

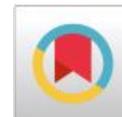


A REVIEW ON ENERGY EFFICIENCY OF STEEL PLANTS IN INDIA

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Abstract:

The steel industry being highly energy intensive in nature is one the major consumers of energy. The iron and steel industry is the largest energy consuming manufacturing sector in the world. It is therefore that the question of fuel or energy has been of the highest importance in steel making, and one can boldly claim that all other conditions remaining constant, saving or wasting of fuel can make the difference between a profit or a loss of a steel plant. Energy conservation in steel plants is very crucial to ensure the competitiveness of the steel producing industries and to minimise environmental impacts. India's leading iron and steel companies, scored averages at best in Centre for Science and environment green rating test. The Indian iron and steel sector's energy consumption of 6.6 GCal per tonne, is 50 per cent higher than the global best practice. The integrated steel plants in India have the opportunities to strengthen their operations and minimise energy losses and wastages to reduce specific energy consumption by 5-6%. To reduce the gaps between India and developed countries we have to follow the technological advancement and implementation of innovative strategies at every stage of the operation of steel plants. The specific energy consumption in the Indian steel industry is high compared to that in advanced countries. Data for four integrated steel plants in India have been analysed. World crude steel production reached 1.621 million tones (Mt) in 2015. To meet the needs of our growing population, steel use is projected to increase by 1.5 times that of present level by 2050.

Keywords: *Steel Plant; Energy Conservation.*

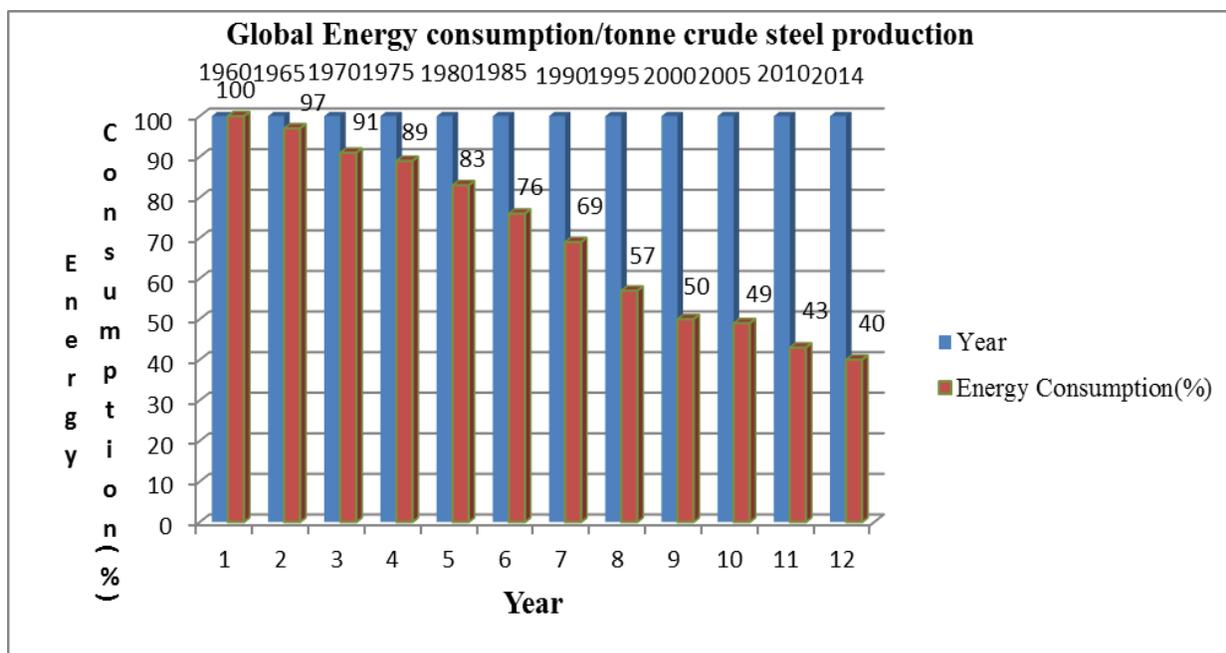
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1. Introduction

