International Journal of Manufacturing & Industrial Engineering – IJMIE
Volume 1: Issue 1 [ISSN: 2374 -1589]
Publication Date : 09 January 2014

Metallurgy of Continuous Casting Technology

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In continuous casting process metal is melted in a furnace and transferred in a tundish. Pouring is accomplished through ceramic piping, and the tundish is covered to prevent oxidation of the metal. From the tundish, it is released into a mould. As the metal cools and solidifies, usually aided with water cooling systems, which surround the mould, finished cast metal protrudes from the far end of the mould. Torches can be used to cut the metal off at set lengths as desired. This presentation discusses on the continuous casting process description, mechanism, and control, hydrodynamics, heat transport, thermal analysis, solidification control and heat transfer, continuous cast product types, range of sections, and advantages of continuous casting technology for ferrous and non-ferrous foundries.

Keywords: tundish, metallurgical length, solidification, macrostructure, hydrodynamics, heat transport, centreline segregation.

INTRODUCTION

Continuous casting technology is most effective, if it is necessary to manufacture semi-finished products of standardized form in large series. This method also provides increased control over the process through automation [1]. Equal and continuous supply of metal, its crystallization and removal of the product allows obtaining a homogeneous semi-finished metal product during the casting process. With intensified cooling with water, it is possible to increase the speed of crystallization [2]. By choosing the right speed, focused crystallization in the material is achieved and a fine structure of crystals with an even chemical composition is produced. Continuous casting allows producing a wide range of different profiles: cylindrical bares, tubes, square bares and tubes, hexagonal profiles, slabs of various thickness and width [3].

CONTINUOUS CASTING PRINCIPLE

The continuous casting process is used to overcome a number of ingot-related difficulties such as piping, mold spatter, entrapped slag and structure variation along the length of the product. It is used to produce blooms, billets, slabs and tubing directly from the molten metal. In this process, molten metal flows into a refractory-lined intermediate pouring vessel, where impurities are skimmed off [4]. From there, the metal travels through a bottomless water-cooled copper mold in the form of a vertical tube open at both ends and begins to solidify as it travels downward along a path supported by rollers. A schematic sketch of the continuous casting process is shown below in Figure-1.

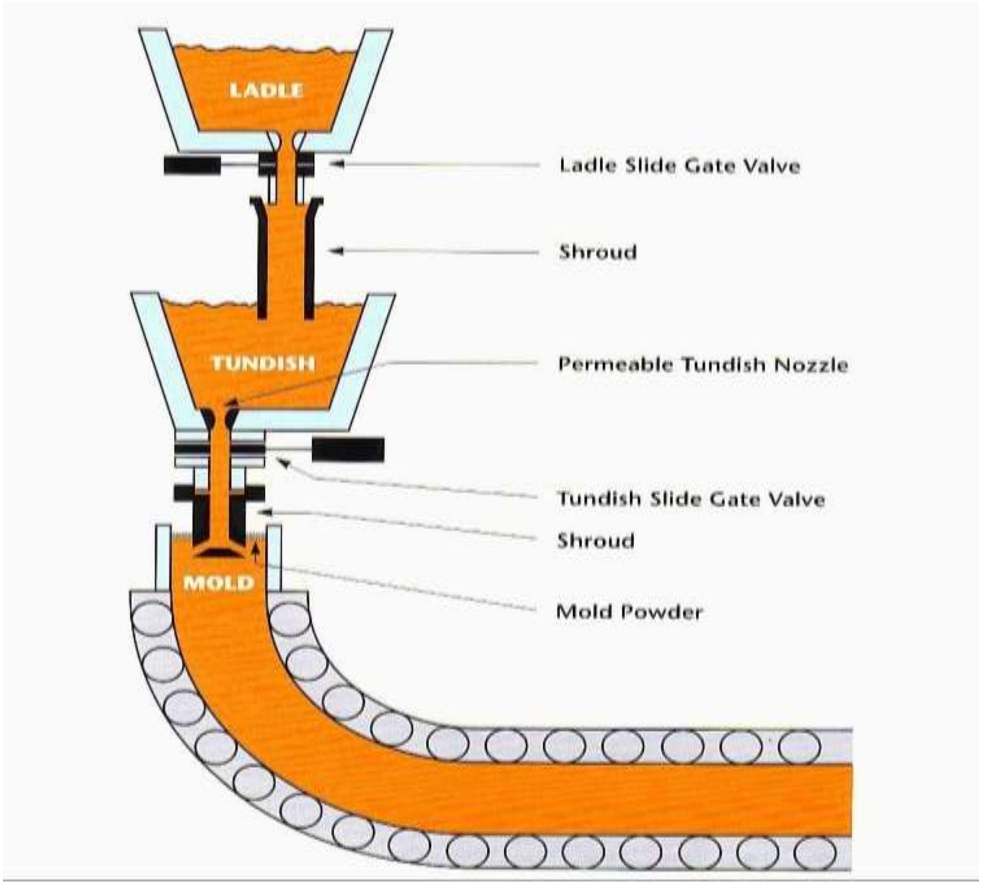

Figure-1 Schematic sketch to illustrate the principle of continuous casting process

Direct water sprays to produce complete solidification then cool the metal. The cast solid is still hot and is either bent or fed horizontally through a short reheat furnace, which makes it perfectly straight. Hollow rods or thick-walled tubing is made by placing a graphite core centrally in the mold to a depth below the level at which solidification is complete. The continuously cast metal may be cut into desired lengths with a torch or a circular saw. It may also be fed directly into a rolling mill for further reduction in thickness and for shape rolling of products such as channels and I-beams. The high pouring temperature requirement in the preparation of steel offers difficulties in the design of mold. The slow solidification rate of steel and the high casting speed make it necessary to have long dies. This increases the chance for bulging of the cast shape due to the deep liquid core [5]. This process is applied to copper and copper alloys, aluminium, steel, grey cast iron, and alloy cast iron. Typical parts made by continuous casting process are tubes, slabs, and gears. These products are obtained by cutting the continuous strand to the required size. Strand can be of rectangular or circular cross-sections.

HORIZONTAL CONTINUOUS CASTING PLANTS IN FOUNDRIES

An industrial horizontal continuous casting plant is shown below in Figure-2. It explains the processing of rod casting and strip casting, which is self-explanatory.

