ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

PRODUCTION OF GREEN STEEL THROUGH GREEN MANUFACTURING USING MOST INNOVATIVE GREEN AND CLEANER TECHNOLOGY

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DOI: 10.5281/zenodo.557206

ABSTRACT
Green & clean technology is the only solution for human survival on earth. This research paper is focused on the methods of green manufacturing to reduce the waste and pollution. Green manufacturing (GM) is a term used to describe manufacturing practices that do not harm the environment during any part of the manufacturing process. The paper also highlights development of a product with less wastage. Many numbers of organizations have begun working towards implementation of Green Manufacturing (GM) because of increased concerns about the pollution increase, natural resources depletion and global warming. The CO_2 emission and the waste that is generated from the industry is one of the main factors for the environmental degradation which leads to global warming and acid rain. Green product, green manufacturing and green energy are essential for this purpose. Specific emphasis has been laid on polluting iron and steel industries.

KEYWORDS: Green Manufacturing, Clean Energy, Green steel, recycling, reheating, water management

INTRODUCTION
Green technology is the application of one or more of environmental science, green chemistry, environmental monitoring and electronic devices to monitor, model and conserve the natural environment and resources, and to curb the negative impacts of human involvement [1]. The need of achieving higher economic prosperity with least environmental impact has led to a new manufacturing paradigm of Green Manufacturing (GM). GM means designing, manufacturing, delivering, and disposing products that produce minimum negative effect on environment and society and are economically viable [2].High energy consumption and pollution" constrains the development of iron industry. Confronted with such bottleneck, green manufacturing, an advanced manufacturing mode has been considered as an effective mode to solve such problem. Based on analyzing the present situation of iron industry, it is figured out that the energy saving and emission reduction are arduous, besides corporate social responsibility is default [3].The main reducing agents in a blast furnace are coke and powdered coal forming carbon monoxide and hydrogen, which reduce the iron oxides. Coke and coal also partly act as fuels. Coke is produced from coal by means of dry distillation in a coke oven and has better physical and chemical characteristics than coal. In many cases, additional reducing agents or fuels are supplied by injection of oil, natural gas and, in a few cases, plastics. A hot blast provides the necessary oxygen to form the carbon monoxide, which is the basic reducing agent for the iron oxides [4] .Steelmaking slag, is a by-product of the steelmaking process. Nevertheless, as has been described so far, almost all steelmaking slag that produced is effectively utilized as a material for road base course material in road construction and other civil engineering projects, calcium-oxide-based reformer (for ground improvement, soil improvement), and raw materials for cement, fertilizer because of its excellent mechanical properties and functions. Because many of these uses represent natural substitutes for man-made materials, we consider that the expansion of the applications of slag is an activity that greatly contributes to environmental conservation. In the future, we wish to further contribute to our society by pressing ahead with the development of new functions for steelmaking slag and further expanding its application [5].China is the largest iron production and consumption country in the world. In 1996, Steel output exceeded 100 million tons in China, and China became the first iron production country. Statistical data revealed that in the first half of 2007 cumulative output of crude steel were 237.1 million tons, a 17.8% increase. Iron industry is one of the biggest industries of resource consumption and pollution emission. Relevant data show that, in iron industry, the total energy consumption amounts to 14.71%. In the past five

