EMERGING ENERGY EFFICIENT TECHNOLOGIES FOR STEEL PLANT

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Abstract:-

Steel industry in one of the most energy intensive sectors among all industrial sectors. Steel plants spend about 20-30% of their total manufacturing cost to meet their energy demand. The global steel industry together with energy management program has taken the lead to reduce energy consumption and co_2 emissions, especially in times of high energy price. This paper presents some emerging energy efficient technologies that have proven cost effective and available for implementation. Energy estimation for these technologies have also been performed and on the basis of the estimation, the potential energy savings of 10.53% have been predicted upto 2024. The energy savings are mostly due to adoption of best available technology in steel industry.

Key words:- Energy efficiency, Best available technology (BAT), specific Energy consumption (SEC)

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Introduction:- Iron and steel industry is one of the largest consumer of energy among all industrial sectors. The sector is the largest emitter of Co_2 also. Energy represents 20-30% of the total manufacturing cost of steel. Although considerable improvements have been made in recent years, the steel sector still has the technical potential to further reduce energy consumption and Co_2emissions by approximately 20%, thereby saving 4.7 EJ (exajoules) of energy and 350 Mt of Co2 [1].

1.1 **Energy management of steel plant:-** Energy management program is one of the most successful and cost effective ways to bring about energy efficiency improvements. It helps to ensure continuous improvement of energy efficiency. Energy management in steel plant provides the following opportunities:-

1. It provides opportunities to adopt best available technology or practices for utilization of energy more effectively.
2. It provides opportunities to reduce energy consumption and Co2 emissions through BATs.
3. It provides opportunities to reduce production costs without negatively affecting product yield or quality.
4. It enables to develop continuous improvement programs along with process control systems which include monitoring, modeling and optimization of process.

2. **Production Processes:-**

Two main processes are used in the production of crude steel.

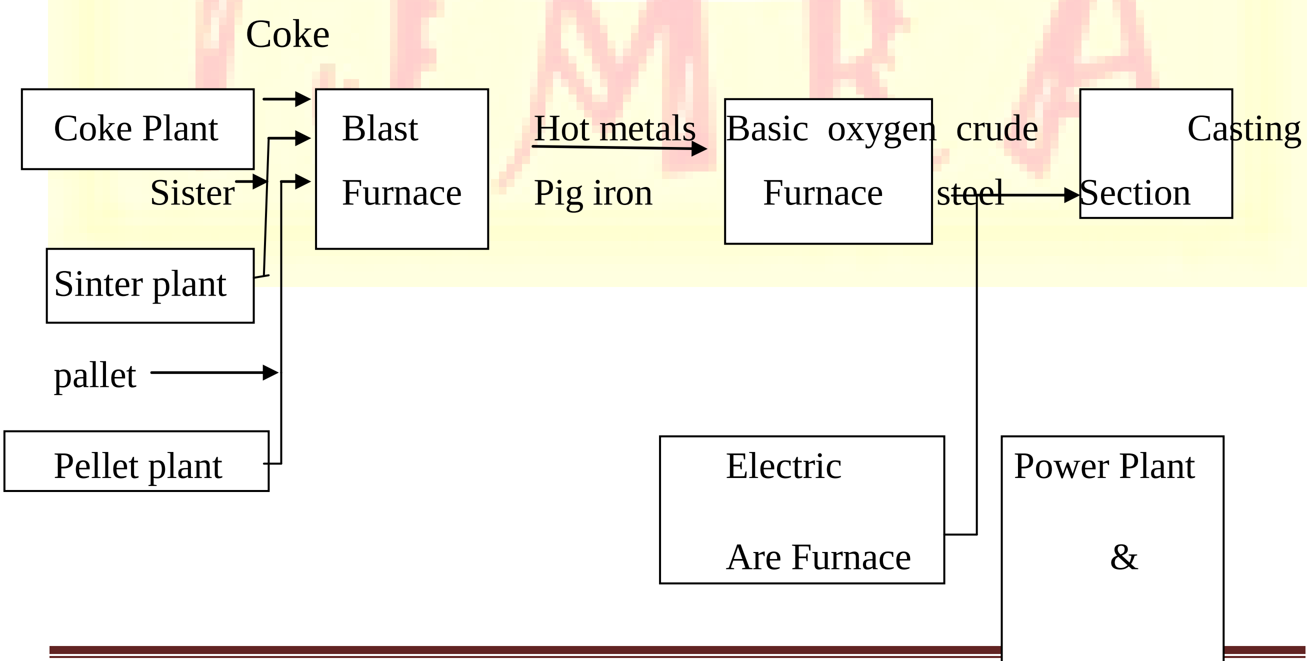
(a) Primary:- Blast furnace (BF)/Basic oxygen furnace (BOF) using iron ore.