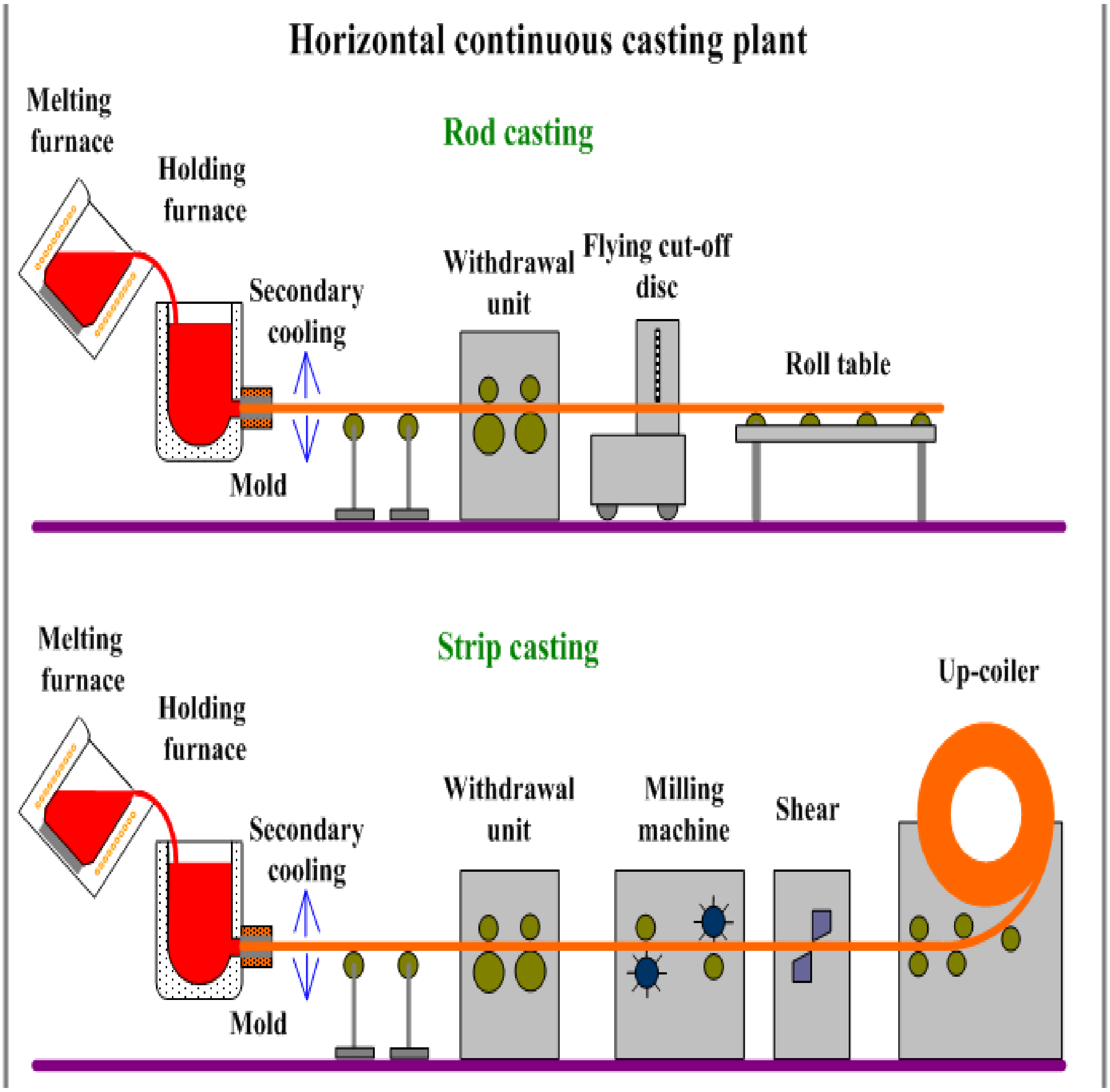

Figure-2 Horizontal continuous casting plant

These processes are the most efficient way to solidify large volumes of metal into simple shapes for subsequent processing. Most basic metals are mass-produced using a continuous casting process, including over 500 million tons of steel, 20 million tons of aluminium, and 1 million tons of copper, nickel, and other metals in the world each year. Continuous casting is distinguished from other solidification processes by its steady state nature, relative to an outside observer in a laboratory frame of reference. The molten metal solidifies against the mould walls while it is simultaneously withdrawn from the bottom of the mould at a rate, which maintains the solid-liquid interface at a constant position with time. The process works best when all of its aspects operate in this steady-state manner [6].

Relative to other casting processes, continuous casting generally has a higher capital cost, but lower operating cost. It is the most cost- and energy- efficient method to mass-produce semi finished metal products with consistent quality in a variety of sizes and shapes. Cross-sections can be rectangular, for subsequent rolling into plate or sheet, square or circular for long products, and even “dog-bone” shapes, for rolling into I or H beams. Many different types of continuous casting processes exist. Vertical machines are used to cast aluminium and a few other metals for special applications. Curved machines are used for the majority of steel casting and require bending and or unbending of the solidifying strand. Horizontal casting features a shorter building and is used occasionally for both nonferrous alloys and steel. Finally, thin strip casting is being pioneered for steel and other metals in low-production markets in order to minimize the amount of rolling required [7].

DESCRIPTION OF CONTINUOUS CASTING PROCESS

In the continuous casting process, molten metal is poured from the ladle into the tundish and then through a submerged entry nozzle into a mould cavity. The mould is water cooled so that enough heat is extracted to solidify a shell of sufficient thickness. The shell is withdrawn from the bottom of the mould at a "casting speed" that matches the inflow of metal, so that the process ideally operates at steady state. Below the mould, water is sprayed to further extract heat from the strand surface, and the strand eventually becomes fully solid when it reaches the "metallurgical length". Solidification begins in the mould, and continues through the different zones of cooling while the strand is continuously withdrawn at the casting speed. Finally, the solidified strand is straightened, cut, and then discharged for intermediate storage or hot charged for finished rolling [8]. Continuous casting process details are shown below in Figure-3(a) and Figure-3(b).

To start a cast, a steel dummy bar seals the bottom of the mould. This bar prevents liquid metal from flowing out of the mould and the solidifying shell until a fully solidified strand section is obtained. The liquid poured into the mould is partially' solidified in the mould, producing a strand with a solid outer shell and a liquid core. In this primary cooling area, once the steel shell has a sufficient thickness, the partially solidified strand will be withdrawn out of the mould along with the dummy bar at the casting speed. Liquid metal continues to pour into the mould to replenish the withdrawn metal at an equal rate. Upon exiting the mould, the strand enters a roller containment section and secondary cooling chamber in which the solidifying strand is sprayed with water, or a combination of water and air referred as "air-mist" to promote solidification. Once the strand is fully solidified and has passed through the straightener, the dummy bar is disconnected, removed and stored [9].

