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Energy Consumption Optimization for Secondary Steel by Six Sigma (DMAIC)

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Abstract- The Environment is becoming more and more a key issue for the Steel Industry. Refining of secondary steel making has become an important part in modern steel works. As one of the fundamental pillar industries in global scenario, the iron and steel industry has developed rapidly. Meanwhile, it is an energy-intensive industry, whose energy cost accounts for 20% of the iron and steel-making process. Therefore, efficient use of energy is crucial for reducing total operation cost. As it is subjected to large amount of variability in raw material prices, manufacturers must continuously improve operations and lower costs. The global warming effect and natural resource saving are the general environmental topics nowadays. In such efforts, many firms implement lean practices. It is suggested that, the usage of Six Sigma (DMAIC) may ultimately aid in optimizing energy consumption. Not only the delight of creating products with a wide variety of additional values must be considered, but also the emission of CO_2, the discharge of harmful wastes during manufacturing, the limitation of waste disposal, and many other factors, must be evaluated comprehensively. The Present Paper summarizes the optimization of Energy consumption in secondary steel manufacturing by Six Sigma (DMAIC) Methodology.

Keywords- scrap recycling; steel bars; six sigma, DMAIC.

I. INTRODUCTION

All the objectives of this paper are to develop advanced energy management systems for an energy efficient and environmentally friendly society and to provide an assessment model for zero emission (of materials) and energy cascade systems. Steel is the world's most used and recycled metal. It is an essential and sizable sector for industrialized economies. Since it is capital and energy extensive, companies have been putting consistent emphasis on technology advances in the production process to increase productivity and to save energy. Prominent industries which consume steel are healthcare, telecommunications, improved agricultural practices, better transport networks, clean water and access to reliable and affordable energy. More than half of the mass input becomes outputs in the form of off-gases and solid wastes or by-products. The emissions from sinter plants dominate the overall emissions for most of the pollutants. The recycling of iron and steel scrap (ferrous scrap) is an important activity worldwide. Iron and steel products are used in many construction and industrial applications, such as in appliances, bridges, buildings, containers, highways, machinery, tools, and vehicles [1]. Because it is economically advantageous to recycle iron and steel by melting and recasting into semi finished forms for use in the manufacture of new steel products, a significant industry has developed to collect old scrap (used and obsolete iron and steel products), and new scrap. The use of scrap metal has become an integral part of the modern steelmaking industry, improving the industry's economic viability and reducing environmental impact. Furthermore, the iron and steel industry is capital as well as energy intensive. The importance of effective process control in this industry on cost and energy reduction and environment protection is by no means less than that in other industries.

II. PROCESS DETAILS

Fig. 1 shows Energy used by Electric Arc Furnaces per tonne of crude steel from 1965 - 1990. Compared to ore extraction, the use of secondary ferrous metals significantly reduces CO_2 emissions, energy and water consumption and air pollution. At the same time, the recycling of steel makes more efficient use of the earth's natural resources. Compared to ore extraction, the use of secondary ferrous metals significantly reduces CO_2 emissions, energy and water consumption and air pollution. For every ton of steel recycled, 2500 pounds of iron ore, 1000 pounds of coal and 40 pounds of limestone are preserved.

