Concept of Direct Rolling in Secondary Steel Sector

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Abstract:

The steel re -rolling mill sector and electric induction furnace sector forms the key segments of the secondary steel production in the country. A significant percentage of units from these two sectors are in the form of 'composite units' wherein induction furnace and rolling mill are present in the same premises. The secondary steel induction furnace and re -rolling mill units are small in capacity, uses obsolete technologies and consumes high level of energy due to use of inefficient technologies. Thus, the sectors possess substantial potential towards implementation of energy efficient technologies and improving the present (baseline) level of specific energy consumptions.

Direct rolling, which is a revolutionary technology, introduced during early 2012, aims at utilizing the latent heat available in the continuous cast hot billets at the discharge of mould tube with a controlled cooling to ensure required solidification till the withdrawal of billet and thereby ensuring the maintenance of temperature required for re -rolling of steel through the existing rolling setup itself. Thus, the technology completely eliminates the use of re -heating furnace and forms a direct transfer mechanism for the hot billets from the continuous casting machine to the rolling mill directly.

The process leads to complete elimination of use of fuel (furnace oil or gas or coal) required for heating of billets in the re -heating furnace. In addition, the technology also ls_to_substantial improvement in the overalll d and productivity of the unit. The implementation of 'Direct Rolling' thus leads to a signi icant savin: of greenhouse gas (GHG) emissions from these plants by eliminating th' e o ossi -lint een ire pro ess.

Introduction:

The secondary steel sector forms an unavoidable link to the overall steel production in India with a significant contribution of around 70% of the total long products manufactured in the country. Due to the versatility of this sector in producing any section or size and any odd tonnage of rolled products, it has created its own niche space in the steel sector. However, the state of the technology in this sector is unsatisfactory as compared to developed countries. There is an urgent need for this industrial sector to modernize & upgrade its technology and adopt energy efficient technologies. Intense competition and high energy cost forces this sector to adopt energy efficient and environmentally sustainable technologies. Additionally, this is an unorganized sector with low' engineering, limited technology innovation & poor R&D base, lack of technically & operationally skilled employees, etc.

Thus, the need for the steel sector for energy efficiency improvement is most essential because of various reasons such as:

- The earth is facing climate change threat as per which it is the first and foremost requirement that the greenhouse gas emissions must be reduced which is possible through adoption of cleaner technologies.
- That the Indian Economy is also facinf stiff competition with large global players. Thus we need to improve our operating system and overall plant efficiency to reduce cost of

operation. This is possible through continuous upgraclation to latest and cleaner technologies.

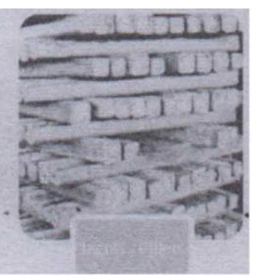
- The small and medium scale units are facing tough competition also from large scale and integrated steel plant. Thus in order to remain competitive, cost optimization through efficient use of energy is a key for survival in the present scenario.

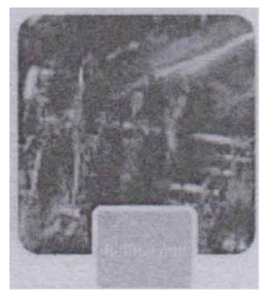
Thus, in the present scenario of rising competition, sustainable development is possible through technological upgradation and adoption of cleaner technologies. The proposed 'direct roiling' technology is one of the recent innovation towards sustainable future for the secondary steel sector and provides an opportunity for making a transformational change in the sector.

Existing conditions:

In a typical composite unit consisting of induction furnace & rolling mill, the process flow of material involves the following:

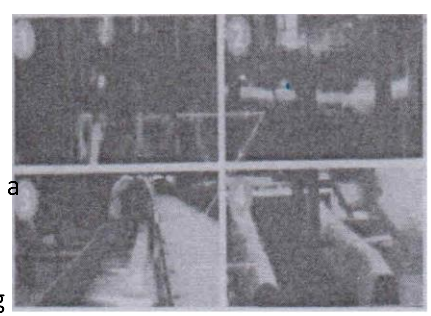
1. Steel scrap or sponge iron is melted in electric induction furnaces to produce M.S. ingot through 'Ingot Moulding'. Some units also have the continuous casting machine which is used to convert the melt to continuously casted billets.
2. Casted ingots or billets are cooled, cleaned, and stacked in the raw material yard.
3. The cooled ingots or billets are then reheated by placing them into a re -heating furnace which operates on fossil fuel like: "furnace oil or coal or gas"; after the billet or ingot is heated up to 1200 °C, these are discharged and taken for re -rolling.