The Indian Iron and Steel industry is vital to the nation's development efforts and to support the required rapid economic growth. Steel finds its application in a wide range of sectors such as automobile, power, machine goods, and infrastructure. Energy efficiency and low carbon growth have emerged as key pathways to reduce the nation's energy intensity and emissions intensity. The industry has taken several initiatives to conserve energy at each sub process by adopting best technologies and innovative process operations or the usage of alternate materials. The efficient use of energy has always been one of the steel industry's key priorities. World steel study estimates

that steel companies have cut their energy consumption per tonne of steel produced by 60% since 1960 as shown below –

Global Energy consumption/tonne crude steel production	
Year	Energy Consumption (%)
1960	100
1965	97
1970	91
1975	89
1980	83
1985	76
1990	69
1995	57
2000	50
2005	49
2010	43
2014	40



2. Major Energy Inputs and Energy Analysis in a Steel Plant

Coke

Coking of coal for the production of coke used in hot metal production from iron ore in Blast Furnace. A certain portion of the coke can be replaced by pulverised coal, oil and tar/pitch etc. The coke oven gas from the coking process is used as fuel in coking plants and blast furnaces but also in the reheating and heat treatment furnaces of rolling mills.

Electricity

Electrical energy is one of the major components, which largely supports the Electric Furnace, machinery operations, drives, fans, lighting and other process supported systems. Among the three major process routes in steel making, 24% and 31% utilise electrical furnaces such as Arc furnace and Induction furnace routes respectively. The power required by the steel industry is estimated to increase to 16,000 MW in 2025-26 from around 8200MW in 2016-17 . Electrical furnaces melt the charged materials to produce specialised steel using electrical energy. A variety of steels are manufactured through electrical furnaces. Reducing the burning losses of iron and readily oxidising the alloying elements are other advantages of electrical furnaces. Use of electricity remains relatively stable. Electricity generally used for the operation of rolling mill motor systems, in electric arc furnaces for melting of scrap and in rolling mills.

Petroleum fuels

Purchased petroleum fuels like fuel oil, furnace oil, Low Sulphur Heavy Stock (LSHS) to meet any short fall in the availability of fuels in high temperature furnaces.

Gaseous fuels

By-product coke oven gas, blast furnace gas and also coal for fuels are used to meet the fuel shortage.

All these forms of energy are used in various forms of Kilns and Furnaces which comprise the bulk of a steel plant, e.g.,

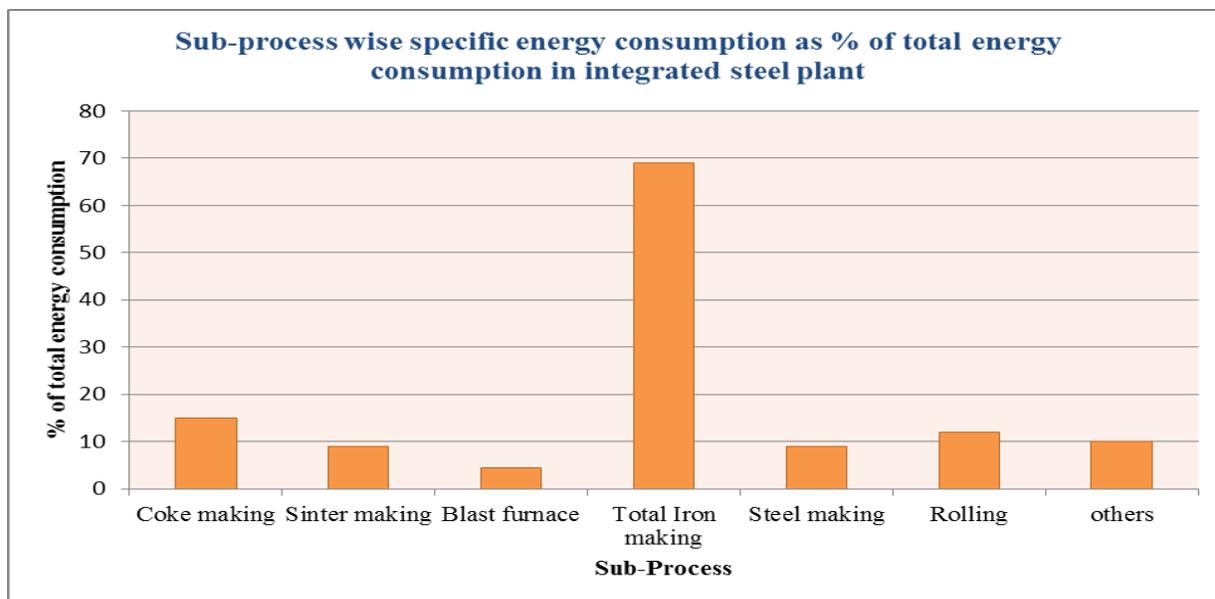
- 1) Ore sintering plant / Pelletizing Plant
- 2) Coke ovens
- 3) Blast furnaces
- 4) Open Hearth Furnaces
- 5) L.D.Converter
- 6) Continuous Casting Plant
- 7) Reheating Furnaces
- 8) Walking Beam Furnaces
- 9) Heat Treatment Furnaces
- 10) Forging Furnaces
- 11) Electric Arc furnaces
- 12) Steel Heating & Processing Furnaces