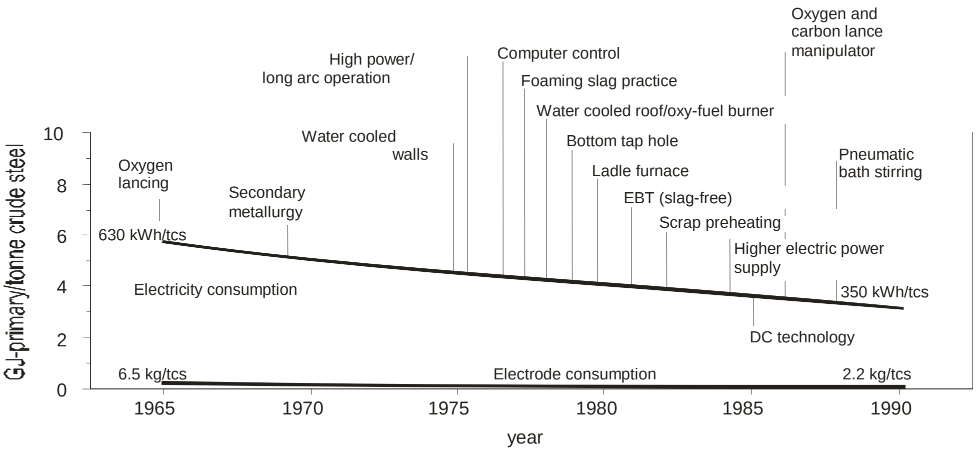

Fig. 1: Energy used by EAFs per tonne of crude steel

2.1 Emissions

The coke breeze may be produced from the onsite coke ovens in integrated iron and steel plants or may be purchased from offsite coke producers. Operation of sinter plants produces emissions of air pollutants like nitrogen oxides (NOx), Sulphur oxides (SOx) and non-methane volatile organic compounds (NMVOCs) from the combustion activities. Off gas from sinter production also contains NMVOCs. Based on recent data BOFs accounted for approximately 63 % of world steel production and EAFs approximately accounted for 37 %.

SO_2 emissions mostly originate from sulphur contained by the coke used as fuel. With calcium oxide (CaO) dominated mixtures SO_2 production is decreased by increasing basicity. From magnesium oxide (MgO) dominated mixtures about 97 % of the sulphur content is converted to SO_2.NOx are mainly emitted as NO due to rapid down cooling of the flue gases.

In an electric arc furnace plant, besides carbon monoxide and carbon dioxide, dust is the main emission. Sixty percent of the dust particles are smaller than ten microns.

The chemical composition of EAF slag depends significantly on the properties of the recycled steel. Compared to BOF slags, the main chemical constituents of EAF slags can vary widely. Typically, the FeO, CaO, SiO2, Al2O3, and MgO contents of EAF slags are in the 10–40%, 22–60%, 6–34%, 3–14%, and 3–13% ranges, respectively. Hence, the chemical composition of ladle slag is highly dependent on the grade of steel produced. As a result, compared to BOF and EAF slags, the chemical composition of ladle slag is highly variable.

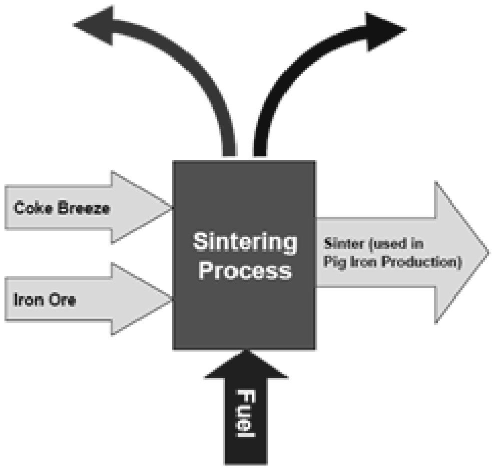

Fig. 2: Production Scheme of Sinter Production Process. Red Arrow Represents Combustion Emissions, Blue Arrow Represents Process Emissions

2.2. Steel Production in the World

Steel is the world's most intensively used metallic construction material, figure 3. It is, therefore, especially important that it is assigned a quantitative environmental impact value that can gradually be improved. During 2010, almost 1,500 million tonnes of steel were produced for a range of products, structures and buildings across the world. Stainless steels comprised about 32 million tonnes of this total while all other metals together accounted for less than 80 million tonnes. Several forecasts indicate that the world's steel consumption will increase by the order of 2,500 million tonnes up to the year 2050.

