Steel Industry and Climate Change

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ABSTRACT

The carbon dioxide emission from steel plants has been recognized as an important concern globally. In the past two decades steel industry has reduced CO_2 emission by 15-20% by adopting newer technologies and improvement in processes. Further reduction by 15-20% is expected in next decade by implementation of newly developed techniques and controls. Drastic reduction CO_2 emission is only possible by adoption of technologies like plasma heating, CO_2 recovery, BF and CO gas injection in Blast Furnaces and use of hydrogen on commercial scale in iron ore smelting. Increased use of recycled steel will also play an important role. Life Cycle Assessment (LCA) for steel products to improve product quality and strength including weight of product will enhance consumer confidence besides reducing the environmental burden. Further reduction of CO_2 in the steel plant globally can come only through adopting flexible mechanisms and CO_2 trading.

This paper describes present scenario, technologies in practice, trends and drivers and flexible mechanisms to reduce CO_2 emission in steel industry. The paper also presents the scenario at Tata Steel and various actions initiated to address the issues related to energy conservation and reduction in CO_2 emission.

Key Words : Iron & steel industry, green house effect, clean technologies, energy taxes.

INTRODUCTION

The earth absorbs radiation from sun at its surface and this energy is then redistributed to atmosphere and ocean and reradiated to space. Some of this reradiated energy is absorbed by Green House Gases (GHG's) present in the atmosphere. The energy thus absorbed by GHG's is reradiated in all directions downwards and upwards. The upward radiation is lost to the space. This radiation is from higher and colder level of the atmosphere. As a result the Earth's surface loses less heat to space due to presence of GHG's in the atmosphere and its temperature is gradually increasing. This phenomenon is known as Green House Effect, mainly responsible for climate change. The carbon dioxide, a gas, emitted during burning of fossil fuels, agriculture and deforestation is considered as main culprit for the climate change. The carbon dioxide emission is the direct result of non-renewable energy usage. Carbon dioxide levels in atmosphere during industrialization period of two centuries have increased from 280 parts per million (ppm) to 370 ppm resulting in global temperature rise of more than 0.6°C. It is expected that in 21st century this rise will be 6°C and ocean level will increase by nearly a metre. A metre rise in sea level will inundate nearly one percent of Egypt, 6% of Netherland, 17.5% of Bangladesh and 100% land of small island countries like Maldives, Mauritius, etc. [1]

Large amount of CO_2 is emitted to atmosphere because of natural and human activities. About 190 Giga Ton of carbon equivalent CO_2 is emitted by natural processes annually and only about 6-8 Giga Ton is emitted by human activities including industrial plants. The man made emission is only 3-4% of the total emission. The atmosphere contains total 750 Giga Ton of CO_2 as carbon, a quarter of which circulates each year in natural carbon cycle. It is estimated that atmospheric levels are increasing by 3.5 Giga Ton of CO_2 per year as a result of human activities.[2]

The international importance of climate change means that industries are under increasing pressure from Governments to reduce CO_2 emissions. Steel industry being major energy consumer and CO_2 emitter faces a serious pressure from Governments and green consumers. Steel industry has responded well so far and reduced CO_2 emission by more than 20% during past two decades. Current technologies in use will help reduce CO_2 emission further to the tune of 15-20% in the next decade. The cost to reduce CO_2 emissions drastically is very high and therefore, flexible mechanisms are being viewed as a solution to this problem. Several countries have imposed or are considering the imposition of energy taxes. Discussions on flexible mechanism are taking shape and issues like, trading of CO_2 is being considered seriously.

This paper describes present scenario, technologies in practice, trends and drivers and flexible mechanisms to reduce CO_2 emission in steel industry. The paper also presents the scenario at Tata Steel and various actions initiated to address the issues related to energy conservation and reduction in CO_2 emission.

IRON & STEEL INDUSTRY – GLOBAL SCENARIO

The Iron & Steel Industry has been recognized as a major source of CO_2 emission. The steel industry globally emits approximately 356 million tons of CO_2 as carbon from cradle-to-gate [3]. The carbon in steel industry is required as a chemical feedstock (reductant) and for energy units (direct or electricity generation). The range of CO_2 emission from steel plants reflects a part of the factors like, iron making and steel making practices, energy efficiencies, national power mixes and the complexity of finishing operations. These factors represent the basis for CO_2 reduction strategies. For example, in Blast Furnace operations the most significant improvements are likely to come from coal injection, coke dry quenching, coke moisture control etc. These factors are likely to save 8-10% of the total energy input. In Electric Arc Furnace, the energy savings arise from use of alternate energy sources to electricity, such as oxygen and coal injection and utilization of waste gas for scrap reheating etc.

New processes and technologies which have been developed in the recent past show a great potential for CO_2 reduction after commercialization. Some of these technologies are direct reduction methods (MIDREX, HyL, FIOR, SLRN processes etc.) and smelting reduction technologies like, COREX, ROMELT, CCF, HISMELT etc. Comparison for various processes with regard to CO_2 emission is given in Table 1.

Table 1 : Trends in CO_2 emission for various proven processes [3]

Sl. No.	Process	CO_2 Emission Ton/Ton of Steel
1	BF-BOF Route	1.9
2	COREX	1.7
3	Direct Reduction (DR)/EAF Route	1.2

Challenges for Steel Industry

Following the Kyoto protocol on the reduction of greenhouse gas (GHG) emissions by industrialized countries, the signatory governments are in the process of developing ways and means to implement such reductions. The order of magnitude of these reductions exceed by far the 5.2% average reduction from 1990 levels agreed upon, since potential increases due to economic growth by 2012 are also to be accounted for.