years, the comprehensive energy consumption per ton of iron has reduced by179 kgce/t, but there is still a large gap to achieve the level in developed countries that is between 12% and 15% [6].Green Manufacturing organizations manufacture products using materials and process that minimize negative environmental impact, help in the reduction of greenhouse gases(GHGs), conserve energy and natural resources, improve safety for consumers, communities and employees and at the same time increase profitability of their organizations as a whole [7]. India is currently the fourth largest producer of crude steel in the world and is expected to become the second largest in the near future. The total market value of the Indian steel sector stood at US$ 57.8 billion in 2011 and is predicted to touch US$ 95.3 billion by 2016. The sector contributes to nearly 2 per cent of the gross domestic product (GDP) and employs over 500,000 people [8].Steel is one of the pillars of the well being of modern societies and it will definitely continue to play an important role in the 21st century. Steel is also a mature basic material and is one of the most environmentally benign mass products due to its high recycling rate and comparatively low quantities of energy required for its making. However, the emission of CO2 is a serious problem for steel industry because steel industry relies heavily on fossil fuels as energy source and limestone for the purification of iron oxides. Steel industry contributes around 6 % - 7% to total anthropogenic emission of CO2. Steel works now face with the increasing demand to minimize emission of GHGs. This situation is intensifying the pressure on steel makers and will certainly impact the direction of the development of steel industry in the 21st century [9].The term green manufacturing can be looked in two ways: the manufacturing of green products, particularly those used in renewable energy systems and clean technology equipment of all kinds, and the greening of manufacturing reducing pollution and waste by minimizing natural resource use, recycling and reusing what was considered waste, and reducing emissions[10].

METHODS-

2. Green Technology-

2.1-Preating steel scrap-Since the EAF process can use up to 100 % scrap for the production of crude steel, it is the main process in which the technology of scrap preheating applies. However, the primary route can use up to 30 % scrap in its process, and because it is the dominant route, the technology of scrap preheating is also valuable for this route. This description will mainly focus on the EAF process. The EAF process has four main outputs:-

a) The liquid steel itself;
b) Cooling losses;
c) Slag
d) Hot waste gases which account for approximately 15 to 20 % of the output.

Essentially, scrap preheating is a technology that uses the hot waste gases of the furnace to preheat the scrap charge. The scrap charge is the scrap that is the input into the EAF process. Preheating the scrap with the hot waste gases lowers the power consumption of the EAFs, as it removes the need for combusting fuel to heat the scrap.

2.1.1-Scrap bucket charge process-In this process, a conventional scrap charging bucket preheating system is schematically illustrated. Preheating scrap has several advantages:

a) Reduced energy consumption;
b) Removal of moisture from the scrap;
c) Reduced electrode consumption;
d) Reduced refractory consumption.

However, the method of scrap charging bucket preheating has some disadvantages limiting its use:

a) Inconvenient to operate as the scrap sticks to the bucket;
b) A short bucket life;
c) Poor controllability of preheating;

The logistics of this method of preheating lead to minimum energy savings.

2.1.2-Consteel Process-

The Consteel process consists of a conveyor belt which carries the scrap through a tunnel, down to the EAF through a hot heel, the technology is in a mature stage with 8 installations in the U.S. and 35 installations worldwide. The conveyor belt continuously transports the scrap charge to the EAF, while the charge is preheated by off gases leaving the furnace. The continuous feeding of the preheated scrap to the EAF is one of the main differing characteristics with other methods.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

2.1.3-The Fuchs shaft furnace-

In contrast to the continuous feed system of the Consteel process, the Fuchs shaft furnace is a batch feed system. Within the shaft, scrap is preheated by low velocity gases from the EAF and then dropped into the EAF. Like the Consteel and scrap bucket charge, this technique is in its mature stage.

2.2- Utilization of steel-waste materials for production of calcium carbonate ($CaCO_3$)-

