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Analysing quality and productivity improvement in steel rolling industry in central India

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ABSTRACT: *The constant improvement in quality is imperative because of competitiveness and quality of life in twenty first century. The quality can be achieved in various ways. Quality improvement in characteristics of quality or quality goals is important for customers and organization itself(17). Number of approaches in quality improvement, viz, lean, six sigma, PDCA, 5S etc, can be employed to achieve the desired level of quality taking into consideration the intricacies of the organization. Various problems which can be faced are the increased complexity of business environment, dependence on number of external factors and environment risk, the risk refers to internal and external business factors. It is a well known fact that the growth is dependent on number of parameters such as the investment climate, quality production, improved productivity, better human resource utilization etc [03]. A country's steel industry provides a more dynamic and expansive means of its economic future. Steel consumption per capita is directly related to the condition in which a population lives. Steel production and consumption is accepted as a barometer of any country's progress. Similarly metal rolling is one of the most important manufacturing processes in the modern world. The large majority of all metal products produced today are subject to metal rolling at one point in their manufacture. More than 90% of production of ferrous and nonferrous alloys goes through this route [07]. Rolled product is influenced by various factors like incoming material, mechanical and electrical equipment, lubrication, control strategies, maintenance of the equipment etc. This paper sets out to look at the state of rolling and re rolling industry in central India and the use of lean six sigma methodology to reduce the gap between the national and international quality standard and various techniques to improve the existing quality.*

Keywords: *Quality improvement, steel, rolling industry, lean six sigma.*

I. INTRODUCTION

The steel industry in India has undergone profound change during the past several decades. Substantial investment has been made to improve processing efficiency and product quality. Two key technological developments have driven this process. The first is rapid expansion of the use of continuous casting, a technology that has improved product quality, reduced energy consumption and greatly increased efficiency. The second is significant growth in electric furnace steelmaking, particularly at highly efficient small-scale mini-mills, that produce an expanding range of steel products using ferrous scrap as the principal raw material. Efficiency and effectiveness of equipment plays a dominant role in modern manufacturing industry to determine the performance of the organizational production function as well as the level of success achieved in the organization. The world steel industry is currently under considerable pressure. The increasing global nature of the steel industry ensures a fiercely competitive environment. The pressure to make incremental improvements in operating costs; product quality continually increases, as does the pressure for significant improvements in environmental performance, although this is no longer enough. The steelmaker now needs to demonstrate higher rates of return (01). Because of increased competency levels and demand of quality products at lower costs, companies needs a comprehensive system to achieve optimum output from the equipment/ machine. (07)

Due to economic globalization, the Indian steel industry is facing severe competition from foreign competitors. To succeed in this environment, the Indian steel industry must significantly improve productivity and quality, and reduce scrap and waste during production. In addition to economic considerations, the environmental concerns and energy consumption requirements also strongly drive the steel industry toward that direction. Therefore, there is an urgent need from steel industry for efficient process quality control.

The country is now the world's third largest steel consumer. Average Indian steel consumption in 2011 stood at around 55kg per person per year, compared to the global average of 206 kg and more than 500 kg in mature economies countries such as the USA and Japan. For India to truly become a global leader in steel production, it must access its domestic market (15). India has seen crude steel production increase by 47 Mt or 174% since the start of twenty first century an average annual increase in output of 14.5%. It now ranks as the fourth largest producer in the world (15). With current scenario in Indian Industry the competitive pressure on the industry has increased substantially. One disturbing fact is that India occupies a lowly 60th place among 139 countries in terms of local supplier quality rating of products and services [24].

India has emerged as the fourth largest steel producing nation in the world, as per the recent figures release by World Steel Association in April 2011. In 2010, India was the 5th largest producer, after China, Japan, USA and Russia had recorded a growth of 11.3% in steel production as compared to 2009. Overall domestic crude steel production grew at a compounded annual growth rate of 8.4% during 2005-06 to 2009-10. The Indian steel industry accounted for around 5% of the world's total production in 2010.