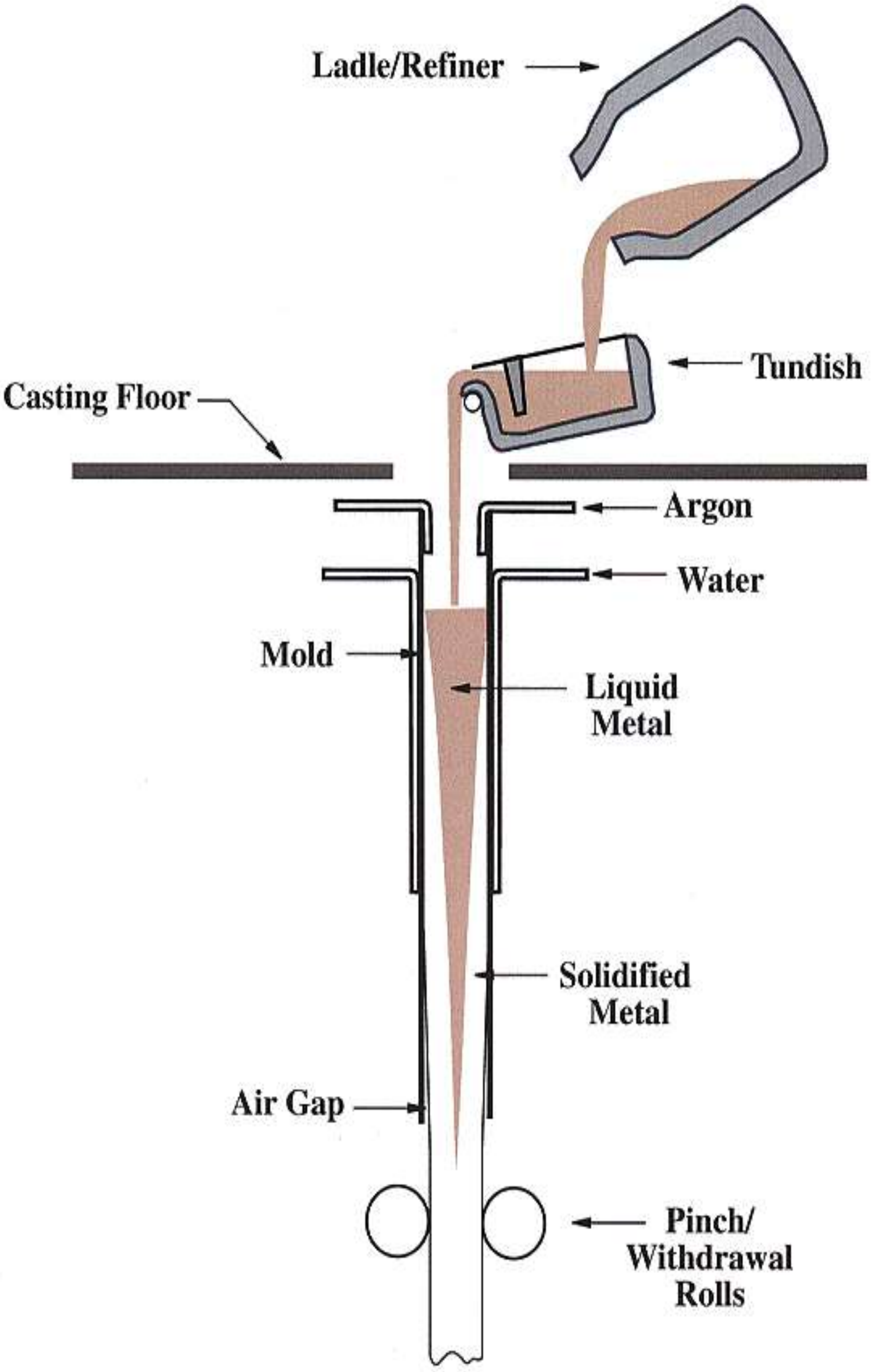

Figure-3 (a) Schematic Sketch of Continuous Casting Process

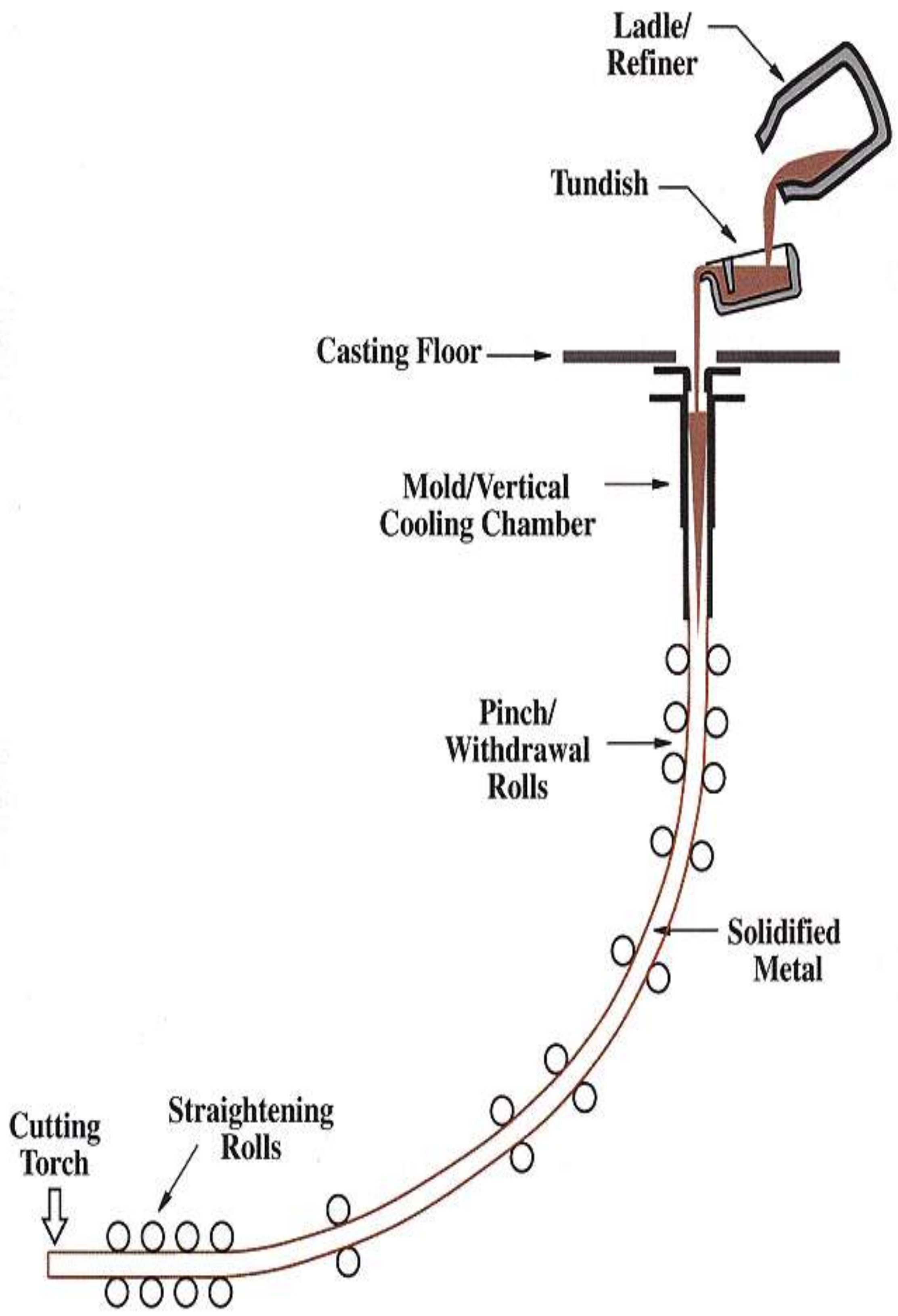

Figure-3 (b) Schematic Sketch of Continuous Casting Process with Straightening Rolls and Cutting Torch

The shape of the tundish is typically rectangular. Nozzles are located along its bottom to distribute liquid steel to the mould. The tundish also serves several other key functions such as to enhance oxide inclusion separation, to provide a continuous flow of liquid steel to the mould during ladle exchanges, to maintain a steady metal height above the nozzles to the mould, thereby keeping steel flow uniform and also to provide more stable stream patterns to the mould. The main function of the mould is to establish a solid shell sufficient in strength to support its liquid core upon entry into the secondary spray-cooling zone. The mould is an open-ended box structure, containing a water-cooled inner lining fabricated from a high purity copper alloy. The inner face of the copper mould is often plated with chromium or nickel to provide a harder working surface, and to avoid copper pickup on the surface of the cast strand, which can otherwise facilitate surface cracks on the product. Mould oscillation is necessary to minimize friction and sticking of the solidifying shell, and avoid shell tearing, and liquid steel breakouts, which can wreak havoc on equipment and machine downtime due to clean up and repairs. Friction between the shell and mould is reduced with mould lubricants such as oils or powdered fluxes. Oscillation is achieved either hydraulically or via motor-driven cams or levers which support and reciprocate or oscillate the mould [10].

