ALL INDIA INDUCTION FURNACES ASSOCIATION

AIIFA

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What's Inside

हमारे सभी सदस्यों को बैसाखी की हार्दिक शुभकामनाऐं

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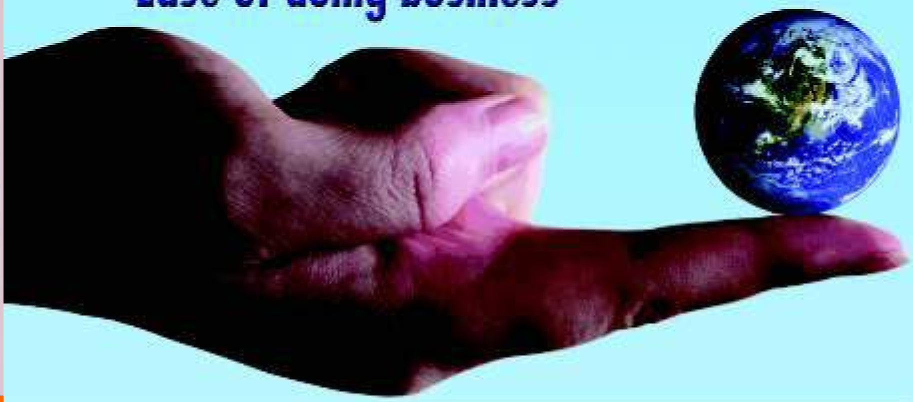

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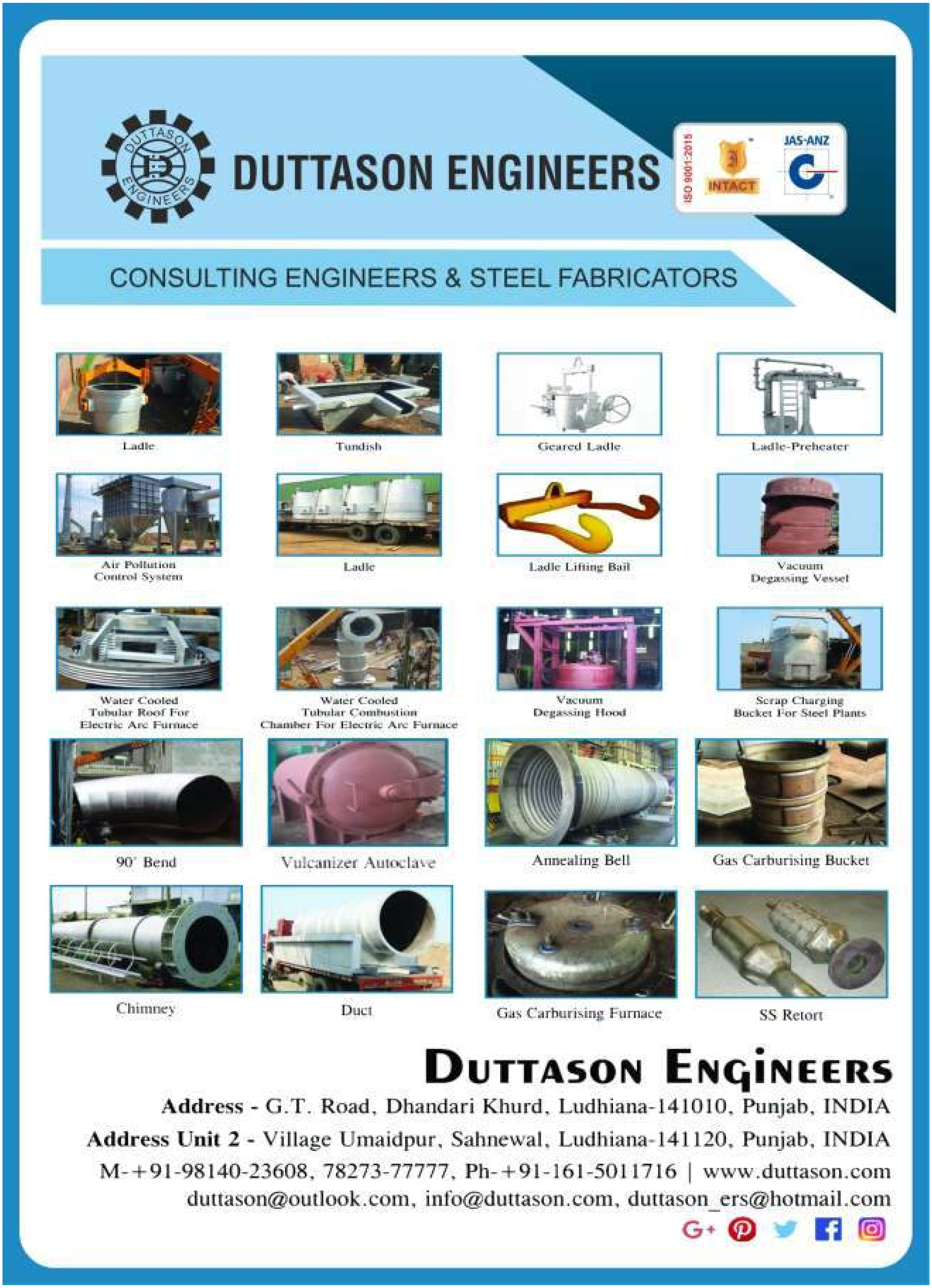
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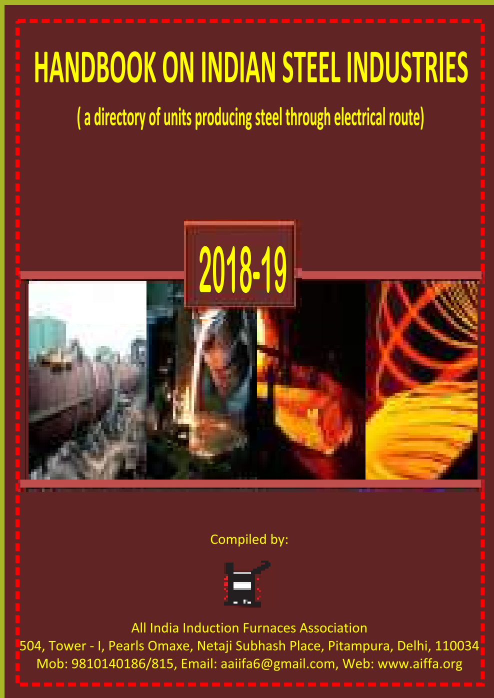

NEW !!!
HANDBOOK ON INDIAN STEEL INDUSTRIES
(a directory of units producing steel through electrical route)

Broadly Covered the following Parameters:

Segment covered: Electric Arc Furnace, Electric Induction Furnace, Rolling & Re-Rolling Mill, Sponge Iron and Ferro Alloy units

Distribution of Units: State-wise

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Steel Making in IF & Casting by Indian Mini Steel Plants

P. Mishra
Sr. Executive Director, AIIFA, Delhi

Steel & Its Classification - Among the steel making processes, Basic Oxygen Furnace accounts for about 70% global steel production by melting together iron ore, steel scrap and liquid iron where carbon content reduced by more than 90% level purified by flux producing liquid steel of varying chemical composition which are refined to make quality steel applying secondary refining process.