The policy makers who are to develop strategies that could lead to such reductions will address different target sectors of the economy, which are likely to include :

- The industrial sectors and particularly the energy intensive ones, of which steel making undoubtedly is a part, will see pressure to become less GHG emitting in their manufacturing processes. There will be a demand for :
  - o More energy efficient manufacturing processes.
  - o Development of manufacturing techniques with reduced GHG emission potentials.
  - o Clean technologies i.e. technologies with the highest possible recycling rates.
  - o The development of products and consumer goods which both at manufacturing and during their useful life, generate lesser quantities of GHG.
- The consumers will be led to choose more sustainable products, including :
  - o Products from clean production techniques.
  - o Products, which require low energy during manufacturing.
  - o Products, which require low energy during their useful life.

These options offer great challenges to steel industries to reduce CO_2 emission. A simulation study carried out for a Modern Steel Mill in France [4] shows the potential for CO_2 reduction for various technological options as illustrated in Table 2.

Table 2 : Simulation of CO_2 emission in the various Model Steel Mills.

Process Route	Input in Blast Furnace (kg)					In Steel Shop	Electricity	CO_2
	Sinter	Pellets	DRI	Coke	Coal	Iron (pig/hot)	kWh/t	(kg/t steel)
Ref. Blast Furnace	1357	103		331	153	1000	187	2111
BF 100% sinter	1600			331	153	1000	191	2156
BF 200 kg PCI	1290	168		290	200	1000	186	2088
BF 250 kg PCI	1290	168		250	250	1000	184	2084
BF + Pellets + DRI	1217	112	94	269	189	1000	185	2052
BF 900 kg hm/tcs	1357	103		331	153	900	174	1904
BF gas recycling	1357	103		224	0	1000	1696	1264
CFC's-Reduction						1000	319	2212
EAF 125 kg pig iron	1357	103		331	153	125	499	323
EAF 160 kg pig iron	1357	103		331	153	160	478	396
Redsmelt 250 kg hm/tcs						250	574	639
EAF 830 kg DRI							798	500
EAF 244 kg hm/tcs	1357	103		331	153	244	468	611
Corex + Midrex + EAF						500	632	1639
EAF 100 Scrap						0	458	68

Some sectors of the steel industry might be more affected than others by the new scrutiny on 'sustainability' of their products. Short life steel products, such as food packaging, might be most affected by the new requirements and new consumer preferences for sustainable products. In addition, since consumer goods producers (appliances, automobiles, etc.) will be increasingly challenged to reduce the energy component of their product, the energy demand during its service life and to extend the products useful life, the consumers will demand more sophisticated and less 'weighty' steel qualities or they may prefer to step away from steel. While strengths of steel lie in its excellent structural performance and durability, steel products with long service lives might be less under pressure.

The Life Cycle Assessment (LCA) will be used increasingly as a tool for monitoring the performance of materials and products both during manufacturing and in their final use. The rules governing LCA need, however, to be fine-tuned for acceptance throughout the industrial community. In order to be ready to take its stance about its products, the steel industry needs to continue its efforts to highlight all the benefits resulting from their use in all types of applications.

Current Technologies in Steel Industry

The technologies contributing to energy saving and CO_2 emission reduction in steel industry and the prospects of their future spread and effects are summarized below [5]:

Waste Heat Recovery

- *Coke dry quenching (CDQ)*
  CDQ is installed at present for over 80% of all coke ovens in Japan. The use of CDQ may increase world wide in next few years. As a result of the decrease in coke production due to the increase in Pulverized Coal Injection (PCI), the effect will be small.
- *CO gas sensible heat recovery*
  Technical developments in this area are necessary. There is, however, a problem of space for equipment installation in existing Coke Plants. Therefore, the spread is slow and the effect is small.
- *Sintering waste-heat recovery*
  Equipment installation for main facilities are in progress all over the world. The future spread is small and the effect is small.
- *Dry-type top gas recovery turbine (TRT)*
  Its spread will progress with future relining of Blast Furnaces, but the effect is small because pig iron production will decrease with the increasing use of scrap.
- *BF slag sensible heat recovery*
  Among un-recovered waste heat this heat is considerably large, but technical development is necessary for its recovery. The effect will be medium.
- *BOF gas sensible heat recovery*
  At present this is practiced only in few plants. This may increase as a long-term prospect. The effect is medium.
- *Pulverized coal injection (PCI)*
  The present average use is 110 kg/thm in the plants having PCI facility. This will continue to increase in a long term prospect. The effect is medium.
- *Coal moisture adjustment*
  The spread is small at present. But this is expected to be adopted by all the steel plants in near future. The effect is medium. The technology, however, is applicable to Top Charge Batteries only.

- *Scrap preheating*
  The spread will progress gradually, but the effect is small.
- *Direct hot charge rolling*
  The ratio in the hot rolling process is low at present, this is expected to increase in future. The effect is large.
- *Increase in the efficiency of in-plant power generation*
  This will spread gradually and the effect is large.
- *High-efficiency oxygen production*
  Although technical developments are necessary, the spread will progress gradually and the effect is large.

Increase in the Efficiency of Production Facilities

- DC electrical furnace - The spread will progress gradually and the effect is small.
- Continuous Casting - The present CC ratio is medium, and this ratio will increase to 100% in future. The effect is small.
- Increase in the efficiency of reheating furnaces - The spread will progress gradually. Technical development is necessary. The effect is medium.
- Continuous hot rolling - The spread will progress gradually. The effect is small.
- Continuous annealing - The spread will progress gradually. The effect is small.

Technical Development

- Next-generation coke ovens (Non recovery type, Continuous Coking, Jumbo Ovens etc.) - Technical developments are under way. The expected effect is medium.
- New smelting reduction process - It is expected that more of pig iron will be produced by this process by 2010. The effect is medium.
- Large-volume consumption of scrap - There is the problem of increase in raw materials cost, but the expected effect is large.