STARTER BAR

Continuous casting process with a starter bar is shown below in Figure-4. The starter bar has a free end portion, which is flexible for storage, and a substantially rigid portion at the end, which plugs the mould [11].

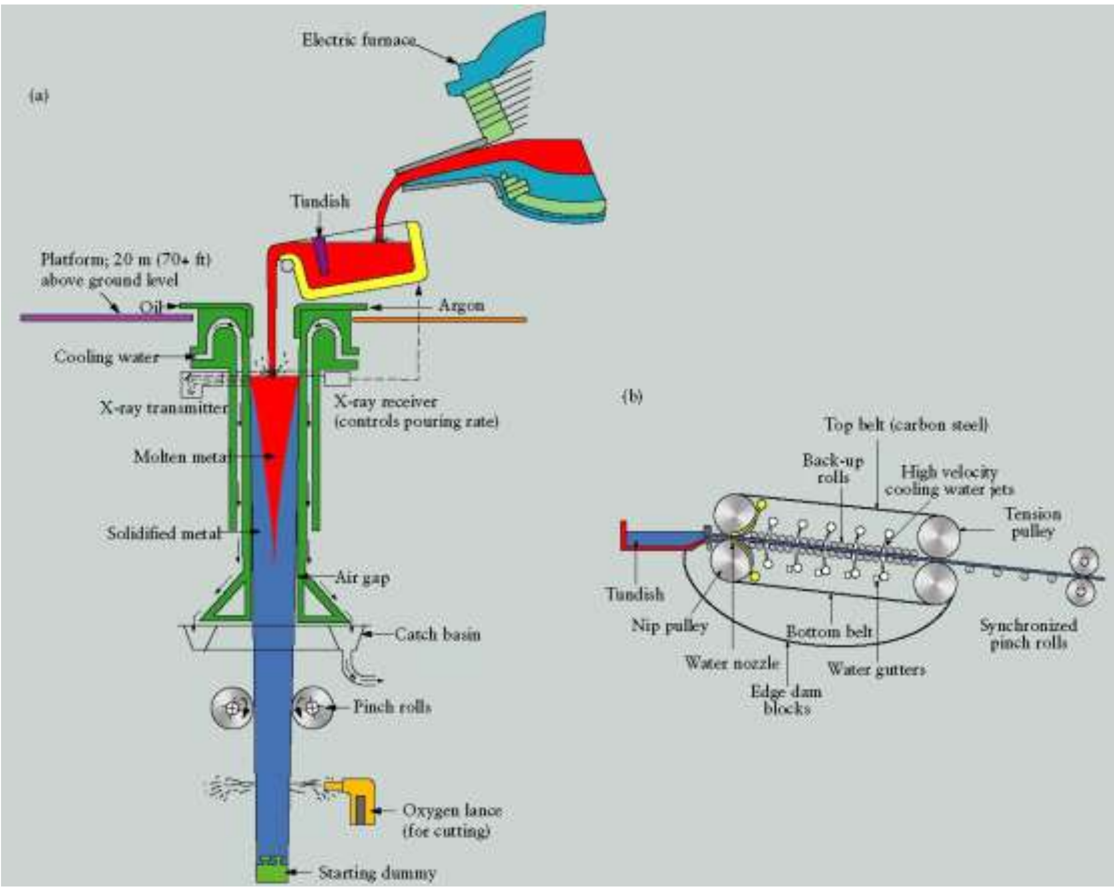

Figure-4 Continuous Casting Process with a starter bar

The starter bar is constructed in discrete blocks secured to one side of a planar spine provided in segments and arranged end to end. Adjustable spacers in the form of tapered blocks are disposed between the blocks of the bar to allow the starter bar to be self-supporting in a curved configuration corresponding to the casting path. A more flexible spine in the end portion of the starter bar allows the starter bar to be curved to a tighter radius than that of the casting path while the blocks fan out in an unsupported configuration. A storage ramp is provided to support the flexible end in the stored position [12].

CONTINUOUS CASTING PROCESS CONTROL

The mechanism of continuous casting process is shown below in Figure-5(a). Starting a continuous casting machine involves placing a dummy bar, essentially a curved metal beam, up through the spray chamber to close off the base of the mould. Metal is poured into the mould and withdrawn with the dummy bar once it solidifies. It is extremely important that the metal supply afterwards be guaranteed to avoid unnecessary shutdowns and restarts, known as 'turnarounds'.

Each time the caster stops and restarts a new tundish is required, as any uncast metal in the tundish cannot be drained and instead freezes into a 'skull'. Avoiding turnarounds requires the melt shop, including ladle furnaces to keep tight control on the temperature of the metal, which can vary dramatically with alloying additions, slag cover and deslagging, and the preheating of the ladle before it accepts metal, among other parameters [1].

However, the castrate may be lowered by reducing the amount of metal in the tundish, although this can increase wear on the tundish, or if the caster has multiple strands, one or more strands may be shut down to accommodate upstream delays. Turnarounds may be scheduled into a production sequence if the tundish temperature becomes too high after a certain number of heats.

Many continuous casting operations are now fully computer-controlled. Several electromagnetic and thermal sensors in the ladle shroud, tundish and mould sense the metal level or weight, flow rate and temperature of the hot metal, and the programmable logic controller, PLC can set the rate of strand withdrawal via speed control of the withdrawal rolls. The flow of metal into the moulds can be controlled by two methods:

- By slide gates or stopper rods at the top of the mould shrouds
- If the metal is open-poured, then the metal flow into the moulds is controlled solely by the internal diameter of the metering nozzles. These nozzles are usually interchangeable.

Overall casting speed can be adjusted by altering the amount of metal in the tundish, through the ladle slide gate. The PLC can also set the mould oscillation rate and the rate of mould powder feed, as well as the spray water flow. Computer control also allows vital casting data to be repeated to other manufacturing centres particularly the steelmaking furnaces, allowing their work rates to be adjusted to avoid 'overflow' or 'underrun' of product [1,2].