Electric Arc & Electric Induction Furnace contributes about 29% global steel production by melting steel scrap and scrap substitutes and the liquid steel is refined by secondary refining processes.

Mini steel plants are producing carbon steel, alloy & special steels in induction furnace being operated by utilizing a strong magnetic field created by passing an electric current through a coil wrapped around the furnace which in turn creates a voltage and subsequently an electric current through, the furnace charge to be melted. The electrical resistance of the charge produces heat, which in turn melts the charge. Presently, all the induction furnace units are keen to improve their operational efficiency starting from charge preparation with right mix of raw material e.g. ms scrap, sponge iron and other scrap substitutes in economical ways and charging stock, melting, refining, teeming in mould or by continuous casting as billet or bloom.

Classification - Steel, an amazing useful material, a type of iron alloy containing different percentage of carbon content and added with other metals to give it extra properties, are mainly classified in four groups viz. carbon steels, alloy steels, tool steels, and stainless steels. Carbon steel is the most important commercial steel alloy as increasing carbon content increases hardness and strength improving harden ability. But at the same time carbon also increases brittleness reducing weld ability because of its tendency of formation of hard marten site. Any steel in Carbon range 0.35 to 1.86 percent can be hardened by hardening and tempering. However, most commercial steels used in various industries are mainly classified into three groups:

A. Plain Carbon steels - These steels usually having less than 1 percent Carbon, plus small amounts of Manganese, Phosphorus, Sulfur, and Silicon. The weld ability and other characteristics of these steels are primarily result from Carbon content, although the alloying and residual elements do have a minor influence and categorized as : **1. Low Carbon steels** , often, called mild steels having less than 0.30 percent Carbon are the most commonly used grades having good fabrication properties. **2. Medium Carbon steels** having Carbon ranging from 0.30 to 0.45 percent with increased hardness, tensile strength, decrease in ductility and more difficult in machining. **3. High Carbon steels** with 0.45 to 0.75 percent Carbon can be challenging to weld. Preheating, post-heating (to control cooling rate), and sometimes even heating during welding become necessary to produce acceptable welds and to control the mechanical properties of the steel after welding. High Carbon steels having 1.50 percent Carbon content require heat treating before, during, and after welding to maintain their mechanical properties.

B. Low-Alloy Steels – These grades are designed for welded applications where Carbon content is usually below 0.25 percent and even below 0.15 percent, common alloys added are Nickel, Chromium, Molybdenum, Manganese, and Silicon for strengthening at room temperatures and increase low-temperature notch toughness. Such alloys, in the right combination, improve corrosion resistance, mechanical properties influencing the steel's response to heat treatment. But there are possibilities of negatively influence crack susceptibility and there use of low-hydrogen welding processes is preferred with preheating the materials. Carbon equivalent is the determining factor for welding, helping in the welding process and calculated as $CE = [C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15]$.

C.High-Alloy Steels - Stainless steel is designated as the most important commercial high-alloy steel which are having at least 10.5 percent Chromium and some have high Nickel contents. The three basic types of stainless are:

1. **Austenitic** stainless steels 200 series or 300 series non-magnetic having high corrosion resistance and excellent weld ability, formability, but aren't stable at room temperature. They can be hardened only by cold working – not by heat treatment. They are highly formable but prone to stress corrosion cracking. There are

three subtypes: Straight, L and H varieties. Popular straight type grades are 201, 202, 301, 302, 303, 304, 305, 308, 309, 310, 314, 316, 317, 321, 347, 348 etc. low carbon (L) 304L, 316L have higher corrosion resistance than the straight types. H types are suitable for use in high temperature environments.

Austenitic stainless steels are used in shafts, valves, bolts, bushings, nuts, aircraft fittings, chemical equipment, food processing equipment, brewing equipment, cryogenic vessels etc. Specific alloying elements must be added to stabilize austenite , most important austenite stabilizer being Nickel, and others include Carbon, Manganese, and Nitrogen. Special properties, including corrosion resistance, oxidation resistance, and strength at high temperatures, can be incorporated into austenitic stainless steels by adding certain alloys like Chromium, Nickel, Molybdenum, Nitrogen, Titanium, and Columbium. Higher Carbon adds strength at high temperatures but can also reduce corrosion resistance by forming a compound with chromium. It's important to note that austenitic alloys can't be hardened by heat treatment. That means they don't harden in the welding HAZ.

2. **Ferritic** stainless steels have 12 to 27 percent Chromium with small amounts of austenite-forming alloys. Ferritic stainless steels are nonhardenable iron-chromium alloys. They include the following: Standard 400-series alloys as well as modified versions of these alloys containing 11 to 27% Cr, 0.08 to 20% C, and small amounts of ferrite stabilizers, such as aluminum, niobium, and titanium. More recently developed low-interstitialcontent (low carbon/nitrogen) grades containing higher chromium (up to 30%), molybdenum (up to 4%), and nickel (up to 2%). Such grades, which exhibit excellent resistance to stress-corrosion cracking (SCC), are referred to as superferritics (see Fig. 1).
3. **Martensitic** stainless steels make up the cutlery grades. They have the least amount of Chromium, offer high harden ability, and require both pre- and post heating when welding to prevent cracking in the heat-affected zone (HAZ). Martensitic stainless steels are similar in composition to the ferritic group but contain higher carbon and lower chromium to permit hardening by heat treatment. They include the following: Standard 400-series containing 11 to 18.0% Cr, up to 1.20% C, and small amounts of manganese and nickel. Nonstandard grades, including free-machining grades, heat-resistant grades, and grades for gears and bearings.
4. **Duplex stainless steels** , Approximately equal amounts of austenite and ferrite microstructure contain in this category of stainless steel having roughly 22 to 25% Cr, 5 to 7% Ni and up to 4% Mo, as well as additions of copper and nitrogen. Duplex stainless steels are not covered by the standard AISI 200, 300, or 400 groups. Some of the more highly alloyed, corrosion-resistant grades are referred to as super-duplex stainless steels, some are referred to by their chromium and nickel contents e.g. alloy 2205 contains 22% Cr and 5% Ni.
5. **Precipitation-hardenable stainless steels –** The elements Al, Cu, or Titanium in chromium-nickel alloys allow this stainless steels to be hardened by a solution and aging heat treatment. This category is classified into subgroups as martensitic, semi-austenitic, and austenitic PH stainless steels which, generally designated by their trade names or UNS number.