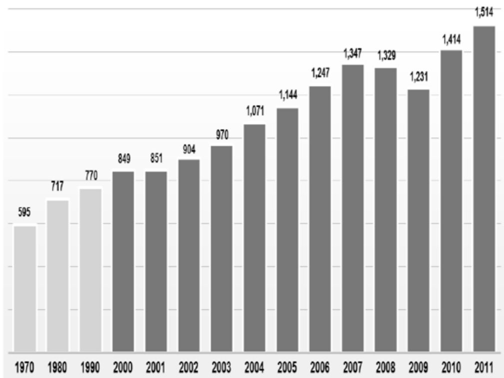

Fig. 3: Steel Production, World (Mt/yr)

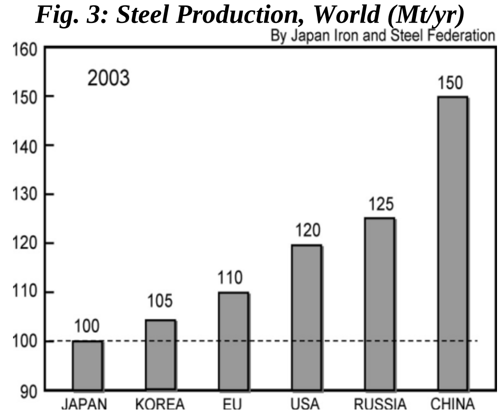

Fig. 4: Comparison of Energy Consumption Among Major Steelmaking Nations.

III. AIMS AND OBJECTIVES

a) The goal of the work is to precisely Optimize Energy consumption in secondary steel manufacturing.
b) High light the weaknesses. Investigation of various parameters in Steel manufacturing and their relative effect on the performance. Fine tuning and stream lining of affecting variables.
c) Thorough Analysis of Quality of the result by using Six Sigma (DMAIC) techniques. Suggest the alternatives available.

IV. METHODOLOGY

It uses a detailed analysis of the process to determine the causes of the problem and proposes a successful improvement. Various approaches are adopted while following Six Sigma methodologies and one of them is DMAIC

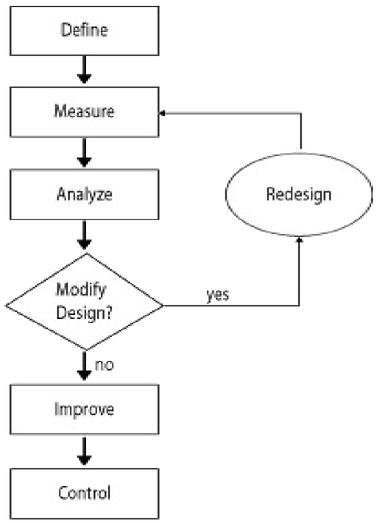

Fig. 5: Flow chart of DMAIC Process

DMAIC (an abbreviation for Define, Measure, Analyze, Improve and Control) refers to a data-driven improvement cycle used for improving, optimizing and stabilizing business processes and designs. The DMAIC improvement cycle is the core tool used to drive Six Sigma projects. It is an integral part of a Six Sigma initiative, but in general can be implemented as a standalone quality improvement procedure.

DMAIC is an acronym for the five phases that make up the process:

- Define the problem, improvement activity, opportunity for improvement, the project goals, and customer (internal and external) requirements.
- Measure process performance.
- Analyze the process to determine root causes of variation, poor performance (defects).
- Improve process performance by addressing and eliminating the root causes.
- Control the improved process and future process performance.

A Control chart can be useful during the Control stage to assess the stability of the improvements over time by serving as:

1. A guide to continue monitoring the process.
2. Provide a response plan for each of the measures being monitored in case the process becomes unstable.

CONCLUSION

In the last 50 years, the steel industry has reduced its energy consumption per tonne of steel produced by 60%. However, due to this dramatic improvement in energy efficiency, it is estimated that there is sufficient scope for further improvement. In an electric arc furnace, reduction of the emissions can be achieved by technological process changes as well as by abatement equipment. Varying the operating conditions or the design of the furnace may lead to a reduction in the amount of dust produced. Use of an 'after burner' reduces the amount of CO emitted. Use of equipment to capture the emitted particles, e.g. fabric filter or electrostatic precipitators (ESP), reduces the amount of dust emitted. The system of byproduct gases in the iron and steel industry is complex. To achieve a lower operation cost, it is important to take the entire system into account in order to avoid sub-optimal operations. By using DMAIC methodology, significant reductions in energy consumption have been observed. Apart from energy consumption, issues like green house gas emissions, wastage dumping can also be minimized by this methodology. In a nut shell this technique is used to holistically improve overall operating performance of Steel Recycling Plants to a next higher level in the coming future. The proposed method is useful and it provides management with important information. However, it was performed successfully in only one actual plant. As a result, further researches are needed to apply this model into other plants in to verify its validity and to find its limitations.

