Drivers for Sustainability of Indian Steel Industry

Introduction

Steel has historically been the building block of a nation’s rapid industrial development. India is a resource-based country and is blessed with large reserves of Iron Ore, Coal, Limestone, i.e., the main raw materials required for Iron & Steel making but its sustainability has always been a major challenge. Indian steel industry has seen several up and downs in the past but despite all odds, it has made rapid strides in the last three decades from 22 MT in FY 1991-92 prior to deregulation, to 106 MT in FY 2018-19, thus becoming the second largest steelmaker in the world, after China.

The Indian steel industry operates under three broad-based process routes for production viz. BF-BOF, EAF and IF. Recognizing the opportunities available in the country, mainly due to very low per capita consumption of steel and increased focus on infrastructure development, the Ministry of Steel, Govt of India prepared a road map in the form of the National Steel Policy -2017 (NSP-17) to create a sustainable Iron & Steel Industry with focus on increasing the production capacity from ~130 MT presently to 300 MT by 2030 and to make country self-sufficient in terms of steel and alloyed steel. Thus, the next 10 years will see huge capital investments in the Iron & Steel sector in setting up of Greenfield plants as well as Brownfield expansions.

Although, India’s steel production has increased significantly but our dependency on technology and supply of some of the critical raw materials has not improved much, which is leading to huge outflow of foreign exchange. It is high time, the stakeholders of steel sector i.e., the design and consultancy organizations, steel producers, R&D organizations, academia and the government work together in developing a sustainable R&D platform capable of indigenous design and manufacture of equipments/facilities as well as provide innovative solutions to the challenges faced by the steel sector in terms of enhancing process and product capability, cost-effectiveness, competitiveness, quality and environmental issues.

Drivers for Sustainability of Steel Industry

The key drivers for sustainability of the Indian steel sector can be classified under following heads:

- Competitiveness
- Cost-effectiveness
- Quality
- Product development
- Environment and energy

Competitiveness

The competitiveness of the steel industry will largely depend on its ability to produce cost-effective steels of desired quality and volume, as per the changing market requirements. India is blessed with huge iron ore reserves of 33.3 billion tons with an average iron content of 64%. Due to high iron content, due importance could not be accorded towards adoption of the advanced...
beneficiation technologies like adopted in other parts of the world. Now, the grades are deteriorating and some of the deposits are facing major challenges because of high alumina content, which leads to formation of viscous slag and low productivity of the blast furnace. Similarly, silica also is increasing continuously and impacting the competitiveness. Thus, optimum utilization of low grade iron ore in one of the most cost effective manner without compromising on environmental performance will be the major challenge for providing sustainability in the sector.

India also possesses large reserves of coal, both thermal and coking coal, estimated to be around 300 billion tons as shown in table-1.

<table>
<thead>
<tr>
<th>Type of Coal</th>
<th>Proved</th>
<th>Indicated</th>
<th>Inferred</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>125909</td>
<td>142506</td>
<td>33149</td>
<td>301564</td>
</tr>
<tr>
<td>(A) Coking :-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Prime Coking</td>
<td>4614</td>
<td>699</td>
<td>0</td>
<td>5313</td>
</tr>
<tr>
<td>-Medium Coking</td>
<td>13303</td>
<td>11867</td>
<td>1879</td>
<td>27049</td>
</tr>
<tr>
<td>-Semi-Coking</td>
<td>482</td>
<td>1004</td>
<td>222</td>
<td>1708</td>
</tr>
<tr>
<td>Sub-Total Coking</td>
<td>18400</td>
<td>13569</td>
<td>2101</td>
<td>34070</td>
</tr>
<tr>
<td>(B) Non-Coking</td>
<td>106916</td>
<td>128838</td>
<td>30249</td>
<td>266002</td>
</tr>
<tr>
<td>(C) Tertiary Coal :-</td>
<td>594</td>
<td>99</td>
<td>799</td>
<td>1493</td>
</tr>
</tbody>
</table>

Out of total 300 billion tons, nearly 34 billion tons are of coking coal which is sufficient enough to meet the present and future demand of the steel industry. In spite of the huge reserve, more than 80% of coking coal need is met by import and become the major reason of our non-steel production, thereby improving their quality, competitive edge, profitability and reducing the dependence on imports.

Cost Effectiveness

In order to be cost-effective, performance capabilities need to be augmented to higher level to match with benchmark performances. The gaps need to be addressed through adaptation of best practices, innovation and new technology development, focus on alternative use of fuels and adopting zero waste approach. Some of the integrated steel producers have made significant progress in this direction but some urgent action may be required by others and also by the secondary sector towards achieving benchmark parameters. Some of the critical parameters can be as follows:

1. Reduction of coke consumption from the present level of 400 – 600 Kg/thm to 300 Kg/thm. This can be partially achieved through reduction of moisture content of the coke to less than 1% and the coke ash content to less than 12% consistently.