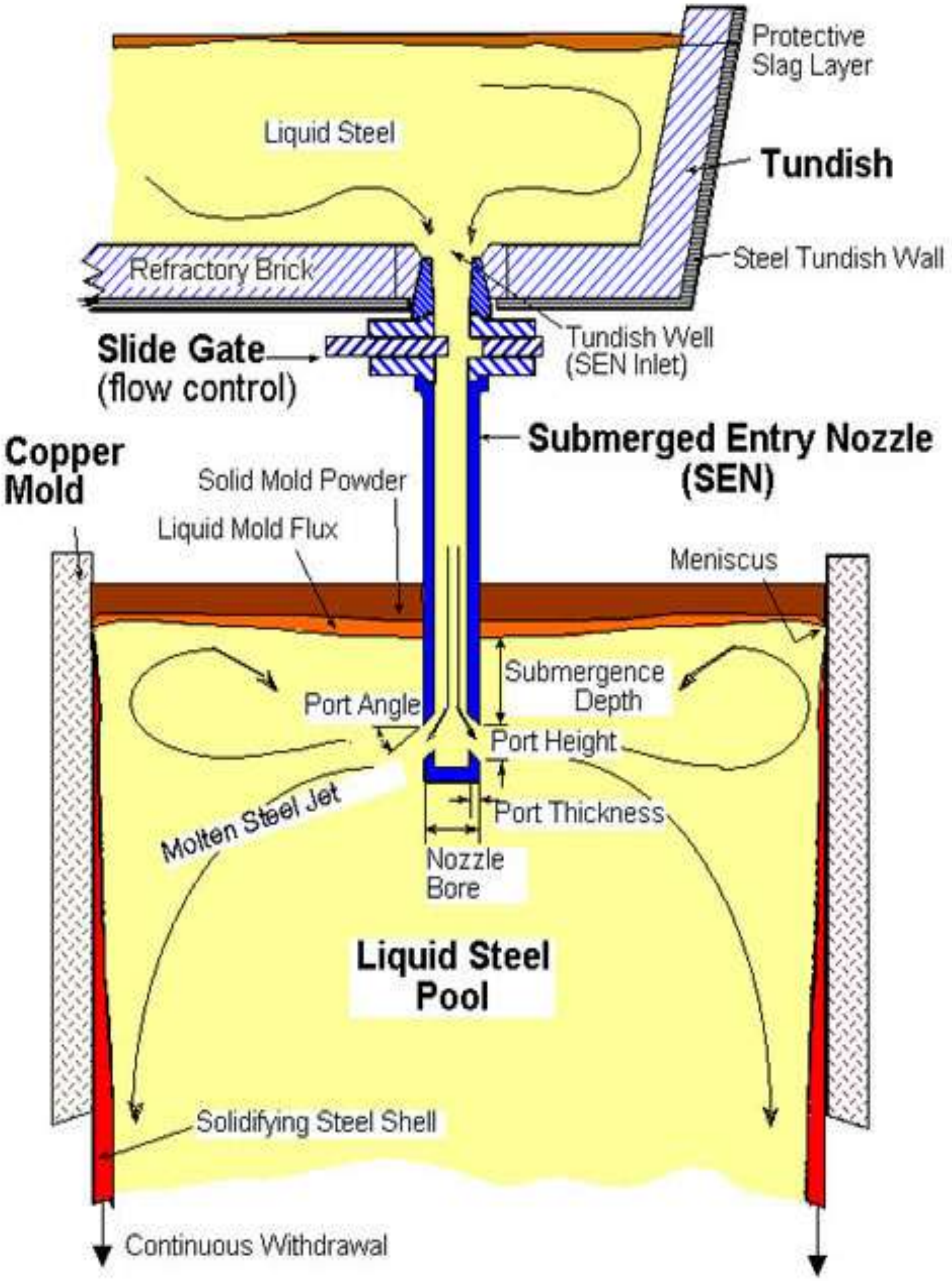

Figure-5(a) Mechanism of Continuous Casting Process

While the large amount of automation helps produce castings with no shrinkage and little segregation, continuous casting is of no use if the metal is not clean beforehand, or becomes 'dirty' during the casting process. One of the main methods through which hot metal may become dirty is by oxidation, which occurs rapidly at molten metal temperatures (up to 1700 °C); inclusions of gas, slag or undissolved alloys may also be present. To prevent oxidation, the metal is isolated from the atmosphere as much as possible. To achieve this, exposed metal surfaces are covered by the shrouds, or in the case of the ladle, tundish and mould, by synthetic slag. In the tundish, any inclusions in the form of gas bubbles, other slag or oxides, or undissolved alloys may also be trapped in the slag layer [6, 8].

A major problem that may occur in continuous casting is *breakout*. This is when the thin shell of the strand breaks, allowing the still-molten metal inside the strand to spill out and foul the machine, requiring a turnaround. Often, breakout is due to too high a withdrawal rate, as the shell has not had the time to solidify to the required thickness, or the metal is too hot, which means that final solidification takes place well below the straightening rolls and the strand breaks due to stresses applied during straightening. A breakout can also occur if solidifying steel sticks to the mould surface, causing a tear in the shell of the strand. If the incoming metal is overheated, it is preferable to stop the caster than to risk a breakout. Additionally, lead contamination of the metal caused by counterweights or lead-acid batteries in the initial steel charge can form a thin film between the mould wall and the steel, inhibiting heat removal and shell growth and increasing the risk of breakouts [1, 8].

Another problem that may occur is a carbon boil, i.e., oxygen dissolved in the steel reacts with also-present carbon to generate bubbles of carbon monoxide. As the term *boil* suggests, this reaction is extremely fast and violent, generating large amounts of hot gas, and is especially dangerous if it occurs in the confined spaces of a casting machine. Oxygen can be removed through the addition of silicon or aluminium to the steel, which reacts to form silicon oxide (silica) or aluminium oxide (alumina). However, too much alumina in the steel will clog the casting nozzles and cause the steel to 'choke off'.

Computational fluid dynamics and other fluid flow techniques are being used extensively in the design of new continuous casting operations, especially in the tundish, to ensure that inclusions and turbulence are removed from the hot metal, yet ensure that all the metal reaches the mould before it cools too much. Slight adjustments to the flow conditions within the tundish or the mould can mean the difference between high and low rejection rates of the product [1, 9, 14]

CONTINUOUS CASTING HYDRODYNAMICS

The motion that is generated in a metal melt at casting and solidification is important for casting material properties and for the reduction of serious casting defects. The flow in the melt is generated at the teeming processes from ladle to mold when the melt is forced to pass a so-called gating system. An incorrect design of the outlet hole in the ladle or of the gating system may cause serious defects such as cold shuts, and numerous macro slag inclusions. In addition, flow of melt is also developed during the solidification process in the form of natural convection, which arises due to temperature or concentration differences in the melt. This flow influences the structure of the material and its physical properties. Experiments have shown that the same laws of hydrodynamics area as valid for molten metals as for other fluids. The result is that the laws of hydrodynamics can be applied to the continuous casting of metals. The principle of continuity and Bernoulli's equation are the two important laws taken from fluid mechanics are applied to the continuous casting of metals and alloys [1]. In continuous casting, a water-cooled metal-mold is used to provide strong and effective cooling of the strand. The solidificied shell of the strand must have enough stability and strength before leaving the chill-mold. A tundish is always used between the ladle and the chill-mold to achieve a constant pressure of the melt at the entrance to the chill-mold. A straight vertical sprue, similar to a casting tube or a submerged entry nozzle between the tundish and the chill-mold is used in continuous casting. The casting tube reduces casting defects such as macro slag inclusions.

The aim of the tundish is to provide a constant casting speed. In this process, it is desirable to have the most even velocity of the casting that can be obtained. By the use of a tundish as an intermediate container between the ladle and the chill-mold, the disadvantage of the velocity of the melt varying with the height of the melt in the ladle is eliminated. The tundish is kept filled and the distance between the tundish and the chill-mold is constant. A sliding gate or a stopper rod controls the flow from the tundish. Flushing with argon gas is performed often to prevent air intrusion or clogging of the nozzle [1, 2, 3].

Another problem is the risk of slag inclusions. To decrease the problem of macro slag inclusions, the upper surface of the melt is covered with casting-powder and the melt transformed from the tundish to the mold through a submerged entry nozzle or casting tube. The flow depends on the geometry, depth and dimensions of the nozzle exit and the flow rate of the jet. The jet causes forced convection in the chill-mold in addition to natural convection that is always present during solidification. To avoid inclusion of trapped slag particles at the solidification front, the penetration depth should be moderate. Therefore, the nozzles often designed with exits on the sides at some angle between zero degree and ninety degree relative to the vertical axis. The casting tube must be made of a material that resists chemical attacks from steel alloying elements, such as aluminium, sulphur, and manganese. Casting tubes are often made of a mixture of aluminium oxide and graphite. The melt flow in the mold is greatly influenced by the jets from the casting tube. The superheated melt leaves the nozzle and it impinges laterally into the mold, splits into two strongly circulating flows are directed upwards and the other one is directed downwards. The violent motion in the melt contributes strongly to the formation of a homogeneous fluid.