In alloy Steels the Pearlite Structure requires less Carbon for it's formation than in ordinary Carbon Steels. Alloying elements change the temperatures at which the structural changes take place as such require different heat treatments than Carbon Steels. Various alloy steels in specific application areas are:

- **Silicon Steel** as most important soft magnetic material today is used in small relays or pulse transformers, generators, motors, and transformers as seen from continued growth in electrical power generation and development as better steels to decrease wasteful dissipation of energy in the form of heat minimizing the physical dimensions of the increased demand of equipments. Silicon Steel being tough and fatigue strength has a very low Carbon content, possessing a very low magnetic hysteresis need careful heat treatment for grain size control and universally used in the iron cores of Transformers; Electric Motors etc. Silicon Steel is also used in making springs when alloyed with Manganese. However, for Automotive valve springs, Manganese is replaced by Chromium for better result during hardening and tempering.
- **Manganese steel**, also called Hadfield steel or mangalloy containing 12-14% Manganese and 1% Carbon is the work hardening steel quench from 1000 deg◦ C having high impact strength and resistance to abrasion usually in austenite state in all sections the structure being Pearlite; Banite etc. Because of its self hardening properties, Manganese steel is very popular for use in mining industry, cement mixers, rock crushers, crawler treads for tractors, elevator and shovel buckets, rail industry (switches and crossings) and other high impact environments. Nowadays Manganese steel is used in the window bars in prisons, the

hacksaw blades of potential escapees, bullet proof cabinets and anti-drill plates. This grade cannot be melted in acid lined IF.

- **Nickel** added to Carbon steel increases the strength, elastic limit, hardness, and toughness narrowing the hardening range but lowers the critical range of steel, reducing danger of war page and cracking balancing the intensive deep-hardening effect of Chromium. Nickel steels are also of finer structure than ordinary steels, and Nickel retards grain growth. At higher percentage of Ni, the steel is very resistant to corrosion. The steel is nonmagnetic above 29% Nickel, and the maximum permeability is at about 78% Nickel. The lowest thermal expansion is at 36% Nickel. The percentage of Nickel in Nickel steels usually varies from 1.5 to 5%, with up to 0.80% Manganese. The bulk of Nickel steels contains 2 and 3.5% Nickel. They are used for armor plate, structural shapes, rails, heavy-duty machine parts, gears, automobile parts, and ordnance.

  The standard ASTM structural Nickel steel used for building construction contains 3.25% Nickel, 0.45% Carbon, and 0.70% Manganese. This steel has tensile strength from 586 to 689 MPa and a minimum elongation 18%. An automobile steel contains 0.10 to 0.20% Carbon, 3.25 to 3.75% Nickel, 0.30 to 0.60% Manganese, and 0.15 to 0.30% Silicon. When heat-treated, it has a tensile strength up to 551 MPa and an elongation 25 to 35%. Forgings for locomotive crankpins, containing 2.5% Nickel, 0.27% Carbon, and 0.88% Manganese, have a tensile strength 572 MPa, elongation 30%, and reduction of area 62%. A Nickel-Vanadium steel, used for high-strength cast parts, contains 1.5% Nickel, 1% Manganese, 0.28% Carbon, and 0.10% Vanadium. The tensile strength is 620 MPa and elongation 25%.High-strength locomotive casting is a Nickel-Vanadium steel.

- **Chromium Steels** are alloyed with chromium. Chromium is one of the most common and key alloying element in stainless steel grades and is contained in most commercially in stainless steel grades increasing the resistance to corrosion. As an austenite former Chromium lowers the critical cooling rate, increases the wear, scaling resistance high-temperature strength, forms a passive layer above the materials underneath which is thin but strongly adheres. With an increasing proportion of Chromium in the alloy, the resistance to corrosion also increases having a positive effect on the resistance to oxidizing acids such as sulfuric acid.

  As a key element in a wide range of Stainless and Heat resisting Steels, it combines freely with Iron but is usually found as Chrome Carbide. In the presence of Carbon some, at least, of the Chromium is found in the Carbide that separates from Austenite on cooling altering the Eutectoid Carbon content and raising the Critical points. Up to 1% increases the strength of Steel without reducing ductility, increases th ability to withstand wear particularly that involving abrasion as opposed to impact damage. Great care must be taken during heat treating as overheating causes brittleness due to the overgrowth of the grains. Carbon free Iron Alloys with over 12% Chromium do not undergo allotropic changes and remain as Ferritic solid solutions at all temperatures.

- **Vanadium** Steels are alloyed with vanadium for strengthening, acts as grain refiner ,it removes oxygen and possibly nitrogen in steel going into solid solution with both alpha and gamma Iron. Above about 1.1% the Iron Vanadium Alloys do not undergo allotropic changes and consist of Ferrite solutions at all temperatures. Vanadium Carbide behaves like Chrome Carbide only it is even more sluggish in going into solution in alpha and gamma Iron. This means that the Steel is not as readily overheated as other Steels. In presence of Carbon, goes into complex Carbides, added to Nickel - Chrome Steel to avoid temper brittleness. V Sometimes used as a part substitute for Tungsten in High Speed Steels

- **Molybdenum** Steels alloyed with Molybdenum in a percentage of 10 to 15 produces a steel similar to tungsten tool steel. Efficient and economical use of Molybdenum improves improve hardenability, reduce temper embrittlement, resist hydrogen attack & sulphide stress cracking, increase elevated temperature strength. It improves weldability in high strength low alloy steels (HSLA) In the present section the focus is on grades and properties of Mo containing alloy steel and iron. Common use of these steels are various engineering industries, automotive, shipbuilding, aircraft and aerospace, drilling, mining, processing, energy generation including boilers, steam turbines and electricity generators, vessels, tanks, heat exchangers, chemical & petrochemical processing, offshore. However, small addition of molybdenum is needed to meet the high end of the application properties.