2. Dry quenching of coking may help in achieving moisture content of less than 1% besides reducing Greenhouse gas emission by 2030 – 31 as already committed in COP 21.

3. Advanced system for washing of coal and automated blending of coal may help in controlling the ash content within a narrow range to have smooth operation of the blast furnace at higher productivity levels.

4. Oxygen enrichment to the extent of 9% and increase of hot blast temperature (HBT) to 12000 C minimum will contribute significantly towards achieving blast
furnace productivity of 2.5-3 t/M3/day from the present level of 1.5 – 2.5t/M3/day.

5. Reduction in tap to tap time and increase in the average number of BOF blows/converter from 15 – 20 to 30 will help in significant increase in production with the existing facilities, provided the downstream facilities such as secondary refining and continuous casting are synchronized to meet the additional volume of production.

6. Specific energy consumption and converter utilization are two other parameters contributing to cost-effectiveness and efficiency of the BOF process and efforts need to be made to achieve 45 – 48 NM3/tcs and greater than 90% respectively.

7. Refractory contributes significantly to the cost of production and thus continuous efforts need to be made to develop new refractory materials suitable for steel ladles and BOF converters. While BOF lining life ranges between 5000 – 6000 heats for the major steel producers, it is the aim to achieve 9000 heats consistently in the long run, thereby reducing the cost of refractory/ton of crude steel and enhance the productive life of the converter before relining.

8. Introduction of zonal lining concept and computerized refractory management system (CRMS) has led to significant improvement in lining life of BOF converters. Similarly, the life of the steel ladles in circulation in LF-CC route and LF-VAD/RH route are 70-90 heats and 130-170 heats. Technological interventions and best practices will enable to achieve 100 heats and 230 heats average for LF-CC and LF-VAD/RH, which has been reported by BSL(SMS-II) and JSW(SMS-I) respectively during 2017-18.

9. In the rolling mill area, which comprises hot strip mill (HSM) and plate mill for flat products, some of the companies have reported mill utilization and rolling hours/day for HSM of 89% and 21.38 hrs/day respectively, which is comparable to the best in the world. Similarly for plate mill operation, the best operating figures w.r.t mill utilization and rolling hrs/day reported by Essar Steel are 95% and 22.8 hrs/day as compared to 80-90% and 19-20 hrs/day for the rest of the other producers.

In brief, the drivers for increasing cost effectiveness shall largely depend on improving performance parameters of different processing units of the steel industry with particular emphasis to blast furnace, coke ovens, steelmaking and rolling. Improving the parameters in the above units from the present level to best in India level and subsequently to best in world level will transform the Indian steel industry to lowest cost producer of steel.

Quality

Quality of the product depends on raw material, iron making, steelmaking, casting and hot rolling process, along with microstructure and mechanical properties of the finished product. Packaging of the material is important to ensure the quality of the material dispatched is retained on arrival at the customers end. The major factors contributing to quality are:

- input raw material
- alloy chemistry
- processing parameters during iron making, steelmaking & rolling process
- alloy chemistry and mechanical properties
- customer feedback

As input raw material has a significant influence on the final product, on-line and off-line analysis of input iron ore, coking coal/coke, limestone and ferro alloys may be helpful in achieving the desired quality. The impact effect of alloying elements on the properties of steel are briefly summarized in Table 2. Sulfur, phosphorus
### Table 2: Effect of alloying elements on properties of steel