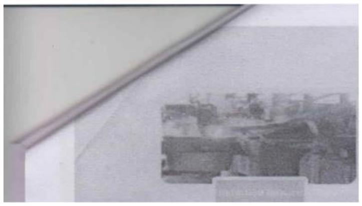


Thus, the process involves lot of fuel consumption in the re -heating furnace as well as burning loss too. In addition to the energy consumption, the production in re -rolling mills also gets affected many times due to the limitations of the manpower handling and the re -heating furnace system. In the re-heating process, there is also a burning loss of about 1.5% of metal. Burning of fossil fuel in the re-heating furnace leads to significant GHG emission into the atmosphere.

Direct rolling concept:



Introduced to the secondary steel industries during early 2012, 'Direct Rolling' has emerged as one of the most revolutionary technologies in the recent past. The technological process of 'Direct Rolling' aims at utilizing the latent heat available in the continuous cast hot billets at the discharge of mould tube with a controlled cooling to ensure required solidification till the withdrawal of billet and thereby ensuring the maihtenance of temperature required for rerolling of steel through the existing rolling setup itself.



In order to achieve this target the following facilities are required to be installed in the CCM section of any induction furnace and re -rolling mill complex:

1. A suitable radius of continuous casting machine (CCM) with preferably double strand facility. However, depending of the capacity of the rolling mill, single strand can also be set up or three or more strands can also be used. But based on the present sizes available in the small and medium enterprises (SME) units, it is proposed to use single strand with a backup availability of second strand which can put into use as per the emergency requirement.
2. A suitable radius mould tube having indirect cooling through demineralized (DM) water followed with a secondary cooling facility having direct spray cooling through controlled spray of water, controlled by programmable logic controller. By varying the flow rate of spray water during the secondary cooling, it is also desired to have a control on the flow of cooling water for the mould tube cooling too; so that the controlled cooling can be achieved,
3. Subsequent to that, in each strand, one hot billet shearing machine should preferably be installed to ensure that billet being cast are cut to the desire length by consuming minimum time and in line with the casting speed without causing any loss of metal and also without creating any distortion in the end of the billet so that, the ends of the billet do not cause any adverse impact at the entry of first pass. Although at many locations people prefer to install only the manual gas torch cutting facility by using acetylene and oxygen or the LPG with Oxygen. But this has several disadvantages over the on line hot shearing machine.
4. Once the hot cast billets are cut to size by the billet shearing machine, the conveying speed of the cut billet is enhanced to ensure fastest travel of hot cut piece of the billet to the first pass. The layout may require that the cut billets to be shifted at 90 degree angle or may it also be possible to convey it straight to reach the rolling mill conveyor. This will depend on the mill layout with respect to the induction furnace layout.

S. Rolling mill conveyors may be required to be designed to provide a linear speed of 1.5 mt/s or even little more to convey the hot cut billets as fast as possible. The conveyors will be driven by variable frequency drive (VFD). In case the distance of conveying is more, it may require that the conveying mechanism is so designed that the heat loss during travel is minimum. The roller conveyors are provided in certain enclosures and canopy covers, made of refractories, to avoid heat loss.

6. The temperature profile from the induction furnace up to the first pass of rolling mill stand should be maintained in the following levels:
   i. Tapping temperature at induction furnace should be maintained between 1660 to 1670℃ depending on the number of factors.
   ii. The ladle designed should be so provided to minimize the loss of heat during transporting the liquid metal up to CCM. It is expected that not more than around 3 to 4 minutes should take to transport the ladle. Temperature drop during pouring will be 40 ℃ and during transport shifting dff ladle to CCM will be 10 to 12 °C. Thus enough heat will be available even with the liquid metal during the casting from ladle.

iii Subsequently during nitrogen purging another 5°C drop will take place.

iv. Accordingly the opening temperature of liquid metal while start of pouring in the mould will be about 1590 °C and is likely to remain above 1550 °C by the time the pouring/casting is completed.