Total crude steel production in India for 2010-11 was around 69 million tonnes and it's expected that the crude steel production in capacity in the country will increase to nearly 110 million tonne by 2012-13. Further, if the proposed expansion plans are implemented as per schedule, India may become the second largest crude steel producer in the world by 2015-16. The demand for steel in the country is currently growing at the rate of over 8% and it is expected that the demand would grow over by 10% in the next five years. However, the steel intensity in the country remains well below the world levels. Our per capita consumption of steel is around 110 pounds as compared to 330 Pounds for the global average. This indicates that there is a lot of potential for increasing the steel consumption in India.

Immense growth potential in Indian Steel Sector:

Domestic crude steel production grew at a compounded annual growth rate of 8.4% in the last few years.

Crude steel production capacity of the country is projected to be around 110 million tonne by 2012-13.

222 Memorandum of Understandings (MOU) have been signed with various states for planned capacity of around 276 million tonnes by 2019-20.

Investments at stake are to the tune of $187 billion in the Steel sector.

Increase in the demand of steel in India is expected to be 14% against the global average of 5-6% due to its strong domestic economy, massive infrastructure needs and expansion of industrial production.

Demand of steel in the major industries like infrastructure, construction, housing, automotive, steel tubes and pipes, consumer durables, packaging and ground transportation.

Target for $ 1 trillion of investments in infrastructure during the 12th Five Year Plan.

Infrastructure projects (like Golden Quadrilateral and Dedicated Freight Corridor) will give boost to the demand in the steel sector in near future.

Projected New Greenfield & up-gradation of existing Airport shall keep the momentum up.

Increased demand of specialized steel in hi-tech engineering industries such as power generation, automotive petrochemicals, fertilizers etc. (Ministry of Steel, GOI, India steel 2013)

Crude steel production has shown a sustained rise since 2007-08 along with capacity .Data on crude steel production, capacity and capacity utilization during the last five years and April-December 2012-13, are given in the table below:

Year	Crude Stee		
	Capacity (mt)	Production (mt)	Capacity Utilization (%)
2007-08	59.85	53.86	90
2008-09	66.34	58.44	88
2009-10	75.00	65.84	88
2010-11	80.36	70.67	88
2011-12	89.29	73.79	83
Apr Dec.2012-13 (prov.)	91.66	58.33	85

(Source: Annual Report 2012-13, Ministry of Steel, GOI)

Trends in production, Private /Public Sector: The following table highlights the total as also the contribution of the private and public sector in crude steel production in the country during the last five years and April-December 2012-13:

Indian Crude Steel production (mt)					
	2007-08	2008-09	2010-11	2011-12	2012-13(A-D)
Public Sector	17.09	16.37	16.99	16.48	12.51
Private Sector	36.77	42.07	53.68	57.31	45.82
Total Production	53.86	58.44	70.67	73.79	58.33

Share of Public sector	32	28	24	22	21

(Source: Annual Report 2012-13, Ministry of Steel, GOI)

Currently, there are two main routes for the production of steel i.e. production of primary steel using iron ores and scrap and production of secondary steel using scrap as the main raw material. A wide variety of steel products are produced by the industry, ranging from slabs and ingots to thin sheets, which are used in turn by a large number of manufacturing industries. Steel production requires several steps that can be accomplished with different processes. Both the input material of each step and the process substantially affect the total quality during production. Some characteristics of the steel industry can be summarized as:
Equipment is large and inflexible in term of product mix.
Products are bulky which limits the choice of transportation mode.
Shut downs are normally long.
Equipment set-up and changeover costs can be substantial.
Some processes must be performed in batches.(10)

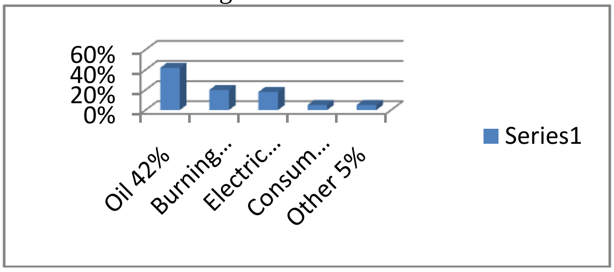
The advent of rolling mill technology and its development during the first half of the nineteenth century had heralded manufacturing of products like pipes and tubes. Rolling is a major and a most widely used mechanical working technique where the quality of the product is influenced by various factors like incoming material, mechanical and electrical equipment, lubrication, control strategies etc.

