ALL INDIA INDUCTION FURNACES ASSOCIATION

AIIFA

INDUCTION FURNACE NEWSLETTER

VOL. No. XXI
ISSUE No. 10,October, 2021

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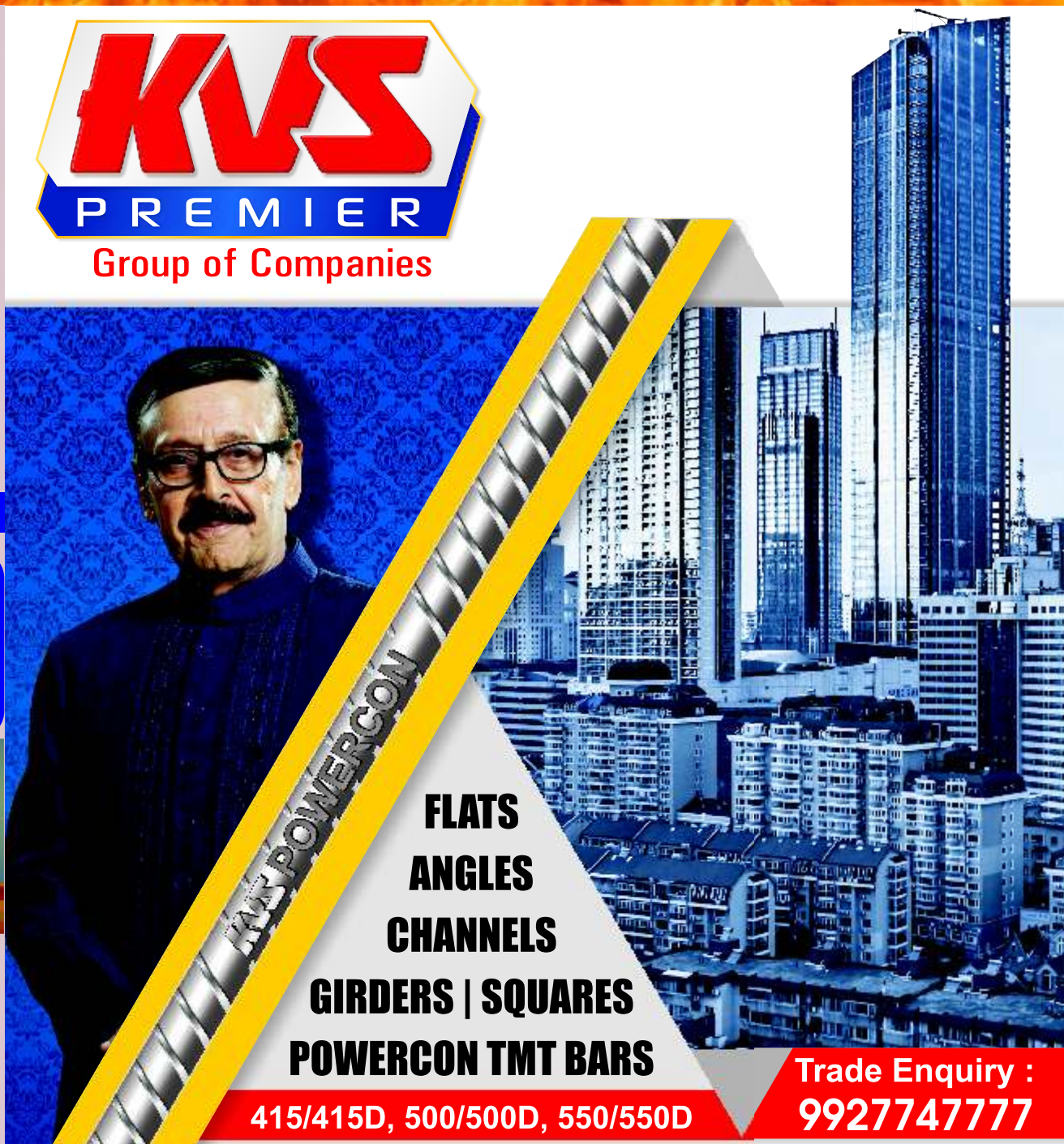

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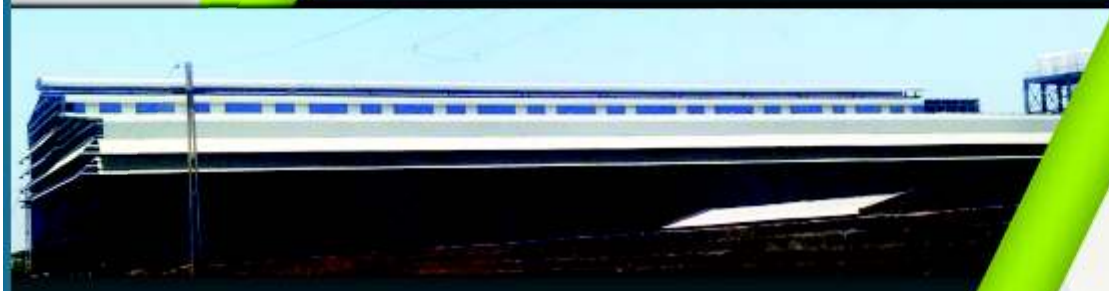

India's Ist 25mtr high SMS Plant in PEB with 75 MT EOT Crane to handle bulk molten steel

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ENVIRONMENT FRIENDLY STEEL

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Steel Industry as Pollutant Emitter

Kamal Aggarwal
Hon. Sec. General, AIIFA

Introduction : Steel production is one of the most energy consuming and CO2 emitting industrial activities in the world. The main ingredient in the production of steel is iron ore mined from Earth. Over 2,000 million tons of iron ore is mined in a year where about 95 percent is used in the steel industry. After crude oil and coal, iron ore is the world's third common product by volume which is the main and major raw material in steel production. Iron ore mining is highly energy intensive and causes pollution as nitrous oxide, carbon monoxide and sulphur dioxide from diesel generation, trucks, and many other equipments. Even, it causes water pollution of heavy metals and acid that drain out from iron ore mines which was going for thousands of year in the world but same has been reduced to a great extent after introducing mining activities in scientific ways.