All these furnaces consume huge quantities of all types of fuels e.g., solid, liquid, gaseous and electric as mentioned above.

The quantity of energy required sub process-wise for production of one ton of steel throughout the world are given in the following diagram:

Sub-process	% of total energy consumption
Coke making	15
Sinter making	9
Blast furnace	45
Total iron making	69

Steel making	9
Rolling	12
Others	10



Estimated Requirement of Raw Materials and Other Inputs by 2016-17

Input Materials	Unit	Estimated Consumption 2011-12	Estimated Consumption 2016-17	Additional Requirement by 2016-17
Coking Coal	Million Tonnes	43.2	90.2	47.0
Non-coking Coal	Million Tonnes	35.3	28.4	---
Iron Ore	Million Tonnes	115.0	206.2	91.2
Natural Gas	MMSCMD	7.2	13.541	6.341
Ferro Alloys	IN '000 tonnes	2152	3673	1521
Refractories	Million Tonnes	1.29	1.97	0.69

In comparison to the developed countries, the Indian steel plants consume coke more by around 30-35%, iron ore or sinter by 7-10% and hot metal, scrap and ferro-alloys by 5-7%. Evidently, the blast furnace productivity in Indian plants is low compared to the developed countries and the quality of coking coal has major impact on it. However, several other factors pertaining to operations management have also substantial impact on the productivity and specific energy consumption in the blast furnace. For example, every 10 kilogram (kg) reduction of coke consumption leads to energy savings of around 0.05 G cal/tCS (Tons of Crude Steel) & 1 kg of coal dust injection and 1 kg of tar injection reduce coke rate by 0.92 kg per Ton of Hot Metal

(kg/tHM) and 1.4 kg/tHM respectively. Similarly, every 10 °C increase in hot blast temperature from a level of 950 °C reduces coke rate by 1 kg/tHM.

The average specific energy consumption in integrated steel plants in some of the developed countries and India is given in following Table:

Country	Energy consumption 10s K Cal / Ton or Grgacalf Ton of crude steel)
Italy	4.032
Japan	4.179
Sweden	5.019
West Germany	5.208
United States	6.062
U.K.	6.069
India	9.500 (Finished Steel = 11.5)

The specific energy consumption figure for production of one ton of steel has been calculated for the last half a century (1940 – 1990) and it has been observed that though very little progress has been made in this regard, in fact the figure has gone higher upon some steel plants in recent years, it is obvious that in the developed countries the specific energy consumption has decreased from a level of 9-12 G Cal / t to 5-7 G cal / t in the last 40-50 years. On the other hand the present specific energy consumption level in the Indian Steel Plants is rather high ranging between 9-15 G Cal / t and download there is hardly any perceptible download trend in the S.E.C. data.

Percentage of Energy consumption in Steel Plants in India and Japan –

India 12.5 x 10 ⁶ Kcal per ton of saleable steel		Japan 6.25 x 10 ⁶ Kcal per ton of saleable steel	
Blast Furnace	54%	Blast Furnace	53%
Sintering	08%	Sintering	12%
Coke Ovens	12%	Coke Ovens	07%
Cold Rolling	05%	Cold Rolling	05%
Hot Rolling	09%	Hot Rolling	10%
Steel making	09%	Steel making	01%
Slabbing & Blooming	03%	Slabbing & Blooming	03%

3. Barriers and Challenges

The Indian iron and steel industry has been working consistently and contributing to the infrastructure development and economic growth of the country in the face of several barriers and challenges. Some of these can be summarized as follows:

- Availability of raw materials such as ores and coal resources
- Supply chain and associated infrastructure (roadways and railways)
- Variation in the international prices
- Land acquisition and grant of environment clearance

- Techno-economics, and production efficiency benchmark in compliance with international standards
- Sustaining in a competitive environment due to global trade agreements
- Reckonable restrictions and high tariff barriers

To overcome these challenges, suitable economic policy framework needs to be formulated to facilitate continuous technology advancements and adoption of energy saving measures with specific national policy mechanisms such as PAT.