v. The solidification of the liquid metal in the mould will take place due to the indirect primary cooling and thereafter controlled spray of direct cooling water during the secondary cooling. The programmable logic controller (PLC) controlled water spray system will help to ensure that the billet is completely solidified at the withdrawal point and also have a skin temperature of above 1050 to 1100°C.

vi. The billet shearing machine should be placed at the closest possible point so as to avoid any more heat loss during further conveying.

vii. The heatloss should be further protected by providing insulated cover over the conveyor roller table

viii. All this protection and minimum time to convey the billet from shearing machine to the first pass should ensure that the maximum temperature drop is not likely to be more than 5 to 10ct.

ix. The insulated cover will also help in protecting the scale losses.

x, The CCM is likely to operate 24 hours whereas rolling mill will require at -least 2 hours of maintenance time. Therefore for accommodating the material casted during this rolling mill shutdown period; the cast billet should be conveyed to the cooling bed for which a sufficient length cooling bed should be provided.

xi. It is important to take into consideration the present melting facilities and re rolling facilities capacity.

xii. In order to efficiently use the direct rolling technology, it is also required to modify the roll pass design to cater to the changed temperature profile. Also, in some cases, the gear box in the first rolling stand needs to be strengthened.

Direct rolling (advantages):

The implementation of direct rolling can bring significant savings in terms of cost optimization, use of energy and GHG emissions. Some of the key advantages of using direct rolling as a technology are as follows:

1. Complete avoidance of furnace oil /coal/gas required for heating of the steel bars which will result into enormous saving in fuel energy and thereby reduce the GHG emission due to the same.
2. Reduction in the mill scale loss to the extent of 1.5 to 2%, which would have been burned in the billet reheating furnace.
3. Savings due to avoidance of runners, risers etc. improving the yield about 2.5%.
4. Savings in the loss of ingot moulds, refractory, etc.
5. The rolling of hot cast billets will also improve the quality of the rolled steel products and also substantially reduce the rejections generated during rolling because of the mould cast Ingots.
6. It will improve the productivity of the mill and also that of the manpower engaged in the plant.
7. It would also result in some saving in power consumption because of the indirect savings of burning loss and improved liquid metal to finished steel etc.

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8, It will also help in reducing the manpower required in any unit and also reduce the risks of lower production caused due to the manpower engaged in vital function of mould settings; ingots finishing and loading in the billet reheating furnace etc.
It will set example before the other similar units operating in the country to follow the suit.

The below graph elucidates the advantages of direct rolling over the traditional rolling process on arious parameters:

Comparision between traditional and direct rolling

100 100 100 100

100
80 60
60 35
40
20 0
0

Fuel consumption Man power Material loss GHG emission

Traditir Direct rolling Parameters

However, implementation of 'direct rolling' calls for certain pre -requites, which needs to be catered to, for effective use of the solutions.

Once the re -rolling process is integrated on line with that of hot cast billet rolling then the entire process must be very well synchronized and it will require very care full and perfect planning in every aspects of operation from beginning till the end such as:

- Proper selection of raw material.
- Complete analysis of the charge and proper material balancing before melting itself to target the proper levels of carbon, phosphorus and sulfur to be achieved,
- Scheduled predictive/preventive maintenance in time for all the facilities.
- Proper selection of the acidic/neutral ramming mass and proper application of the same. Timely relining of the crucible well in advance and after every defined number of heats,
- Proper ant' equate arrangements for proper ramming mass.
- Controlling the melting temperature and time to achieve the scheduled sequence.
- Maintenance of the desired temperature profile as planned.
- Maintenance of the passes and the mill area equipment in perfect operating conditions.
- Adequate stocks of the spares and emergency backup facility along with the emergency backup power.
- Proper training to the manpower from testing, operation, maintenance to qu4lity and inventory control.
- Reduce the dependence on any manual handling even in the re -rolling mill, Hence the re-rollir g mill feeding and discharge of the rolling objects must be automated.
- Cooling bed must also be made automatic.
- It is to be realized that after the induction furnaces are synchronized with the re -rolling mill through the caster then the success of the plant depends on the failure free and maintenance free operations. Thus all the equipment and machines & spares must be carefully procured from very good and reputed makes & manufacturers.