(b) Secondary:- Electric ore furnace (EAF) process using scrap steel.

These two production routes arc expected to remain the main process of steel production for years to come. Other process dohowever exist, most notably the production of Direct Reduced Iron (DRI). DRI is produced by reduction of ores below the meting point in relatively small scale plants and has different properties than pig iron. It serves as a high quality alternative for scrap in secondary steel making.

Figure-1 Presents a simplified scheme of steel production routes.

Fig-1



Boilers

In the blast furnace route, iron ore is agglomeratedto obtain sinter or pellet. These agglomerates are charged together with coke and coal into blast furnace, which produces hot metal/ pig iron. Most of the carbon in hot metal is removed in a basic oxygen furnace, which results in liquid steel. In the electric arc furnace route, liquid steel is produced from recycled scrap in EAF. The liquid steel obtained through both routes is casted to make specific shape and size in finishing section. The casting process involves either ingot casting or continuous casting to make blooms or slabs. Blast furnace route have boilers and power plant near the site to generate steam and electricity. These are mainly operated by gaseous fuels that are released in coke plants or blast furnace.

3. **Energy use by production process:-** The net primary energy used by production process for steel making includes fuel consumption and electricity consumption. The table shows the net primary energy use by different processes for steel making [2]

Processes	Sinter	Coke	Hot Stove	Blast furnace	BOF	EAF	Continuous casting	Reheating furnace	Hot strip mill
Net primary energy (MTtu/ton product	1.6	3.75	1.5	10.	0.3	3.9	0.12	1.1	0.8

It can be seen from the table that primary steel making route is more energy intensive than that of the Secondary steel making due to the fact that coke has to produced as fuel and iron ores have to be reduced to molten iron, whereas Electric arc furnaces use steel scraps and therefore do not need energy for reduction of iron ore to iron. Fired heaters, particularly the blast furnace and other furnaces, represent the bulk of energy use upto 81%. Boilers use another 7% of total energy use. Motor system, which include rolling mills, pumps, conveyors and fans consume another 7% of energy use. Heating, cooling and lighting of facilities accounts for 3% energy use [7].

It is observed that nearly one quarter of the energy (23%) that enters the plant is lost prior to use in process units. The losses occur in equipment and distribution systems supplying energy to process operations. Losses can very between facilities, as they are dependant on plant configurations, the effectiveness of heat sources and sinks and operating and maintenance practices [7].

Steam represents upto 10% of energy used. A profile of U.S. Iron & steel industry shows that about 44% of energy inputs are lost due to system inefficiencies. Most of these losses occur in boiler, depending upon the age of boiler and fuel burned [7].

4. **Energy efficient technologies and measures:-**

The International Energy Agency (2007) estimates the total primary energy and savings potential to be 9-18% through the adaptation of best available technologies (BATs) These are described as follows:-

4.1 **Power plant measures:-** Most power plants operating on steel gases have boiler in combination with steam turbine, which provides necessary flexibility to operate on different types of gases produced in steel making process. The total efficiency for conversion from steel plant gases to electricity is currently 32% [2] Thecurrent average efficiency of power and steam production is below the best practice, the aim of BAT is to increase the efficiency of energy conversion.