- **Tungsten Steel**, Addition of W in steel provide great hardness, good stability at high temperatures. It is one of the most important element in high speed steels having better flexibility. Tungsten-steel alloys are widely used for the manufacture of high speed cutting tools such as taps, dies, twist drills, reamers and saw blades as well as rocket engine nozzles. It goes into solid solution with both alpha and gamma Iron and in presence of Carbon goes into complex Carbides. In High Speed Steels from 14% - 22% Tungsten is used. In this case a very hard Iron Tungstide is formed which increases the temperature at which the structural changes take place standing at very high temperature. The cooling changes are, however, greatly retarded so that the Steels are strongly air hardening. The Steel will stand up to much higher temperatures without the Martenistic structure breaking down.

- **Cobalt Steel**, Addition is done in limited grades but in highly specialized applications of alloy steels. Its behavior is similar to nickel, forms a complete series of solid solutions with iron at elevated temperatures and is also extremely soluble in ferrite. It is a potent ferrite strengthener; this solid solution strengthening persists to quite high temperatures, and cobalt is therefore found in several grades of high speed tool steels, among others. Like nickel, cobalt is ferromagnetic leading to its use in a series of magnetic steels as well as in Alnico alloys. Cobalt is an important constituent of the 18% Ni maraging steels and several other ultrahigh strength steels and added to one grade of austenitic stainless steel. Introduced into Magnet Steel to improve their remanence and coercivity in proportions from 3% - 35%.The Steel is expensive and difficult to forge. Added to High Speed Steels to improve "red hardness". i.e. The Steel will remain hard even when red hot and the cutting efficiency will not be impaired.

- **Steel Making in Induction Furnace** - Scrap is the main raw material for induction furnace steel making. Domestic scrap in large part recovered in the steel consuming regions are classified into three categories according to the mode of generation, namely : Internal scrap, Producer scrap Capital scrap. Scrap lacks elasticity in supply and the price fluctuates. International sources of scrap are limited to few industrialized countries. Improvement in fabrication practice and increasing application of the continuous casing process have significantly reduced the availability of recycled scrap. But on the other hand scrap collected in the market is increasing with the economic development and the continuous reduction in the life span of consumer goods, demolition of old equipments etc. Availability of scrap is one of the important conditions to determine the location of a mini steel plants. However, prices of the final products produced by the mini steel plant are greatly influenced by the prices of scrap. Sequencing of casting result improved yield.

- **Power Input in IF** - The power provided for running an induction furnace during its melting operation has an important role on the overall energy consumption of the furnace which has to run at maximum power since beginning for increasing melting rate reducing cycle time of heat. The second essential input for the mini steel plant next to adequate and cheap scrap is cheap electric power availability. Energy efficiency production can play an important role in leading to multiple benefits in mini steel plants. The up-scaling energy efficient production should be undertaken with the main objectives of (i) Improve energy efficiency to save energy and consequently the money spent on fuels (ii) mitigation of GHG emissions (iii) improve productivity through technological support from Govt. For energy efficient production in induction furnace, power factor should be maintained near to one ensuring no voltage drop from the source which is a measure of how effectively induction furnace is using electricity.

  Improving the PF can maximize current-carrying capacity, improve voltage to equipment reducing power losses lowering electric bills. The simplest way to improve power factor is to add PF correction capacitors to the electrical system which act as reactive current generators helping offset the non-working power used by inductive loads, thereby improves the power factor. The interaction between PF capacitors and specialized equipment, such as variable speed drives requires a well designed system. Grade-wise tap temperature within tolerance range is to be calculated avoiding unnecessary superheat.

- **Furnace Lining** - Lining plays an important role in overall performance of melt shop operation as well as saving energy. Due consideration should be given for selection of appropriate lining material, maintain proper lining thickness and its sintering for energy saving. Thick lining reduces furnace crucible volume and hence the molten metal output is less resulting high specific energy consumption. Thin lining, on the other hand, though improves the power density but promotes heat loss from the side walls. Further lining material with high thermal conductivity causes more heat loss. Long sintering cycle time consumes much energy for the first heat to get ready. Pre-mature failure occurs from improper lining, attention for lining maintenance to be given. However, furnace lining and ramming activities are to be done as suggested by furnace supplier or following standard operating practice to get optimum result for energy consumption. Slag deposition in lining needs to be avoided as far as possible.

- **Scrap Quality** – Nature, size and quality of segregated scrap free from sand/dirt, oil/ grease in charge play another important role in reducing power consumption. Rusty scrap not only takes more time to melt but also contains less metal per charging. The return scrap from steel foundry i.e. runner and risers, normally, contain 2 - 5% sand of scrap which should be removed before charging in the furnace. For alloy addition, exact weights as per chemical composition of grade considering recovery and yield are to be calculated before charging without any delay. The maximum size of single piece scrap should not be more than ⅓rd of crucible diameter, sharp edge heavy or bulky scrap must be avoided to save furnace lining. However, efficiency of melting in induction furnace depends on scrap mix, size, quality and charging mode. Lesser air pocket between scrap pieces lead to more power density and higher heat conductivity resulting faster melting with least energy consumption. Higher slag generation takes away more time for slag removal affecting furnace utilization and this should be removed quickly. (Nominal Charge calculation shown below for 10T IF)

Metallic Charge (Nominal)	HBI/ DRI (60% of total , Yield 85%)	-	6.8 T
	Scrap (30% of total, Yield 92%)	-	3.4 T
	Cast & Pig Iron (10% of total Yield 94%)	-	1.16T
	Total – (For 10T Liquid Steel)	-	11.36T

Steel Quality – Customer expectations are gradually rising because of competitiveness in the market place, and to remain competitive in their specific areas, OEMs are demanding higher quality from their suppliers. It is a fundamental premise of steel producing units that high-quality finished products cannot be produced in cost effective way from low-quality inputs even adhering standard process at processing stages. Quality deficiencies at ingot stage or during forging or rolling or even heat treatment may cause generation of sub-standard products. Mini steel units should adopt quality as a competitive strategy finding that they are better able to weather cyclical swings in their businesses and that their product costs are lower reaping benefits by exceeding the quality levels required. By this strategy, mini steel plants can carefully target revenue earning prioritizing improvements in terms of their effect on the organization's operational and financial goals, as well as overall business objectives. It has been well known that the individual or combined effect of carbon [C], phosphorus [P], sulphur [S], nitrogen [N], hydrogen [H] and total oxygen (T.O.) in steel can have a remarkable influence on steel properties, such as tensile strength, formability, toughness, weldability, cracking-resistance, corrosion-resistance, fatigue-resistance, etc. Also, clean steel requires control of non-metallic oxide inclusions and controlling their size distribution, morphology and composition.