The steel industry produces, besides steel, also solid mineral by-products or slags, while it emits large quantities of carbon dioxide (CO_2). Slags consist of various silicates and oxides which are formed in chemical reactions between the iron ore and the fluxing agents during the high temperature processing at the steel plant. Currently, these materials are recycled in the iron making processes, used as in construction, or land filled as waste. The utilization rate of the steel slags can be increased by selectively extracting components from the mineral matrix. As an example, aqueous solutions of ammonium salts such as ammonium acetate, chloride and nitrate extract calcium quite selectively already at ambient temperature and pressure conditions. After the residual solids have been separated from the solution, calcium carbonate can be precipitated by feeding a CO_2 flow through the solution. Precipitated calcium carbonate (PCC) is used in different applications as a filler material. Its largest consumer is the papermaking industry, which utilizes PCC because it enhances the optical properties of paper at a relatively low cost. Traditionally, PCC is manufactured from limestone, which is first calcined to calcium oxide, then slaked with water to calcium hydroxide and finally carbonated to PCC. This process emits large amounts of CO_2, mainly because of the energy-intensive calcinations step. This paper presents research work on the scale-up of the above-mentioned ammonium salt based calcium extraction and carbonation method, named Slag2PCC. Extending the scope of the earlier studies, it is now shown that the parameters which mainly affect the calcium utilization efficiency are the solid-to-liquid ratio of steel slag and the ammonium salt solvent solution during extraction, the mean diameter of the slag particles, and the slag composition, especially the fractions of total calcium, silicon, vanadium and iron as well as the fraction of free calcium oxide. Regarding extraction kinetics, slag particle size, solid-to-liquid ratio and molar concentration of the solvent solution have the largest effect on the reaction rate. These findings are implemented in demonstration scale experimental process setups. For the first time, the Slag2PCC technology is tested in scale of ~70 liters instead of laboratory scale only. Additionally, design of a setup of several hundreds of liters is discussed. For these purposes various process units such as inclined settlers and filters for solids separation, pumps and stirrers for material transfer and mixing as well as gas feeding equipment are dimensioned and developed. Overall emissions reduction of the current industrial processes and good product quality as the main targets, based on the performed partial life cycle assessment (LCA), it is most beneficial to utilize low concentration ammonium salt solutions for the Slag2PCC process. In this manner the post-treatment of the products does not require extensive use of washing and drying equipment, otherwise increasing the CO_2 emissions of the process. The low solvent concentration Slag2PCC process causes negative CO_2 emissions; thus, it can be seen as a carbon capture and utilization (CCU) method, which actually reduces the anthropogenic CO_2 emissions compared to the alternative of not using the technology. Even if the amount of steel slag is too small for any substantial mitigation of global warming, the process can have both financial and environmental significance for individual steel manufacturers as a means to reduce the amounts of emitted CO_2 and land filled steel slag. Alternatively, it is possible to introduce the carbon dioxide directly into the mixture of steel slag and ammonium salt solution. The process would generate a 60-75% pure calcium carbonate mixture, the remaining 25-40% consisting of the residual steel slag. This calcium-rich material could be re-used in iron making as a fluxing agent instead of natural limestone. Even though this process option would require less process equipment compared to the Slag2PCC process, it still needs further studies regarding the practical usefulness of the products. Nevertheless, compared to several other CO_2 emission reduction methods studied around the world, the within this method developed and studied processes have the advantage of existing markets for the produced materials, thus giving also a financial incentive for applying the technology in practice.

List of abbreviations and symbols

BOF - ----Basic oxygen furnace

CCUS -------- Carbon dioxide capture, utilization and storage

GCC--------- Ground calcium carbonate

PCC------------ Precipitated calcium carbonate

Slag2PCC------- Process concept for production of precipitated calcium carbonate from steel slags