<table>
<thead>
<tr>
<th>Element</th>
<th>Improves</th>
<th>Lowers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>Most important constituent of steel. Improves tensile strength, hardness, &amp; resistance to wear &amp; abrasion.</td>
<td>Ductility, toughness and machinability.</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>Tensile strength, hardness, hardenability, toughness, resistance to wear &amp; abrasion, corrosion, &amp; scaling at elevated temperatures.</td>
<td></td>
</tr>
<tr>
<td>Niobium (Nb)</td>
<td>Increases strength through grain refinement and precipitation hardening without affecting ductility and toughness</td>
<td></td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Beneficial to atmospheric corrosion when present in amounts exceeding 0.20%. Weathering steels have greater than 0.20% Cu.</td>
<td>Leads to brittleness and cold-shortness in steel.</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>Improves tensile strength, hardness, hardenability, and resistance to wear. Combines with sulfur to form MnS and improves the toughness of steel.</td>
<td></td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Increases strength, hardness, hardenability, and toughness, as well as creep resistance and strength at elevated temperatures.</td>
<td></td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>Increases strength and hardness without sacrificing ductility and toughness. Enhances corrosion and scaling at elevated temperatures when introduced in suitable quantities in high-chromium (stainless) steels.</td>
<td></td>
</tr>
<tr>
<td>Phosphorous (P)</td>
<td>Improves machinability and corrosion resistance.</td>
<td>Leads to brittleness and cold-shortness in steel.</td>
</tr>
<tr>
<td>Silicon (Si)</td>
<td>A deoxidizer and degasifier. It increases tensile and yield strength, hardness, forgeability and magnetic permeability.</td>
<td>Affects cold workability and ductility.</td>
</tr>
<tr>
<td>Sulfur(S)</td>
<td>Improves machinability in free-cutting steels.</td>
<td>Adversely affects weldability, impact toughness and ductility. Strong segregation tendency leading to cracking.</td>
</tr>
<tr>
<td>Titanium (Ti)</td>
<td>Strong nitride and carbide former. Used as stabilizing elements in stainless steels and IF steels. Used in small quantities in micro-alloyed steels for high strength.</td>
<td></td>
</tr>
<tr>
<td>Tungsten (W)</td>
<td>Increases strength, hardness, wear resistance and resistance to shock impact. It also enhances the red-hardness properties of high-speed metal cutting tools.</td>
<td>It retards grain growth, permitting higher quenching temperatures.</td>
</tr>
<tr>
<td>Vanadium (V)</td>
<td>Used as a micro-alloying element in HSLA steels. Achieves high strength through precipitation hardening and grain refinement.</td>
<td></td>
</tr>
</tbody>
</table>

and nitrogen are undesirable and needs to be reduced to the extent demanded for a particular grade of steel through primary and secondary steelmaking processes. For example, in extra deep drawing (EDD) steels, the carbon, sulfur, phosphorus and nitrogen content should be as low as possible to achieve the desired ductility and formability properties required to deep draw automobile components of complex shapes. In case of linepipe steels required to transport sour gases, the sulfur content should be controlled to less than 0.005
% to achieve the desired hydrogen induced cracking (HIC) and sulfide stress corrosion resistance (SSCC) in the steel. Similarly, in the case of CRNO and CRGO steels, the silicon level should be in excess of 2% (depending on the grade) in addition to low carbon and high aluminium to improve the volume resistivity and lower core losses. High strength rails rely on high carbon and manganese content to achieve the desired strength and abrasion resistance along with low hydrogen content (less than 1.6 ppm) to reduce hydrogen induced cracking propensity in the rails.

In order to empower and strengthen the secondary sector towards production of quality steel and meet the growing market of special and alloy steels, Ministry of Steel has initiated a number of special programs involving interventions in technology, R&D and financial support to improve the quality of steel and make the process more cost competitive, energy efficient and environment friendly. More initiatives are required in this direction for growth and sustainability of the secondary sector.

In conclusion, it may be mentioned that thrust requires to be given to on-line process control of raw material input, modeling and automation of BOF process and introduction of secondary refining facilities to achieve desired chemistry and temperature.

**Product Development**

To maintain a competitive edge in the steel sector, it is imperative to continuously innovate and develop new grades of steel with attractive product attributes at competitive cost for new and existing end-applications. Though India has made significant strides in the area of product development, there are a number of high value grades which are still getting imported in large volumes. An example, cold rolled grain oriented (CRGO) steel which is used for the manufacture of transformers and generators for the power sector. The entire requirement of around 3 lakh tons annually is sourced through imports. Another class of silicon steel known as cold rolled non-oriented (CRNO) steel are principally used for motors, alternators, ballasts, small transformers and a variety of electro-magnetic applications requiring good electrical conductivity such as refrigerators, electric iron, light fittings, fans, mixies etc. Though, some attempts have been made in the country to produce such steel, but consistent quality and yield is always an issue and thus major steel producers are not showing much interest. Thus, the bulk requirement for these grades are being sourced through import.

The increased focus on exploration and development of upstream and downstream hydrocarbon industry has resulted into huge demand of linepipe steel in the country for the transportation of oil and natural gas. The demand is to the tune of 5-6 lakh tons annually. Linepipe steels are covered under API 5L specification and covers grades ranging from X-42 to X-100. Though steel industries in India such as JSW, ESSAR, SAIL and TATA Steel are producing grades up to X-70/X-80, but the entire domestic demand is not met and a substantial tonnage is being imported.

The automotive industry is also growing fast and all over the world this industry is continuously striving towards development of new designs and materials for achieving reduced weight and improved crash resistance of vehicles. A large number of grades such as IF, TRIP, dual phase, multiphase steels have been developed and commercialized. These grades exhibit high strength along with excellent ductility and formability properties. A lot of research is under
The Indian steel industry needs to quickly gear up and achieve self sufficiency in meeting the requirements of this important and high premium sector, both in terms of volume and quality.

