All the past years, the need was not felt strongly for Reduce, Reuse, Recycle or Recover in handling the Steel Plant waste, specially, sludges and dusts.

The Ministry of Environment & Forest (MOEF) has launched the Charter on "Corporate Responsibility for Environmental Protection (CREP)" in March 2003 which in nutshell directs all steel companies that

Industry shall not store/dump solid wastes outside the factory premises in any circumstances without prior permission of the Board. Industry shall submit a time bound action plan to reduce solid waste by its proper utilization and disposal.

In recent years, un-sustained mining practices have led to exploitation of natural resources causing extensive environmental degradation. Moreover, continually increasing demand for metals, declining ore grades and complex new deposits are all contributing to a rise in greenhouse gas (GHG) emissions from primary metal production. The consequence of this is fact that the mineral processing and metal production sector is coming under increasing pressure to improve the overall sustainability of its operations, especially by decreasing energy consumption, GHG emissions and waste disposal.

Global environmental compliance is an important objective in corporate activities. Government institutions and enterprises have taken various initiatives to contribute to sustainable development. It is associated with the moving towards a more Circular Economy (CE).

The concept of a circular economy has been first raised by British environmental economists Pearce and Turner in 1990, who pointed out that a traditional open-ended economy was developed with no built-in tendency to recycle, which was reflected by treating the environment as a waste reservoir. The aim of circular economy is to reduce the resources so that the system functions in an optimal way. An important advantage of circular economy systems is to keep the added value of products for as long as possible and eliminate waste (‘zero waste’).
During the production of steel, integrated steel plants utilize mostly five materials as raw materials, air, water, fuel and power.

In recent years, more and more attention is paid to the concept of a life cycle approach for sustainability of products and services. It is associated with Product Lifecycle Management (PLM) which is a system for overseeing manufacturing processes, from the design and development of a product to its ultimate disposal. This strategy aims at taking into account sustainability impacts (environmental, economic, and social) that a product or service will have throughout its life cycle from ‘cradle to grave’.

Industrial sustainability is the ultimate goal of modern society, particularly so for the iron and steel making industries.

Sustainable steelmaking goals were defined by Fruehan as:

- Conservation of natural resources (ore, coal, etc.)
- Reduction of greenhouse gas emissions
- Reduction of volatile emissions
- Reduction of landfill waste
- Reduction of hazardous waste

Steel production is one of the most important and fundamental industrial processes.

According to,’ zero waste’ strategy, waste generated in the steel-making sector need to be improved. In the steel works, four groups of solid waste should be mentioned:

- Iron & Steel slag
- Scale
- Scrap metal
- Dusts and Sludges

Depending on the type of waste, it can be returned to the process as energy source or raw material for steel fabrication or else be traded as co-product to other industrial applications. The reuse of these products is of great importance for the sector regarding both economical and environmental aspects.

Scale is the product of oxidation of the surface of steel products during their high temperature plastic processing (eg. rolling, forging, and extrusion). Scale is mainly a mixture of iron oxides at a different oxidation state and trace amounts of other metal oxides, which are admixture of converted steel. It is one of the most valuable secondary raw materials of iron and currently it is transferred to external customers for reuse.
**Scrap metal** is an important raw material for steel making in the secondary market. Iron present in the metallic form, requires only melting and final refining processes to obtain the full value of the product as a specific grade of steel.

**Recycling of dust and sludges** becomes possible only after overcoming technological problems related to giving them forms allowing their use as feed material. It is required to change this waste into the form of granules with sufficient strength, eg. Dust recycling is realized as outside recycling in cement plants, or at the plant, dust is re-circulated to the process.

A limitation of dust to be fully re-used is its variable composition and the high cost of implementing new technologies of recycling. But with the changed statutory obligations, public protest/ban against landfill and high cost of disposal has made it possible to economically recycle many wastes. The cost of storing 1 Mg of dust may account for 50% of the price of 1 Mg of steel rods. These dusts cannot be stored in open landfills.

However, there were high iron oxide bearing wastes which always had very lucrative return on investment and the technology too was available, but never put in practice for the facts known better to our past policy makers. For example briquetting the BOF sludge and use is as coolant.