Reduction in CO_2 Emission from Steel Industry - Trends & Drivers

The steel industry has responded well to the global need to reduce CO_2 emissions and to this effect it has achieved 20% reduction in past 20 years. Adoption of various processes in very recent past will have an equal impact on CO_2 reduction. These processes are :

- Concentration of steel production at most efficient installations.
- Rebuilding/modernization of plants to improve efficiency.
- Process step elimination.
- Energy optimization in existing processes.
- Use of natural gas instead of coke in Blast Furnaces.
- Ore reduction with natural gas in installed DRI processes.
- Recycling and reuse of steel plant waste.

These measures in short term, will bring further reduction in CO_2 emissions. The industry, however, has to look beyond traditional means of energy saving and should look for long term methods to bring down CO_2 emission drastically. Table 3 presents some of the long term options, with the status of their techno-commercial viability.

Table 3 : Overview of solutions to reduce CO_2 emission.

Time	Core Activities		Supporting Technologies	CO_2 Emission ($t\ CO_2$ / tcs)		Technological Aspect	Cost Effect
				Reduction & Refining	Scrap Melting		
Past				2.300	0.600		
Present & Short	BF-BOF Efficiency (recycling slag, wastes gases, sensible heat)	Coal Injection		2.119		Known	Known
		NG Injection		1.886		Known	Known
	EAF				0.462	Known	Known
			CCPG (1)		0.380	Known	Known
Medium	Smelting Reduction		CCPG (1)	2.055		Known	Known
	BF-BOF BF min coke rate TSC (3)	Coal Injection	CCPG (1)	1.783		Known	Known
		NG Injection	CCPG (1)	1.599		Known	Known
	EAF + TSC (3)		CCPG (1)		0.275	Known	Known
	DRI NG based + Electricity		CCPG (1)	0.957		Known	Known
Long	BF + H_2 + Electricity (Plasma) + TSC (3)		CCPG (1) NCPG (2)	0.846		To be studied	To be studied
	EAF		NCPG (2)		0.1	Known	Known
	H_2 Reduction		NCPG (2) Electrolysis	0	0.1	To be studied	To be studied
	Ore Electrolysis		NCPG (2)	0	0.1	Known	Known
CO_2 sequestration	All processes BF, SR, DRI, DAF		CO_2 sequestration	0	0	Known	To be studied
			Biomass	0	0	Known	To be studied

(1) Combined Cycle Power Generation: Efficiency improvement of power generation from 0.35 to 0.45.

(2) Non-Carbon based Power Generation: Nuclear, Solar, Hydro, Biomass.

(3) Thin Slab Casting

The advantages/disadvantages of some of these options are briefly presented here below :

- When steel is produced from recycled scrap, the CO_2 emissions are four (4) times lower than for steel production based on ore reduction. Thus production of steel from end of cycle product scrap up to 40% would reduce the CO_2 emissions by 10%. Actual reduction will be higher than 10% as the industry replaces its old inefficient process.
- The development of steel products and consumer goods which have higher strength and lower weight will also impact the scenario favourably in absolute CO_2 emissions to the atmosphere.
- Majority of CO_2 emission from steel plants are contributed due to purchased power (electricity) which is largely coal based. Shift to cleaner fuels like byproduct gases, natural gas will favourably impact CO_2 emissions. Natural gas, however, due to its limited availability cannot be considered as long term solution. Non-CO_2 emitting sources of power like, solar, nuclear, wind and biomass are also being explored to reduce CO_2 burden on the atmosphere. It may be noted that nuclear power is likely to be phased out due to other environmental considerations associated with it. The CO_2 emission potential for different sources for power generation is given below
  - Nuclear - 4 gm/kWh
  - Gas - 439 gm/kWh
  - Oil - 719 gm/kWh
  - Coal - 856 gm/kWh
- An alternate solution to CO_2 reduction is to remove CO_2 from flue gases and store the same in ocean reservoirs. The cost for such storage is very high (USD 50/t of CO_2) and is a matter of concern. Large afforestation projects could also help in increasing the carbon sink potential of nature. For a 10 MTPA plant, to provide CO_2 sink, a forest area of 95×95 km^2 is required.
- Hydrogen is seen as alternate to fossil fuels and in conjunction with electricity generated from non-conventional and renewable resources, could offer a long term option for drastic reduction of CO_2 emission. At present and into foreseeable future, the industrial production of H_2 with no accompanying CO_2 emission can only be carried out by electrolysis or via biomass gasification and reforming. Electrolytic H_2 costs are around 0.13-0.25 USD/Nm^3 and biomass H_2 costs also may be similar. This higher cost may keep the use of H_2 in steel plants away for some more years i.e. until cheaper sources of power generation are commercialized.
- Electrolysis of iron ore promises large CO_2 reductions, provided power is available at 3 to 4 times lower rates than what is prevailing currently. Nuclear fusion and its commercialization is not expected before 2050.
- Recycling of waste products offer tremendous potential for energy saving and CO_2 reduction. Blast Furnace slag after granulation when used in cement making reduces CO_2 emission from steel works (credit) to the tune of 220 kg/thm.[3] Similar potential exists for LD slag usage in cement making.

- Biomass provides more flexible solutions as reforestation does not have to take place close to the steel plant and the land required for biomass production, although larger (50% higher) than forest area, could be made available in remote places.
- Recycling of CO_2 and conversion of this gas to various chemicals can further reduce CO_2 emissions. Blast Furnace top gas recycling and synthesis of BF gas are further discussed here as under.

Blast Furnace Top Gas Recycling

The BF top gas recycling can further reduce CO_2 emission. Fig. 1 shows various methods for recycling.

