit organizations. Nevertheless, the subject of Green Manufacturing, enterprises, play the key role in the process of consciousness which is long and lasting.

In developing countries, take China as an epitome, the majority of the enterprises took no consideration of Green Manufacturing with little concerns about resources consumption and environmental discharge. Plenty of the corporations regarded Green Manufacturing as a burden of environmental protection that would not bring any effectiveness, or even bring some troubles. In reality, even some of those corporations authenticated by ISO 14001 Environmental Management System, whose ultimate goal is to simply reach the requirements of the environment department, have not be aware of the value of Green Manufacturing.

However, some enterprises suffer direct economic loss for the shortage of resources, the worsen environmental pollution, and the continuously increasing green trade barrier. For instance, the two instructions of EU, ROHS (Restriction of the use of certain Hazardous Substances) and WEEE (Waste Electrical and Electronic Equipment), challenge the export of mechanical and electrical products from China. In this case, the industries affected by green trade barriers start to find out solutions to gradually carry out Green Manufacturing while those unaffected corporations are still indifferent in Green Manufacturing. On the contrast, a group of leading companies in the world have regarded Green Manufacturing as one of the prior developing strategies, where many transnational enterprises have set specific strategic goals for Green Manufacturing, striving to be the green leaders and establish green criteria for the whole industry. Obviously, the awareness of Green Manufacturing is the key issue in its implementation. Green Manufacturing set up good images for a corporation, forming a green brand and promoting its competitiveness in the market, which will eventually create more profit.

❖ 4R principles of Green Manufacturing

Figure : 4R of Green manufacturing

The core ideas of Green Manufacturing refer to the realization of "4R" Theory, that is, Reduce, Reuse, Recycle, and Re manufacturing.

1. Reduce requires to decrease the consumption of resources including energies as well as the emission of wastes, which may help to cut down the environmental burden, resulting in doing less harm to people's health.
2. Reuse requires reusing the products or components, aiming at prolonging the life of the products to reduce the waste.
3. Recycle requires the products to be able to transform into reusable resources instead of

rubbish that cannot be used any longer. There are two ways of recycle, one of which is recycle at the same level which refers that the waste can be recycled to produce the same kind of new products, the other is secondary recycle where the wastes are transferred into raw materials of other products.

4. Remanufacturing is an approach to recover the dragged products back to the ones close to new products after a series of processes including dismantle, cleaning, examination, renewal, repair, and equipment.

Reproduce is an approach to recover the scraped products back to the ones close to mew products after a series of processes including dismantle, cleaning, examination, renewal, repair, and equipment.

But when it comes to the practice of realizing the "4R" Theories, relative techniques are required.

V. RESULT AND DATA ANALYSIS

Green Manufacturing Total inventory result suggests that the Lean Manufacturing practices have been a great tool to reduce inventories in the factory. Table shows that the target set by the company has been virtually achieved by unit through the action plans proposed.

Now, it's important analyzing each result particularly:

Raw material stock: The action plans implemented suggest that new raw material stock policy bring good results and the goal has been achieve only upper the control of stock.

Finished products stock: During the action plans implementation, the factory team has realized there was a problem to achieve the targets. Even though factory would achieve its deadlines and would deliver the goods on time, the costumer couldn't receive it. Analyzing better this issue, it can suggest a reliability problem, because the unit used to expedite the goods late, so the costumers still used to anticipate the orders to prevent delays. Then, when the factory has started to respect the deadline, the costumers haven't been able to receive the products.

Work in process: This target is too linked to the productivity and as the productivity has been improved more than the company suggested, so this goal has been achieved easily.

INVENTORY RESULT

Invetory.	Previous level (min/ton)	Targets (min/ton)	Current level(min/ton)
Raw material stock	544 (26 days)	313 (15 days)	306 (14,7 days)
Finished product stock	158 (7,6 days)	62 (3 days)	73 (3,5 days)
Work in process	20 (1 day)	18 (0,9 day)	17 (0,85 day)
Total inventory	**722 (34,6 days)**	**393 (18,9 days)**	**396 (19,05 days)**

Total productivity result suggests that the plans bring profit results to the unit, every targets set by the company have been achieved. The results about productivity are shown in the Table 7.