Steel re-rolling is one of the most important segments of the steel industry, as it constitutes an unavoidable link in the total supply chain of iron and steel. The secondary steel production constitutes approximately 57% of the total steel production in India. It mainly takes place in steel re-rolling mills (SRRM) that usually are family-run small and medium enterprises (SMEs) with 75% of units in the small scale. The SRRM sector is comprised of about 1,200 (working) re-rolling mills. The SRRM sector grew with 6% annually during 1997-2002. The share of secondary is expected to grow in the near future, also because the sector has some competitive edge due to flexibility in production for meeting low-tonnage requirements in various grades, shapes and sizes to serve niche markets [26].

The product and services must be made to rise above customer expectations, delighting them rather than merely satisfying them [09]. With reference to rolling process inconsistencies can be divided into two groups. The first one consists of those of the material origin and the second one regards inconsistencies of rolling origin. Inconsistencies that occur can be divided into several groups depending on a kind of a defect. Such as ,Incorrect shape of a product, Inaccurate measurements, External upsets like cracks, capillarity of cracks, small tears and holes. The unsuitable quality of the surface. The main inconsistencies that are listed in this group are: inclusions of refractory materials, teeming laps, dents of the scale and roughness. Defects that result from unsuitable heating caused by incorrect operating a furnace not only by heating up to too high temperature but also by excessive keeping the charge in high temperatures.

Since the rolling operation is often the last process step, the scrap at rolling stage is very costly and hence the quality control of rolling process is very important. Severe competition in Indian steel industry urges quality improvements in rolling processes. Among all the quality concerns, the surface integrity is an extremely important quality characteristic of the rolled products. Products with severe surface defects have to be scrapped. Therefore, it is highly desired to detect, reduce, and eventually eliminate the surface defects if possible. Unfortunately, the surface defects remain as the most troubling problems in the hot rolling process. Major challenges in the surface quality control fall into two aspects (19). Effective surface sensing system to measure the surface condition in real-time during production environments (high temperature, high speed, noise, and dirty conditions) is not available. Surface defects have been a long-standing troubling issue in hot rolling processes due to the ineffectiveness of existing detection methods (18). The root causes of surface defects in hot rolling processes are very complicated. Surface defects could be originated from multiple sources. For example, the nonmetallic impurities in the billet during solidification as well as the mechanical failures in the rolling mills are all important potential sources of surface defects. (19).

One of the current rolling industry challenges include manufacturing operations - existence of mixed (old and new) technology, old plant layouts, inefficient operations are few of the operational issues. Optimal utilisation of key assets, decision on the best product mix, improving product quality and yields contribute heavily on production cost. To tackle these challenges, in production consistency an implicit approach is necessary for better planning and improving the production process [04]. The rolled product quality depends on the quality of the charge, the construction of a rolling machine, setting of the rolls, a kind and state of armament, temperature and a way of heating as well as the level of training a worker and his experience (14). From the following Chart we can have an idea about the various factors of cost affecting the business. Cost wise break up of running expenses of conversion into finished goods is shown below.



Because of large scale production even a minute saving per ton adds up to a enormous sum that can be one of the causes for motivation as well as feasibility of taking up research project in this area similarly value addition to raw materials in India through applications of technology has remained low compared to other nations such as Israel, Finland, Japan, and South Korea [21].