The Indian Steel industry will need to adopt suitable economic policy and investment framework to facilitate continuous upgradation to best available technology which will result in reduction in the energy consumption.

On a study of the energy consumption in steel plants it will be revealed that –

70% of the energy is consumed in iron making stage in the Blast Furnace. Therefore the energy conservation efforts in the iron making areas have to be accorded a very high priority.

The major consuming centres of the petroleum fuels in the steel plants are also to be given high priority as it contributes to about 14% of the total fuel bill of the steel plants while it contributes only about 3% of the total energy input.

The amount of Coke Oven Gas and Blast Furnace gas generated and consumed in Steel Plant also requires attention because these two gases produced in-situ plays an important role in steel making.

4. Energy Conservation Measures

Sintering Plants

Sintering process can contribute to energy conservation in our steel plants in a big way though in an indirect manner, it is known that the percentage of a sinter in the blast furnace reduces the coke rate. Therefore the following steps should be taken-

- To increase the bed thickness to a level of 400-450 mm in order to fully utilise the fuel consumed.
- To increase the capacity of the blowers.
- To recover sensible heat of the sinter which is discharged at a temperature of 700-8000C.

A process similar to coke drying quenching process for recovery of the sensible heat of the hot sinter has been developed in Japan.

Coke Ovens

The coke ovens in Indian Steel Plants suffer from the three following defects e.g.,
Low Coke Oven Gas yield – The yield of coke oven gas varies in India from 23-290 nrW per tonne of coal with 18-21% ash and 22-C6% volatile matter as against 320 NmJ per tonne of coal charge using coal having 8% ash and volatile matter of 27%.

High C.O. gas usage for under firing - Specific Heat Consumption in Indian Coke Ovens varies from 0.6 to 0.7 G Cal / ton of coal charged , it has been observed that not only specific heat consumption is high but also the uses of coke oven gas for under firing is high.

High Wastage Energy - Heat balance of Coke Ovens reveals that the various heat losses e.g., sensible heat of the coke and the gas and the stack losses are 1.3×10^6 G Cal per year.

For energy conservation in Coke Ovens in Steel Plants the following methods have been proposed: To reduce the use of coke oven gas for coke oven under firing it is essential that the health of the Coke Ovens be properly maintained.

In addition improved combustion control, maintaining proper thermal regime in the ovens it is necessary to introduce automatic control of air and fuel ratio in the ovens.

To increase the yield of Coke Oven it is essential to minimise leakage and avoid incidence of undercharging of ovens.

Increased yield of Coke Oven gas contributes to improvement in the gas balance of the steel plant.

To introduce waste heat recovery technologies like preheating of coal charge, coke dry quenching technology, it is necessary to introduce waste heat recovery system which will bring down the requirement for fuel input from a level of 0.56 G Cal per tonne of coal charge to 0.5 G Cal per tonne of coal charge.

The energy value accounts for the quality of energy, higher temperature being suited for energy generation. The sensible heat accounts for low temperature steam as the main target for heat recovery. There is a significant energy recovery potential for sinter plants.

The total sensible heat recovery possible from ISP is 5.53 GJ/trs out of which 4.88 GJ/trs is commercially practiced. As the steam pressure increases, the amount of steam generated decreases due to increase in boiling point and steam enthalpy. The boiler efficiency assumed for the calculations is 90%. The steam can be utilised in the process wherever required.

WHR Boilers (WHRB) can be installed at coke oven and hot stove exit points. Waste heat can be utilised in the following ways:

- 1) Power – Steam Rankine Cycle
- 2) Power – Organic Rankine Cycle
- 3) Integration with Captive Power Plant

The exhaust gases emanating from different sections of an ISP are at a high temperature. The enthalpy of the exhaust gases can be utilised to supplement the heat requirements of the steel plant.

The exhaust gases from different processes are made to pass through heat exchangers to generate steam. The steam generated from each section is collected and used to run a turbine to generate electricity.

The following are the technologies available for producing power from exhaust gases of an iron and steel plant.