It is very important that the design and operations of the plant is given in hand of experierced and expert persons only. The success of the plant brings profit and happiness to tre unit arid at the same time protects the environment and makes the steel industry as more sustainable. The life of earth is increased due to reduced GHG emission.

Case study:

In the year2004, UnitedNations DevelopmentProgramme(UNDP) along withMinistry ofSteel, Go..enment of India and Global Environmental Facility (GEF) launched a project titled as "Removal of barriers to energyefficiency improvement in the Steel re -rollingmill sector in India". The project aimed in penetrating energy efficiency technologies in the SRRM sector, thereby reducing associated emissions of Green House Gases (GHG). At the end, the project developed 34 model units equipped with energy efficiency equipment/technologies.All these units were able to reduce their specificenergy consumptionsand associatedemissiontoa great extenton comparingto their baseline. Out of these 34 model units,3units had gone for direct rolling and thereby achieved a milestone of*"steel goes green"* i.e. steel making process without the re -heating furnace and thus saving 100 percent thermal energy.

The following passage, describe the benefits attained through direct rolling by one of the model unit in Raipur. The unit was initially using furnace oil as fuel for re -heating the ingots and high cost was spent on this,

No.	Parameters	Unit	Baseline	Post implementation
1	Production	tph	10.5	13.2
2	Annual production	tpy	37,800	47,520
3	Type of fuel		Furnace oil	Direct rolling
	Specific fuel consumption	Lit	45.34	0

Fuel savings:

Fuel saved per tonne 45.34-0

45.34 L/t

Overall annual fuel savings = 45.34 " 37,800

1,714 kL of furnace oil.

% Cost of furnace oil INR 35/L

Total cost saved annually =1,714,000 * 35

=INR 59,990,000 = INR 6 crores (approx.)

Investment towards energy efficiency = INR 1.5 crores

Simple payback period = (Investment / savings per year) * 12

(1.5 / 6) * 12=3months

GHG emissions reductions:

% Calorific value of furnace oil = 40.4 Mijkg

Density of furnace oil = 0.94 kg/m3

% Specific fuel consumption (baseline) , 45.34 Lit

45.34 * 0.94

42.62 kg/t

- 42.62 * 40.4

1722 MO

Since, the unit had adopted the direct rolling the specific fuel consumption for post implementation is zero,

Specific fuel consumption (post implementation) = **0 MJ/t**

COi emission factor for furnace oil = 77,4 tCO2/Ti (as per IPCC guidelines)

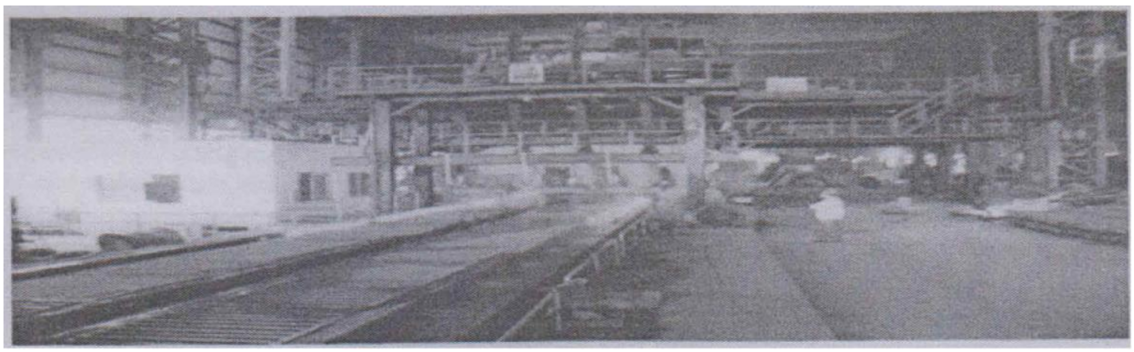
Total CO2 emissions — baseline (1,722 * 77.4) / 10^-6 = **0.13 tCO2/t**

Annual CO. emissions = 0,13 37, 800

4,914 tCOSY

Total amount of CO2 reductions avoided per year = 4,914 —0 = **4,194 tCOdy**

By implementing direct rolling the unit was able to completely eliminate the usage of fossil fuel in re-heating the ingots/billets andthus saving the 100 % fuel and also reduce the GHG emission substantially.



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