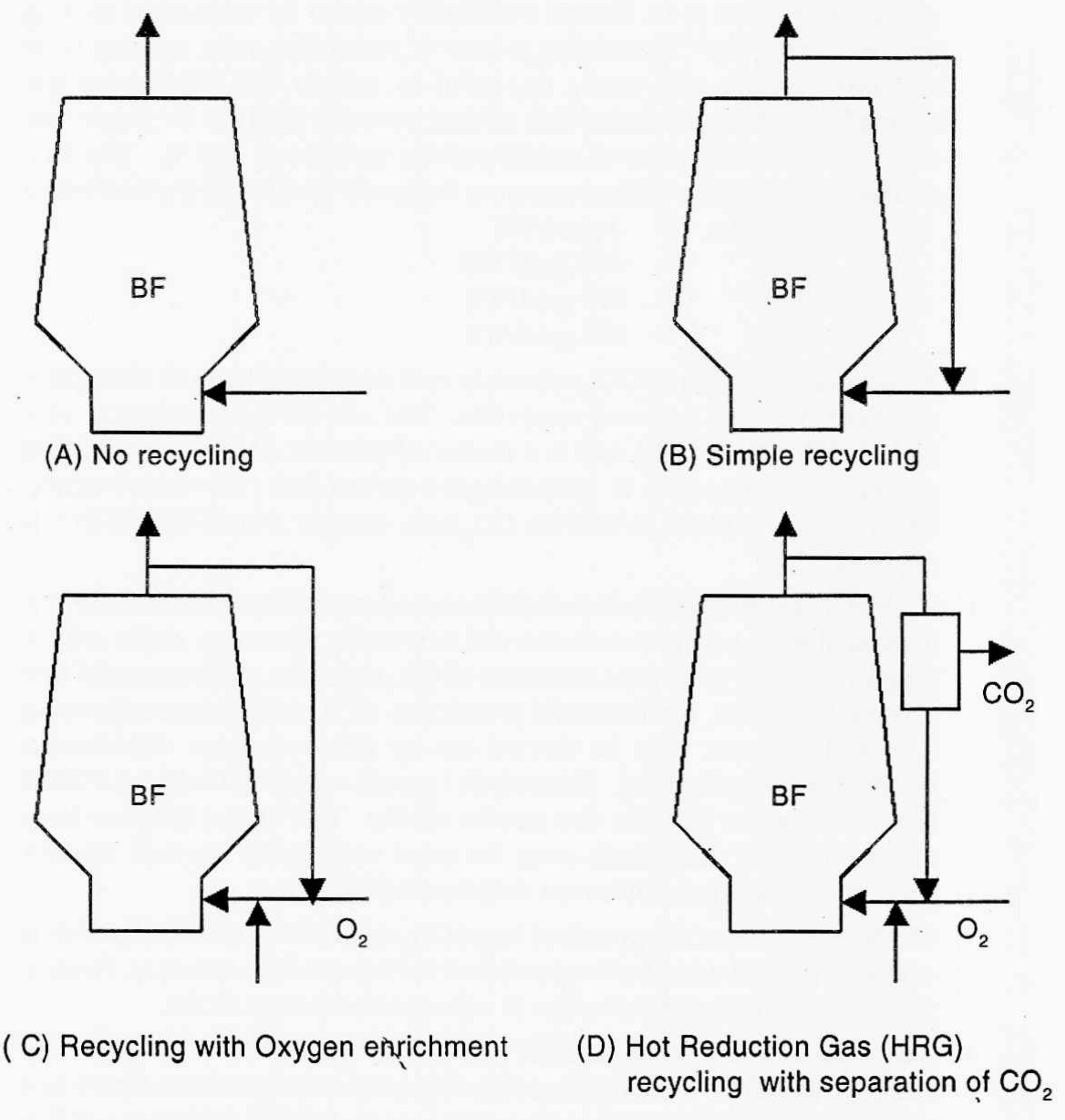

Fig. 1 : BF top gas recycling

The Case B and C in Figure-1 result in decrease in productivity and increase in fuel rates due to cooling effects of CO_2 in the recycled gas and Case D offers productivity increase by 25% and fuel rate decrease by 20%. In all 13 field tests during the period of 1985 – 1990 producing 250 ton of hot metal with a pilot complex in RPA, Russia were conducted. The process steps followed were, "Compression of dedusted top gas ⟶ removal of CO_2 ⟶ reheating ⟶ injecting into the BF hearth through tuyeres".

The results of these tests are reflected below :

- Reduction of coke rate to 280-300 kg/thm (Carbon input decreased by 28-30%).
- Increasing BF efficiency by 25-30% while reducing GHG emissions
- Cut down on the separation cost of CO_2 by raising its content in the BFG (100% recycling means nitrogen free process).
- Stable operation of the furnace was possible.

The technical problems associated with these tests were :

- Engineering problem due to high temperature Hot Reducing Gas (HRG) injection with O_2.
- Economic problem due to large scale oxygen preparation and CO_2 separation.

Blast Furnace Iron Making System Integrated with Methanol Synthesis.

The process principle adopted for synthesizing CO_2 to methanol are given in Fig. 2.

Conventionally Methanol is produced from natural gas which mainly contains CO, CO_2 and H_2. In the Blast Furnace process CO_2 can be separated from the top gas and used for methanol synthesis. The methanol thus produced can be used as a fuel for vehicles, feed stock for chemical industries etc. In this process there is a reduction of 20% CO_2 emission in Blast Furnace. It may be noted, the worldwide consumption of methanol is only 2 million tons per annum. It is too small compared to the projected yield from BF gas conversion.

Recycling of Coke Oven & Blast Furnace Gas in Iron Making.

- Possible combination (partially not proved technically) is given in Fig.-3.
- Process description :
  - o BFG recycling with or without CO_2 separation.
  - o Process control O_2 enrichment.
  - o COG recycling.
  - o Reformed gas recycling of BFG + COG
    CO_2 (BFG) + CH_4 (COG) ⟶ 2CO + $2H_2$
- Problems :
  - o Impurities of BFG and COG : dust, tar, etc.
  - o Fouling effect of catalyst.