HEAT TRANSPORT IN CONTINUOUS CASTING

Casting of metals is closely related to heat release and heat transport during solidification and cooling. The rate of heat removal is very important as it determines the solidification time of the casting and the temperature distribution in the material. These control directly or indirectly the structure of the material, precipitation of pores and slag inclusions and distribution and shape of shrinkage of pores, and hence the qualities and properties of castings. In the case of solidifying metal melts, thermal conduction will be the most important way of heat transport. Continuous casting is based on casting of a metal in a vertical chill-mold [1, 9]. The metal flows from the ladle via the tundish down into the vertical, water-chilled copper mold. During the passage into the chill-mold, the melt starts to solidify and a solid shell is formed. This shell is drawn continuously out of the chill-mold into the chill-zone where complete solidification occurs. The velocity of the shell is called as casting velocity or casting rate. A necessary condition for continuous casting is that the shell has such mechanical properties that are rigid outside the chill-mold. Water-cooling is therefore very important in this process. Continuous casting is a typical example of heat transport with poor contact between the chill-mold and metal. To obtain maximum yield, the highest possible production velocity is required. This demands careful control of the cooling and casting conditions. With poor contact between the mold and the metal, there is a discontinuity of the temperature at the interface.

SOLIDIFICATION CONTROL IN CONTINUOUS CASTING OF STEEL

Solidification in continuous casting technology is initiated in a water-cooled, open-ended copper mould. The steel shell, which forms in the mould, contains a core of liquid steel, which gradually solidifies as the strand moves through the caster guided by a large number of roll pairs. The solidification process initiated at meniscus level in the mould is completed in secondary cooling zones using a combination of water spray and radiation cooling. Solidification speciality of continuous casting technology arises from the dynamic nature of the casting process.

In particular this relates to handling of very high heat flux in the mould, nurturing of the initial thin and fragile solid shell for avoidance of breakout during descent of the strand down the mould, designing of casting parameters in tune with the solidification dynamics of the steel grade for minimisation or elimination of surface and internal defects in the cast product. Safe caster operation, i.e., without metal breakout and achievement of acceptable product quality require understanding of both process engineering and metallurgy of solidification. Early solidification in continuous casting occurs in the form of partial freezing of the meniscus curvature originating from the mould liquid contact point. To minimise shell sticking and tearing, friction between the strand surface and mould wall must be kept below a critical level depending upon the shell strength. Minimisation of the friction and continuous release of the shell from the mould have been achieved through the introduction of mould oscillation aided by lubrication [1, 2, 4].

HEAT TRANSFER IN CONTINUOUS CASTING

By its nature, continuous casting is primarily a heat-extraction process. The conversion of molten metal into a solid semi-finished shape involves the removal of the following forms of heat.

- Superheat from the liquid entering the mould from the tundish.
- The latent heat of fusion at the solidification front as liquid is transformed solid, and finally.
- The sensible heat, i.e., cooling below the solidus temperature from the solid shell.

These heats are extracted by a combination of the following heat-transfer mechanisms:

- Convection in the liquid pool.
- Heat conduction down temperature gradients in the solid shell from the solidification front to the colder outside surface of the cast.
- External heat transfer by radiation, conduction and convection to surroundings.

Because heat transfer is the major phenomenon occurring in continuous casting, it is also the limiting factor in the operation of a casting machine. The distance from the meniscus to the cut-off stand should be greater than the metallurgical length, which is dependent on the rate of heat conduction through the solid shell and of heat extraction from the outside surface, in order to avoid cutting into a liquid core. Thus, the casting speed must be limited to allow sufficient time for the heat of solidification to be extracted from the strand [1]. Heat transfer not only limits maximum productivity but also profoundly influences cast quality, particularly with respect to the formation of surface and internal cracks. In part, this is because metals expand and contract during periods of heating or cooling. That is, sudden changes in the temperature gradient through the solid shell, resulting from abrupt changes in surface heat extraction, causes differential thermal expansion and the generation of tensile strains. Depending on the magnitude of the strain relative to the strain-to-fracture of the metal and the proximity' of the strain to the solidification front, cracks may form in the solid shell. The rate of heat extraction also influences the ability of the shell to withstand the bulging force due to the ferrostatic pressure owing to the effect of temperature on the mechanical properties of the metal. Therefore, heat transfer analysis of the continuous casting process should not be overlooked in the design and operation of a continuous casting machine.

MACROSTRUCTURES IN CONTINUOUSLY CAST MATERIALS

The microstructure of a continuously cast material resembles the macrostructure found in ingots. The formation mechanisms of the crystal types and crystal zones are same in both cases, and the discrepancies that appear originate from the different casting conditions. The growth of macrostructure in a continuously cast product is shown below in Figure-6 [13].

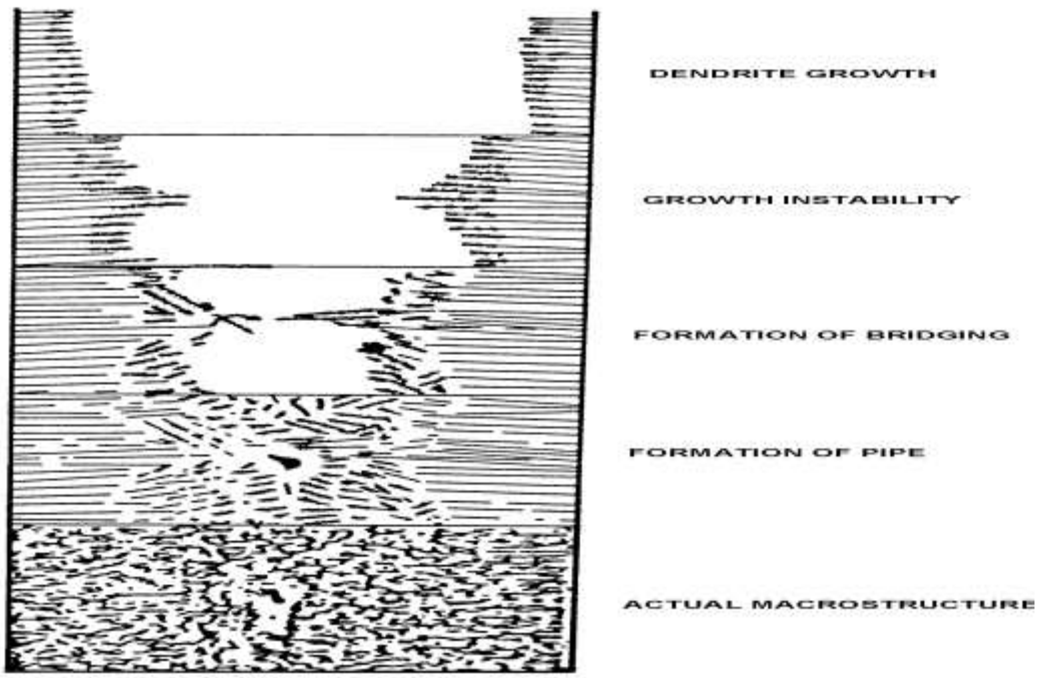

Figure-6 shows the macrostructure of a slab cast in a continuous casting machine [13]

