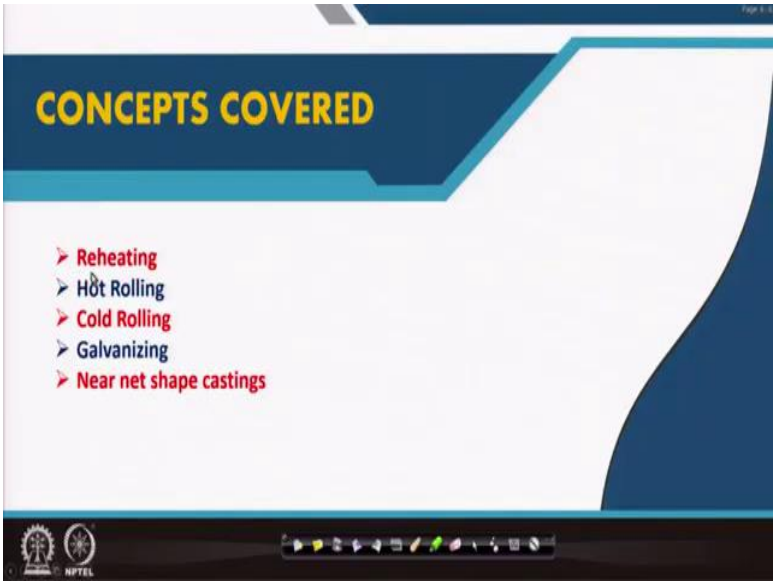
Iron Making and Steel Making
Prof. Gour Gopal Roy
Department of Metallurgical and Materials Engineering
Indian Institute of Technology, Kharagpur

Module - 10
Lecture – 50
Downstream processing and near net shape casting

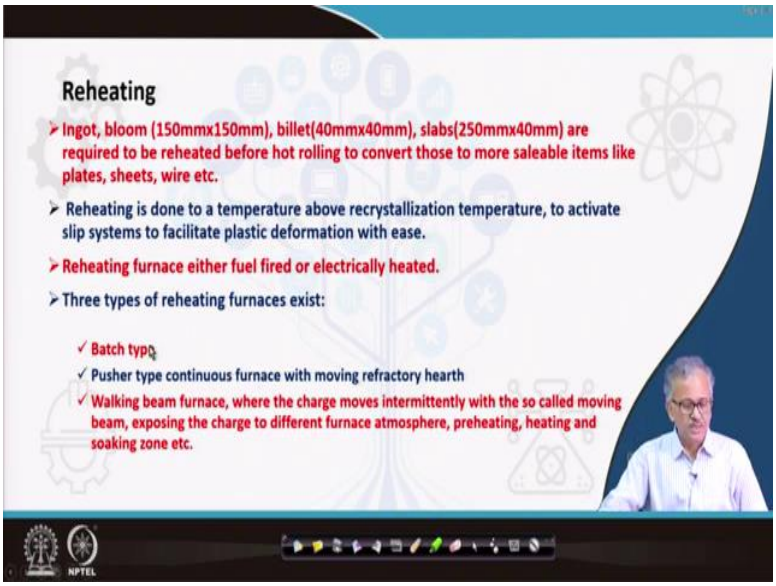
In this lecture, we will talk about some downstream processing of the continuous casting as well as near net shape casting.

(Refer Slide Time: 00:41)



Topics covered include downstream processing like reheating, hot rolling, cold rolling, galvanizing, and finally the near net shape casting, which eliminates downstream processing partially to various extent.

(Refer Slide Time: 00:57)



During reheating ingots like bloom, billet, slabs are required to be reheated before hot rolling, and to convert them to more saleable product like your plate, sheets and wires. Thickness has to be reduced significantly from 150mm to 1 to 5mm in several stages. Reheating is done above the recrystallization temperature when the slip system becomes much more active to facilitate the plastic deformation to reduce the thickness from 150 mm to 40mm in roughing mill. Residual strains also get released and form strain free new grains due to reheating.

Reheating furnace is either fuel fired or electrically heated. Concast slab after shear cutting directly goes to reheating furnace before hot rolling in hot strip strand. Three types of reheating furnace exist, as shown in Figure 50.1. First is the batch type as shown in Figure 50.1(a). Here, ingots are loaded in batches in the furnace and reheated to the desired temperature for subsequent hot rolling. This type of reheating furnaces are used for batch ingot casting.