A large variety of special steel grades catering to different end applications are required in small tonnages and different thickness/size, which are difficult to be supplied by the major steel producers. These grades and tonnages when added up, amounts to a substantial tonnage which is presently sourced through imports. The secondary sector can play a vital role by meeting these small tonnage requirements. This requires strengthening of the secondary sector through introduction of contemporary energy efficient technologies and knowledge base to produce quality steels as per requirements of the market.

2.1 Environment and Energy

The iron and steel industry is one of the largest industrial emitters of CO₂, accounting for around 4% of total CO₂ emissions globally. Use of energy efficient technologies and partial replacement coal/coke fuel with alternate green fuels such as hydrogen, natural gas, and coal based methane will significantly reduce the carbon footprint of the steel sector and help to achieve COP-21 commitments of 30-35% reduction in energy from 6.7 to 5 Gcal/tcs. Another alternative before the Indian steel industry is to increase the percentage of electric steel (EAF/IF) production which relies on steel scrap, DRI as opposed to iron ore and coking coal in the BF-BOF process. Around 20% energy reduction per ton of steel produced is possible using the electric route.

The ongoing UL-COS (ultra low carbon dioxide steelmaking) program supported by European Commission and 48 steel producers across the world aims to reduce CO₂ emission by atleast 50%. In the first phase of the program, the following potential processes have been identified for further development.

- Top gas recycling blast furnace which is based on separation of the off gases so that the useful components can be recycled back to the furnace as a reducing agent.
  - Hisarna process combines two process units, the cyclone converter furnace (CCF) for ore melting and pre-reduction and a smelting reduction vessel (SRV) where the final reduction to liquid iron takes place.
  - Ulcored process involves direct reduction of iron ore by a reducing gas produced from natural gas. The reduced iron is in solid state and will require an EAF to melt the iron.
  - Other process like MAGMA Technology, Plasma etc are also being actively being persuaded to minimize dependency on coking coal and provide flexibility in use of various raw materials, particularly of low grades.

Other energy reduction possibilities involves dry quenching of coke and utilization of the heat for steam or power generation, use of alternate fuel in the BF, dry granulation of slag and heat recovery, utilization of the heat of the slabs emerging from the casters where direct rolling is not practiced, direct rolling of slabs and compact strip production (CSP). The steel industry is moving towards green steel production with the aim to reduce the energy consumption and carbon dioxide emission.
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SUMMARY

India’s steel sector is growing fast and consistently achieved a growth rate in excess of 6-7%. Sustainability of the Iron & Steel sector is very crucial for the targeted economy and the same is achievable with focused approach. In brief, sustainability need can be summarized as follows:

1. India has become the second largest steel producer in the world with 106 MT productions during FY 2018. It contributes about 2% to the country’s GDP.

2. The key drivers for sustainability of Indian steel sector are competitiveness, cost effectiveness, quality, product development, energy & environment.

3. The competitiveness of the steel industry can be enhanced through efficient use of our natural resources, development of indigenous technologies suitable for Indian steel industry and development of new value added steels.

4. Cost-effectiveness shall to a large extent depend upon improving the performance indicators w.r.t best in the industry and best in the world. This will enable not only production of steel at low cost but will also concurrently enable making the process more energy efficient and environment friendly.

5. The quality of steel depends on the control and management of input raw material, alloy chemistry, processing parameters, microstructure and mechanical properties and customer feedback. Modeling and automation of the BOF process will help in consistently achieving the desired chemistry and temperature. Modeling and online prediction of microstructure and mechanical properties during hot rolling and use of Gleeble Simulator to minimize susceptibility to cracking during continuous casting and plater hot strip rolling are certain initiatives towards production of quality steel. To meet the growing requirement of quality steels in small tonnages, it is imperative to augment the facilities in the secondary sector.

6. R&D efforts are required to meet the domestic requirements of special grades of steel such as, CRNQ, CRGO, linepipe, automotive high strength steel, coated products and thinner gauges of HRC, which are being imported in large volumes.

7. Technologies need to be developed for replacement of coal/coke in BF with alternative fuels such as, hydrogen, natural gas, coal based methane etc. Further, increased use of the EAF/IF route through technology interventions will help in reducing the energy requirement and CO2 footprint. Other areas of reducing energy involve dry quenching of coke, dry slag granulation, use of Nano technology, utilization of wastes, mainly slag in different applications like construction, agriculture etc., compact strip rolling/ utilization of the heat of the slab.

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