Other significant quality parameters which need to be addressed are; Raw Material Inspection and Approval Process, Finished Product quality Approval Process, Geometrical Parameter Test, Physical Parameter Test, Chemical Test:

For optimized cost-efficiency and to maximize material usage, tight tolerances for the thickness are critical. Product quality can only be efficiently enhanced if the mechanical, electrical and instrumentation equipment as well as the control plan solution fit together. Further within the rolling industry today, manufacturers are more aware that maintenance processes and practices have an overall impact on cost of steel rolling production. Only through a planned approach, maintenance optimization can be achieved. The foundation of such an approach is the systems required to measure and monitor the equipment's performance. As enhancements are implemented, reliability and component lifetimes are expected to improve. With the systems in place, it is then possible to effectively evaluate potential enhancements with a high degree of probability for what the enhancement will yield in terms of cost benefits.

It is obvious that the adoption of quality tools in manufacturing or quasi manufacturing units would thus entail reinforcement of operations management principals with gusto. Rolling industry shows adequate potential to exploit the use of quality tools such as lean six sigma. Aim to the possible best quality of final product is a factor, which to a great degree decides both about achievement of the customers' confidence and about the company's position on market. To succeed new products or improve on existing ones is not easy. (19)
Lean and Six Sigma as a quality improvement framework have been gaining considerable attention in recent years and are recognized among the most significant threads of development in the technology and quality measurement domain (Walker 2005). Most archival research related to the Lean and Six Sigma implementation is qualitative in nature. For example, Pavnaskar et al. (2003) developed a classification scheme for lean manufacturing tools which can better help companies implement the Lean and Six Sigma concepts. Banuelas and Antony (2003) examine the differences and similarities of Six Sigma improvement methodology compared with the Design for Six Sigma (DFSS) approach, and managerial aspects are their primary focus.(07)

Six-Sigma has been sweeping the business world and increasing manufacturing and service quality that uses statistical tools and techniques to reduce costs and cycle times, eliminate defects, improve customer satisfaction and boost profitability. In statistical terms, Six-Sigma means 3.4 defects per million opportunities (DPMO) (Furterer and Elshennawy 2005, Tsou and Chen 2005, Lee and Choi 2006, Desai 2008). Lean production works produce high quality system that meets customer demand with minimal waste, and its strategy employs a set of proven tools and techniques to reduce lead time,inventories, set-up times, equipment downtime, aswell- as scrap, reworking and other waste in the hidden factory (Dedhia 2005, Green 2006, Cigolini et al. 2008).

Traditionally under the six sigma approach a five-phased DMAIC methodology is applied which tackle specific problems to reach six sigma levels of performance (Breyfogle, 1999). These phases are: (D)efine. Who are the customers and what are their priorities? Where are their problems? Which do we tackle first?. (M)easure. How is the process measured and how is it performing? What is its current state of performance? (A)nalyse. What are the most important causes of performance failure? (I)mprove. How do we remove the causes of poor performance? (C)ontrol. How can we embed and maintain the improvements made? Six Sigma focuses on eliminating the variation within the process. To eliminate the variation, Six Sigma uses advanced statistical analysis tools to investigate and isolate the sources of variation. Six Sigma assumes that once the variation is minimized the process is improved [08].

The "lean" concept has often successfully allowed companies to deliver bottom-line savings in production through improves process efficiency. Lean is aimed at reducing waste and adding value to production systems so that systems performance is significantly improved and a company "does more with less". A typical example is applying TPM techniques to poorly maintained machinery. This provides for value-added inputs by way of ensuring machinery remains in productive operation for longer periods of time (Jostes and Helms, 1994). Maintenance procedures and systems are designed so that they are easier to accomplish and this is achieved through machine redesign and modifications in order to facilitate this process.

The basic lean philosophy relies on a five phase approach. This is:

(1) Identify value (from the point of the customer).
(2) Measure the value stream.
(3) Pull on customer demand.
(4) Create flow.
(5) Achieve perfection.