Allover the World, Governments of different countries and national/ international organizations are continuously taking actions for protection of air quality controlling emission at the generating points and forcing industries to comply specified ambient air quality standards and guidelines, issued by environmental protection authorities. Climate change has emerged as the most pressing global challenge of the 21st century. Today, there is an increasing understanding about the climate change transcending political boundaries affecting the global population, making them stakeholders to the solutions too. However, despite the ubiquity of climate change, its more immediate impacts are felt differently by different groups of countries. Developing countries, with their low adaptive capacities and high dependence on climatic variables, are highly susceptible to climate-induced tragedies.

Importance of Steel : The iron and steel sector is regarded as the core of Indian economy. Its players are big and powerful. It is extremely resource and pollution-intensive. On top of this, it is expanding at a phenomenal rate. This makes the sector a fit case for environmental scrutiny. Delhi non-profit Centre for Science and Environment studied the sector for two years to prepare its environmental profile and rate the performance of its top companies. The exercise undertaken by its Green Rating Project sprang a surprise: the steel sector is struggling to meet even the minimum statutory pollution norms. State pollution control boards do not have the capacity to monitor and regulate these behemoths. What's worse, the sector is non-transparent and shy of public scrutiny—more than any other sector rated by the project in the past.

The first independent assessment of the steel sector also found it is wasteful in resource use. This is a cause for concern because steel production in the country is likely to increase five times in the next two decades. At this rate, the industry's energy, water, land and iron ore demand will be immense and un-sustainable. Steel production is a major industrial process sourcing carbon dioxide emissions. In steel production process, iron is melted and refined to lower its carbon content. Major and Main steel industries produce steel in bulk tonnage by the process Coke Oven Blast Furnace - Basic Oxygen route where oxygen is combined with the carbon coming from molten pig iron creating carbon dioxide. On an average, 1.9 tonnes of CO2 are emitted for every tonne of steel produced. However, steel

produced from electric induction furnaces in greener ways by scrap melting creates opportunities for making more efficient products, equipments, structures for different consuming sectors, with smaller ecological footprints in most cost-effective ways. Steel is not only recyclable but it also dissolves in high heat to produce high-quality steel. The iron and steel industry is responsible for 11% of global carbon dioxide (CO2) emissions and will need to change rapidly to align with the world's climate goals.

Steel production from induction furnace saves about 62% of the energy compared to the conventional steel making units significantly reducing carbon dioxide emissions. Induction furnace steel makers in India pay attention to the entire life cycle starting from sourcing clean raw materials, production of steel in cleaner ways, dispatching products to customer, using steel products after end of life right up to recycling and re-melting to form new steel. Because of such cleaner eco-friendly process without carbon addition during melting, there is no possibility of emission of any harmful gases which are generated from other steel making process like BF+BOF and even EAF where graphite electrodes used for arcing and supply carbon in melt as well as lancing oxygen.

Understanding the need of eco-friendly steel making, shaping, treating process and products to provide more than just peripheral attention to the economic implications of unusual changes in climate still slowly percolate in many industries in developing countries despite the poor economic conditions and high dependence on geophysical elements in such regions. However, there is an increasing awareness in the steel making industries about the importance of eco-friendly production taking into account the economic costs and risks of climate change. However, one of the keys to making production process greener is by reducing energy usage.

- **Paris Agreement, 2015 & Climate Change :** This is a historic moment for the global response to climate change the common concern of humankind, Parties emitting pollutants from different industries should take action addressing climate change, respect, promote and take action considering their respective obligations on human rights and health, protecting environment. The agreement solidified long-term, international goals to tackle the climate crisis recognizing that sustainable lifestyles and sustainable patterns of production and consumption with developed country Parties taking the lead, play an important role in addressing climate change agreeing as -

1. To hold global temperature rise well below 2 degrees C and aim to limit it to 1.5?C,
2. To increase adaptation and resilience to climate change and
3. To align financial flows with low-carbon and sustainable development. But details for how to implement the global pact were left unresolved.

Countries spent three years negotiating guidelines for bringing the Paris Agreement fully to life, and in December 2018 in Katowice, Poland they agreed on the Paris Agreement Rulebook to put those guidelines. While a few elements of the Rulebook are still to be finalized, countries have now established processes and rules for how they will work together in a fair and effective manner to achieve their collective goals.

To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework should be put in place supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework. Post-Paris Climate Summit paradigm prioritizes environmental sustainability and the business

leaders of steel are following the suit, expanding environmentally friendly business practice in steel making chain across its diverse sectors opting for environmental sustainability for the sake of public interest considering the global community setting the tone for environmental sustainability, consumer demand and life cycle assessment. Considering the environmental impact, versatile, convenient and recyclable steel from induction furnace steel is expected to draw more attention in the future both from the industry and consumers.

The Paris Agreement provides a framework for financial, technical and capacity building support to needing countries reaffirming taking lead by developed countries in providing financial assistance to countries that are less endowed and more vulnerable, while for the first time also encouraging voluntary contributions by other Parties. Climate finance is needed for mitigation, because large-scale investments are required to significantly reduce emissions. Climate finance is equally important for adaptation, as significant financial resources are needed to adapt to the adverse effects and reduce the impacts of a changing climate.

- Climate Change & Greenhouse Gas -: GHGs prevent the earth from losing heat into space, thus changing the climate affecting adversely on industrial production worldwide, making droughts, floods and storms more frequent and raising the sea level. Carbon dioxide, emitted by industrial processes including, steel plants, thermal power generation station is the principal GHG in the atmosphere. This emission model is actually part of a much larger model that includes a global carbon cycle model and a climate model. It works as → Total Emission transfers carbon from a reservoir called Fossil Fuels that represents all the Gigatons of carbon stored in oil, gas, and coal (which add up to 5000 Gt) into the atmosphere.

