Renewable Energy - Greening Steel Industry

Sh. Shiromani Kant
General Manager (Business Development - Green Hydrogen & Ammonia)
ACME Group

Introduction

The steel industry is an important sector that plays a significant role in various economies, worldwide. It is used in many sectors, like construction, transportation, energy, and infrastructure to name a few. India is currently the second largest steel producer in the world and has become one of the major steel hubs in the world for both the production and consumption of steel. India's per capita consumption of steel @ 78Kg is one of the lowest against global average of 228Kg. Being a developing country, steel demand set to increase. The Ministry of Steel has planned for the creation of a steel production capacity of 300 MT by 2030, and 500 MT by 2047 from an existing Gas based Direct Reduced Iron (DRI) Capacity of 90 Lakh tonne / Annum, While the demand for steel grows, it is important to note that the Steel sector is major energy guzzler and a huge emitter of CO2, and has a significant impact on the environment.

The Steel sector contributes to 8-9% of the country's total greenhouse gas emissions, making it one of the largest contributors to climate change. The steel industry is the largest industrial sector in terms of intensive energy and resource use, it accounts for one-fifth of industrial energy consumption. India is a signatory of the Paris agreement and in Conference of the Parties (COP26) on climate change has announced ambitious targets of reduction of carbon emissions by 2030 and hit net-zero carbon emissions by 2070. To achieve the climate goal, India is promoting decarbonization of the steel sector and transitioning towards the production of 'Green Steel' in the country. This write-up intends to explore the concept of environment-friendly green steel and the transition toward its production.

What is Green Steel?

As per BusinessWire, Green steel is environmentally friendly steel that has a lower carbon footprint than traditional steel-making processes. The implementation of non-coal-based alternative technologies results in a reduction in this footprint. In most cases, green steel production uses green hydrogen instead of the traditional carbon-intensive manufacturing route of coal-fired plants. Experts are focusing on Green Hydrogen as the future fuel for producing Green Steel.

Green steel is also produced using recycled scrap metal instead of virgin iron ore, reducing the need for mining and extraction activities. The concept of green steel is relatively new and still evolving. However, as the world seeks to reduce carbon emissions and combat climate change, it is gaining popularity.

Transition Towards Green Steel

Green Steel manufacturing is an expensive process involving high cost. The transition towards green steel requires significant changes in the way steel is produced, starting from raw materials to the production processes. The transition involves the following:

- **New Technological Developments**

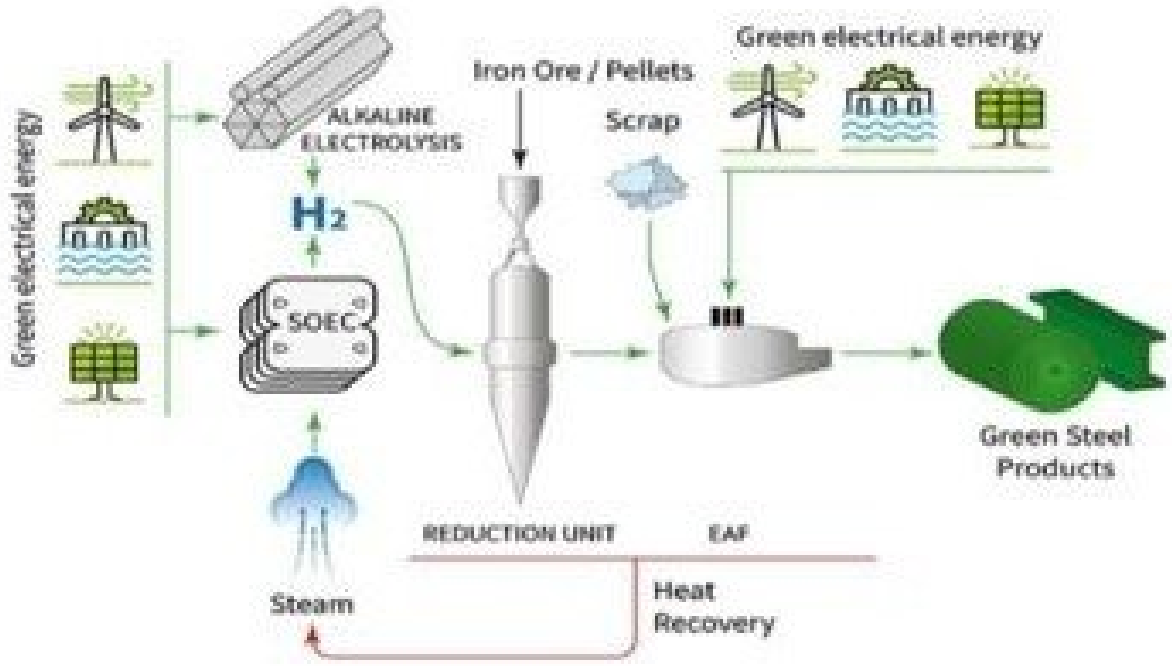
  Green steel making process is similar to the conventional Direct reduced iron (DRI)-Electric Arc Furnaces (EAF) route of steel making with the following major changes in the process:

  - Instead of coke, green hydrogen is used to reduce iron ore in the DRI process to generate iron. Green hydrogen is also utilized as a fuel source to provide heat for the iron-making process.

  - Renewable Energy (RE)-based electricity is used to supply energy for steel production in EAF and other plant power needs.

  The aforementioned modification renders the green steel substantially emission-free.