Consistent quality is the expectation of all customers. If quality standard or services change on a whim, customer can be left feeling dazed and confused. It is also a sure fire way to lose any gained trust that has already been established. Maintaining consistency in customer relations also helps the customer to manage their own expectations because they will always know what to expect. Listening to customer concerns and complaints will help to determine where inconsistencies occur and what the shortcomings are. Consistency builds trust and trust leads to long lasting business relationships.

Steel product	Maximum allowed impurity fraction	Maximum allowed inclusion size
Automotive and deep-drawing Sheets	[C]≤30 ppm, [N]≤30 ppm	100 μm
Alloy steel for Pressure vessels	[P]≤70 ppm	
Alloy steel bars	[H]≤2 ppm, [N]≤20 ppm, T.O.≤10 ppm	
Line pipes	[S]≤30 ppm, [N]≤50 ppm, T.O.≤30 ppm	100 μm
Plates for welding	[H]≤1.5 ppm	
Bearings	T.O.≤10 ppm	15 μm
Heavy plate steels	[H]≤2 ppm, [N]=30-40 ppm, T.O.≤20 ppm	Single inclusion 13 μm Cluster 200 μm

Material Properties – In the application areas, design of an engineering component involves three interrelated problems:

(i) Selection of proper material with desired composition, quality and properties,

(ii) Specifying a shape with tolerance level and

(iii) Choosing a manufacturing process i.e. forging or rolling, heat treatment conditions satisfying properties

Some customers are most concerned with characteristics such as Yield Strength Ultimate Tensile Strength, Ratio of Yield and Tensile Strength, Shear Strength, Hardness value, Creep behavior at different temperatures, Fatigue strength, Fracture Toughness, Corrosion properties etc. Further, processing industries demand material characteristics like Thermal Properties Thermal expansion coefficient, Thermal conductivity, Specific heat capacity, Magnetic Properties, Fabrication Properties, Ease of machining, Ease of welding, Hardening ability, Formability etc.

- **Maintenance Quality & Cost** – To optimize maintenance quality and cost, mini steel plants should analyze all the components of maintenance costs e.g. material costs, maintenance by contractors and own maintenance, etc. inclusive of saving possibilities, risk estimation and other major issues concerning maintenance. Possible solutions of the maintenance optimization can be represented by side condition for solution adapting the maintenance to the changed conditions, improving activity scheduling, capacities in the own maintenance with possible comprehensive strategy ensuring high work quality and improvement potential with spare part repairs building up skills and knowledge. However, maintenance strategy should be in line as:

1. Breakdown strategy (run to failure),
2. Condition based preventive maintenance (exchange after inspection),
3. Time based preventive maintenance (exchange after fixed period of time)

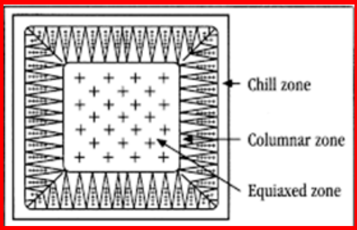
- **Overall Cost Aspect** – The total cost in mini steel plants covers all costs associated with the actual construction of the steel plant and includes the costs of site preparation, production and auxiliary department, utilities, auxiliary buildings, engineering. And administration charges during construction, as well as contingencies, The costs is also incurred on capital spares, preliminary and promotional expenses, start-up expenses, construction facilities and interest during implementation which are to the plant cost to arrive at the "fixed investment". The capacity ranges for the economical operation of the respective units in the entire plant.

Production cost of steelmaking in induction furnace varies depending on the conditions under which the plant handles the grade and products.

If a mini steel plant produces products made with relatively small scale production facilities, such as forgings, rolled products, reinforcing steel bars, medium and small sections products then the unit is feasible due to the depreciation, administration and fixed costs, all of which are lower than those of integrated large scale plants. However, too many mini steel plants, mostly in the same region, will result in keen competition with each other which will, hopefully, provide enough opportunities for improvement maintain competiveness.

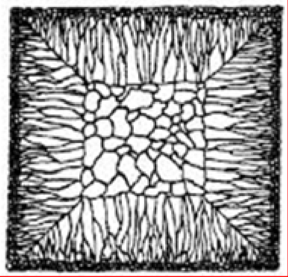
- **Continuous Casting**- Mini steel plants are seeking strategies for cost-effective and efficient production units utilizing local resource and distribution markets. This development originates from the requirement of a sustainable, energy efficient and cost-optimized steel production continuous casting process from melting shop to finishing line to meet the market demand. In the photograph below shown billet caster, ingot teeming and their solidification zones.

4-Strand Billet Caster



Solidification Zones in C.C Billet

Up-Hill Teeming of Ingot



Solidification of Ingot Structure

The principle of the continuous casting method is simple The liquid steel in a ladle is transferred to the casting machine. When the casting operation starts, the nozzle at the bottom of the ladle is opened and the steel flows at a controlled rate into the tundish and from the tundish through a submerged entry nozzle (SEN) into one mold or several molds. The molds are generally water-cooled copper molds. The first solidification takes place at the metal/mold interface. The thickness of the solidified shell increases progressively when it is withdrawn through the machine. At the mold exit, the shell must be thick enough to support the liquid pool. Below the mold, the shell is cooled by spraying water. The mold cooling is called the primary cooling and the spray cooling the secondary cooling. At the machine end, the strand is cut off and transferred to a rolling mill.

The big challenge in continuous casting is to cast steel continuously without interruptions and without many kinds of defects. Solidification control is important for surface and internal quality. Steel cleanliness is determined essentially already by the preceding operations in the ladle and in the tundish but can be influenced even in the casting operation. Important control parameters in solidification are, e.g., steel chemistry, casting speed, mold level, mold powder, mold oscillation, liquid steel temperature, secondary cooling conditions, as well as parameters affecting the flow phenomena in the mold. The research and development work in the continuous casting field is continuing quite intensively today, the main purposes being better quality of cast product and to develop methods to cast extra difficult steel grades with special problems and requirements. Today also the energy efficiency and the ecological aspects are of special importance.