These successful results have made the team thinking more about the numbers and explore why this action plans have had this magnificent result.

Initially, the factory team has thought that the action plans have spent more resources than the factory demanded to achieve the targets. But thinking well about it, the staff have realized that how the most part of action plans has been linked to managements, discipline and learning, they have had an indirect impact on improving all processes.

Because of this, not only the productivity of production has increased, but also of all processes around the production. So the team have realized that Lean fundamentals have started to bring good results to the unit

PRODUCTIVITY RESULT

Processes	Previous productivity (kg/h)	Targets (kg/h)	Current productivity (kg/h)
Production	28	32	34
Binding	1318	1318	1781
Expedition	162	162	190
Total Productivity	28	32	34

Lastly the productivity and inventory levels achieved by the unit have been satisfactory to improve the unit competitiveness on its marketplace because reduced significantly the costs in the industrial processes.

ENVIRONMENTAL IMPACT OF STEEL PRODUCTION

Steel production has a number of impacts on the environment, including air emissions (CO, SOx, NOx, PM2), wastewater contaminants, hazardous wastes, and solid wastes. The major environmental impacts from integrated steel mills are from coking and iron-making.

Climate change

Virtually all of the greenhouse gas emissions associated with steel production are from the carbon dioxide emissions related to energy consumption.

Emissions to air

Coke production is one of the major pollution sources from steel production. Air emissions such as coke oven gas, naphthalene, ammonium compounds, crude light oil, sulfur and coke dust are released from coke ovens.

Emissions to water

Water emissions come from the water used to cool coke after it has finished baking. Quenching water becomes contaminated with coke breezes and other compounds. While the volume of contaminated water can be great, quenching water is fairly easy to reuse. Most pollutants can be removed by filtration.

Waste

Slag, the limestone and iron ore impurities collected at the top of the molten iron, make up the largest portion of iron-making by-products. Sulfur dioxide and hydrogen sulfide are volatized and captured in air emissions control equipment and the residual slag is sold to the construction industry. While this is not a pollution prevention technique, the solid waste does not reach landfills.

Gaseous emissions and metal dust are the most prominent sources of waste from electric arc furnaces.

VI. CONCLUSION

From the results presented by the application, one can conclude that:

1. Lean manufacturing might be an excellent philosophy to identify and eliminate wastes on the factory.
2. Discipline and training, in this case, was the most important elements to achieve the goals, these elements came from the Lean practices.
3. Through the thinking lean the unit changed some processes and spent little financial resources to achieve the targets.
4. In this case, Lean practices have shown the way to achieve more productivity using fewer resources and reducing inventory.
5. Stream Value Map has been a great tool to identify what process is really important to the costumers.
6. Lean fundamentals showed significant cost reduction, increased productivity and a consequent increase in the company's competitiveness.

This article allows concluding that the practices of Lean proved quite effective to increase the productivity and reduce the inventory levels so was proposed by the company.

Tasks of this thesis are also fulfilled well.

- Research and refine current knowledge hierarchy of Green Manufacturing
- Find out regularity, principle, characteristic and feasibility of Green Manufacturing.
- Develop a new framework.
- Present the examples of implementation of new framework .
- Sum up the knowledge of Green Manufacturing

On the basis of analyzing the present situation of Steel industry points were put out that steel industry in the world is now in a dilemma, and increased wastage & pollution is default. Then analysis of the relationship between green manufacturing and wastage & pollution in iron industries is done. The concept and implication of Green manufacturing are discussed from the viewpoint of sustainable development in the steel industry It is pointed out that adequate environment protection in a “green” steel plant does not just mean a accept disposal of pollutants emitted from its operation units, but rather the effective implementation of a strategy whereby the formation of any polluting agents in any part of this plant is include proper choice and control of raw materials, and a constant endeavor effort to optimize the complete manufacturing process of the whole iron & steel plant. Through the findings of this work, recycling of steel scrap is suggested as an alternative to boost the local content of steel production, reduce energy consumption, carbon dioxide emission (as the world production and manufacturing system is going green). The implementation of green manufacturing focused on investigating the energy saving & co2 emission from producing steel & effective utilization of recycling of steel scrap as a way of sustainable development in steel industry .

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