Emission from Integrated Steel Plant

Steel Plants Aim Zero Emission by 2050

The number of countries announcing pledges to achieve net-zero emissions over the coming decades continues to grow. But the pledges by governments to date – even if fully achieved – fall well short of what is required to bring global energy-related carbon dioxide emissions to net zero by 2050 and give the world an even chance of limiting the global temperature rise to 1.5 °C.

This special report is the world's first comprehensive study of how to transition to a net zero energy system by 2050 while ensuring stable and affordable energy supplies, providing universal energy access, and

enabling robust economic growth. It sets out a cost-effective and economically productive pathway, resulting in a clean, dynamic and resilient energy economy dominated by renewable like solar and wind instead of fossil fuels. The report also examines key uncertainties, such as the roles of bio-energy, carbon capture and behavioral changes in reaching net zero. Some of the carbon stays in the atmosphere, but the majority of it goes into plants, soil, and the oceans, cycling around and between the reservoirs. The amount of carbon that stays in the atmosphere then determines the greenhouse forcing that affects the global temperature There are many industrial processes like integrated steel making unit that produce significant amounts of carbon dioxide emissions as a by product of chemical reactions needed in their production process. The growth of emissions and the balance between different countries will be strongly driven by the changing mix of different production processes.

Emission Produced & Discharge Status From Steel Making Units Units	
BF- BOF Route	2.3 tonnes of CO2 per tone of steel produced
DRI with Gas as Input	1.1 tonnes "
Electric Arc Furnace	Almost 0.4 tonnes if Electricity comes from Zero "C" source
Induction Furnace	Produces Almost Nil

While average BF-BOF furnaces produce emissions of about 2.3 tonnes of CO2 per tonne of steel produced, DRI with gas as the input produces about 1.1 tonnes, while EAF produces about 0.4 tonnes, and less still if the electricity used comes from zero-carbon sources whereas EIFs produce almost nil. Given these different intensities, the predicted shift in the mix of steel production from primary to secondary and from BF-BOF to EAF or EIF explains why forecasted emissions grow only 10% even while total steel demand grows over 25%. But if the world is to have any chance of meeting the Paris climate objective of keeping the global temperature increase to well below 2°C, total emissions from global energy use across all economic sectors must be cut from today's 36 Gt to 20 Gt by 2040, below 15 Gt by 2050 and reach net zero around 2070. It is therefore essential to develop a strategy to dramatically reduce steel industry emissions by 2050 and to eliminate them by 2070

The steel industry releases large amounts of pollutants into the air during all its processes—be it while handling raw material, producing iron and steel or disposing of solid waste. The main pollutants are particulate matter, oxides of sulphur and nitrogen and carbon monoxide. Steel production requires large inputs of coke (a sort of coal) which is extremely damaging to the environment. Coke ovens emit air pollution such as naphthalene that is highly toxic and can cause cancer.

Waste water from the coking process is also highly toxic and contains a number of carcinogenic organic compounds as well as cyanide, sulfides, ammonium and ammonia. On average, 1.83 tons of CO2 is emitted for every ton of steel produced making steel production a major contributor to global warming adding over 3,3 million tons annually to global emissions. To achieve target as envisaged in National Steel Policy-2017, Govt. should encourage entrepreneurs for setting up induction furnace steel making units for green steel production at least nearness to scrap availability units/ scrap recycling units to achieve target maintaining second highest producing country in the world after China.

In 1950, the annual global steel production was 189 million tons, in 1975, 644 million tons and by the year 2000, production reached 850 million tons. In 2018, global steel production had doubled compared to 2000 and reached 1808 million tons. That's 57 tons of steel a second around the clock, 365 days a year. The main steel producing country is China producing

more than 50% of the world's steel. China is followed by India, Japan, the US, South Korea and Russia and these six countries produce over three quarters of the world's steel. India's steel industry is set to more than triple its carbon footprint by 2050 as demand for the metal in the world's second-biggest producer soars. Carbon dioxide emissions from the global steel industries are projected to jump to 837 million tons over the next three decades from 242 million tons now as India's demand for steel more than quadruples to about 490 million tons, The Energy and Resources Institute said in a report. It will also contribute more than a third of the nation's total loss .

Steel Production by Major Countries

Year	2020	2019	2018	2017	2016	2015	2014	2013
world	1877.5	1874.4	1808.4	1674.8	1606.3	1620.4	1670.1	1649.3
China	1064.8	995.4	920.0	831.7	786.9	803.8	822.7	779.0
India	100.3	111.4	109.3	101.5	95.5	89.6	87.3	81.2
Japan	83.2	99.3	104.3	104.7	104.8	105.2	110.7	110.6
US	72.7	87.8	86.6	81.6	78.5	78.9	88.2	87.0

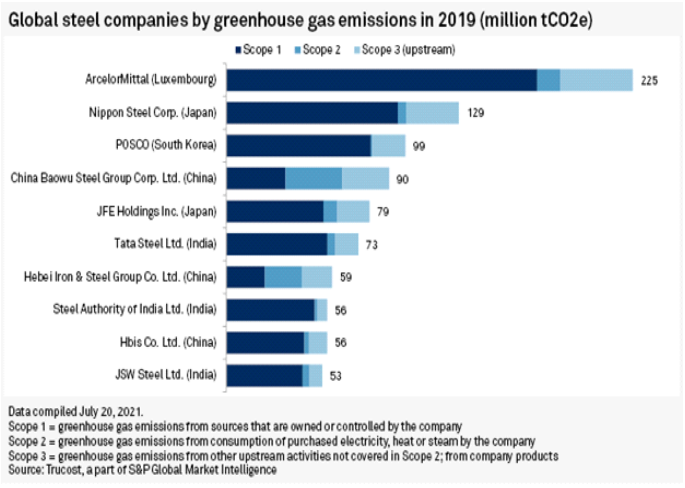
Country's (%) share in Global CO2 emission

China – 28 2, US - 15, India - 7, Japan - 3, Germany - 2, South Korea -2, Iran - 2 , France, Italy, Polland, UK, Australia, Turkey, Brazil , Mexico – All at 1% level & Rest of World together about 21%.

