(- Cont. from September 2008 issue)

Selection of Appropriate Steelmaking and Casting Technologies for Cost Effective Steel Production

- by B. Pandey, S. K. Dey & S. K. Gupta - Mecon Ltd.

- Paper Presented at Iron & Steel Summit'08

Thin Slab Casting

The first thin slab casting plant was installed in 1989 at NUCOR, USA based on the technology developed by SMS, Germany and is known as Compact Strip Production (CSP) Technology. T his technology is fully established as more than 30 plants are working based on this technology producing about 50 Mt of thin slabs per year. Voest Alpine (VAI) of Austria & Danieli of I taly have also developed thin slab casting technologies. The technology of VAI is known as Continuous Thin Slab Casting and Rolling T echnology (CONROLL) and produces slabs up to thickness of 125 mm.T he technology developed by Danieli is known as Continuous flexible T hin Slab Rolling (fT SR) and produces slabs in the thickness range of 70-90 mm.

Today one strand thin slab caster and finishing mill can produce upto 1.35 Mt of hot rolled coils per year. T he latest plant, which is likely to be commissioned in July 2007 in Severcorr, USA, will be the widest thin slab caster which will produce slabs in width range of 900-1,880 mm. This plant is being built by SMS-Demag to produce about 1.35 Mt per year of HR coils from single strand thin slab caster, a tunnel furnace and 6 stand hot strip mill. A Pickling & Oiling line, a 3.0 Mt/yr 5 stand T andem Mill, a temper mill and 0.4 Mt/yr galvanising line is also being setup to produce about 17% to 18% of output for exposed automotive application and the balance for other end uses like pipe, construction product, unexposed automotive products. SMS Demag is calling the plant as the third generation CSP technology. Recent innovations made in thin slab casting technologies are given

- Design of mould
- Hydraulic mold oscillations
- Use of electromagnetic brakes (EMBR)
- Use of high pressure descaler and roller side guide (edger) in the mill
- Dynamic liquid core reduction (LCR)
- Mold powder quality and redesigned SEN
- Water spray cooling

Casting speed of 6.0 m/min for slab thickness of 50/55 mm is quite common for medium thin slab casters. Initially, only commercial quality plain carbon steels were being cast through thin slab caster route. However, of late the machine suppliers are claiming that most of the steel grades including low, medium & high carbon, HSLA line pipe grades and steel grades for automotive application including IF grades can be cast through thin slab caster route. The grades of steel which can be produced from existing thin slab casters are given Table- 10

T able – 10 : Grade of Steel Cast through Thin Slab Casting Route

Sl. No.	Item
A.	Steel grades already cast through thin slab route
1	Low and extra low C steel grades in DD & EDD quality
2	Low C unalloyed steels for welded pipes and structural tubings
3	Higher strength microalloyed steel for cold forming and cold rolling
4	HSLA steel with improved atmospheric corrosion resistance
5	Silicon steel for electrical application
6	Medium and high C steels
7	EDD grades steel for non-exposed automotive parts
8	Alloyed steels for heat treatment
9	Ferritic stainless steel
10	Line pipe grade API -5L upto X-70 grade
11	IF – steel
12	Extra low C steel sheets for CR for application in exposed automotive part
13	Dual Phase Steels and TRIP
14	Line pipe beyond X - 80 (under trial)
15	Peritectic grade steels (under trial)

Major Advantages of Thin Slab Casting Technologies

It is estimated that when compared with conventional continuous casting route for production of HR coils, thin slab casting (thickness; 40-70 mm) followed by necessary hot rolling will require considerably less energy.

The energy consumption through thin slab route including heat energy is between 150-200 kWh/t as against about 450-500 kWh/t through conventional route.

Improvement in Yield

Adoption of thin slab casting route improves yield for production of hot rolled flat products when compared with conventional casting-hot rolling route. A potential saving of 1.20% to 1.30% is achievable from liquid steel in ladle to HR coil production.