The second type is the pusher type reheating furnace (Figure 50.1(b)). Here ingots are pushed continuously inside the furnace from one end to the other through different temperature regimes (preheating/soaking) and disposed off from other end. This type of furnace are used for concast billet reheating.

Another is called the walking beam furnace, where the charge moves intermittently through different temperature zones (two preheating zones and soaking zone at desired temperature, Figure 50.1(c)). Each zone has independent control on burner and temperature. The charge is

allowed to reside in different zones for different allocated time before it emerges from the furnace. All types of concast ingot could be reheated effectively in this furnace.

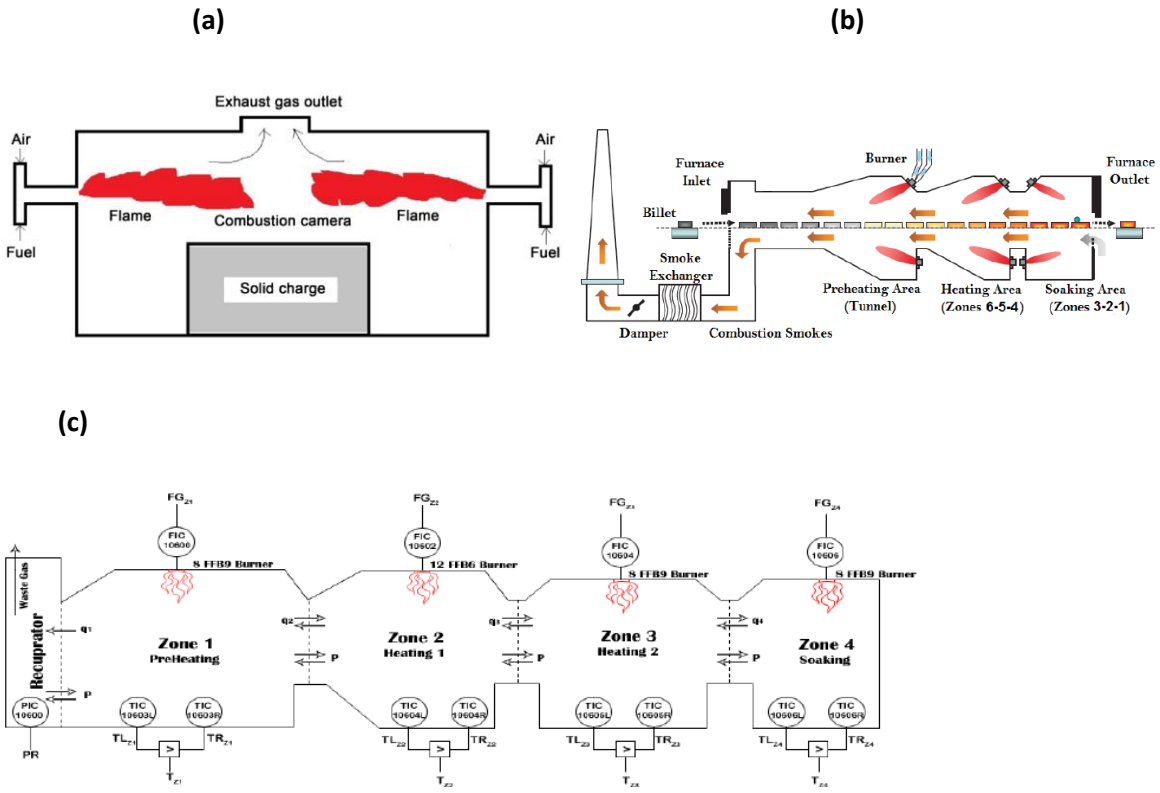
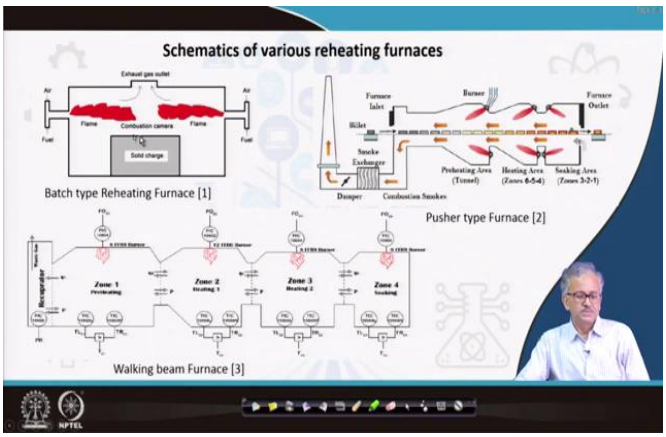
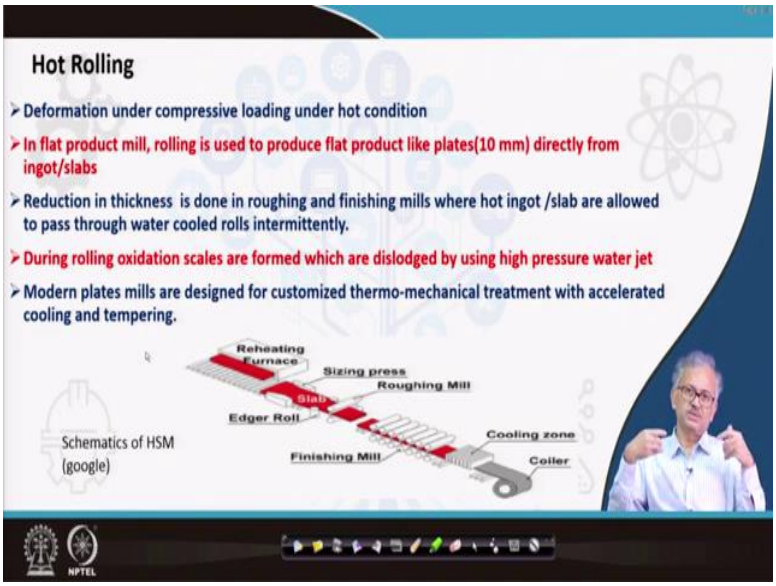