 [ISSN: 2374 -1589]
Publication Date : 09 January 2014

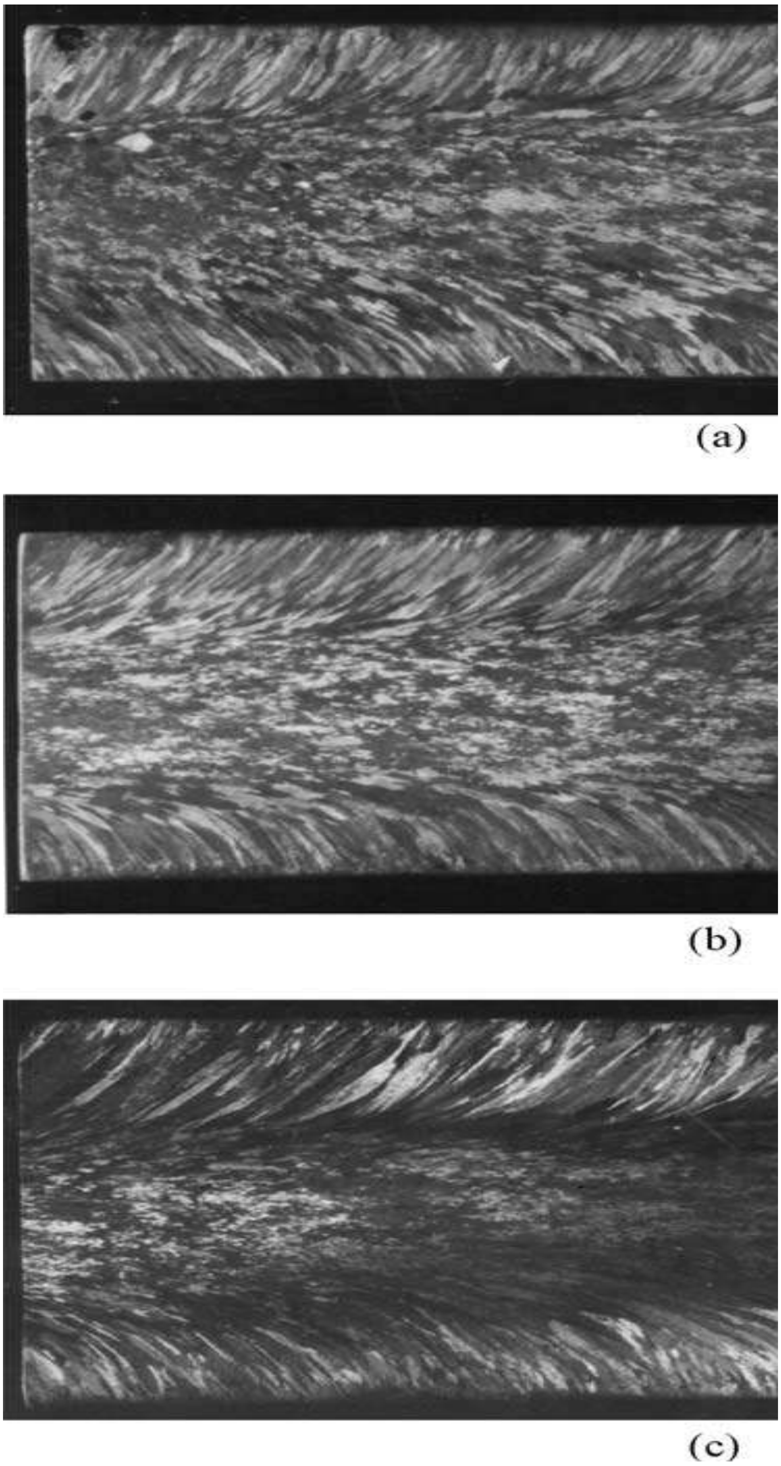

Figure-7 Macrostructure of continuously cast Al–1.2Li–0.8 Hf alloy ingot. (a) Top, (b) Middle and (c) Bottom parts [14]

Figure-7 show the macrostructure of the continuously cast Al–1.2Li–0.8Hf alloy ingot for its top, middle and bottom parts, respectively. The bottom part is first cast section and it is composed of columnar grain, elongated in the cast direction, and formed from the outer surface to the centre of ingot [14]. Finer equiaxed grains are observed in the central part of ingot. This solidification pattern is similar to that found in the pure aluminum ingot, but this one revealed a grain size larger than that found in the Al–1.2Li–0.8Hf alloy [14].

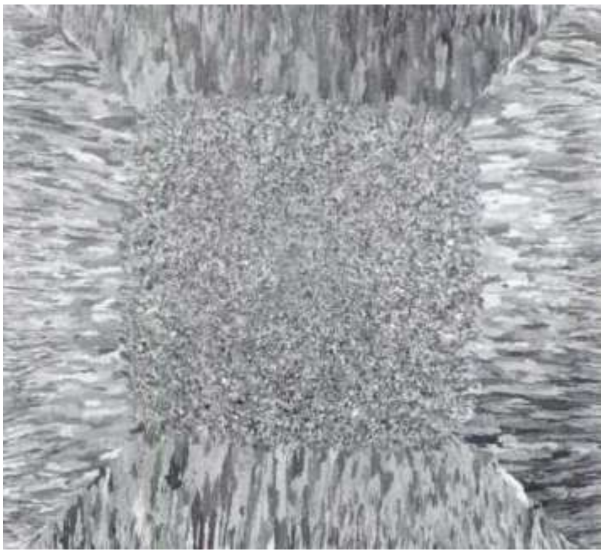

Figure-8 Macrostructure of a continuously cast stainless steel bloom

The above Figure-8 shows the macrostructure of a continuously cast stainless steel bloom. The size, shape and the orientation of the grains reveal two distinct zones:

- ✓ A central region of fine randomly oriented equiaxed grains
- ✓ An outer region of columnar grains, elongated normal to the ingot surface. Careful examination shows that their width increases from the surface to the centre.
- ✓ A third zone, corresponding to very fine chill crystals, is present at the extreme skin.

SOLIDIFICATION AND COOLING SHRINKAGE DURING CONTINUOUS CASTING

During continuous casting, the melt must be strongly cooled since no metal must be left inside the strand, when it leaves the machine. If the walls and bottom of a chill-mold are strongly cooled, a large temperature gradient is formed in the melt. The dendrites grow mainly in the direction of the temperature gradient and the shrinkage cavities appear in the shape of a narrow pipe in the centre [1, 2].

Corresponding cooling conditions with strong temperature gradients are also valid during continuous casting, when the walls of the strand are cooled by water spraying in the chilled zone below the chill-mold. Pipe formation appears at the end of the solidification of the strand when the supply of new melt from the tundish has ceased. Figure-9 shown above is a schematic sketch of an axial section of a continuous cast ingot.