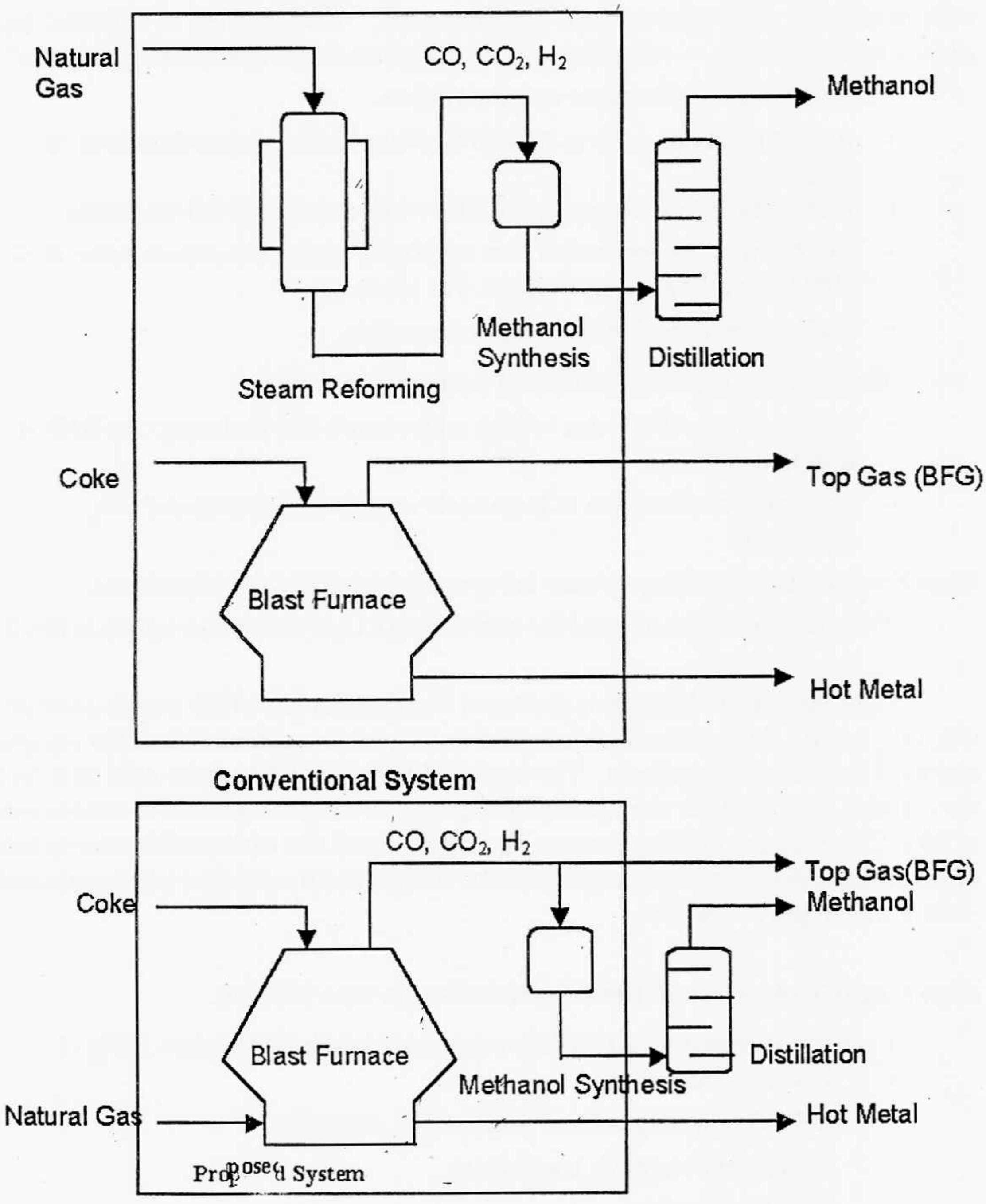

Fig. 2 : Manufacture of methanol from CO_2

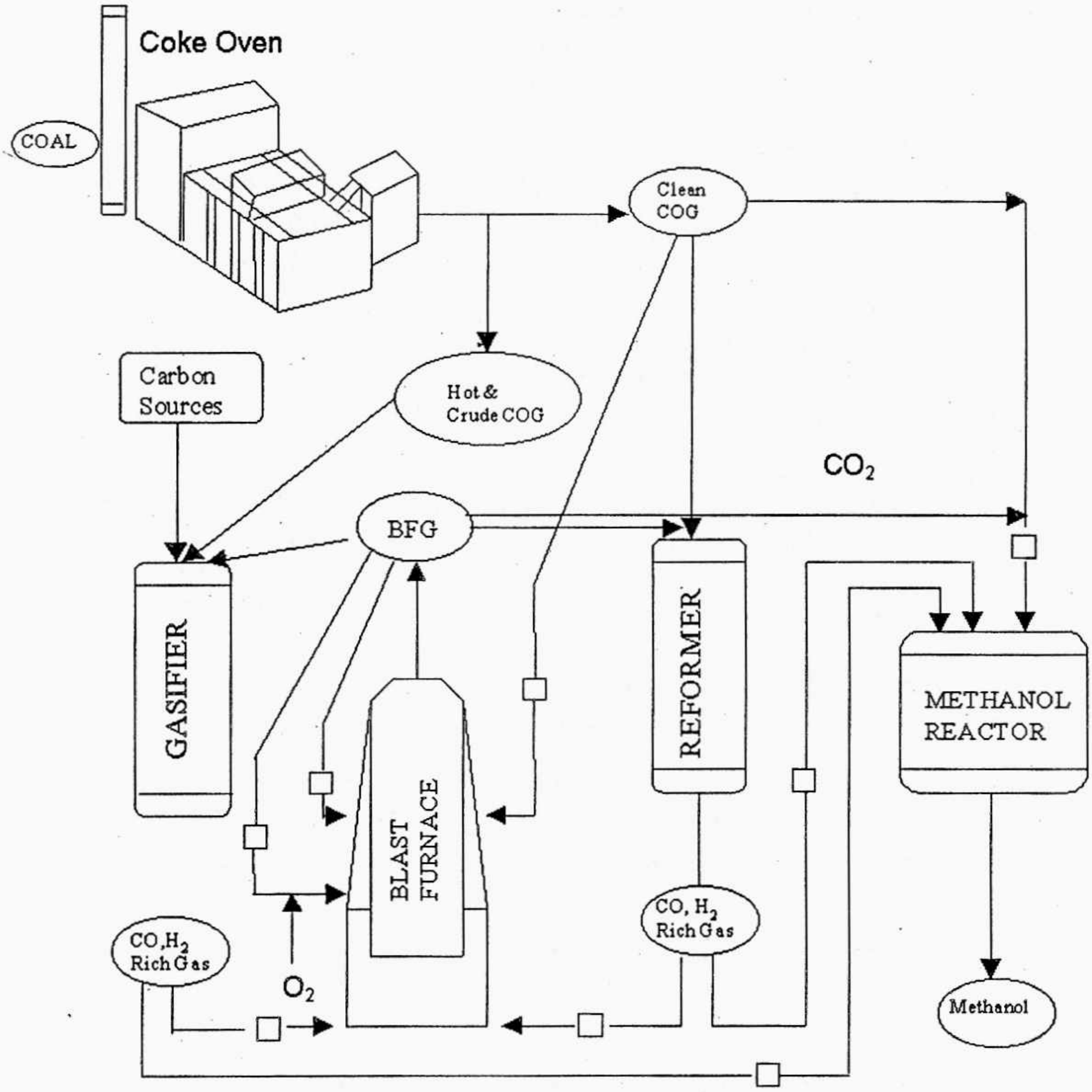

Fig. 3 : Recycling of CO & BF gas in iron making

- Discussion
  - o The combination of BF top gas recycling and methanol synthesis can reduce technically total emission of CO_2 and energy consumption.
  - o It is also economically feasible, but further investigation on variable reaction paths, catalyst and separation process are necessary.
  - o Marketing of chemical feedstock (methanol) is not easy because of surplus availability of methanol globally.

Special Blast Furnace Process

In BF-BOF route of steel making, nearly 65-70% of total energy required in steel making is consumed up to iron making. Steel plants world over had been concentrating on Blast Furnaces to reduce coke rate by increasing hot blast temperature, pulverized coal injection, oxygen enrichment, automation etc. These conventional changes have brought down energy consumption by more than 20% during past one or two decades. In order to reduce energy consumption and resultant CO_2 reduction, a few long term options are being studied. These are :

The PIROGAS Process

The PIROGAS process[5] consists of replacing, in part or in total, the hot blast blown through the blast furnace(s) tuyeres by reducing gas heated to a temperature of about 2000°C. The heating or overheating and, eventually, the production of reducing gas, can be achieved directly in the plasma heater. Up to 80% of the coke required