Figure 50.1: Various types of reheating furnace (a) batch type, (b) Pusher type (c) walking beam type

(Refer Slide Time: 04:19)



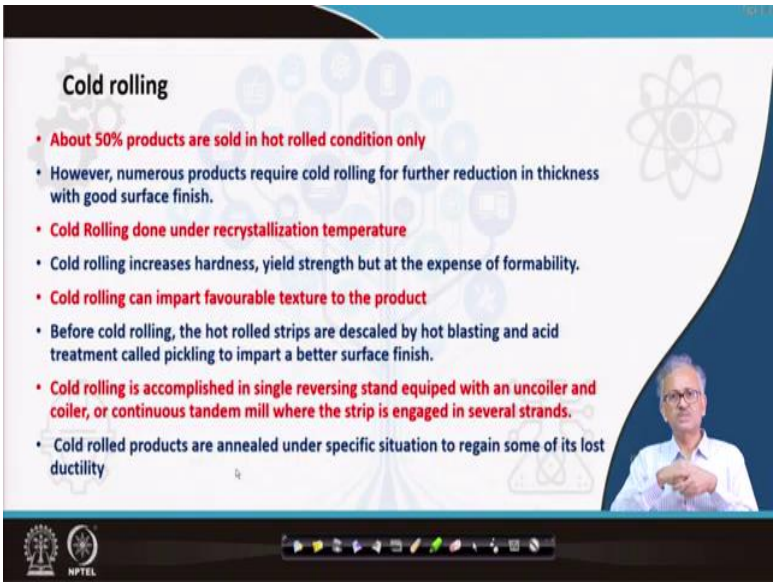
(Refer Slide Time: 06:09)



Hot rolling is the deformation at hot condition under compressive load. Slabs thickness may be reduced from 150 mm to 5 mm plates in different stages of rolling, namely roughing and finishing mill. After the ingot is reheated to 1250^{o}C, those are sent to roughing mill where their thickness is reduced from 150 to 20 to 40mm. Subsequently those are transferred to finishing mill, which consists of a series of horizontal mills where final reduction of thickness is achieved with high dimensional tolerance. Inter strand cooling headers are there to reduce the strip temperature to desired level for subsequent rolling in the next mill. Finally the strip passes through run-out table where strip is cooled from both side to desired temperature before it is rolled to coiler.

Today, modern plate mills are equipped with customized thermo mechanical treatment. You can do the accelerated cooling, and heating, and tempering; all facilities are there. It is possible to achieve desired microstructure through tailor made thermo-mechanical processing

(Refer Slide Time: 08:27)



Most of the products are sold in the hot rolled condition, like sheet, plates, wire etc. And some special products are there, which requires the cold rolling. Advantage of the cold rolling is that it can provide a particular grain texture to the product. These textures are helpful for developing some special property of the steel. Several products require cold rolling for further reduction in thickness with good surface finish.

