Energy saving by direct rolling of hot billets through high speed casters

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Introduction

Modern steel making has been divided into two main categories, primary route and secondary route. The steel produced using iron ore as a raw material in initial stage is considered as primary route of steel making. The process in which steel is produced using scrap and / or sponge iron is known as secondary route of steel making. The furnaces that are used to melt scrap and / or sponge iron in secondary route are induction melting furnaces (IMF) or Electric Arc Furnaces (EAF).

For mini steel mills, induction furnace is widely used equipment due to its several advantages over EAF. From induction furnace, steel is tapped in ladle. The ladle is taken to the refining station for dephosphorization and desulphurization if needed [1]. After ladle furnace treatment, or otherwise, the ladle is placed on continuous casting machine (CCM). The product of continuous casting machine is called billet. Billets are cast through CCM and traditionally cooled to the ambient temperature. During this time, heat is lost from billets to the atmosphere.

Until a couple of years back, steel melt shops usually produced either ingots/billets, cooled them to almost ambient temperature and then transferred them in the reheating furnace of the rolling mill that was fuel fired (coal/oil/diesel/gas). The billets are reheated to a temperature of about 1100°C and then pushed in the rolling mill for producing either round, TMT bar or any other section. The cooling of billet involves the heat loss of 0.8 GJ/T by means of convection and radiation. For rolling, the same heat needs to be supplied by means of reheating furnaces which operate at 40-50% efficiency.

To counter the problem, Electrotherm (India) Limited has introduced the concept of charging of hot billets from the caster output for direct rolling.

The concept of hot billet charging

Hot billet charging implies converting the billet in to a rolled product without any intermediate reheating arrangement, thereby avoiding criminal waste of energy. As per this new concept, billet coming out of the caster is directly charged to the rolling mill. The billet that comes out of caster has surface temperature of about 1100°C while the core temperature is still higher. The same hot billet is sent to the rolling mill where it is rolled through roughing stand, intermediate stand and finishing stand.

During continuous casting, the billet is cooled from surface to core. The heat is lost by means of convection and radiation. In conventional method, the billet is transferred to the cooling bed after casting where it is cooled to the ambient temperature. The heat loss to the atmosphere is about 0.8 GJ/T of billet. Before rolling, the billet is pushed to reheating furnace, where it is heated to about 1100 ^{0}C. In reheating furnace the billets are heated from outer surface. Thus, the heat transfer is from surface to core. The billets are allowed to soak and are then transferred to rolling mill for further processing.

In state-of-the-art new concept developed by Electrotherm, the billet obtained from the caster is transferred to rolling mill in hot condition itself. To make it possible, it is very important to obtain a proper balance between solidification of billet in caster and transfer time to rolling mill before the temperature goes below rolling temperature. Depending on the billet size and section, the rolling temperature is decided. This rolling temperature is achieved by precise temperature control at the continuous casting machine. To obtain this control, Electrotherm has developed a special software where cooling rate is controlled and casting speed is varied based on inputs like rolling speed, billet size, section to be rolled, etc.

In order to achieve achieve direct hot billet charging, the caster and transfer conveyor should be properly engineered and synchronised to extract 100% hot billet charging from the set up. A little mis-match between them may lead to 80% or even just 50%

hot billet charging. Remaining billets will have to be cooled down in the atmosphere and rolled using reheating furnace.

As explained above, the concept of hot billet charging is purely based on heat transfer mechanisms. The important heat transfer mechanisms that play role in heat dissipation from the billet are conduction, convection and radiation.

The classical example of 100x100 mm^2 billet can be considered where the heat transfer is observed as a function of temperature. Figures 2, 3 and 4 depict the temperature profile of the billet after 5 seconds, 20 seconds and 50 seconds time interval respectively. The colour bar below the billet displays the temperature at various points across the cross section of the billet. The outside atmosphere of the billet is maintained at 300^0C with insulation. The temperature profile is obtained by numerical analysis. Various temperature profiles can be simulated by changing boundary conditions and one can observe the temperature profile across the cross section. With time in progress, the temperature difference is reduced from 290^0C to 155 ^{0}C in 45 seconds for the given boundary conditions. With time the billet continues to dissipate the heat to the atmosphere. It can be noted that for the case under consideration, billet should reach to the roughing stand of the rolling mill in less than 50 seconds.

Heat dissipation for billet of a particular cross section is purely the function of time after billet is cast. The travelling time of billet from caster to rolling mill can be minimised or controlled by the high speed conveyor design. Therefore, the factor which plays important role in heat loss of billet is the casting speed. The conventional casters operate with the average casting speed of 1.8 to 2.5 m/min. To obtain a 4 m long billet cut, such casters would take 120 to 150 seconds. This allows drastic temperature drop from the billet as the temperature gradients are the highest. Further, the synchronization between billet casting speed and rolling speed is also reduced. With several experiments and continuous study, it has been observed that casting speed affects 80% of direct rolling while remaining 20% is affected by speed of billet transfer after cutting table to rolling mill.