Other Benefits

Other potential benefits of thin slab caster include the following :

- Reduction in capital investment
- Reduction in manpower
- Reduction in floor space
- Reduction in processing cost

Direct Strip Casting (DSC)

In 1999 NUCOR / BHP/I HI started a 0.5 Mt per year capacity plant at NUCOR, USA and has developed the process as "Cast Strip Process". Thyssen Krupp Steel / Usinor / VAI has developed the process as "Eurostrip Process". In this process, liquid steel is poured between two counter rotating rolls. Two ceramic side plates press against the front faces of the casting rolls to contain the liquid steel bath. A shell of steel forms on both the roll surface fed by the molten meniscus. T he shell grows up to the kissing point (narrowest point) between the rolls where the two shells join as they pass between the caster rolls forming a continuous strip, which exits the cast in a downward direction. The casting speed ranges typically from 40 m/min to 130 m/min depending on the strip thickness, casting roll size and pool height.

The technology has tremendous features and merit, once it is fully established for larger plant module of plant capacity 1.0 Mt/yr and above and other quality aspects are fully proven.

08. Select ion of technogical process route for cost effective steel production

Installation of an integrated iron and steel plant today, being very capital intensive, requires a long period for gestation. It is, therefore, necessary to carefully analyse and select the optimum technologies and process route before embarking on such a project.

The evaluation process is more relevant due to the emergence of large number of new competitive technologies in steelmaking and continuous casting areas. Such an evaluation normally involves an analyses of past achievements, present status and future prospects of each technology under consideration, keeping in view the following criteria

- Capacity of the plant
- Selected proucted mix
- Amenability of available raw materials
- Availability and extent of energy consumption
- Extent of environment pollution
- Cost considerations

The availability of infrastructural facilities and logistics of operation are also to be kept in mind while evaluating a technology for its possible adoption.

Possible technological options

In order to select the possible technological facilities, popular steelmaking plant capacities for following cases have been considered as given in Table –11

Facility planning

Based on the intended product-mix and size of proposed plant, facility planning for three different cases have been given in subsequent paragraphs.

Case I : Mini Steel Plants

Worldwide plants having annual capacity upto 1.0 Mt falls in mini steel plant category. Such plants are usually operated with local available raw materials, services like electric power and cater to specific market requirement. In view of its relatively low capital investment, non-flat products like wire rods, bar and rod products and medium structural products using EAF-

Table -11 : Steelmaking Plant Capacities

Cases	Type of Plant	Plant Capacity, Mt/yr	Remarks
CaseI	Mini Steel Plants	Between 0.5 to 0.7	Set-up to cater the local market, produce special quality products and fits to non-flat mill production capacity
Case II	Mid Size Integrated Steel Plant	1.2 – 1.4	Usually such capacity plants are for flat steel products through BOF/EAF thin slab casting route. BOF –conventional slab caster –steckel Mill / Plate Mill is also being followed for quality plate products. Thin slab caster-hot rolling mill offers the possibility of doubling the capacity to around 2.5 Mt/yr through addition of one caster and tunnel furnace
Case III	Mega Module Integrated Steel Plants	3.0 Mt and Beyond	Mega module plants are invariably through BOFConventionalslab-HSM route. Such plant are used for mass production and capacity expansion is achieved by modular add-on facilities in BF-BOF-CC area.

CC route can be produced economically. A typical materials flow sheet for a 0.6 Mt mini steel plant is shown in Fig 01. These type of plants can be set up with minimum investment, minimum space requirement and tailor made product-mix. This is an established process route and many Asian and North American plants are operating in this route.

Steels for special applications such as structural products like beam/joists, I - beams, H - beams, parallel beams, etc. can be made from beam blanks or blooms produced from bloom-cum-beam blank caster in a cost-effective manner with superior metallurgical properties. Additionally, wire rods, HSLA re-bars can be produced from billets for application in high rise apartments, social utility buildings, stay wire bridges. By proper co-ordination of operating regime of casters and down stream - mills, a good proportion of cast products can be hot charged resulting in savings of energy consumption.