- Rankine Cycle
- Organic Rankine Cycle
- Kalina Cycle

The potential for WHR from different sections together is in the range of 12 - 56 MW depending on the capacity of the plant.

Scrap Utilization

Scrap is an important raw material for secondary steel makers which reduce the energy demand per ton of crude steel production. According to the Bureau of International –what? recycling scrap purchases by steel works worldwide has increased by 17.2% to 340million tonnes in2010

Use of Alternative Fuels in Blast Furnace

Blast furnace is the most energy intensive sub process in an ISP. The main energy source for the process is coke which is expensive. India has low reserves of coking coals and mostly depends on import of coking coals. It is necessary to search for alternative fuels injection in blast furnace to reduce energy consumption and minimize the import dependency.

The possible alternative energy sources that can be used in the blast furnace operation are biomass, biochar, waste plastics, natural gas, fuel oil, etc.

Availability and Quality of Coal

Coal is another major source and according to present situation the availability of coking coal is a matter of serious consideration for steel industry for different reasons. Direct usage of Indian coking coals is a constraint due to high ash content. It should either be washed or blended with imported coal before usage. The production of quality coking coal is low in India. As per 2011 findings, the total coking coal reserves in India was 33.474 billion tonnes with 17.67 billion tonnes of “substantiated” category and total non-coking coal resources of 252.39 billion tonnes with 96.33 billion tonnes of “substantiated” category. The total coal requirement including coking coal is 613.62 million tonnes to meet the 2016-17 targets.

Environmental Pollution Norms

Iron and Steel sector has high emissions due to the energy intensive processes utilised. Indian steel industry emissions are higher than the global steel producers and emission levels and this could be due to technology or raw material variations. The emission standards for Iron and Steel industry are described below

Coke Ovens

The effluent standards for coke ovens are suspended solids 100 mg/l, oil and grease 10 mg/l, Ammonical nitrogen as N 50 mg/l and phenol 1 mg/l

Stack emission standards are SO₂ 800 mg/Nm³, NO_x 500 mg/Nm³, PM 50 mg/Nm³ and sulphur in coke oven used for heating is 800 mg/Nm³

Sinter Plant

The effluent standards for suspended solids, oil and grease are 100 mg/l and 10 mg/l respectively from sinter plant

Stack emission standards are PM is 150 mg/Nm³

Blast Furnace

The suspended solids 50 mg/l, oil and grease 10 mg/l, ammonical nitrogen as N 50 mg/l are the effluent standards for blast furnace.

Stack emission standards are SO₂ 250 mg/Nm³, NO_x 150 mg/Nm³, PM 50 mg/Nm³ and CO 1% (v/v)

Steel Making Process

The effluent standards for steel making process are suspended solids 100 mg/l, oil and grease 10 mg/l

Stack emission standards are SO₂ 200 µg/Nm³, NO_x 150 µg/Nm³, PM 100 mg/Nm³ and CO is 5000 µg/Nm³ for 8 hour operation, 10000 µg/Nm³ (34)

Integrated Steel Plant

Waste water generation standard for an ISP is 16 m³ per ton of finished steel.

Stack emission standards are SO₂ 800 mg/Nm³ NO_x 500 mg/Nm³, PM 50 mg/Nm³ and sulphur in coke oven used for heating is 800 mg/Nm³.

5. Summary and Conclusions

The Indian Iron & Steel sector has plants which are energy efficient and are comparable to the best in the world after adjusting for the availability and quality of the key inputs such as iron ore and coal. Some of the major plants in India recover most of the useful by-product gases and reuse their inherent calorific value in other processes. However, there are plants which operate under conditions of smaller scale, older technology, lower grade iron ore and coal and without adequate access to knowledge of best practices and finance options for deployment of EE measures.

The key levers for improving EE in a typical Iron and Steel plant include sub-process Energy Efficient technologies such as Pulverised Coal Injection, Coke Dry Quenching and Top Recovery Turbine can be deployed in order to contribute to energy savings. Recycling Blast furnace slag, Waste Heat Recovery options, effective Alternate Fuel Resources are other such options that can be implemented in iron and steel plants.

Energy efficiency in India is a national priority given that large sections of rural households do not have access to energy. The Indian iron and steel industry and energy policy implementing agencies such as the BEE have embarked on a cooperative journey which is vital to the country's roadmap for low-carbon inclusive growth.

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