for a conventional blast furnace can be replaced by substitute reducers. The PIROGAS process makes it possible to optimize the ratio between fossil fuels and electric power consumption to achieve optimum economic operation.

Trials carried out on a full size commercial Blast Furnace have confirmed that the plasma heater does not affect the operation of the furnace adversely and, reciprocally, the unavoidable fluctuations in blast furnace operation do not perturb the functioning of the plasma heater. Plasma heaters have a high thermal efficiency (80%) and their electrical behaviour is excellent (power factor >0.9 and no harmonics).

Model simulations show that H_2 overheated by plasma torches and injected through the main tuyeres instead of hot blast, following the PIROGAS process as described above, will decrease the coke rate drastically to 143 kg/thm. However, such an operation has never been demonstrated on a modern Blast Furnace. By assuming that such an operation is feasible, the CO_2 emissions will fall to 0.846 t CO_2/tcs.

It may be concluded from above discussion that for iron ore based steel making using all technically proven processes for production and energy conservation, the limiting CO_2 reduction could be achieved at a level of 1200-1300 kg/t of steel as shown in Fig.-4[4].

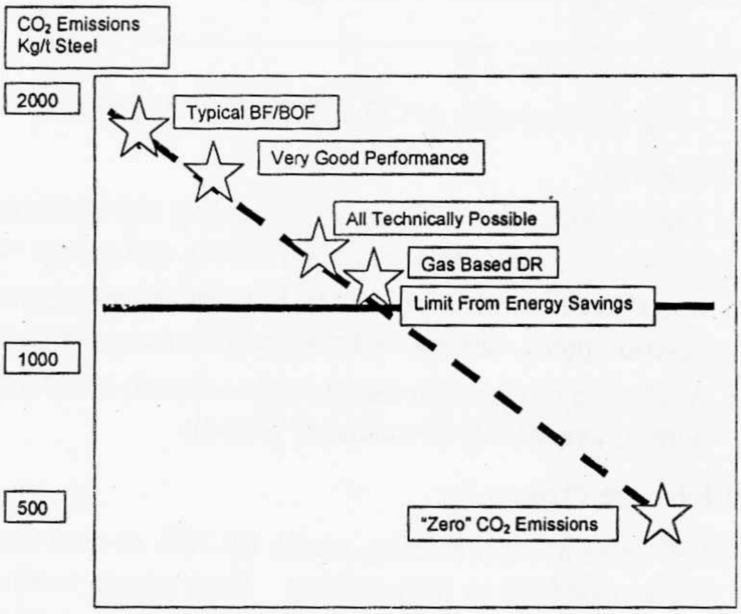

Fig. 4 : CO_2 Emissions from iron ore based steel making

Further reduction is possible only by adopting plasma heating and hydrogen based technologies.