In the metallurgy of iron and steel, ‘the problem has been presented of utilizing iron bearing materials, such as the fines of natural iron ore, the iron oxide-containing flue dust and sludge, which otherwise represent Waste products. In the reduction of iron ore to metal in the blast furnace, as well as in the refining of steel, lump ore is preferably used as a raw material source, or treating agent, because it is ‘a physical impossibility to introduce the relatively fine particles, as such, ore fines, flue dust and sludge into such metallurgical processes. As a consequence, natural iron ore fines, as well as the iron oxide containing by-products from blast furnace operations, such-as flue dust and sludge, have here before been discarded and their iron content becomes lost as a source of raw material.

This loss has amounted to very considerable proportions in the past.

Our Paper is confined to the reuse/recycle of high iron content sludge and dust in the form of briquettes to substitute high value steel scrap/coolant added to the BOF.

There are numerous methodologies and processes developed to recycle the steel plant waste, like collecting all fine dusts, sludge and mill- scale and agglomerate into micro pellets to use in the Sintering Plant or Blast Furnace as substitute to iron ore.
However, we should not use high iron containing oxides for micro pelletisation and use as substitute for low value iron ore when that rich iron oxide can be recycled as high value coolant for BOF.

**The Briquetting of Blast Furnace and Steel Melting Shop Sludge**

Numerous attempts have been made in past in India and abroad, to agglomerate fine particles of iron bearing material by mixing them with a binder and forming into briquettes. Tar, pitch, molasses, silicate of soda, glucose, cement, such as "Portland cement, have all been tried out as binding agents in making such briquettes.

However, these previous attempts possess certain disadvantages and meet with practical difficulties when commercial adaptation thereof has been attempted. The ideal metallurgical briquette for use in the iron and steel refining processes should possess the property of resisting spalling, shattering, and decomposition and thermal disintegration at high temperatures, otherwise the disintegration of the briquettes charged to a convertor, for example, merely results in the blowing of the fine particles out through the top with an incident increase in the fine dust and sludge waste. A satisfactory and successful briquette for commercial use should possess sufficient compression and impact strength so that it can withstand the rigorous handling to which it is subjected in conveyors, loading and charging devices. Such strength should be imparted to the briquette not only immediately upon its fabrication, but during its subsequent period of handling and storage prior to use. A satisfactory briquette ‘must also be resistant to leaching action, that its binder must be capable of withstanding the washing out action of water.

The use of incombustible binding agents should also be-kept to a .minimum if a satisfactory briquette is to be made, otherwise-the slag content of the melt is increased. Portland cement has also been used in the making of metallurgical briquettes, but such briquettes have been-found subject to the disadvantage of undergoing thermal disintegration at the temperatures encountered in blast furnace and convertor.

A briquette made from mix of SMS or BF sludge, Calcium Hydroxide and Mill Scale with a binder of water soluble molasses and silicate of soda is capable of withstanding thermal disintegration but it requires a drying period before it can be handled or stacked. The control of the moisture content of the briquette is of special importance. Not only the iron oxide raw material contains appreciable amount of moisture, but also the addition of more water to .the briquette through the medium of the binding agent increases the ‘ultimate moisture ‘content of the finished “product which is to be charged or fed to the
BOF. If such moisture content is too high, difficulty will be encountered in molding the briquettes, and also in the use of the briquettes due to the generation of an excessive amount of steam.

We have successfully prepared briquettes of a mix of BOF sludge and only molasses which had shown good results when charged to the BOF as coolant. However, it was found that if a mix of High Iron Oxide Sludge (total Fe +60% or more and dried to less than 8% moisture), mill-scale, quick lime fines and suitable binders is briquetted, cured over 110°C over a desired period has given a very good results to substitute it as coolant for BOF.

**BRIQUETTING ADVANTAGES**

- The process of briquetting technology is simple, some difficulty is binding.
- Briquetting is an environmentally friendly method of agglomeration.
- An economic solution enabling to evitate the loss of product under dust shape, uniformity of product obtained, reduction of dust volume, recycling of a product at high value added.
- An ecologic solution, accepted on the environment level, consisting of the problem solution associated to the producing and dispersion of dust and therefore to the atmosphere and ground pollution.