4.2 **Sinter plant waste Gas Heat Recovery:-** Sintered ore from Sinter plant is used as raw material in the blast furnace. The exhaust gas from sinter bed can be returned to sinter bed as combustion air. This can be applied to reduce energy consumption by economizing on coke use. Secondly, energy from hot sintered ore is recovered at the end of sinter bed using cooling system. The hot air can be applied to generate steam. Energy recovery by means of this system is 23% of the energy input [3].

4.3 **Coke Dry Quenching (CDQ):-** This process is alerternative to traditional wet quenching of coke. Red hot coke is charged into cooling tower and inert gas is blown into tower from the bottom. The energy recovered by this gas is used to generate high pressure steam, which can be used to generate electricity. The Steam recovery rate is about 0.55 GJ/ton coke. Further coke manufactured by CDQ reduces the amount of coke consumption in the blast furnace by 0.28 GJ/ton molten iron. [3].

4.4 **Variable speed Drive coke oven Gas compressors:-**

Coke oven gas is generated at low pressure andis pressurized for transport in the internal gas grid. These types of compressors can be installed to reduce energy consumption. It saves about 6-8 MJ/ton coke [2].

4.5 **Pulverized coal Injection (PCI):-** One of the main efficiency measure in iron making is replacing part of the coke by another hydrocarbon source that is injected in the blast furnace. PCI saves part of coke production, thereby saving energy and reducing emissions and maintenance costs. The energy savings in blast furnace due to coal injection is estimated to be 3.76 GJ/ton coal injected Natural gas can be injected simultaneously with PC that improves productivity and performance of blast furnace [2].

4.6 **Injection of plastic waste:-** The injection of plastic waste also allows for reduction in coke production. Plastic waste has higher heating value than coal. Like injection of natural gas, the injection of plastic waste increases the amount of hydrogen in the blast furnace. The steel industry in Japan effectively reuses plastic waste.

4.7 **Top- pressure Recovery Turbines (TRT):-** The top gas from blast furnace has an over pressure which can be utilized to produce additional electricity with TRT. The potential generating capacity with gas volume is nearly 7 MW. In Japan all blast furnaces are equipped with TRT [3].

4.8 **Stove waste Gas Heat Recovery:-** A waste gas heat recovery system (WGHR) improves the efficiency of hot blast stoves as the heat from waste gas of hot blast stove is partially recovered by external heat exchangers. The recovered heat is used to pre heat the BF gas or combustion air. For a specific waste heat recovery device, the recovery rate of heat is about 40-50% and reduction of heat consumption is about 0.126 GJ/ton of pig iron [3].

4.9 **Recovery of BOF Gas and heat:-** Recovery of BOF gas is the single most energy saving improvement in BOF process, making it a net energy producer. BOF gas is combusted in the converter gas and subsequently the sensible heat is recovered in a waste heat boiler, generating high pressure steam. The total Savings vary between 0.54 and 0.92 GJ/ton steel, depending on the way steam is recovered [3].

4.10 **Electric Arc Furnace (EAF) measures:-** In EAF high intensity electric energy is passed between electrodes to create an arc that melts steel scraps. Most of crude steel products in India are produced using direct reducing iron (DRI)- EAF process. In countries where plentiful steel scrap is available, EAF contributes considerably to energy saving since it does not require energy intensive iron ore reduction process, which needs about 70% of total energy to produce steel via BF-BOF route.

4.11 **Process control system:-** The use of control system plays an important role in reducing energy use. The system relies on information from many stages of process, Modern controls which use sensors to reduce electricity consumption to a greater extent. An example of improved monitoring is the real time monitoring of off gas in EAF, allowing a 50% increase in recovery rate of chemical energy due to past combustion control [7].