Figurer 1: Depiction of Green Steel Production



- **Production of Green Hydrogen**

  Green Hydrogen technology is based on the electrolysis of water (H2O) to produce hydrogen (H2) and oxygen (O2) by Electrolysers. This approach separates the hydrogen from the oxygen in water using an electric current generated from renewable sources like solar, wind, etc which is an environmentally friendly and carbon emission-less process. Broadly, there are four types of electrolyzer technologies available—Alkaline Electrolysis (AE), Proton Exchange Membrane (PEM) Electrolysis, Anion Exchange Membrane (AEM) Electrolysis, and Solid Oxide Electrolysis (SOE). To promote the development of Green Hydrogen economy, India has published its Green Hydrogen Mission Policy document. Many companies have made announcements for establishing Green Hydrogen Projects in the country some of the prominent ones are Reliance Group, NTPC, ACME, IOCL, Greenko, Renew, etc.

- **Shifting to Renewable Energy Sources**

  In the transition towards green steel, the industry needs to shift to renewable energy sources such as solar, wind, and hydrogen. These sources of energy do not emit CO2, making them environmentally friendly thereby helping in reducing carbon footprints.

- **Reusing Scrap Metal**

  Green steel is produced using recycled scrap metal instead of virgin iron ore. The use of scrap metal reduces the need for mining and extraction activities, which are energy-intensive and emit large amounts of CO2. Recycling also reduces waste and conserves natural resources.

Green Steel – Challenges

Currently, the production of Green Steel is being undertaken in a pilot project mode the commercial production of conventional steel at competitive prices is anticipated at a later stage. There are however several challenges that need to be addressed for the financial viability of sustainable production of green steel.

- In DRI-based facilities, there is a high demand for high-grade iron ore (Fe content 66%). The availability of such high-grade iron ore is not only limited but has been declining due to the heavy exploitation of high-grade ore resources. Promoting beneficiation and palletization to yield DR-grade pellets that can be utilized in a DRI plant can be a way out. R&D is required for the creation of technologies that permit the use of low-grade iron ore.

- 50-55 kWh is required to produce 1 kg of hydrogen and theoretically 54 Kg and practically around 70-80 Kg of Hydrogen is required to produce each tons of steel. Therefore, infrastructure development on a massive scale is necessary to support the enormous quantity of green hydrogen generation.

- At current estimates Green Steel is 50 to 120% costlier than conventional steel production. The primary reason for the prohibitive cost is the high Levelized cost of Hydrogen (LCOH) . Of the total cost of production of green hydrogen, 50-55 % can be attributed to Renewable energy (RE) power cost and 30 -35 % to the electrolysers, and rest 10-20% to others. The cost of RE-RTC (round the clock) power from sources such as solar, wind power and battery are relatively high, and the technology for producing green hydrogen is still in its early stages thereby making it more expensive than grey hydrogen.

Way Forward

In the decarbonization journey, the transition from grey to green steel would require groundwork with a clear road map to have a substantial influence on the acceptance of green steel. Some of the key focus areas could be as under:

- Availability of RE RTC: The availability of RE sources is intermittent and dependent on weather conditions. This makes it difficult to rely solely on RE sources for consistent hydrogen production and it will limit the efficiency of electrolyser to the RE generation hours only. Therefore, in order to increase the efficiency of electrolyser, RE RTC power is required at cheaper cost so that the electrolyser can be operated for higher number of hours throughout the day and low-cost green hydrogen can be produced.

- Robust transmission infrastructure: Green hydrogen and ammonia projects requires significant quantum of power throughout the day without any interruption. Therefore, a robust evacuation infrastructure is required to make sure that reliable power is made available to Green hydrogen and ammonia projects

- Ramping up production and efficiency of Electrolysers: Improving the efficiency of electrolysis and achieving economies of scale to reduce the LCOH will make it competitive with respect to grey hydrogen. R&D in the electrolytic process technologies would make them more efficient.

- Development of Infrastructure: Specialized infrastructure is required for hydrogen production, storage, and distribution which currently is based on fossil fuels. Significant investment and planning are required to replace or adapted to accommodate green hydrogen.

- Addressing safety issues: Hydrogen is highly flammable and safety concerns will have to be addressed to ensure the safe and effective use of green hydrogen during its production, storage, and transportation.

- Collaboration and Investment: To drive the demand for Green Steel and to make investments in Green Steel production profitable for the steel manufacturers, there is a need for collaboration between industry players, governments, and investors. Collaboration is necessary to develop new technologies, share knowledge and resources, and create policies that support the transition. Investment in research and development, infrastructure, and training is also essential to facilitate the transition.

- Policy & Regulatory Support: To generate the initial demand for green steel production in India, the government may introduce various regulatory policies for reducing emissions from the iron and steel sector in a phased manner. Considering the higher costs of Green Hydrogen at present, natural gas based DRI Steel plants could begin by blending a small percentage of Green Hydrogen in Natural gas. The blending proportion could be progressively increased as cost-economics improve and technology advances. Further, it may be mandated at an appropriate stage that any upcoming natural gas based DRI steel plants should be able to operate with Green Hydrogen. This would ensure that these plants are competitive in future global Steel markets.

DRI technology using hydrogen will be essential to the future manufacture of high-purity steel. The availability of green hydrogen, access to reliable RE power, and detailed policy & regulatory support that incentivize the low emission steel making would go a long way in achieving India's net-zero targets.

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