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

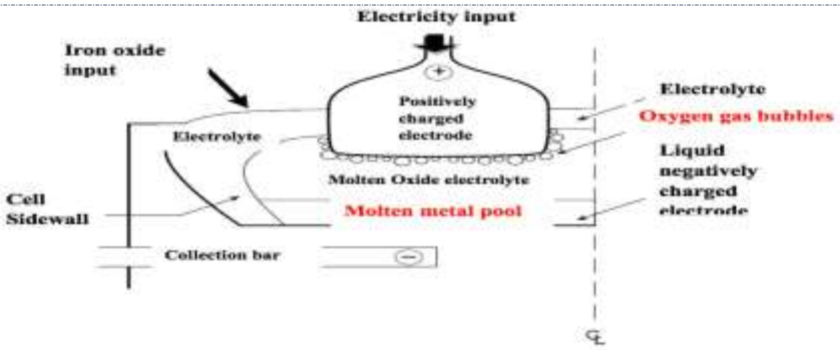
Ca------ Calcium
$CaCl_2$-------- Calcium chloride
$CaCO_3$--------- Calcium carbonates (calcite, aragonite, and limestone)
CaO------------ Calcium oxide (free lime)
$Ca(OH)_2$--------- Calcium hydroxide
$CaSiO_3$--------Calcium silicate
Ca_2SiO_4-------- Dicalcium silicate
CO_2---------- Carbon dioxide
$(CO_3)_2$------- Carbonate ion
HCl -------Hydrochloric acid
NH_4Cl ---------Ammonium chloride
$(NH_4)_2CO_3$---- Ammonium bicarbonate
NH_4OH----- Ammonium hydroxide

Industrial waste materials can be utilized to partly replace existing production of calcium-rich materials such as calcium carbonate ($CaCO_3$), which currently is primarily based on natural resources. Examples of solid, calcium-containing waste streams suitable for carbonate production are different ashes, gypsum waste and cementitious materials as well as slags from steelmaking industry. This work focuses on usage of steel slags, in particular steel converter or basic oxygen furnace (BOF) slag, because of their high calcium content compared to several other alternatives.

$$CaO(s) + 2NH_4Cl(aq) + H_2O(l) \rightarrow CaCl_2(aq) + 2NH_4OH(aq)$$
$$Ca_2SiO_4(s) + 2NH_4Cl(aq) + H_2O(l) \rightarrow CaCl_2(aq) + CaSiO_3(s) + 2NH_4OH(aq)$$
$$2NH_4OH(aq) + CO_2(g) \leftrightarrow (NH_4)_2CO_3(aq) + H_2O(l)$$
$$(NH_4)_2CO_3(aq) + CaCl_2(aq) \leftrightarrow CaCO_3(s) + 2NH_4Cl(aq)$$

2.3-molten oxide electrolysis method to produce green steel-Producing steel that is free of CO_2 emissions this process, known as molten oxide electrolysis (MOE), was initially employed to generate oxygen. The product generated was oxygen and, steel. This research paper gives details the working of MOE, a process which uses electricity as a means of breaking down iron oxide (key raw material) into its metal form and releasing oxygen. Very pure steel was produced as an unintentional by-product of the process, without any CO_2 generation. Conventional steel-making route involves heating iron oxide in a furnace along with coke at temperatures ranging from 900°C to 1,300°C and producing hot metal with impurities such as carbon and trace amounts of sulphur, and huge amounts of CO_2. M.O.E. (see 'Molten oxide electrolysis' process), however, works at 1,600°C, produces pure carbon-free steel and zero CO_2 emission. Like any other electrolysis process, M.O.E. consists of two oppositely charged plates—electrodes—immersed in a solution containing iron oxide along with other metal oxides—electrolyte. Electricity is passed through these electrodes into the electrolyte and the end product is molten iron, which collects on the negatively charged electrode and oxygen is released from the positive electrode. Since the purpose of the research was to generate oxygen using lunar soil to be used in possible future human bases on the moon, the process was performed on lunar-like soil, rich in iron oxide. Being an electricity-intensive process, M.O.E. consumes approximately 3,500 units of electricity to produce one tonne of steel. This electricity was supplied from a carbon-free source (possibly a renewable source) and had an emission factor (ratio between the amount of carbon dioxide produced and the amount of raw material, processed) of 0.09 kg of CO_2 per unit of electricity generated (kWh). Total CO_2 generated was 0.315 tonne CO_2 per tonne of steel, a five-fold decrease from the current conventional steel-making process.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7