4.12 **Oxy-fuel Burners:-** Modern EAF use oxygen fuel burners to provide chemical energy to the cold spots, making the heating of steel more uniform. Oxy fuel burners reduce electricity consumption by substituting electricity with fuels and increase heat transfer. Energy savings in this process is between 10 to 20 kwh/ton [3].

4.13 **Scrap pre-heating:-** Preheating of scraps is a technology that can reduce the power consumption in EAF process by using waste heat of the furnace to preheat the incoming scrap charge. Such preheating is performed either in scrap charging baskets or in shaft furnace added to EAF. It allows energy savings upto 100 kwh/ton liquid steel which is about 25% over all electricity input [3].

4.14 **Carbon capture and storage (ccs):-** CCS is a technology of decarbonization of steel plants. Co_2 is separated fromflue gases and then compressed and cooled and transported by pipelines to be stored underground. Steel plants are suitable for carbon capture because their emissions originates from fixed points highly concentrated in Co_2 [4].

4.15 **Direct Reducing Iron (DRI):-** Direct reducing is process of converting iron arc to iron using a reducing agent at temperature lower than melting point of ore. There are two processes for DRI manufacturing; coal based and gas based processes. Coal based DRI process requires non coking coal as reducing agent which is available in plenty in India. The raw material consists of iron ore, coal and dolomite charged into rotary kiln. Hot sponge iron is discharged at discharge end.

In gas based DRI process, gas is used as reducing agent as fuel instead of coke. India has adopted two gas based technology namely MIDREX and HYL [6].

5. **Energy Estimation:-** The efficiency of steel making varies with the kind of production route, type of iron ore and coal and operational technology. It is observed that 45% steel is produced by BF-BOF route and 55% by electrical furnace route [2]. The blast furnace process is energy intensive and 48% of total energy input is used in blast furnace operations. The Best available technology (BAT) indicates the specific energy consumption (SEC) of 16.4 GJ/tcs through BF-BOF route, 19.3 GJ/tcs by smelt reduction, 19.0 GJ/tcs through coal based DRI-EAF route and 15.9GJ/tcs through gas based DRI-EAF route in 2009 [5]. The average SEC from selected major steel plant in India during 2012 was about 6.3 G cal/tcs and this could reduce to 5.52 G cal/tcs by 2024. The projected value of SEC is estimated using method of least square for the period 2014-2024. The line of best fit is calculated as y= 7.081-

0.065 x and graph is plotted between year (x) and SEC (y). Similarly energy requirements is estimated for the period 2014-2024 and the line of best fit is calculated, using least square method, as y=6.183+3.35x and graph is plotted between year (x) and energy requirements(y). The energy requirements during. 2012 was about 46.4 Mtoe and this could increased to 86.58 Mtoe by 2024. Figure-2 shows the projected Energy consumption and Energy requirements.

It is observed from fig-2 that energy consumption is gradually decreasing while energy requirements are gradually increasing. On the basis of energy analysis the potential energy savings of 10.53% could be predicted by 2024.

These energy savings are mostly due to adoption of best available technologies in steel industry. Accordingly, the projected increase in energy requirements are due to increased production for the same period i.e. 2014-2024.

Conclusion and Future scope:- This paper presents different types of energy efficient technologies along with basicproduction processes for steel manufacturing. BATs include PCI, CDQ, TRT, DRI-EAF, WGHR options that can be deployed in order to contribute to energy Savings and CCS option can be deployed to reduce Co_2 emission. On the basis of energy estimation, the potential energy savings of 10.53% could be predicted by the year 2024. The decreasing trend of energy of consumption due to adoption of BATs is encouraging and further reduction in energy consumption and Co_2 emission can be achieved by continuous evaluation of improvement measures through effective energy management programs.

There are good opportunities of potential energy savings through innovative technology for steel industry in the near future.