Case II : Mid Size Integrated Steel Plants

Mid size plants in the range of 1.2 to 1.4 Mt per year capacity using BF-BOF –CC route or EAF-CC are the most popular range among the steel producers because of its high flexibility in products mix, capability of producing steel in an energy efficient way, availability of matching upstream and downstream plant facilities.

Typical material flow sheets for about 1.2 Mt integrated steel plant based on BOF – conventional slab caster and BOF – thin slab caster route are shown in Fig 02.A and 02.B respectively. Plate products above 5 mm thickness and upto 3,200 mm width for application in construction-cum-other infrastructural sectors can be produced from BOF – conventional CC – Plate mill route in the most economic way. Plate mill of 1.2 Mt per year production capacity is quite common. Keeping in view the present demand of steel proouscts like Q&T plates, API – 5L upto X – 120, OCTG plates for oil and natural gas, application of good secondary refining facilities, state-of-the-art conventional slab caster and wider size plate mills are the common choice for present day investors.

BOF – thin slab route have reported production of DD, EDDQ and IF steels of acceptable metallurgical characteristics for application in automobile sector. However critical grades as mentioned above are still to be produced as per stringent quality requirement.

Case III : Mega Module Integrated Steel Plants

Worldwide mega module steel complexes are gaining popularity because of its low specific investment, economics of operation, mass production, long term lease with resource materials, low specific energy consumption and low less handling of intermediate products. Such steel complexes are primarily based on BF – BOF route and located at the pit head or near to the port. Downstream facilities are selected based on the prevailing market scenario and emerging steel consuming centres.

The modular steelmaking capacity ranges between 2.5 Mt to 3.0 Mt and it is subsequently expanded by add on facilities. The ultimate capacity of such plants ranges between 10.0 Mt to 12.0 Mt per year.

Fig 03 shows the material flow sheet for a 3.0 Mt capacity integrated steel plant based on BF – BOF route. It is required to put two (2) nos of 300 t capacity BOFs and one twin strand conventional slab caster to cast entire liquid steel into slabs. One 4 Hi Semi - continuous Hot Strip Mill (HSM) will be adequate to convert entire slabs into HR coils.

Conclusion

The global environment with mergers and acquisitions has imposed fierce competition for survival and development. Only those companies who can produce quality products at competitive prices have a chance to survive. T he technology of steelmaking and casting will continue to play dominant role in providing cost competitiveness to the industry.The various technologies discussed in this paper are the basic tools in steel production in terms of cost, quality and volume.

The Asian region has witnessed unprecedent growth in steel sector in 21st century. Growth of steel consumption is dependent much upon the degree of advancement made in various application sectors.

An attempt has been made in this paper to categorise steel plants based on productmix, steelmaking capacity and economics of operation.

EAF based steel plants with billet/bloom casting facilities are the cost effective route of steel production in small capacity range between 0.5 Mt to 0.8 Mt per year capacity. These plants can be setup with minimum investment for catering to specific market. Steels for application in construction sector can be produced economically through this route.

BOF – thin slab casting route in mid size plants of 1.2 to 1.3 Mt/yr capacity has well been accepted worldwide as cost effective flat steel production route. Because of obvious advantages in metallic yield, reduced specific energy consumption, reduction in processing cost and ability to produce many critical grade steel products for special sectors like autobody application, many entrepreneurs have opted for this route of steel production.

Plates of High strength from similar size plants have also been produced for application in infrastructural sector using BOF – conventional slab caster – plate mill route. More than 30 plants worldwide are in-operation producing more than 50 Mt of steel per annum. Mega modules of 10.0 – 12.0 Mt per year capacity are being conceived by some steelmakers using BOF – conventional slab caster route with an obvious aim of reduced specific investment cost, low production cost, high per capita production rate and low environmental emission.