2.4 Direct-reduced iron (D.R.I.)-It is also called sponge iron, is produced from the direct reduction of iron ore (in the form of lumps, pellets or fines) to iron by a reducing gas or elementary carbon produced from natural gas or coal. Many ores are suitable for direct reduction. Reduced iron derives its name from the chemical change that iron ore undergoes when it is heated in a furnace at high temperatures in the presence of hydrocarbon-rich gases, carbon monoxide or elementary carbon. Direct reduction refers to processes which reduce iron oxides to metallic iron at temperatures below the melting point of iron. The product of such solid state processes are called direct reduced iron. The reducing gas is a mixture of gases, primarily hydrogen (H_2) and carbon monoxide (CO). The process temperature is typically 800 to 1200 °C. Direct reduction processes can be divided roughly into two categories, gas-based, and coal-based. In both cases, the objective of the process is to drive off the oxygen contained in various forms of iron ore (sized ore, concentrates, pellets, mill scale, furnace dust etc.), in order to convert the ore, without melting it (below 1200 °C), to metallic iron. The direct reduction process is comparatively energy efficient. Steel made using DRI requires significantly less fuel, in that a traditional blast furnace is not needed. DRI is most commonly made into steel using electric arc furnaces to take advantage of the heat produced by the DRI product. In modern times, direct reduction processes have been developed to specifically overcome the difficulties of conventional blast furnaces. DRI is successfully manufactured in various parts of the world. The initial investment and operating costs of direct reduction plants are low compared to integrated steel plants and are more suitable for developing countries where supplies of coking coal are limited.

Factors that help make DRI economical:-

1-Direct-reduced iron has about the same iron content as pig iron, typically 90–94% total iron (depending on the quality ofthe raw ore) as opposed to about 93% for molten pig iron, so it is an excellent feedstock for the electric furnaces used by mini mills, allowing them to use lower grades of scrap for the rest of the charge or to produce higher grades of steel.

2-Hot-briquetted iron (HBI) is a compacted form of DRI designed for ease of shipping, handling, and storage.

3-Hot direct reduced iron (HDRI) is iron not cooled before discharge from the reduction furnace that is immediately transported to a waiting electric arc furnace and charged, thereby saving energy.

4-The direct reduction process uses pelletized iron ore or natural "lump" ore. One exception is the fluidized bed process which requires sized iron ore particles.

5-The direct reduction process can use natural gas contaminated with inert gases, avoiding the need to remove these gases for other use. However, any inert gas contamination of the reducing gas lowers the effect (quality) of that gas stream and the thermal efficiency of the process.

6-Supplies of powdered ore and raw natural gas are both available in areas such as Northern Australia, avoiding transport costs for the gas. In most cases the DRI plant is located near natural gas source as it is more cost effective to ship the ore rather than the gas. This method produces 97% pure iron.

India is the world's largest producer of direct-reduced iron, a vital constituent of the steel industry. Many other countries use variants of the process, so providing iron for local engineering industries.

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2.4.1- COAL D.R.I. PLANT-The coal based iron making process involves direct reduction of iron ore to solidified iron in a rotary kiln. The process uses non-coking coal which acts both a reducing agent and an energy source. Lump ore (and increasingly ore pellets) is used as iron burden. In the coal based direct reduced iron (DRI) process, a part of the non-coking coal and the entire lump iron ore (both of size 5-20 mm) are fed at the higher end of the kiln. Limestone or dolomite is also added for removing the sulphur present in coal. Combustion air is fed at the discharge end, and by special fans located throughout the length of the kiln shell. The product appears in the form of spheroids with sponge like appearance. This process is also called coal based sponge iron process.

The reaction gases coming out from the kiln is burnt in an after burning chamber for removing traces of carbon monoxide. The flue gases are finally passed through an ESP to capture the dust before release through the stack. The coal DRI process is extremely polluting by nature. The major air pollution sources are the kiln exhaust gases and the cooler discharge/production separation areas. The other significant sources of air pollution are the coal and iron ore storage and handling areas. Further, the process also generates large amounts of solid wastes, which are not recyclable and hence land-filled, mostly outside plant premises.The coal DRI process urgently needs overall improvement in raw material quality, operational performance, control of air emissions and management of solid waste disposal, among others.