Briquetting is a process of compaction of fines into briquettes of a size similar to the premium product in almond shapes. In this form, the full volume of fines can be reclaimed.

This can significantly improve plant productivity and cut unit costs by making up use of raw material.

Binders or lubricants are used to improve the briquetting process:

- Binders are additives that increase the strength of the briquette by helping to hold the particles together.
- Lubricants are classified as internal or external. **Internal lubricants** are mixed into the feed material before briquetting and provide a denser briquette by reducing friction between particles during compaction. **External lubricants** work by reducing friction between the surfaces of the agglomerates and the rolls that form them.
- The moisture rate of dust to agglomerate that is generally high; a preparation unit of product can be integrated in the process for the drying of steel-making by-products.
• This pre-treatment unit can be realized by the introduction of a dryer enabling the by-products drainage before their passages in the press.

• Another solution enabling to reduce the moisture rate of by-products consists in the introduction of quick lime by the means of a mixer and so enabling to cause a chemical reaction of product dehydration.

Pilot plant trials successfully demonstrated the viability of recycling of sludge in the form of Briquettes in the Converter as coolant and do give a suitable solution to that are now big environmental challenge.

• There are many successful example world over where the BOF Sludge has been briquetted and charged as coolant.

• In Great Lake’s steel work, briquettes were made from mill scale and ESP dust, mixed in 1:4 ratio. High to medium sloping was observed when used in BOF as coolant. An increase in the hot metal ratio (hot metal/scrap) by 3.38% was achieved when 100% steel scrap.

• Mr. S. R. Balajee, P. E. Callaway, Jr L. M. Kilman, and L. J. Lohman stated in Steelmaking Conf. Proceedings, in 1995, that they had briquetted BOF waste oxides (35% dewatered sludge and 20% girt) with 45% mill scale, using molasses and lime as binder, and recycled the briquettes to the BOF shops of the Inland Steel. They found that 2.2 ton of waste oxide briquettes (WOB) replace 1.1 ton of scrap, increasing metallic yield and accommodating more hot metal.

• The Mc.Lauth Steel in collaboration with the Horse Head Resource Development used Iron Rich Materials (IRM) both as flux and iron source in the basic oxygen process. IRM was found to be a good substitute for fluor spar, lime and iron ore together with increased steel yield by 0.4% and a decrease in dolomite lime and oxygen consumption, by 5% and 1.5%, respectively.

• For example (as quoted in an article of STEEL WORLD, June 2016)

In STELCO work, the dust and sludge generated in LD converter and blast furnace were briquetted along with carbon with port land cement and lime as binders. The refining trial in LD converter showed better metallic yield without any slopping or increasing iron oxide in slag.
ADVANTAGES OF USING SLUDGE BRIQUETTES

- This technology will fulfill commitment towards Zero Solid Waste Discharge and Zero Liquid Discharge. It will also comply to CPCB directives and ensure substantial savings of water and costly minerals.

- This process utilises the inherent value of available Fe in the slurry, which is otherwise being dumped outside and getting wasted.

- The process of briquetting technology is simple and effective without entailing operational encumbrances.

- Briquetting is an environment-friendly method of agglomeration.

- It is an ecological solution, accepted at the environment level and prevents the accumulation and dispersion of dust contributing to a Swacchh Bharat.

- Savings in the cost and energy wasted for disposal of sludge.

- Savings in the expenditure required in maintaining disposal equipment like sludge pumps, pipe lines, tailing/ash ponds, etc.

- There is potential of saving about Rs 45 crores per year in a BOF shop of 2.5 Mtpa capacity

- Elimination of pollution hazard in handling and storage of sludge in tailing/ash pond and later heaped outside, causing space constraints.

- Preserves our Natural Resources by decreasing the demand for virgin and precious raw materials.

- It conserves Energy and reduces Greenhouse Gas emissions by decreasing the demand for products like Scrap steel made from energy intensive manufacturing processes.

- This technology also adds Carbon credits for processed material recovery.