Employing therefore a standard operational framework for implementing both lean and six sigma approaches is seen as an obvious and necessary step for companies to achieve simultaneous benefits from the both strategies (George, 2002). To this end the DMAIC process is used as the main functional system for the implementation of lean six sigma (LSS) approach. Figure 1 shows the conceptual development of the LSS framework. The main phases of the integrated LSS approach are: Ater DMAIC methodology,

Implement 5S technique.
Application of value stream mapping (VSM).
Redesign to remove waste and improve value stream.
Redesign manufacturing system to achieve single unit flow (SUF).
Apply total productive maintenance (TPM) to support manufacturing(06)

"In a system that combines the two philosophies, Lean creates the standard and Six Sigma investigates and resolves any variation from the standard" (Breyfogle, 2001). A leading Lean Six Sigma advocate, Michael George from the George Group, states that the purpose of Lean Six Sigma is twofold. First, "to transform the CEO's overall business strategy from vision to reality by the execution of appropriate projects," and second, "to create new operational capabilities that will expand the CEO's range of strategy choices going forward" (George, 2002). Alternatively, Lean Six Sigma has been defined as "a defined approach that synthesizes the use of established tools and methods" (Shere, 2003). The tools and methods of the Lean Six Sigma practitioner encompass the tool sets of both Lean production and Six Sigma. Dr. Jiju Antony (2003), a researcher of Lean and Six Sigma at the Caledonian Business School of Glasgow Caledonian University, concludes that "…the disciplined and systematic methodology of Six Sigma combined with the speed and agility of Lean (methodology) will produce greater solutions in the search for business and operations excellence."[01]

II. METHODOLOGY

The steel industry is one where managers seem to strongly believe in the traditional way of doing business, which could bring resistance against any new quality improvement tool like lean six sigma for example. However, it should be clear from the above that very significant benefits are possible if lean tools are implemented. This proposed study aims to assess and formulate a model comprising of several quality parameters on quality and productivity basis for improving the rolling production process and taking it at par with national/international guidelines. Quality enhancement leads to an environment of positive competition in the industry. It generally leads to technical up gradation and improved quality of products.

Technology issue is also one of the most important subjects because the sector has remained relatively insular from the technological developments over the years. Hence there is deficiency in modern and efficient rolling processing tools/equipment. Roll Erosion, Roll Corrosion, Wear, thermal fatigue significantly affects the entire process. The skilled human resource personnel, inefficient utilization of equipment, deficiency in modern technologies for the rolling mills drastically affects the equipment performance and thereby overall production efficiencies.(16)

The proposed study involves wide-ranging research in rolling process. It calls for systematic examination and appraisal of rolling process quality performance. Data collection through a range of methods can be planned. Quality performance of Rolling Process and the quality problems faced by them will form the focus of data collection. The data collected can be analyzed using various Statistical tools. The analysis will help in identification of Critical Success Factors for rolling process. The study visualizes integration of Critical Success Factors (CSFs) to develop quality improvement frame work for rolling process. The developed frame work can be tested in rolling mill to validate the frame work.

III. RESULTS

In this paper we have analyzed the potential for the improvement of rolling process parameters that can be realized in the long term. The developments described above point to the peculiarities of rolling processes and their consequences. The proposed study can critically explore the relevance by assessing the objectives against problem to be solved and to analyze current scenario of rolling industry in Central India and explore all possible areas of rolling Process. The assessment of the relationship between input and output can improve the efficiency and can facilitate the identification of input and output parameters for best possible rolling system. Reviewing the effectiveness as reflected in the relationship between the result (outcomes) and the purpose of the proposed work.i.e.to discover how rolling industries in Central India can benefit by implementing the popular continuous improvement methodology Lean Six Sigma. The benefits preserved from the emerged work can contribute to enhance quality of various parameters and in sustaining quality management programs.

IV. DISCUSSION AND CONCLUSIONS

The concept presented here will provide a guideline to approach for improving quality and productivity improvement in rolling products by using lean six sigma methodology. A substantial scope exists for developing models in rolling process and their validation in industrial practice. To conclude Lean six sigma can be applied at different phases and can help an organization to satiate its quest for quality.

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