2.4.2- GAS D.R.I. PLANT-Gas based Direct Reduced Iron (DRI) production process uses natural gas instead of coal as a source of energy and reducing agent. Natural gas which mainly contains methane is converted into reducing gas - a mixture of carbon monoxide and hydrogen, using reformer. The reformed gases are used in shaft furnace for reduction of iron ore in DRI.The gas based process produces DRI with high degree metallic iron and it also enables lower specific energy consumption and lesser pollution problems. MIDREX and HYL are two different gas based DRI production technologies installed in Indian plants. Limited natural gas availability and high price has been a major reason behind limited capacity addition of gas based DRI plants in India. Technologies for achieving better energy efficiency and air pollution control have been the key aspects for consideration in the gas based DRI plants globally.

2.5 PULVERIZED COAL INJECTION (P.C.I.) -The technology of PCI in blast furnace not only enhances energy utilization efficiency but also increases productive efficiency. PCI is the short form of Pulverized Coal injection. Declining supply of quality coking coal and escalating prices of coke have led iron and steel manufacturers to seek other carbon-based products to reduce the consumption of the more expensive coke. One solution is the technology of injecting pulverized coal into a blast furnace as an auxiliary fuel to reduce the amount of coke consumed and therefore to reduce operating costs in the production of pig iron and then ultimately crude steel. The technology involves injecting very fine particles of coal at high rates into the chamber of the blast furnace as a fuel.

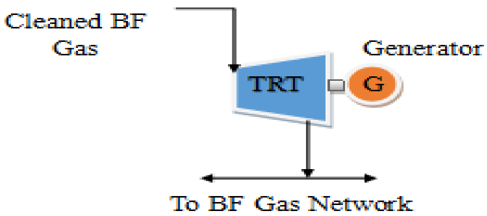
2.6 COKE DRY QUENCHING (C.D.Q.)- Coke making process involves quenching of red hot coke produced from coke oven. In case of wet quenching, significant quantity of water is lost during quenching. Besides, waste water is also generated and heat is lost in the environment. Dry quenching method saves water (around 0.5-1.0 m3/tonne of gross coke), reduces water pollution as well gives opportunity for waste heat recovery of around 0.286 GCal/tonne gross coke. Stable coke quality and energy efficiency of the process are key driving forces for this technology.Indian best practice:- As of 2009-10, only two integrated plants in India had installed CDQ facilities - Vizag steel (for all four batteries) and Neelachal Ispat Nigam Limited (for one battery).

2.7 CONTINUOUS CASTING TECHNOLOGY (C.C.T.)-C.C.T. is an energy efficient casting method that could enhance energy utilization efficiency greatly. Continuous casting transforms molten metal into solid on a continuous basis and includes a variety of important commercial processes. These processes are the most efficient way to solidify large volumes of metal into simple shapes for subsequent processing. Most basic metals are mass produced using a continuous casting process, including over 500 million tons of steel in the world each year. The development of CCT not only saves energy, promotes finished steel products rate, decreases cost, but also solves
the mutual confining problem of mold casting, initiative roll process.

2.8 Oil Injection -Heavy fuel oil or waste oil can also be injected instead of coke. The coke replacement rate is 1 ton of oil (0.9 tonnes) to replace 1.2 tons (1.1 tonnes) of coke. Like natural gas, oil contains hydrogen, leading to decreased CO2 emissions. If oil injection is used along with oxygen burner technology, the amount of oil injected can be increased by 100 percent as compared to regular burners. This increase would correspond to a one-to-one weight ratio between the oil injected and the hot metal produced.