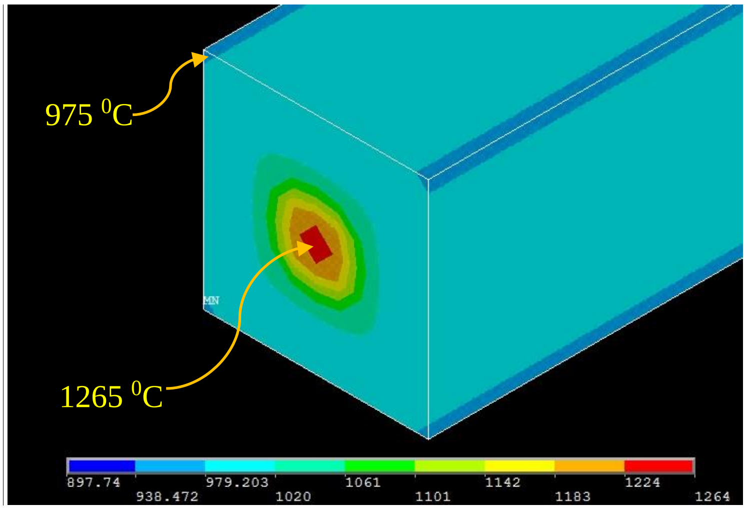

Figure 1 Temperature profile after 5 seconds from CCM cut

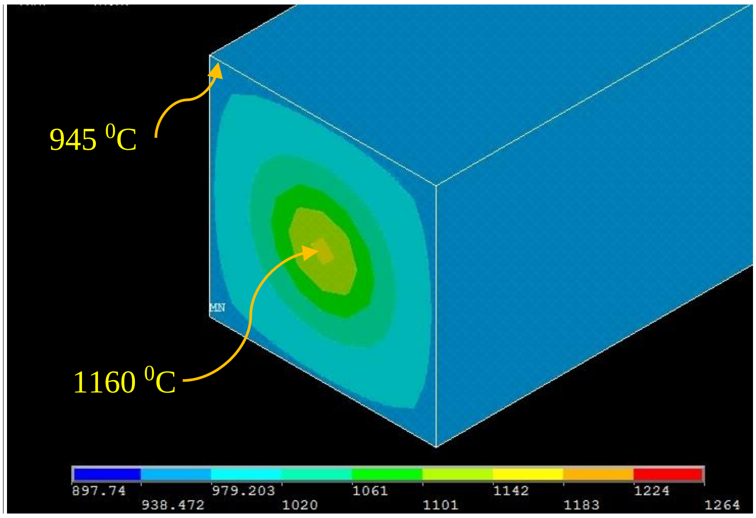

Figure 2 Temperature profile after 20 seconds from CCM cut

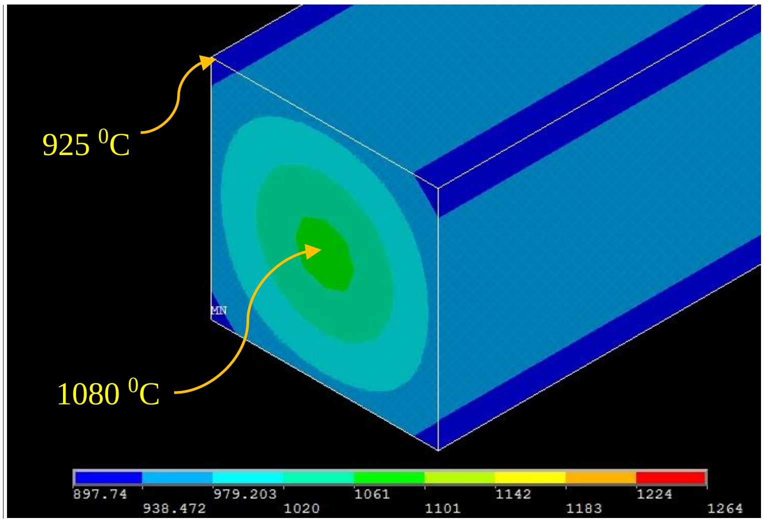

Figure 3 Temperature profile after 50 seconds from CCM cut

To counter this problem, Electrotherm has developed high speed caster with the top speed of 3.5 m/min to 5.5 m/min depending on caster size and cross section of billet being cast. With this speed, 100% hot billet charging or direct rolling has become possible. The state-of-the-art concept developed by the Electrotherm allows the billet to solidify thoroughly and deliver the billet to high speed conveyor within shortest possible time.

Adoption of hot billet charging and present scenario

By adopting the concept, in recent time, those steel melt shops that have a rolling mill within the same premises have switched over to hot billet charging. The trend now is to have a composite unit that comprises of a steel melt shop and rolling mill which uses hot billets coming from the caster without any reheating. A very important piece of information that should be shared here is that billets that travel a distance as long as 320 metres too are being hot rolled without any intermediate heating support. Standalone steel melt shops and standalone rolling mills have started envisaging a bleak future because of this development, and the correction that is being adopted is installation of the missing facility to remain competitive in the market and still continue to make profit.

Hot billet charging facilitates saving of about 35-40lit/T of furnace oil or diesel oil. Thus, total saving of steel maker due to hot billet charging can be of the order of Rs.1000-1200 /- per ton of steel. In addition to this, environmental pollution due to reheating furnaces is saved. Total of about 1.2GJ /T of energy behind reheating of billet is saved by the new concept of hot billet charging for direct rolling, which is provided by Electrotherm.

Today, India produces about 30-33 million T steel per year through induction furnace route [2]. Even if 25% of the steel plants can adopt the concept of hot billet charging through high speed caster, the total of about 9 million GJ energy will be saved annually [3]. This will also reduce environmental pollution hugely as about 400 million Nm^3 / year CO_2 emission can be saved. From monetary point of view, adoption of at least 25% induction furnace based steel makers can save the expenses of about Rs. 1000 Crores annually. Thus, the concept of hot billet charging is helpful to keep the environment clean along with huge financial benefits.

Conclusion

Hot billet charging is a very novel concept developed and established by Electrotherm. A steel plant can adopt the concept to roll 100% billets produced by high speed caster. The exclusion of reheating furnace can save a huge energy, CO_2 emission to environment and money for steel plants. The process is ecofriendly and helpful to reduce environmental pollution remarkably.

References

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