REFERENCES

[1] Mohan Yellishetty a, Gavin M. Mudd a, P.G. Ranjith a, A. Tharumarajah c, Environmental life-cycle comparisons of steel production and recycling: sustainability issues, problems and prospects. Environmental Science & Policy 14 (2011) 650 – 663.

[2] Kristian Nolde, Manfred Morari, Electrical load tracking scheduling of a steel plant. Computers and Chemical Engineering 34 (2010) 1899–1903.

[3] Guangyu Maa,b, Jiuju Caia, Lihong Zhangc, Wenqiang Suna*, Influence of Steam Recovery and Consumption on Energy, ICAEE-11, Energy Procedia, 14 (2012) 566 – 571.

[4] Russell Smyth a, Paresh Kumar Narayan b, Hongliang Shi c, Substitution between energy and classical factor inputs in the Chinese steel sector, Applied Energy 88 (2011) 361–367.

[5] Chia Jou Lin a,n, F.Frank Chen b, Hung-daWanb, YuhMin Chen a, Glenn Kuriger b, Continuous improvement of knowledge management systems using Six Sigma methodology. Robotics and Computer-Integrated Manufacturing 29 (2013) 95–103.

[6] Sharif H. Melouk n, Nickolas K. Freeman, David Miller, Michelle Dunning, Simulation optimization-based decision support tool for steel manufacturing, Int. J. Production Economics 141 (2013) 269–276.

[7] Min Wua, Ping Duan a, Weihua Cao a, Jinhua She a,b, Jie Xiang, An intelligent control system based on prediction of the burn-through point for the sintering process of an iron and steel plant, Expert Systems with Applications 39 (2012) 5971–5981.

[8] A. Mariajayaprakash a, T. Senthilvelan b, Failure detection and optimization of sugar mill boiler using FMEA and Taguchi method, Engineering Failure Analysis 30 (2013) 17–26.

[9] Kazuo Matsuda a,*, Shigeki Tanaka a, Masaru Endou b, Tsutomu Iiyoshi c, Energy saving study on a large steel Plant By total site based pinch technology, Applied Thermal Engineering 43 (2012) 14-19.

[10] Jianling Zhang_, Guoshun Wang, Energy saving technologies and productive efficiency in the Chinese iron and Steel Sector, Energy 33 (2008) 525–537.

[11] ChiaJou Lin a,n, F.FrankChen b, Hung-daWanb, YuhMinChen a, GlennKuriger b, Continuous improvement of knowledge management systems using Six Sigma methodology, Robotics and Computer-Integrated Manufacturing 29 (2013) 95–103.

[12] B. Karwat, Optimization of production schedules in the steel production system, archives of civil and mechanical engineering 12 (2012) 240 – 252.

[13] J. Ghaisari a, H. Jannesari b, M. Vatani a, Artificial neural network predictors for mechanical properties of cold rolling Products, Advances in Engineering Software 45 (2012) 91–99.

[14] Editorial, towards high performance manufacturing, Int. J. Production Economics 133 (2011) 487–488.109.

[15] Haining Kong *, Ershi Qi, Hui Li, Gang Li, Xing Zhang, An MILP model for optimization of byproduct gases in the integrated iron and steel plant, Applied Energy 87 (2010) 2156–2163.

A.D. Jayal, F. Badurdeen, O.W. Dillon Jr., I.S. Jawahir *, Sustainable manufacturing: Modeling and Optimization challenges at the product, process and system levels, CIRP Journal of Manufacturing Science and Technology 2 (2010) 144–152.