2.9 Top Pressure recovery Turbine (T.R.T.) - Green Technology refers to the advancement in the technical evolution for power generation. In this paper, a green technology called Top Pressure Recovery Turbine (TRT) is used. TRT is a clean and efficient technology, mainly consisting of a gas expansion turbine with pressure control mechanism coupled to an alternator. The TRT runs on utilizing pressure and flow of blast furnace gas (BFG) to rotate the turbine. BFG is produced during the reduction of Iron ore to Iron (liquid metal) in Blast Furnace and this is the heart of iron making process simply referred to as Blast Furnace Model. This gas is recovered from the top of the blast furnace and given to the Gas Cleaning Plant (GCP), where the dust and other particles are removed using scrubber mechanism. Purified or cleaned gas is then fed on to the gas turbine, where gas expands and the pressure energy of BFG rotates the turbine which is coupled to an alternator as shown in Fig. Here TRT involves utilization of pressure energy to generate power and no intermediate thermal energy is generated in the project activity. At the same time the low pressure BFG at the turbine outlet is passed through the BFG network and further used in the thermal Power Plant (TPP) boilers along with coal and COG for power generation [11].

Fig. is shown below



2.10 Polymer Injection Technology (P.I.T.)-It prevents millions of old car tyres ending up in landfill while reducing the economic and environmental of steel manufacturing. Importantly, PIT doesn't have any bad effects on steel quality and it improves the environmental sustainability of the steelmaking process. For builders, engineers and architects, this means they can take advantage of steel's strength and flexibility while boosting their environmental credentials. In fact, using PIT will earn one Green Star point if using reinforcing steel in buildings. Savings of 15–35 per cent on total carbon injectant costs makes the technology attractive for fabricators, distributors and developers, who can expect improvements in yield and productivity, inject oxygen consumption, refractory and electrode consumption and injection system wear. It uses recycled polymers (particularly old car tyres and high-density polyethylene plastic) as alternate carbon injectants to produce the foaming slag required for the electric arc furnace (EAF) steel making process. Conventionally, non-renewable coke or anthracite is used to produce the slag that acts as a blanket over the molten steel during the steelmaking process. This practice has faced criticism for its energy consumption, but PIT boosts the volume and foaming properties of the slag, which improves electrical energy efficiency by 3 per cent – a figure not to be sneezed at considering electricity costs can represent more than 20 per cent of the per-tonne cost of steel. PIT has been shown to perform better than metallurgical coke alone in EAF and can reduce the total amount of inject carbon required per heat by 10–20 per cent, while decreasing heat loss through the slag and sidewalls. Ultimately, the technology delivers cost savings through reduced energy consumption, cheaper injectables and lower greenhouse gas emissions.

2.10.1-Case Study On polymer injection technology-Polymer Injection Technology is an exciting new patented process, which partially substitutes the use of coke with polymers, including rubber, as an alternate carbon injectant to produce foaming slag in Electric Arc Furnace (EAF) steel making. This innovation offers an excellent opportunity to improve steel cost efficiency while having a positive impact on the environment through energy savings and recycling polymers, including rubber. Implementation of this technology at One Steel's Sydney and Melbourne based EAF facilities achieved the following benefits:

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

2.10.2 One Steel's Sydney Steel Mill- is located in the outer suburbs of Sydney, Australia. The melt shop was commissioned in 1992 and it produces 570,000 tonnes of product a year using a high performance EAF to produce billets from scrap steel. Scrap makes up about 85% of the charge with the remainder made up of pig iron. In Initial trials of the new technology were conducted over 14 months and concluded successfully in May 2007. The design and modification of the injection equipment was carried out in-house and injection initially occurred on the second bucket only. The Mill then proceeded to inject the new polymer blend throughout the whole heat as standard procedure. Injection occurred over 6-8 heat sequences using a Fuchs door lance. Following the completion of successful trials, Polymer Injection was then trialled over a 24-hour period. Ending July 2008, One Steel has conducted 3,115 heats using coke/rubber injectant blend. In the production of 3,115 heats, One Steel diverted approximately 38,000 passenger tyres from landfill to value-added steel products. In operating this technology as standard practice at One Steel's Sydney Steel Mill, there is potential to recycle more than 85,000 passenger tyres per annum.The following table provides a sample of results achieved at Sydney Steel Mill during a recent trial conducted under controlled conditions:

SSM Summary	Specific Electrical Energy (kwh/t)	Carbon Injection (kg/heat)	Tonnes/minutes
Coke	424.00	462.00	2.12
Rubber Blend	412.13	406.91	2.20

- Reduced specific electrical energy consumption of approximately 3%
- Reduced carbon injectant of approximately 12%
- Increased furnace productivity (tonnes per minute) of 4%
- Slag FeO levels were maintained within the required range
- Reduced emission levels for NOx, CO and SO_2

In addition, the staffs at One Steel's Sydney Steel Mill have observed a longer electrode life span.

2.10.3 Laverton Steel Mill- located outside Melbourne became part of One Steel's operations in August 2007 following a merger with Smorgon Steel Group. Following the benefits One Steel achieved from Polymer Injection Technology at the Company's Sydney facility, One Steel proceeded to implement the technology at its Laverton, Melbourne EAF. Work to install the materials handling system was undertaken during December 2007 and January 2008. Initially, the team ran 258 heats with one injection module during which time specific energy savings similar to those achieved in Sydney were identified using a coke/rubber injection blend. As at July 2008, One Steel's Laverton facility is fully operational in the use of Polymer Injection Technology. The team now injects with 2 modules as standard practice and has undertaken 1414 heats using coke/rubber blend. In the production of 1,414 heats, One Steel diverted approximately 36,000 passenger tyres from landfill to value added steel products. In operating this technology as standard practice at One Steel's Laverton Steel Mill, there is potential to recycle more than 200,000 passenger tyres per annum.The following table provides a sample of results achieved at Laverton Steel Mill during a recent trial under controlled conditions:

SSM Summary	Specific Electrical Energy (kwh/t)	Carbon Injection (kg/heat)	Tonnes/minutes
Coke	398.50	1020.00	2.09
Rubber Blend	387.00	856.00	2.13

- Reduced specific electrical energy consumption of approximately 3%
- Reduced carbon injectant of approximately 16%
- Increased furnace productivity (tonnes per minute) of2%
- Slag FeO levels were maintained within the required range.

2.10.4 Features and Benefits of Polymer injection technology-

- Improved slag foaming resulting in reduced energy consumption and therefore lower greenhouse gas emissions produced by coal fired power stations.
- Reduced quantity of injectant required.
- Lower cost of rubber injectant over coke.
- Increased furnace productivity resulting from reduced power-on time.
- Reduced emission levels for NOx, CO and SO_2

CONCLUSION

On the basis of analyzing the present situation of iron industry points were put out that iron industry in the world is now in a dilemma, and increased wastage & pollution is default. Then analysis of the relationship between green manufacturing and wastage & pollution in iron industries is done. The concept and implication of Green manufacturing are discussed from the viewpoint of sustainable development in the steel industry. It is pointed out that adequate environment protection in a “green” iron & steel plant does not just mean a accept disposal of pollutants emitted from its operation units, but rather the effective implementation of a strategy whereby the formation of any polluting agents in any part of this plant is include proper choice and control of raw materials, and a constant endeavour effort to optimize the complete manufacturing process of the whole iron & steel plant. Through the findings of this work, recycling of steel scrap is suggested as an alternative to boost the local content of steel production, reduce energy consumption, carbon dioxide emission (as the world production and manufacturing system is going green). The implementation of green manufacturing focused on investigating the energy saving & co_2 emission from producing steel & effective utilization of recycling of steel scrap as a way of sustainable development in steel industry.

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