As world's biggest steel producer country, China has the ability of producing steel output nearer to 2000 million tones in 2021 giving serious attention on emission control in entire steel industry meeting pollution control targets curbing CO2 emissions. However, the report drawn up by climatic analytics provider as transition to zero level may not earn profit to the expected level.(Ref: Diana Kinch, Mathew Grey – Transition Zone Analysts). "With additional action, China could reduce emissions and show climate leadership in the run up to COP26. Continued growth indicates in steel production is likely due to the country's stimulus-filled construction boom post-COVID-19, according to Transition Zero's analysts. However, China is still expected to meet its overall net-zero carbon target by 2060 "because it won't have any choice.

China was home to many of the world's most polluted cities and is the world's largest emitter of greenhouse gases (GHGs). The Beijing-Tianjin-Hebei (Jing-Jin-Ji) region experienced particularly severe air pollution, with an annual average fine particulate matter (PM2.5) concentration of 93 micrograms per cubic meter (µg/m3)which is far exceeded both China's national standard and the standard advised by the World Health Organization (WHO).

Greenhouse gas emission by Global Steel Companies:.



Efforts for Emission Control by Major Integrated steel Plants in India:

SAIL - Latest pollution control equipment have been/ set up for running efficiently, to contain the emissions from various operational processes in different integrated steel plants like RSP, BSP, DSP, BSL, RINL & Special Steel Plants resulting in progressive decline of emission of Particulate Matter (PM), emission load (kg/tcs). During the modernization-cum-expansion program of the SAIL, being a corporate entity, an array of clean and environment friendly technologies have been introduced in all the SAIL units which has resulted in the improved environmental performances reducing specific CO2 emission. SAIL, is striving to address the issues and opportunities in synergistic ways and actions in India to limit average global temperature increase causing climate change. Various strategies are being chalked out in the area of Low Carbon Steel Making. SAIL has envisaged installing a Carbon Capture & Utilization Plant at Chandrapur Ferro Alloy Plant where Submerged Arc Furnace (SAF) off-gas has been planned for recovery and use commercially.

TATA Steel's climate change activity in all positive ways is probably the biggest challenge ever to confront Indian and global steel industry. In response to this challenge, TATAs are minimizing the environmental impact of its operations and products in meeting the objective of reducing CO2 by consistently improving processes, and investing in breakthrough technologies that reduce the environmental impact over the product lifecycle. The systems all through the industry remove several stages of pre-processing raw materials combining with the capture and storage of waste gases. TATA could lower CO2 emissions by 80 percent level undertaking extensive research in making the process of steelmaking more energy-efficient and environmentally sustainable. TATA has identified 'Industry 4.0' as a strategic imperative to attain as a mart factory status with enhanced productivity, customer centricity and sustainable performance, .Tata Steel Jamshedpur is the Indian benchmark for CO2 emissions intensity

JSPL the divestment is in line with JSPL's strategic objective to continuously reduce its debt and carbon emissions and focus on its India's steel business. JSPL has been an ardent advocate and practitioner of sustainable development since its inception and is whole-heartedly committed to improve its sustainability performance and making a positive difference in the society aiming to incorporate sustainability into its businesses by strengthening economic, social, environmental, human, governance pillars and mitigating the impact of operations.

JSPL is a signatory to the World Steel Sustainable Development Charter, 2015 and is also a Climate Action member with the World Steel Association. Company's policies reflect the purpose and intent of United Nation Global Compact, World Steel Sustainable Development Charter and the Global Reporting Initiative Standards. They have recognized climate change as one of the most pressing problems that is being felt across the globe and are striving hard to avoid and manage climate-related risks and reduce carbon emissions. JSPL have implemented some of the most innovative technologies and best practices at their plants to address the various environmental issues reducing overall carbon footprint.

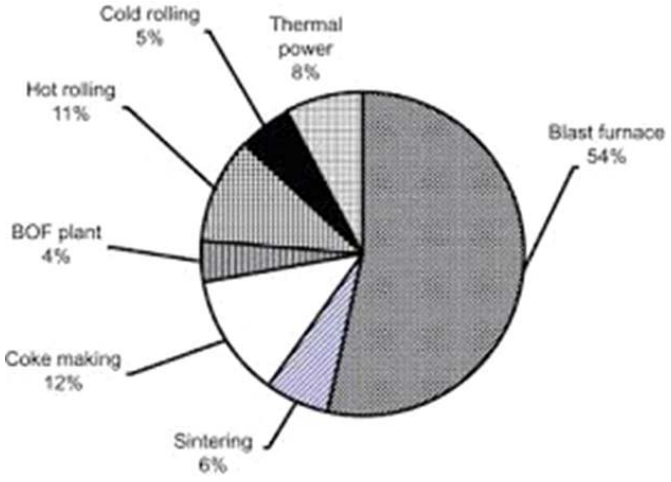
Through various initiatives, approaches and products, JSPL is committed to achieve the United Nations Sustainable Development Goals striving to build a strong and lasting relationship with stakeholders, making investments to mitigate the effects that operations have on the environment,

incorporate transparency and accountability into management policies and decisions.

IF as secondary steelmaking methods only melting scrap and scrap substitute which differs between BOF/ BOS and EAF methods. BOF methods add recycled scrap steel to the molten iron in a converter. At high temperatures, oxygen is blown through the metal, lowering silicon, manganese and phosphorous levels and lowering carbon content to between 0 - 1.5%. The addition of chemical cleaning agents called fluxes help to reduce the sulfur and phosphorous levels.

Emission of Pollutants at Different Stages in Steel Making::

1.Emission from Sinter Plant – Emissions from sinter plants are generated from the raw material handling, windbox exhaust as primary source of particulate emissions mainly iron oxide, sulphur oxide, carbonaceous compounds etc. from discharge end (associated sinter crushers and hot screens), cooler, and cold screen processes. Iron oxide, sulfur oxide, carbonaceous compounds, aliphatic hydrocarbons, and chlorides. Sinter strand windbox emissions commonly are controlled by cyclone cleaners followed by a dry or wet electrostatic precipitator, high pressure drop wet scrubber, or bag filters. This processing stages account for more than 90 percent of the SO2 emissions in the steel industry.