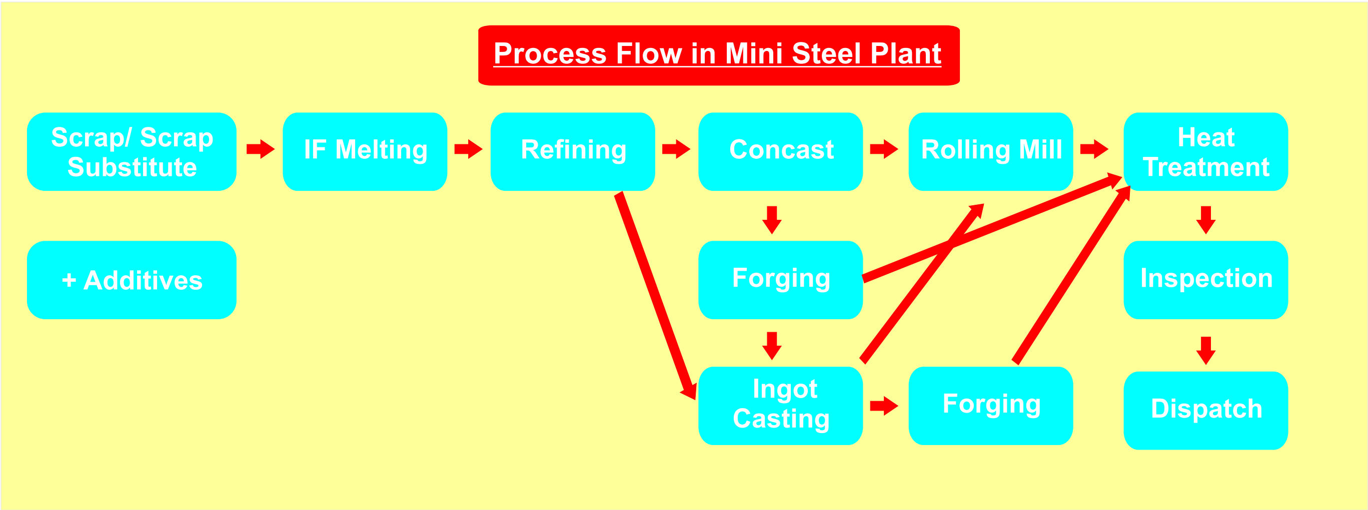
Secondary steelmaking and continuous casting are the central process phases with strong influence on the final quality of the steel products. Liquid steel processing in ladle, tundish, and mold and final solidification consist of a complicated series of successive chemical, physical, and thermal phenomena. Strict control and smooth operation are extremely important but quite challenging tasks due to scarcity of direct measurements which would describe dynamic changes in steel chemistry, temperature, flow conditions, and interactions with, e.g., covering slag, refractory materials, or mold wall. Modeling of reactions, flow dynamics, and heat transfer can give a better understanding of different phenomena and their relations to different process parameters as well as it can advice to optimize the process run.

Decisions on, the casting speed, the spray water flow rates and super-heating in the tundish can only be made with the knowledge of the solidification progress i.e. cooling inside the mould and in the secondary cooling zone. It is the preferred route for converting liquid steel to semi-finished shapes allover the world attending high degree of sophistication in comparison to many other metallurgical operations. The liquid steel is poured from ladle to refractory tundish and then into a water-cooled copper mould. The semi-solidified steel strand is withdrawn with a constant speed, cooled by water sprays in both the sub-mould region and the secondary region until solidification is completed.

The casting speed or the spray water flow rates can only be made with the knowledge of the solidification progress for product quality, productivity in continuous casting and determined by heat transfer and the stress status of billet solidification. The metallurgical standards of solidification i.e. solidified thickness at the exit of the mould, the liquid pool depth, and the billet surface temperature, are governed by heat transfer characteristics. Deformation capacity of the solidified crust should be limited. It is observed that 700-750◦ C corresponds to the lowest elasticity, and at 900-1100◦ C the elasticity is at its highest value. Bloom/ billet of an average surface temperature of over 900◦ C before straightening is ideal, according to steel grade. Due to ferro-static pressure of the liquid steel, bulging may occur between the two rollers, creating tensile stresses along the solidification front, and causing a central segregation line. Optimum casting parameters will, hopefully, control the problems arising out of formation of the air gap between the cooled strand and the mould due to the shrinkage.

Effect of water-spray heat transfer coefficient on distance needed for complete solidification cooling rate should be kept at its lowest acceptable level to keep these temperatures near the recommended values. It is also noted that average surface temperature of the billet is always higher than the minimum acceptable value of 800°C, even under the lowest water-surface cooling condition. To achieve such a temperature, water cooling should be followed by air cooling of much lower rate before bending of the strand starts. Minimum average surface temperature reached at the end of solidification is about 680°C. Further air cooling from the surrounding will cause a rise in surface temperature in spite of the drop in body temperature. The reason for this is that, cooling by water causes higher rate of surface cooling, and sharp drop in temperature in the layer near the surface. Higher surface cooling rates, lead to shorter cooling times and shorter distances. Thus, total cooling time is mainly affected by surface cooling either directly as in the secondary zone, or indirectly as in the 'primary zone.

Sequencing Production of Casting and Rolling - For reduction of energy consumption and yield loss optimizing process cost, the best option to the mini steel plants is setting up of billet/ bloom continuous casting linking with rolling process and finishing the rolled products with uninterrupted sequencing as far as possible. By applying the direct casting of billet/ bloom and rolling such products, more than 90% of the energy required for reheating of the billets is saved when compared to a conventional production concept. Quality and product yield will also improve in such process sequencing.



Conclusion – Indian entrepreneurs have established mini steel plants with induction furnace melting solely using scrap and scrap substitutes and processing subsequently by the down stream processing units which are running successfully producing quality steel products at lesser cost which have become a significant factor globally in the entire steel industry. It is hoped that technological breakthroughs will, hopefully, make possible mini steel plants having induction furnace to produce all the critical grade products and in all the shapes to meet the market demand of priority sectors which are being imported presently. Management of the plants, gradually, are investing for product and process development to become competitive. However, management of the units are seeking help and support from Steel Ministry in the areas beyond control of the management. The problems of the induction furnace have largely been concerned with the volatile price of scrap, availability of good quality scrap and high power rate. Although the induction furnace is also a high-power consumption device, the interference to the grid is much smaller than that of the EAF and has become attractive and accepted melting process in respect of the impact on the environment, the very low noise level during melting as well as emission of smoke, gas, dust and waste residue is relatively small.

References: AIIFA News Letter, ASTM Std,/ AISI Specification. Process Observation in Mini Steel Plants.

Steel Sector News

India to surpass US as second biggest steel consumer by end of this year

10 Apr 2019

The apparent consumption of finished steel at 97.5 MT, registering an annual growth of 7.5%, the highest among the global players, has made India nearly touching the level of the US and in all likelihood India would occupy the second position in steel consumption by the end of CY19.