ENERGY CONSUMPTION AND CO_2 EMISSION SCENARIO AT TATA STEEL

Energy consumption scenario at Tata Steel along with a comparison with IISI average is furnished below in Table 4.

Table 4 : Energy consumption at Tata Steel

Production Process	Hoogoven GCal/tcs	Kimitsu Gcal/tcs	Consumption at Tata Steel GCal/tcs	IISI Average GCal/tcs	Gap with respect to IISI
Coke Making	0.565	0.458	1.044	0.516	0.528
Sinter Plants	0.524	0.671	0.562	0.433	0.129
Iron Making	2.85	3.387	3.785	2.544	1.241
Steel Making	0.054	0.115	0.314	0.040	0.274
Wire Rod Mill	0.66	0.423	0.052	0.049	0.003
Section Mill			0.058	0.078	(-) 0.020
Hot Strip Mill			0.410	0.223	0.187
Boilers/Utilities	Nil	Nil	0.667	0.026	0.641
Auxiliaries	0.05	0.143	0.543	0.191	0.352
TOTAL	4.703	5.197	7.435	4.100	3.335

Energy consumption in steel industry has direct impact on CO_2 emission and in most of the Steel Plants world wide, energy is derived from fossil fuel. At Tata Steel, the overall CO_2 emission trend is furnished in Fig. 5. A comparison of over all CO_2 emission from various steel plants in the world is also presented below in Table 5.

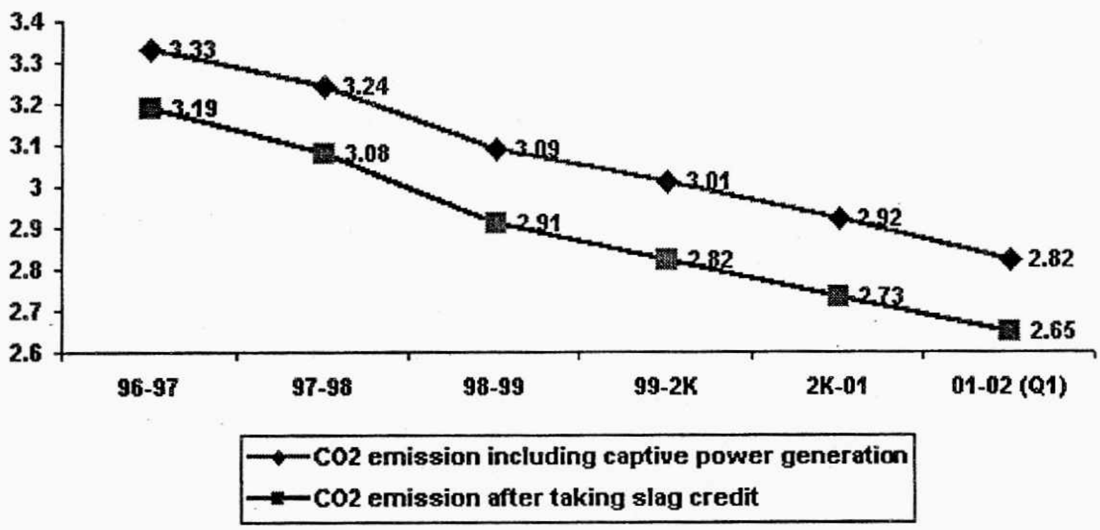

Fig. 5 : CO_2 emission at Tata Steel

The table shows wide variation in CO_2 emission from various plants. This is mainly due to variations in technology adopted, power mix and difference in auxiliary facility and power generation practices. There are many steel plants which are outsourcing the facilities like, Refractory and Lime Production, Coal based Power Plants and Foundries etc.

Table 5 : CO_2 Emission from various plants.

Steel Plant	CO_2 Emission (kg/t of steel)
Hoogovens Steel, Holland	1200 (FY 1998)
Dofasco, Canada	1300 (FY2000)
Kimitsu Works, NSC, Japan	1845 (1999-2000)
Raahe Steel Works, RAUTARUKKI Steel, Finland	1900 (FY 1998)
Tata Steel, India	2650 (2000-2001)
SAIL, India	2900 (1999-2000)

Gap Analysis

Following factors are responsible for the gaps in CO_2 emission and energy consumption at Tata Steel :

Coke Making	:	Lower coke, gas and tar yield; higher steam consumption, higher fuel rates are largely responsible for the gaps.
Sinter Making	:	Higher coke breeze consumption, absence of sensible heat recovery.
Iron Making	:	Higher coke rate; lower hot blast temperature; higher steam consumption, poor solid waste recycling, lower top gas pressure (No TRT).
Steel Making	:	Lower gas recovery, large slag volumes, more O_2 consumption.
Mill	:	Lack of hot charging. Low furnace efficiency, high power consumption.
Boilers & Power Houses	:	Inefficient boilers, low pressure steam generation, poor power generation efficiency and large auxiliary power consumption.
Auxiliaries	:	Large bleeding losses, steam/compressed air leakages, large fleet of smaller carriers consuming more diesel and several auxiliary facilities like Refractories and Lime Production, Foundries, Engineering Shops etc. (which are outsourced in modern plants).