It may be seen that steel making by major steel plant in integrated way, the emission level is 76% in steel making together with (Sintering 6%, Coke making 12%, BOF steel production 4%), Rest 24% (Hot Rolling 11%, Cold Rolling 5% , Thermal Power 8%). Day by day, legislated limits in controlling emissions

become more and more stringent, sinter plants are under increasing pressure to further decrease emissions. One of the best available techniques for de-dusting is the use of ESP plus Fabric Filter for removing particulate matter. In addition to the control of dust emissions from the wind boxes, adequately sized capture and de-dusting controls for both the feed and discharge ends of the sinter strand. Crusher and hot screen emissions are usually controlled by hooding with a bag-house or scrubber, while emissions generated from other material handling operations are captured and vented to a baghouse.

2. Emissions from a blast furnace : Significant emissions to all media occur from the blast furnace process, because of the high input of reducing agents (mainly coke and coal), this process consumes most of the overall energy input of an integrated steel majo and main steel plants in India. The primary source of blast furnace emissions is the casting operation at cast house where particulate emissions are generated when the molten iron and slag contact air above their surface.

Casting emissions also are generated by drilling and

plugging the tap hole. The occasional use of an oxygen lance to open a clogged tap hole can cause heavy emissions. During the casting operation, iron oxides, magnesium oxide, and carbonaceous compounds are generated as particulate matter. Casting emissions at existing blast furnaces are controlled by evacuation through retrofitted capture hoods to a gas cleaner, or by suppression techniques. Emissions controlled by hoods and an evacuation system are usually vented to a bag filters.

3.Emission from BOF Steel Making : Another potential source of emissions in primary steel making area is from a basic oxygen furnace to air from various sources such as primary and secondary de-dusting, hot metal pretreatment and secondary steelmaking, and various solid process residues are the main environmental issues in BOF steelmaking . The most significant emissions from the BOF process occur during the oxygen blow period. The predominant compounds emitted are iron oxides, although heavy metals and fluorides are usually present. Charging emissions will vary with the quality and quantity of scrap metal charged to the furnace and with the pour rate. Tapping emissions include iron oxides, sulfur oxides, and other metallic oxides, depending on the grade of scrap used. Hot metal transfer emissions are mostly iron oxides. Basic oxygen furnaces are equipped with a primary hood capture system located directly over the open mouth of the furnaces to control emissions during oxygen blow periods. India's steel industry is set to more than triple its carbon footprint by 2050 as demand for the metal in the world's second-biggest producer soars. Globally, carbon dioxide emissions from the steel industry are projected to jump to 837 million tons over the next three decades from 242 million tons now.

4. Emissions from Electric Arc Furnace : The emissions to air from the EAF furnace consist of a wide range of inorganic compounds e.g. iron oxide dust, heavy metals and some organic compounds. The operations which generate emissions during the electric arc furnace steelmaking process are melting and refining, charging scrap, tapping steel, and dumping slag. Iron oxide is the predominant constituent of the particulate emitted during melting. During refining, the primary particulate compound emitted is calcium oxide from the slag. Emissions from charging scrap are difficult to quantify, because they depend on the grade of scrap utilized. Scrap emissions usually contain iron and other metallic oxides from alloys in the scrap metal. Iron oxides and oxides from the fluxes are the primary constituents of the slag emissions. During tapping, iron oxide is the major particulate compound emitted. Emissions control techniques involve an emissions capture system and a gas cleaning system EAF methods, alternatively, derive from 90 -100% recycled steel

scrap and passed high power electric arcs (temperatures up to 1650 °C) to melt the metal and convert it to high quality steel.

5. Emission from Induction Furnace Steel Making

The induction furnace is heated faster and has higher thermal efficiency. The heat is generated in the furnace (liquid steel), so the heating speed is high. In the arc furnace, the heat of the arc after the material is cleared must be transferred to the molten steel

through the slag, which is indirect heating The advantage of the induction furnace is **a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting.** Only air pollution occurs and no water or noise pollution takes place in induction furnace. The scrap charge when melted emits metallurgical smoke due to oxidation having solid particles as well as gaseous pollutants. The steel melting scrap charge may have dust and rust which on heating disintegrates from metal. Some refractory lining may also contribute to the solid pollutants. Thus the solid pollutants will consist of suspended particulate matters of iron oxide, alumina, silica, magnesia, calcium oxide and alkali oxides. The gaseous pollutants will consist of CO, CO2, HC, and small proportion of SO2.

Steel is widely considered as environmentally friendly for its recyclable nature in the world. Electric induction furnace steel making industries are extremely conscious for eco-friendly steel production and emission of harmful gases. In this process, steel is produced under controlled conditions and there is little or no construction waste. Continuous innovation in production techniques and methods has provided a permanent reduction in energy used and emissions. Eco-friendly steel production by EIF can excel at is in recycling and reusing waste materials.

Emission from Sponge Iron Plant, Scrap Recycling & Ship Breaking Industry

Observation of IPCC (Inter-governmental Panel on Climate Change): The most authoritative body on climate change shows that present impacts creating crisis are just the beginning which will seem mild compared to what we will face if we do not act because world still has a narrow path to limit average global warming to 1.5 degrees C (2.7 degrees F) which is necessary for avoiding the worst effects of climate change, actions will require rapid, transformational change this decade. World's major emitters Govt. and productive business houses must set up their commitments followed by actions in

meeting challenges as World is facing an emergency situation for climate change. Countries not yet have announced new and more ambitious targets need to come forward immediately to curb emission by 2030.

Economic success of any country depends on steel production and usage as this is the only metal producing critical products generating revenues , employment, revenue and investment in modern economies. The role of the steel industry needs to be considered within the context of a progressive industrial policy and governments need to engage with the steel industry when developing a carbon policy that would impact the industry.