The performance of Indian steel industry in FY19 deserves special mention amidst a minor slowdown in industrial production in the last few months. Crude steel production at 106.4 MT has made India climb up the second position, surpassing Japan and the differential is likely to get widened in the coming years.

The apparent consumption of finished steel at 97.5 MT, registering an annual growth of 7.5%, the highest among the global players, has made India nearly touching the level of the US and in all likelihood India would

occupy the second position in steel consumption by the end of CY19. The finished steel production at 131.7 MT plus imports (finished) at 7.8 MT minus exports (finished) at 6.4 MT and after deducting inter plant transfer and double counting (HR to CR, CR to Coated, HR to Pipes) at 33.1 MT and adjusting for stocks (additions are minus with depletion as plus) of (-) 2.6MT, we get a finished steel consumption of 97.5 MT. A few aspects of this performance may be noted.

First, the consumption growth in carbon steel market is substantially lower at 5.7% as compared to consumption growth of 25% in alloy and SS market. The gross production of 11.03 MT in the special steel segment is a record and as these two segments are predominated by large number of SMEs, the rise in production and consumption has benefited SME sector the most. JPC data on alloy/SS category wise is currently made available only at the production level and not at the consumption level (even though imports and exports of alloy/SS is available product wise) which makes it difficult to arrive at product wise market share. The production data needs to be bifurcated at least into major producer wise (SMEs can be grouped together) to align with the reporting for the carbon steel market.

The market segments of the two types of steel are not entirely different and automobile, railways, transport (ART), architecture, building and construction (ABC) are the major common sets of consumption. It appears that growth rates in alloy/SS in these sectors enjoy the impact of low base volume and there is a distinct shift towards use of special steel by the consumers in these traditional areas. However, the auto sector after undergoing a steady monthly growth between 10-12% in the past one year is showing signs of deceleration at 7% growth in FY19.

The auto component sector is suffering due to lower orders from the car manufacturers. The repo rate reduction of 50 basis points in two tranches by RBI is likely to make personal loans cheaper and may stimulate demand in the sector in the coming months. As auto sector growth is employment intensive, it is essential that the sector gets back on rails early and demand for CRS, HRC, Rounds also moves up. This sector is also important to prompt domestic producers to build up capacities of making advanced high strength steel, body sheets and panels and thereby bring down imports of high value added steel. Nippon Steel, JFE, Hyundai, POSCO are some of the global players that have set up indigenous facilities (service centres) for supplying customised steel to auto sector and therefore the growth sustainability of the sector is a major determining factor for the success of Make In India programme.

Second, the total imports (including semi finished steel) in FY19 at 8.8 MT has grown by 4.6% over last year, while total exports at 8.5 MT falls short of last year's level by 26.4%. The plausible reasons of the US' unilateral act of duty enhancement under section 232 followed by retaliatory steps by China and the EU (definite safeguard duty and quota based entry) and the application of a wide range of ADD and CVD notified by many countries against various steel products have led to a shrinkage of space for the movement of steel for trading purposes and no wonder Indian steel exports have faced stiff entry barriers. The slower growth in global trade had its adverse impact on manufacturing growth also. It has resulted in limiting steel export destinations from India to Nepal, Italy, Vietnam and the UAE. While imports to India have been primarily undertaken by Japan, South Korea (under free trade in RCEP) and China, together accounting for 66.6% of total imports and maximum imports took place in respect of HRC, coated products, CRC and bars and rods, the product categories of HRC, semi finished steel, coated products, CRC and bars and rods comprise the major components of Indian steel exports in FY19. Melting scrap has been imported a record level of 6.6 MT in the year. The import of defective grade coated sheets to the tune of around 1,50,000 tonne worth `612.2 crore is a cause of concern.

Globally, the manufacturing sector is performing below desired level. The PMI in manufacturing in the US, China, Germany, South Korea and Japan at 52.4, 50.8, 44.1, 48.8 and at 49.2, respectively are generally lower than February level. The silver lining is that stimulus measures in terms of additional public investment and appropriate policy support (monetary and fiscal) for building of infrastructure, real estate, ports and ship building and other steel intensive sectors would continue unabated in the US, Germany, Japan, China, Indonesia, the UAE, Saudi Arabia and India. This factor alone would make the deceleration in specific sectors rather short lived.