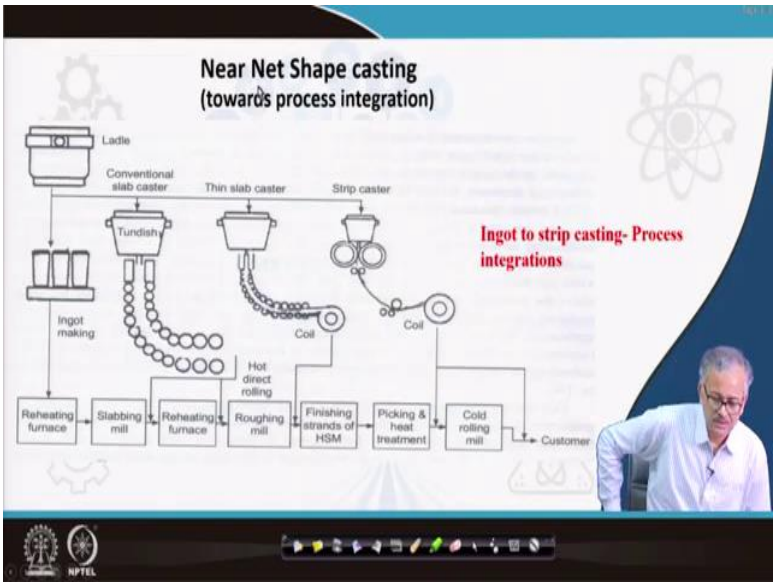
So, sequence of processes in cold rolling are: descaling of hot rolled strips/reduction of thickness by cold rolling/annealing.

Descaling of hot strip is done by chemical dissolution in acid solution, called pickling. Scales are not very adherent and can also be removed by mechanical force like water jet, shot blasting, bending/unbending ect. Cold rolling is done below the recrystallization temperature; so cold rolling generates strain in the structure; as a result work hardening take place.

So, the structure become harder with higher yield strength at the expense of formability. But cold rolling can impart a favorable texture to the product. Cold rolling also offers a better surface finish. Cold rolling can be accomplished in a single strand equipped with an uncoiler and the coiler,or, it can done in several strands just like hot strip mill.

Cold rolled products are annealed. It has to be annealed to release the residual strains and in the process some lost ductility is regained.

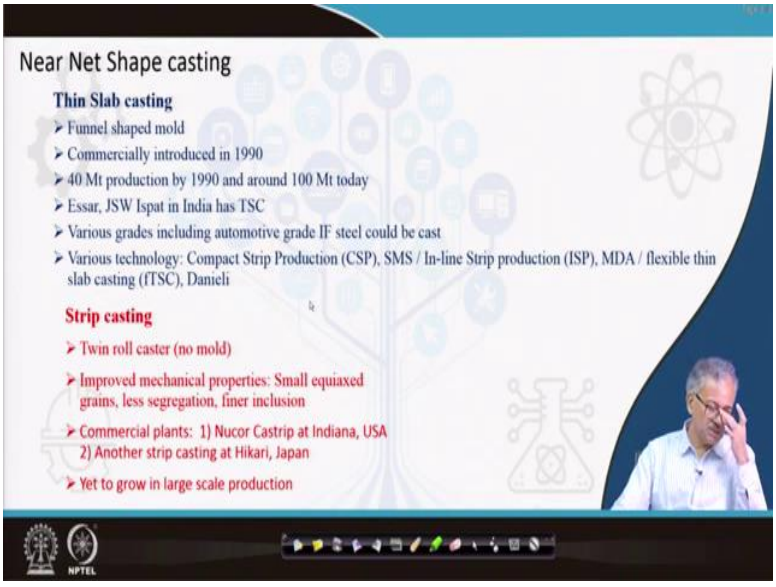
(Refer Slide Time: 10:51)



Now, I coming to the near net shape casting, which can partially overcome some of the downstream processing. One of the major breakthrough of continuous casting is thin slab casting where a slab of thickness of 50 to 80 mm can be cast directly. It eliminates the steps like reheating and roughing mill and can directly join the finishing mill. This provides energy saving and consequently helps in mitigating CO_2 emission.

In strip casting a strip of 2 to 5 mm can be cast directly. It directly enters to the cold rolling for surface finish. It has recently been commercialized.