Conclusion: Management of steel plants both Public Sector & Private Sectors particularly in MSME & SME categories seek timely support and necessary help from Govt. in the identified recognized areas which are beyond their control through their authorized bodies/ associations. Govt. of India is always eager to help mini steel units who have limited facilities and resources. Managements of mini steel plants also have noticed about the supports during pandemic situation caused due to Covid-19 and even its after effects. However, steel industries work jointly as partners to overcome the technological aspects for clean and green steel production to ensure progress, profitability and productivity in the steel industry creating a strong and healthy industrial base climate in a sustainable economy.

India has demonstrated leadership in promoting energy efficiency and addressing the global issue of climate change. Government of India has undertaken a two-pronged approach to cater to the energy demand of its citizens while ensuring minimum rise in CO2 emissions, so that the global emissions do not lead to irreversible damage to the ecosystem. On the generation side, the Government is promoting greater use of renewable in the energy mix mainly through solar and wind and at the same time shifting towards supercritical technologies for coal-based power plants. Steel is a CO2 and energy intensive as well as highly competitive industry which enables major CO2 mitigation in other sectors.

However, there is a risk that inequities introduced by carbon pricing mechanisms could jeopardize fair competition. The OECD Council feels that “Attempts to price carbon implicitly or explicitly will have distributional consequences that may be contentious which requires the determination and creativity of governments to find the right level of arbitrage between the economic efficiency and the political and social sustainability of climate policies.

Policy, better, should promote to ensure steel plants in one area are not put at a disadvantage with steel producers from other areas also in competition. Life cycle approach is an important tool for future environmental policy. Governments should take into account the full life cycle of products when creating new regulations. Consideration of life cycle, sustainability, end of life of steel products will, hopefully, create reliable and predictable frameworks for cost effective energy and environmental policies. Govt. should promote and encourage a circular economy approach leading to: innovative design, a reduction in the amount of materials used, encouraging to reuse and recycling of all materials minimizing wastage prioritizing the collection and recycling of end-of-life steel products. Progress in breakthrough technology development in steelmaking, implementation should be maintained or accelerated including reuse of CO2 and the potential benefits to society, policy supporting funding for environmentally focused research and development requiring the financial burden to be shared by both government and the private sectors including provisions on technology transfer, climate risk, international funding in collective ways.

INVENTORY MANAGEMENT FOR SPARES AND EQUIPMENT

P. Mishra, Sr. *Exe. Director, AIIFA*

INTRODUCTION

Inventory Management involves the control of assets being produced for the purposes of sale in the normal course of the company's operations. The goal of effective inventory management is to minimize the total costs - direct and indirect - that are associated with holding inventories. However, the importance of inventory management to the company depends upon the extent of investment in inventory.

The task of inventory planning can be highly complex in manufacturing environments. At the same time, it rests on fundamental principles. The system used for inventory must tie into the operations of the firm. Inventory planning and management must be responsive to the needs of the firm. The firm should design systems, including reports that allow it to make proper business decisions.

PURPOSE OF INVENTORIES

The purpose of holding inventories is to allow the firm to separate the processes of purchasing, manufacturing, and marketing of its primary products. The goal is to achieve efficiencies in areas where costs are involved and to achieve sales at competitive prices in the marketplace. Within this broad statement of purpose, we can identify specific benefits that accrue from holding inventories.

1. **Avoiding Lost Sales :** Without goods on hand, which are ready to be sold, most firms would lose business. Some customers are willing to wait particularly when an item must be made to order or is not widely available from competitors. In most cases, however, a firm must be prepared to deliver goods on demand. Shelf stock refers to items that are stored by the firm and sold with little or no modification to customers. An automobile is an item of shelf stock. Even though customers may specify minor variations, the basic item leaves a factory and issold as a standard item. The same situation exists for many items of heavy machinery, consumer products, and light industrial goods.

2. **Gaining Quantity Discounts :** In return for making bulk purchases, many suppliers will reduce the price of supplies and component parts. The willingness to place large orders may allow the firm to achieve discounts on regular prices. These discounts will reduce the cost of goods sold and increase the profits earned on a sale.

3. **Reducing Order Costs :** Each time a firm places an order, it incurs certain expenses. Forms have to be completed, approvals have to be obtained, and goods that arrive must be accepted, inspected, and counted. Later, an invoice must be processed and payment made. Each of these costs will vary with the number of orders placed. By placing fewer orders, the firm will pay less to process each order.

4. **Achieving Efficient Production Runs:**

Each time a firm sets up workers and machines to produce an item, startup costs are incurred. These are then absorbed as production begins. The longer the run, the smaller the costs to begin producing the goods. As an example, suppose it costs $12,000 to move machinery and begin an assembly line to produce electronic printers. If 1,200 printers are produced in a single three-day run, the cost of absorbing the startup expenses is $10 per unit (12,000/1,200). If the run could be doubled to 2,400 units, the absorption cost would drop to $5 per unit (12,000/2,400). Frequent setups produce high startup costs; longer runs involve lower costs.

These benefits arise because inventories provide a "buffer" between purchasing, producing, and marketing goods. Raw materials and other inventory items can be purchased at appropriate times and in proper amounts to take advantage of economic conditions and price incentives. The manufacturing process can occur insufficiently long production runs and with pre-planned schedules to achieve efficiency and economies. The sales force can respond to customer needs and demands based on existing finished products. To allow each area to function

effectively, inventory separates the three functional areas and facilitates the interaction among them.

Reducing Risk of Production Shortages: Manufacturing firms frequently produce goods with hundreds or even thousands of components. If any of these are missing, the entire production operation can be halted, with consequent heavy expenses. To avoid starting a production run and then discovering the shortage of a vital raw material or other component, the firm can maintain larger than needed inventories.

TYPES OF INVENTORIES

Four kinds of inventories may be identified:

Raw materials Inventory:

This consists of basic materials that have not yet been committed to production in a manufacturing firm. Raw materials that are purchased from firms to be used in the firm's production operations range from iron ore awaiting processing into steel to electronic components to be incorporated into stereo amplifiers. The purpose of maintaining raw material inventory is to uncouple the production function from the purchasing function so that delays in shipment of raw materials do not cause production delays.