Actions Planned to Reduce Gaps

- Reduction in ash percentage in BF coke to 17.5% by using low ash coal from Australia.
- Reduction in alumina content in blended fines by 0.20% through improvement in crushing and screening facilities.
- Up-gradation of "F" Blast Furnace and closure of "B" Blast Furnace.
- Closure of Top Charge Battery#3.
- Use of 100% by-product gases for steam and power generation by installation of two numbers of Boilers of 150 TPH capacity. This will have one back pressure turbine and all the old six Boilers at Boiler House#1 shall be shut down.
- Waste heat recovery from ammonia incinerator by installing a waste heat boiler in new incinerator of 10 TPH capacity.
- Improvement of condenser vacuum at Power House#4.
- Increase of CO gas yield to 330 Nm^3 / tdc by renovating Primary Cum Deep Coolers and reducing leakages.
- Waste oil injection into Blast Furnaces along with tar (10 barrels per day).
- Recovery of flash steam from Boiler blow down at PH#4.
- Reduction of steam consumption in Canteens through provision of Pressure Reducing Station (PRS) in all canteens.
- Reduction of steam consumption in Blast Furnaces.
- Reduction of steam leakages by changing old steam lines.
- Optimization of pump operation at PH#2.
- Recovery of additional LD gas (10,000 Nm^3 / hr) by installing additional gas booster and modifying distribution network.
- Enhanced supply of CO gas to PH#4 by modification of Booster suction and by installing additional Booster.
- Energy saving items at Oxygen Plant (replacement of electrical heater by steam heater, replacement of heat exchanger by direct cooler).
- Replacement of Air Separation Units (ASU1 and ASU2) columns with new columns having structured packing.
- Coke rate reduction in A-G Blast Furnaces by 30 kg per ton of hot metal.
- Coal tar injection in "C" Blast Furnace.
- Sensible heat recovery from "G" Blast Furnace stove waste gases.

These measures are planned to be implemented by December 2003 and the projected energy consumption will be reduced to 6.60 GCal/tcs from a level of 7.435 GCal/tcs in 2000-2001. The corresponding CO_2 emission shall be of the order of 2.1 ton per ton of crude steel. Tata Steel is also planning to get its plant audited for energy by M/s. Nippon Steel Corporation, Japan, to reduce the energy consumption at its plant to less than 6.0 GCal/tcs.

Other options under study for implementation in the long run at Tata Steel are presented below. These options when implemented will further reduce the energy consumption to a level of 5.50 GCal/tcs and with corresponding CO_2 emission around 1900 kgs/tcs.

- TRT for "G" Blast Furnace.
- Coke Dry Quenching.
- Waste Heat Recovery from sinter coolers.
- Second LD Gas Holder.
- Waste heat recovery from A-F Blast Furnaces.
- Sensible heat recovery from LD Gas.
- Automatic heat input control in Coke Oven Batteries#5, 6 & 7.
- 100% BF slag granulation (potential reduction 8-10%).
- Phasing out of PH#3 (potential 30% less for equivalent power, if purchased from Tata Power).
- Coke oven gas injection in Blast Furnace.

FLEXIBLE MECHANISM FOR CO_2 REDUCTION - GLOBAL RESPONSE

Only a few countries have introduced energy taxes related to CO_2 emissions. Table 6 gives the details of energy taxes introduced [7] in some of the countries. With regard to CO_2 emission, these taxes would lead to more energy efficient industry.

Table 6 : Energy taxes in the EU (1996) for industrial manufacturing
(In Euro Currency)

Country	Heavy Fuel Oil (100 kg)	Coal (1000 kg)	Natural Gas (1000 m^3)
Austria	38	-	52
Belgium	19	-	-
Denmark	16	1	1
Finland	36	12	12
France	24	-	13
Germany	20	-	21
Greece	42	-	-
Ireland	13	-	-
Italy	43	-	6-10
Luxembourg	19	-	-
Netherlands	31	11	8
Portugal	28	-	-
Spain	13	-	1.5%
Sweden	47	25	20
United Kingdom	22	-	-

Considering the taxation content of the debates on environmental impacts, Europe appears to be at the leading edge of 'green' taxes. A report from the European Environment Agency (EEA) in Copenhagen claimed that 'green' taxes adopted by individual European countries over the past decade were gaining acceptance. They included revenue-producing fiscal taxes, incentive taxes designed to change environmental attitudes and 'cost-covering charges' intended to charge polluters for the cost of regulating emissions. Moreover, the European Commission has declared its strong interest in green taxes in its Fifth Environmental Action Plan. Newly industrialized countries such as Korea, Taiwan and Singapore are beginning to follow Europe's lead with energy and waste taxes.

Certain observers believe that 'green' taxes are unlikely in the USA, at the federal level, in the immediate future, owing partly to the complexity of, and the 'checks and balances' within, the legislative process. However, some action is occurring at the State level. For example, Louisiana has introduced an 'environmental scoreboard' for companies to measure compliance with environmental laws. Good scores were rewarded with graded exemptions from property taxes.

Notwithstanding the varied legislative and fiscal background, international public policy might seek to impose carbon taxes or similar restrictions on CO_2 emissions, which would impact negatively on the International Iron and Steel Industry. A Carbon/ CO_2/Energy Tax would have a damaging impact on the steel industry's costs, its profitability and hence its ability to survive and invest. A tax applied in an unequal way could result in production switching to less efficient steel producers, thereby increasing total global CO_2 emissions.

Reduction of emissions from the international steel industry will be most effectively reduced by maximizing the recycling of scrap, the transfer of technology to producers with higher energy efficiency and the development of more efficient processes.

CONCLUSIONS

The carbon dioxide emission from Steel Plants has been recognized as an important concern globally. In the past two decades steel industry has reduced CO_2 emission by 15-20% by adopting newer technologies and improvement in processes. Further reduction by 15-20% is expected in next decade by implementation of newly developed techniques and controls. Drastic reduction in CO_2 emission is possible only by adoption of technologies like plasma heating, CO_2 recovery, BF and CO gas injection in Blast Furnaces and use of hydrogen on commercial scale in iron ore smelting. Increased use of recycled steel will also play an important role. Life Cycle Assessment for steel products to improve product quality and strength including weight of product will enhance consumer confidence besides reducing the environmental burden. Further reduction of CO_2 in the steel plant globally can come only through adopting flexible mechanisms and CO_2 trading.

At Tata Steel, various measures initiated and to be implemented in next five years will reduce CO_2 emission and energy consumption to world average levels.

There are challenges and opportunity available in steel industry to address this vital issue of CO_2 reduction which is essential for its survival.

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