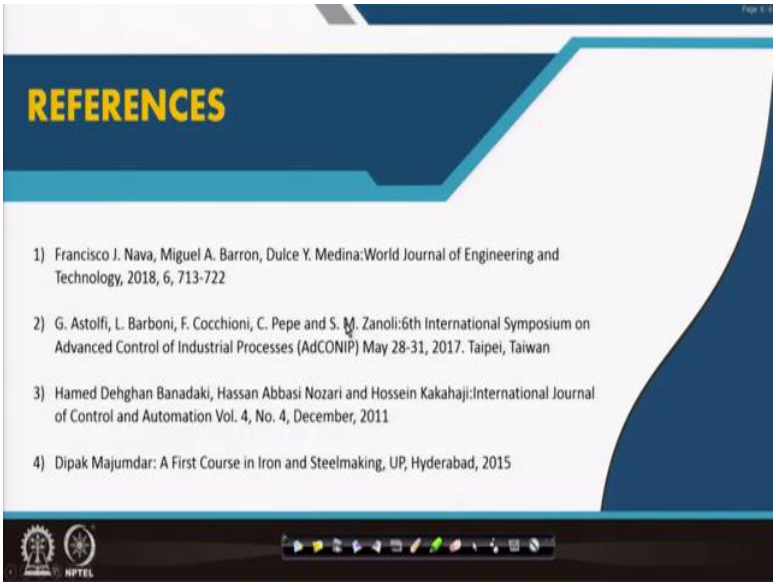
(Refer Slide Time: 13:16)



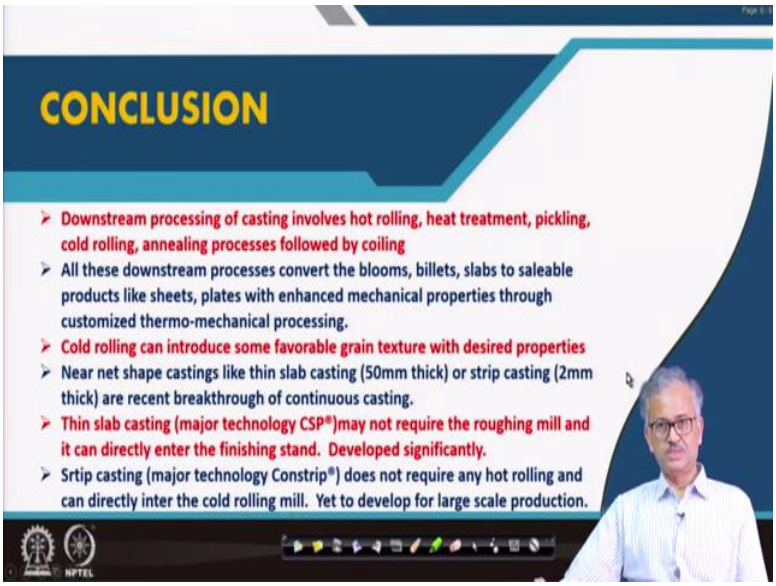
Thin slab is cast in a special funnel shaped mold. Commercial production of thin slab casting (TSC) has started in 1990 with 14 million ton and more than 100 million ton of TSC is cast today. And in India we have TSC in Essar and JSW. Initially TSC was limited to low carbon steel and today various grades of steel namely, low carbon, medium carbon and IF steel are also cast as TSC. Various technologies are there like Compact Strip Production by SMS Germany (the original TSC producer), In-line-strip casting ISP, Germany, flexible thin slab casting by Danieli, Italy.

For strip casting no mold is required. It is cast between two water cooled drums called the twin roll caster. The product is 2-5 mm strip with fine grain structure, less segregation, finer inclusions, and improved mechanical properties. It has been recently commercialized and commercial plant is there in Nucor Castrip Indiana, USA. Another plant is there in the Hikari, Japan. But surface finish is still a real challenge; so it is yet to grow in a large scale production.

(Refer Slide Time: 16:10)



(Refer Slide Time: 16:24)



Conclusion: Downstream processing of casting involves reheating furnace, hot rolling, cold rolling. And all these downstream process convert slab, blooms, billets to saleable products like sheets, plates with tailor made micro-structure through thermo-mechanical processing in the strand itself. Cold rolling can introduce some favorable grain texture and good surface finish. Most of the products are sold as hot rolled products. Cold rolling is only required for some products with special property.

Thin slab casting is a great breakthrough in continuous casting, where 50mm thick slab can be cast directly using funnel shaped mould. It is commercialized in large scale producing 100 mtpa in the world today. It does not require reheating and roughing milling and can directly join the finishing mill that saves energy.

The strip casting is a near net shape casting with thickness 2-5 mm. It is cast in a twin roll caster. It has recently been commercialized but it needs to cross a bigger hurdles of surface finish before it could be commercialized in large scale.