Stores and Spares:

This category includes those products, which are accessories to the main products produced for the purpose of sale. Examples of stores and spares items are bolts, nuts, clamps, screws etc. These spare parts are usually bought from outside or sometimes they are manufactured in the company also.

Work-in-Process Inventory:

This category includes those materials that have been committed to the production process but have not been completed. The more complex and lengthier the production process, the larger will be the investment in work-in-process inventory. Its purpose is to uncouple the various operations in the production process so that machine failures and work stoppages in one operation will not affect the other operations.

Finished Goods Inventory:

These are completed products awaiting sale. The purpose of finished goods inventory is to uncouple the productions and sales functions so that it no longer is necessary to produce the goods before a sale can occur.

COST ASSOCIATED WITH INVENTORIES

The effective management of inventory involves a tradeoff between having too little and too much inventory. In achieving this trade off, the Finance Manager should realize that costs may be closely related. To examine inventory from the cost side, five categories of costs can be identified of which three are direct costs that are immediately connected to buying and holding goods and the last two are indirect costs which are losses of revenues that vary with differing inventory management decisions.

The costs of holding inventories are:

Material Costs of Inventory:

These are the costs of purchasing the goods including transportation and handling costs.

Ordering Costs:

Any manufacturing organization has to purchase materials. In that event, the ordering costs refer to the costs associated with the preparation of purchase requisition by the user department, preparation of purchase order and follow-up measures taken by the purchase department, transportation of materials ordered for, inspection and handling at the warehouse for storing. At times even demurrage charges for not lifting the goods in time are included as part of ordering costs.

Carrying Costs:

These are the expenses of storing goods. Once the goods have been accepted, they become part of the firm's inventories. These costs include insurance, rent/depreciation of warehouse, salaries of storekeeper, his assistants and security personnel, financing cost of money locked-up in inventories, obsolescence, spoilage and taxes.

Cost of funds tied up with Inventory:

Whenever a firm commits its resources to inventory, it is using funds that otherwise might be available for other purposes. The firm has lost the use of funds for other profit-making purposes. This is its opportunity cost. Whatever the source of funds inventory has a cost in terms of financial resources. Excess inventory represents an unnecessary cost.

INVENTORY MANAGEMENT TECHNIQUES

While the total ordering costs can be decreased by increasing the size of order, the carrying costs increase with the increase in order size indicating the need for a proper balancing of these two types of costs behaving in opposite directions with changes in order size.

Again, if a company wants to avert stock-out costs it may have to maintain larger inventories of materials and finished goods, which will result in higher carrying costs. Here also proper balancing of the costs becomes important.

Thus, the importance of effective inventory management is directly related to the size of the investment in inventory. To manage its inventories effectively, a firm should use a systems approach to inventory management. A systems approach considers in a single model all the factors that affect the inventory.

A system for effective inventory management involves three subsystems namely:

1. Economic order quantity
2. Reorder point
3. Stock level

ECONOMIC ORDER QUANTITY

The economic order quantity (EOQ) refers to the optimal order size that will result in the lowest total of order and carrying costs for an item of inventory given its expected usage, carrying costs and ordering cost. By calculating an economic order quantity, the firm attempts to determine the order size that will minimize the total inventory costs.

Total inventory cost = Ordering cost + Carrying cost
Total ordering costs = Number of orders x Cost per order= $ U / Q X F

Where
U = Annual usage
Q = Quantity ordered
F = Fixed cost per order

The total carrying costs = Average level of inventory x Price per unit x Carrying cost (percentage)

Total carrying costs
= $ Q / 2 x P x C
= $ QPC over 2

Where
Q = Quantity ordered
P = Purchase price per unit
C = Carrying cost as %

As the lead-time (i.e., time required for procurement of material) is assumed to be zero an order for replenishment is made when the inventory level reduces to zero.

The level of inventory will be equal to the order quantity (Q units) to start with. It progressively declines (though in a discrete manner) to level O by the end of period 1. At that point an order for replenishment will be made for Q units. In view of zero lead-time, the inventory level jumps to Q and a similar procedure occurs in the subsequent periods. As a result of this the average level of inventory will remain at (Q/2) units, the simple average of the two-end points Q and zero.

From the above discussion the average level of inventory is known to be (Q/2) units. From the previous discussion, we know that as order quantity (Q) increases the total ordering costs will decrease while the total carrying costs will increase. The economic order quantity, denoted by Q*, is that value at which the total cost of both ordering and carrying will be minimized. It should be noted that total costs associated with inventory T= $ UF / Q + $QPC / 2

Where the first expression of the equation represents the total ordering costs and the second expression the total carrying costs.

The total cost curve reaches its minimum at the point of intersection between the ordering costs curve and the carrying costs line. The value of Q corresponding to it will be the economic order quantity Q*. We can calculate the EOQ formula.

Behavior of costs associated with inventory for changes in order quantity. For order quantity Q to become EOQ the total ordering costs at Q should be equal to the total carrying costs.

Using the notation, it amounts to stating:

UF/Q + QPC / 2 (i.e.) 2UF = Q^2PC or Q^2 = 2UF / PC units To disguish EOQ from other order quantities, we can say:

2 UF* EOQ = Q* PC

In the above formula, when `U' is considered as the

annual usage of material, the value of Q* indicates the size of the order to be placed for the material, which minimizes the total inventory-related costs. When `U' is considered as the annual demand Q* denotes the size of production run.

Suppose a firm expects a total demand for its product over the planning period to be 10,000 units, while the ordering cost per order is $100 and the carrying cost per unit is $2. Substituting these values, EOQ = 2 x10, 000 x100 = 1000 units. 2 Thus, if the firm orders in 1000-unit lot size, it will minimize its total inventory costs.

Inflation affects the EOQ : model in two major ways. First, while the EOQ model can be modified to assume constant price increases, many times major price increases occur only once or twice a year and are announced ahead of time.