Source: Financial Express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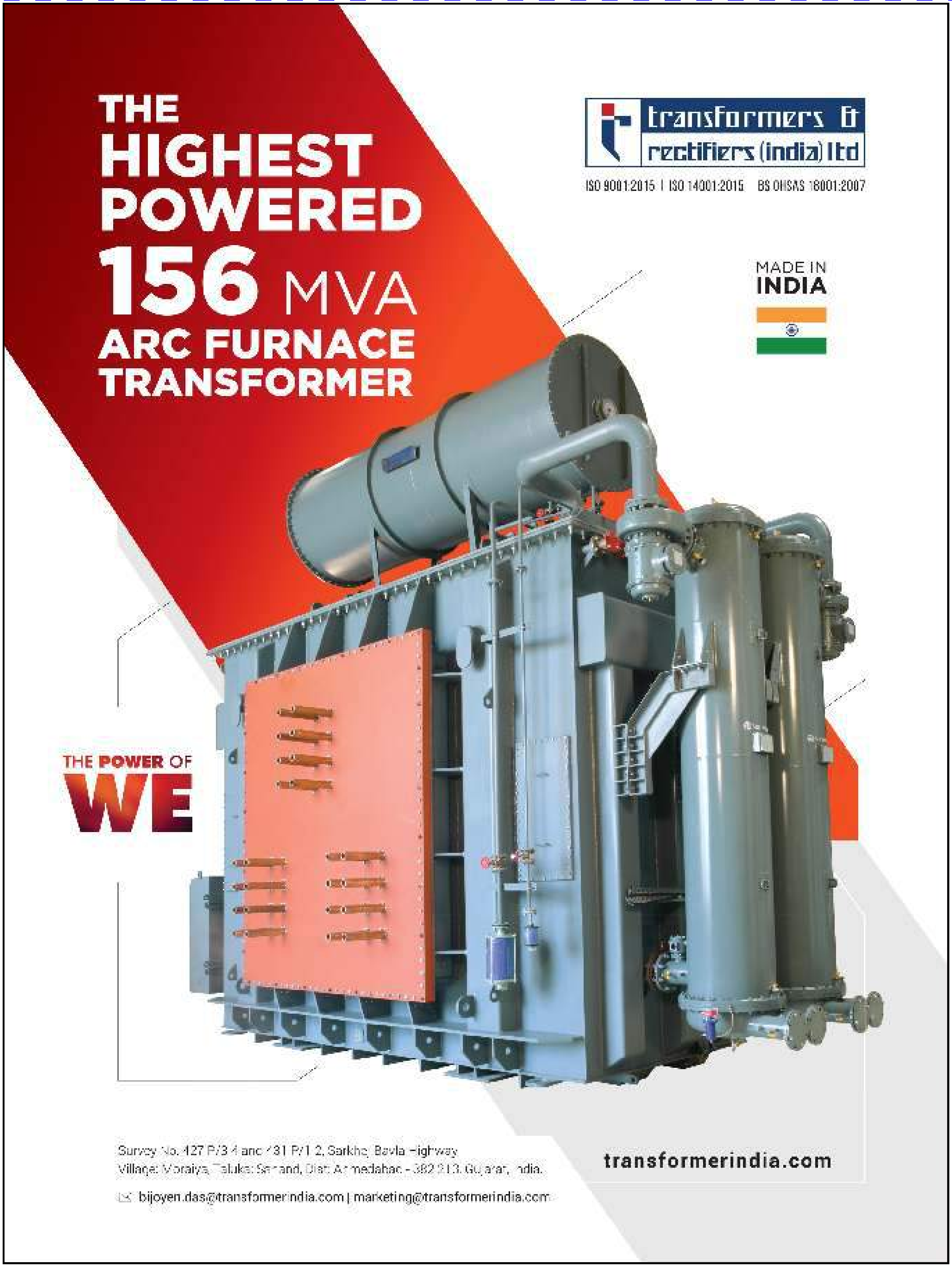
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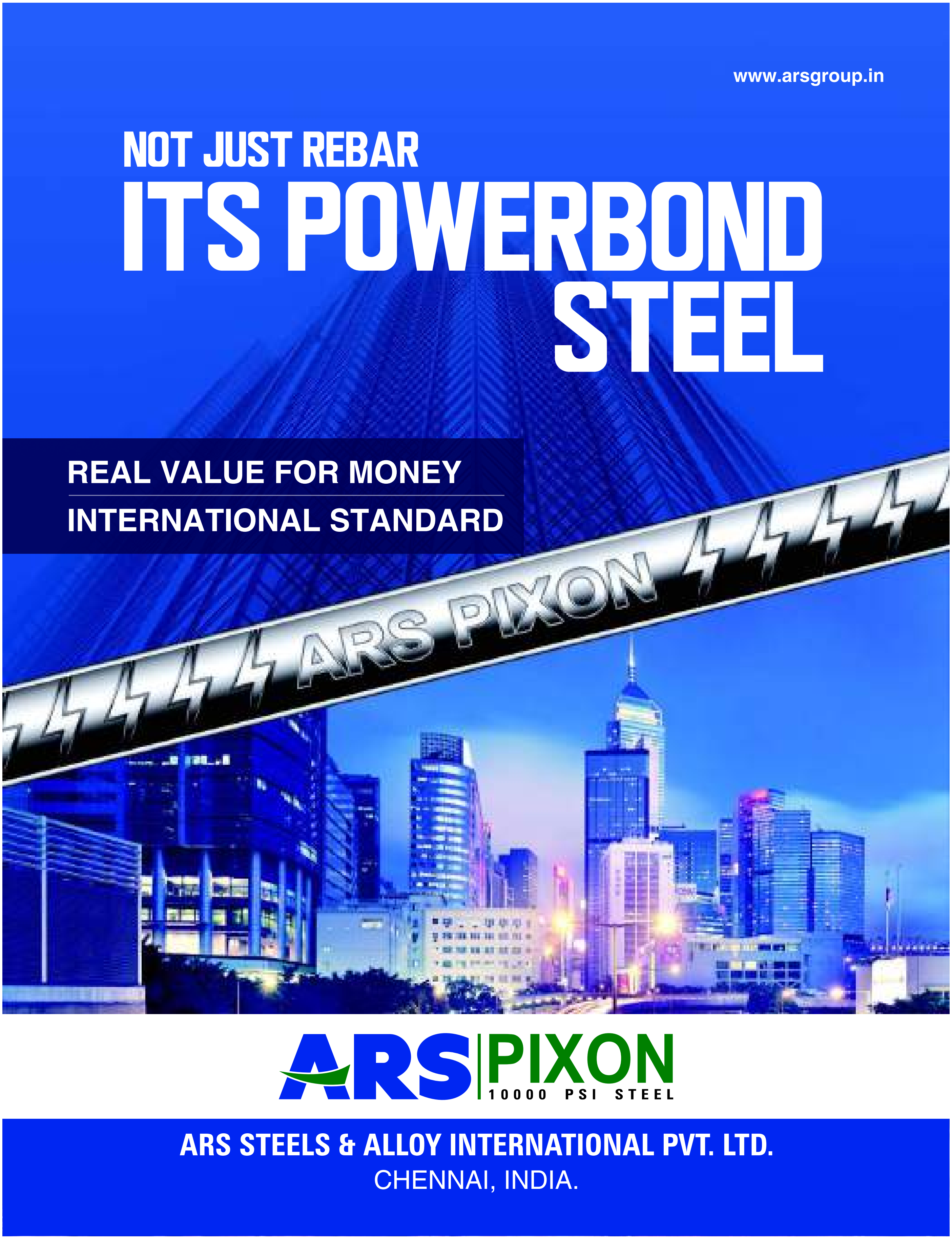
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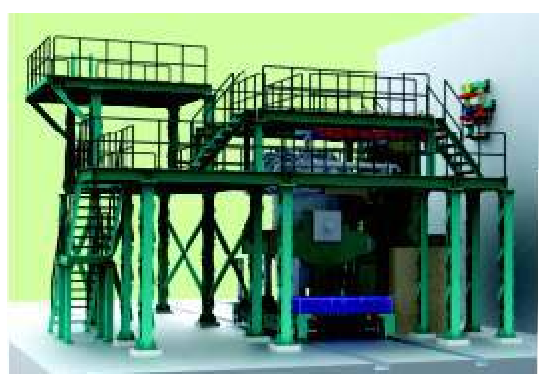
- Dephosphorization and Desuphurization
- Degassing and inclusion modification
- Trimming / alloying
- Superheating of liquid steel
- Homogenization of chemical composition and temperature
- Buffer between melting and casting equipment to facilitate sequence casting



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