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About the Author

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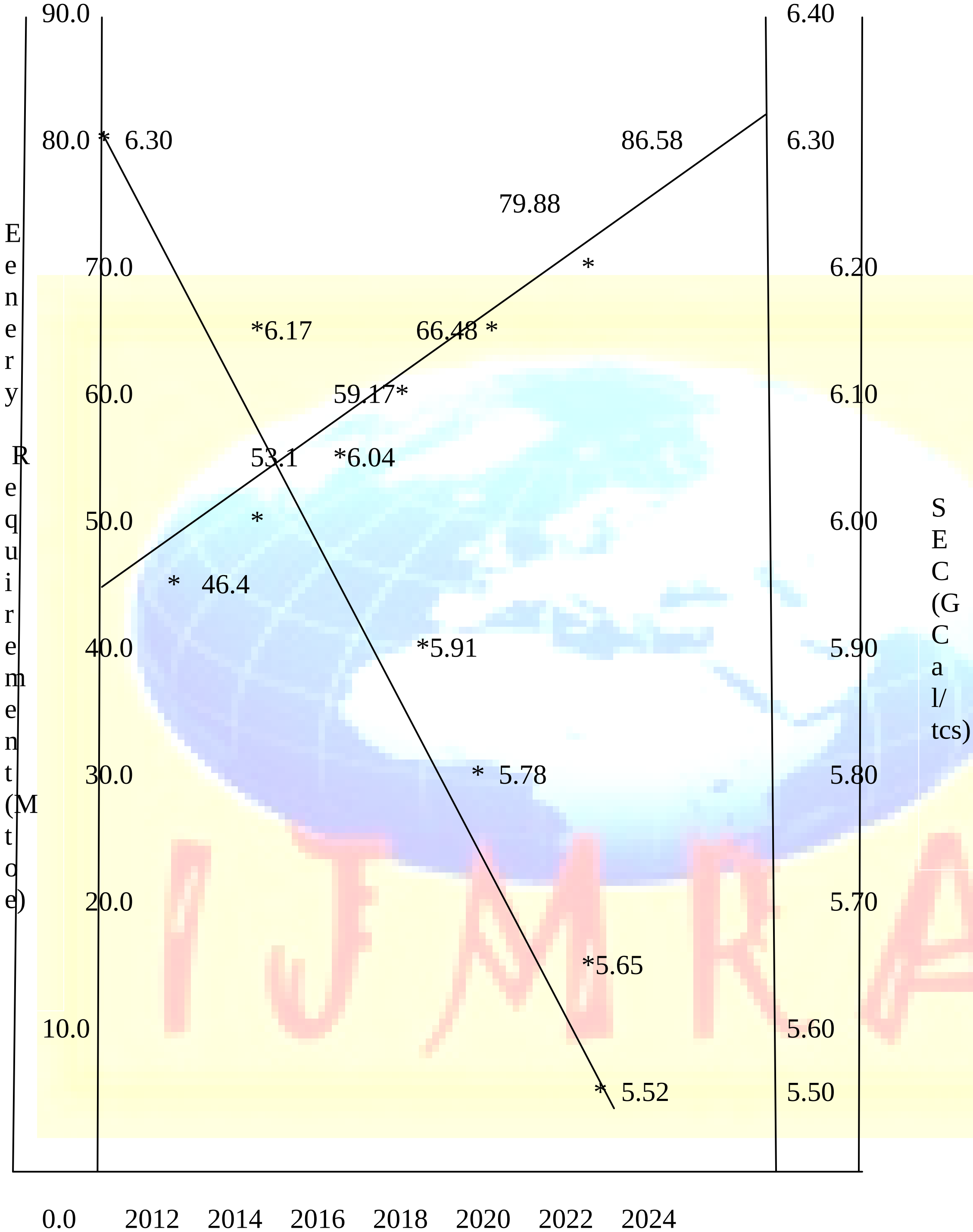
Fig.-2



Year

Estimated Value of Energy Consumption

and Energy requirement for 2014-2024