REORDER POINT SUBSYSTEM

In the EOQ model discussed we have made the assumption that the lead-time for procuring material is zero. Consequently, the reorder point for replenishment of stock occurs when the level of inventory drops down to zero. In view of instantaneous replenishment of stock, the level of inventory jumps to the original level from zero level. In real life situations one never encounters a zero lead-time. There is always a time lag from the date of placing an order for material and the date on which materials are received. As a result, the reorder level is always at a level higher than zero, and if the firm places the order when the inventory reaches the reorder point, the new goods will arrive before the firm runs out of goods to sell. The decision on how much stock to hold is generally referred to as the order point problem, that is, how low should the inventory be depleted before it is reordered.

The two factors that determine the appropriate order point are the procurement or delivery time stock which is the Inventory needed during the lead time (i.e., the difference between the order date and the receipt of the inventory ordered) and the safety stock which is the minimum level of inventory that is held as a protection against shortages.

Therefore, **Reorder Point = Normal consumption during lead-time + Safety Stock.**

Several factors determine how much delivery time stock and safety stock should be held. In summary, the efficiency of a replenishment system affects how much delivery time is needed. Since the delivery time stock is the expected inventory usage between ordering and receiving inventory, efficient replenishment of inventory would reduce the need for delivery time stock. And the determination of level of safety stock involves a basic trade-off between the risk of stock-out, resulting in possible customer dissatisfaction and lost sales, and the increased costs associated with carrying additional inventory.

Another method of calculating reorder level involves the calculation of usage rate per day, lead time which is the amount of time between placing an order and receiving the goods and the safety stock level expressed in terms of several days' sales.

Reorder level = Average daily usage rate x lead-time in days.

From the above formula it can be easily deduced that an order for replenishment of materials be made when the level of inventory is just adequate to meet the needs of production during lead-time.

If the average daily usage rate of a material is 50 units and the lead-time is seven days, then **Reorder level =Average daily usage rate x Lead time in days = 50 units x 7 days = 350 units**

When the inventory level reaches 350 units an order should be placed for material. By the time the inventory level reaches zero towards the end of the seventh day from placing the order materials will reach and there is no cause for concern.

STOCK-LEVEL SUBSYSTEM

This stock level subsystem keeps track of the goods held by the firm, the issuance of goods, and the arrival of orders. It maintains records of the current level of inventory. For any period of time, the current level is calculated by taking the beginning inventory, adding the inventory received, and subtracting the cost of goods sold. Whenever this subsystem reports that an item is at or below the reorder-point level, the firm will begin to place an order for the item.

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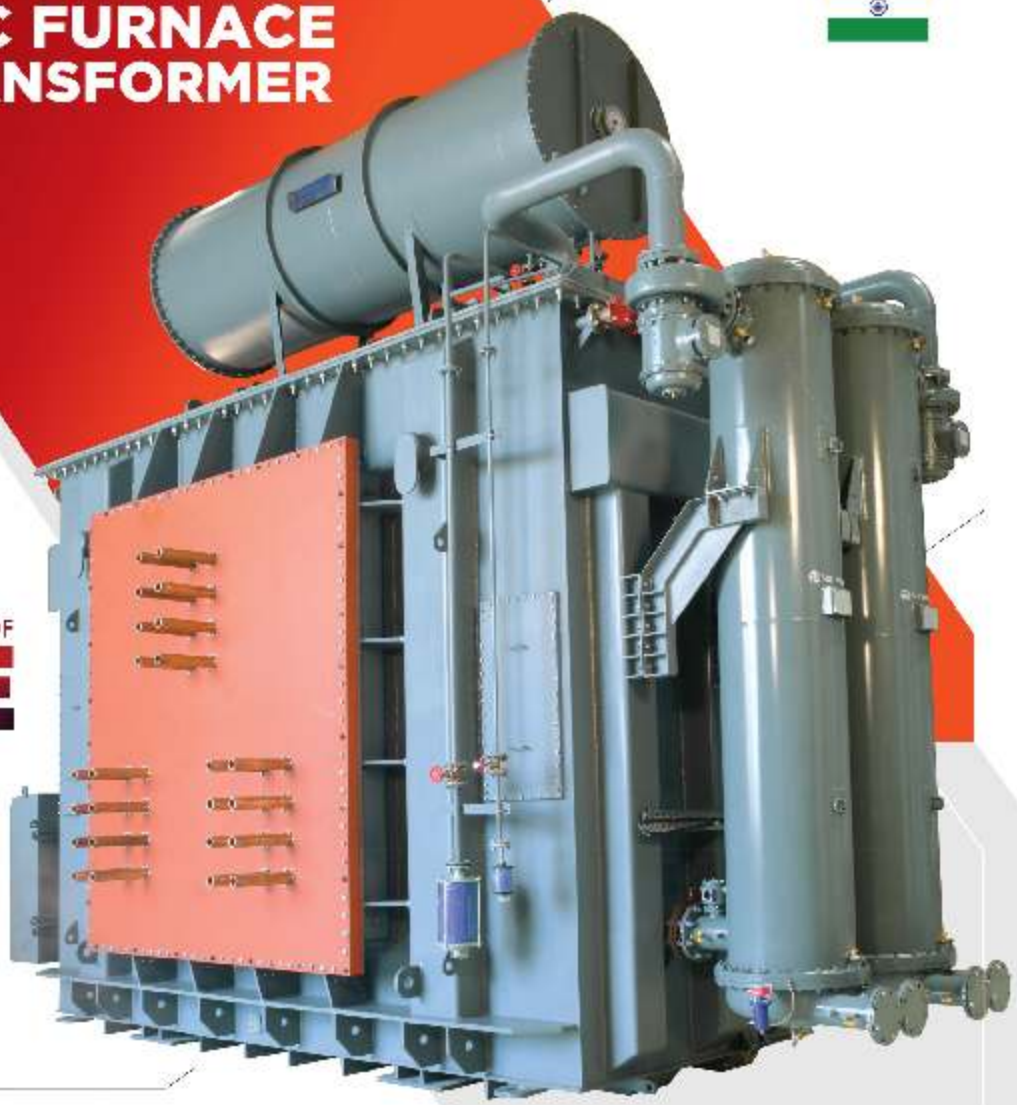

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