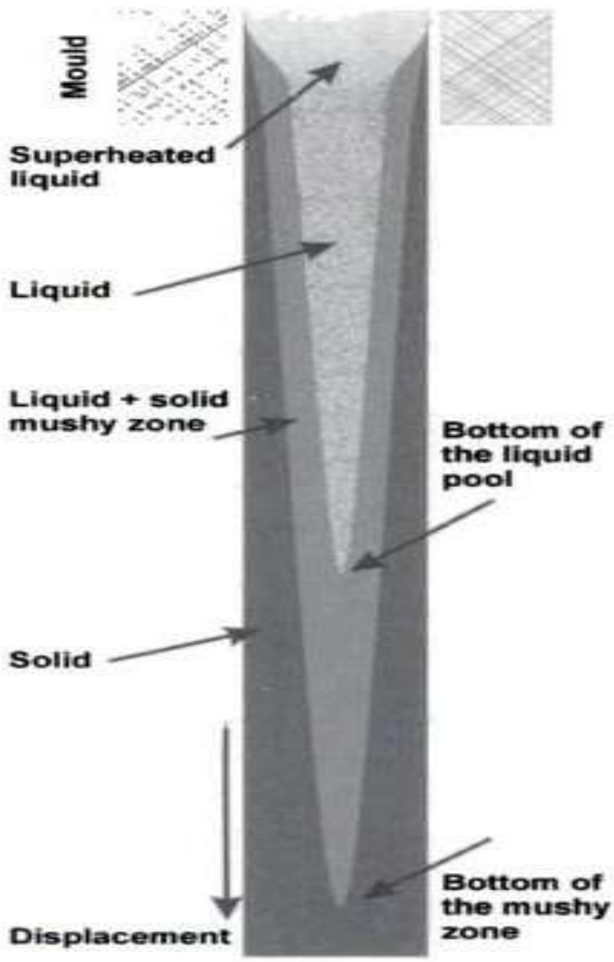

Figure-9 Schematic sketch of an axial section of a continuously cast ingot

In continuous casting, melt is continuously added to the mold and the volume decrease due to solidification and cooling shrinkage is thus compensated. Then situation is changed at the end of the casting process when the supply of melt from the tundish above the mold ceases. The pipe volume can be reduced by different practical methods and is in most cases not a major problem in continuous casting process. However, the mechanism of pipe formation in a continuously cast strand is the same that of centreline segregation, which is a severe problem. The pipe is well developed in billets but less marked in casting of slabs. The reason for this difference is found in the design of the casting machine and the casting conditions in the two cases. Experimental examinations show that the pipe volume during continuous casting is so large that it cannot be explained entirely by solidification shrinkage. The central cavities in continuous casting are caused by combined solidification and cooling shrinkage.

CENTRE SEGGREGATION DURING CONTINUOUS CASTING

Figure-10 show the features of macro segregation in longitudinal section of continuously cast billets [13]. Centre segregation in continuous casting process is caused like pipe formation, by solidification and cooling shrinkage. Melt flow through a two-phase region and fills the cavity, which is caused by the shrinkage at the centre. Simple and closely packed V-segregations appear in the region above and below bridges across the pipes.

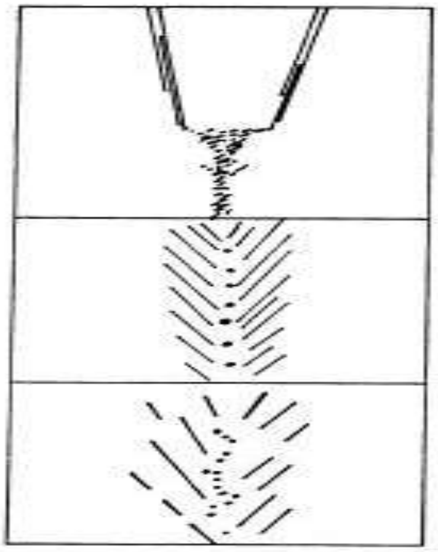

Figure-10 Features of macro segregation in longitudinal section of continuously cast billets [13]

Centre segregation and pipe formation in continuous casting can be minimised by the following methods:

- Reduction of the casting rate during the final stage of the casting.
- Application of an external pressure on the strand at an optimal distance from the mold.
- No interruption of the pressure treatment until the strand has solidified completely.
- Design of the secondary cooling in an optimal way; additional cooling from a certain optimal position is favourable.

CONTINUOUSLY CAST SECTIONS

- Casting machines are designated to be billet, bloom or slab casters.
- Slab casters tend to cast sections with an aspect ratio that is much wider than it is thick:
  - Conventional slabs lie in the range 100–1600 mm wide by 180–250 mm thick and up to 12 m long with conventional casting speeds of up to 1.4 m/minute.
  - Wider slabs are available up to 3250×150 mm.
  - Thick slabs are available up to 2200×450 mm.
  - Thin slabs: 1680×50 mm
- Conventional bloom casters cast sections above 200×200 mm. Casts sections of 560×400 mm. The bloom length can vary from 4 m to 10 m.
- Billet casters cast smaller section sizes, such as below 200 mm square, with lengths up to 12 m long. Cast speeds can reach up to 4 m/minute.
- Rounds: either 500 mm or 140 mm in diameter

- Conventional beam blanks: look similar to I-beams in cross-section; 1048×450 mm or 438×381 mm overall.
- Near net shape beam blanks: 850×250 mm overall
- Strip: 2–5 mm thick by 760–1330 mm wide

CONTINUOUSLY CAST PRODUCTS

Depending on the design of the casting machine, the as-cast products of the continuous cast process are slabs, blooms, billets, or beam blanks. The cross sections of these products are shown below in Figure-11.

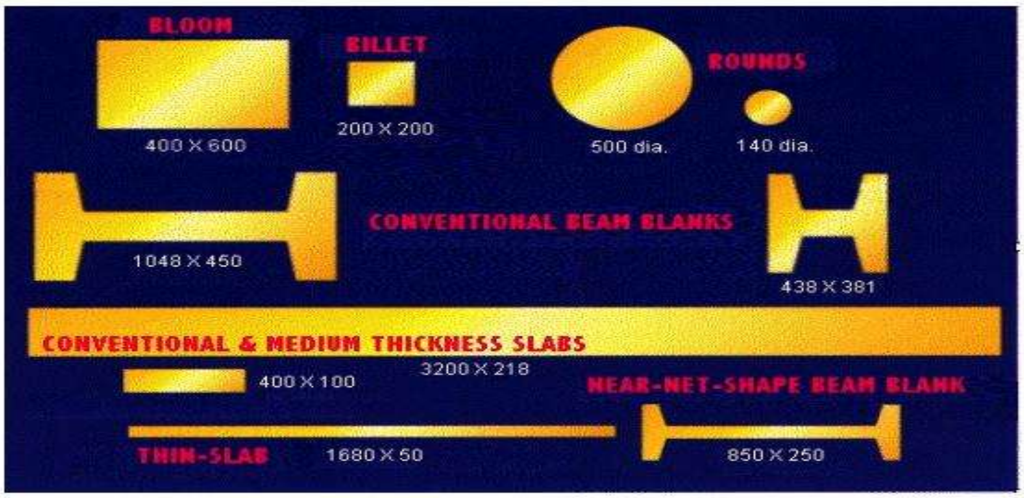

Figure-11 Continuously Cast Products

Billets have cast section sizes up to about 200 mm square. Bloom section sizes typically range from approximately 200 mm to 400 mm by 600 mm. Round billets include diameters of approximately 140 mm to 500 mm. Slab castings range in thickness from 50 mm to 400 mm, and over 2500 mm wide. The aspect ratio (width-to-thickness ratio) is used to determine the dividing line between blooms and slabs. An aspect ratio of 2.5:1 or greater constitutes an as-cast product referred to as a slab.

ADVANTAGES OF CONTINUOUS CASTING TECHNOLOGY

- ✓ Reduced cost and improved quality.
- ✓ Less variability in chemical composition both along the thickness and along the length and surface has fewer defects.
- ✓ Increased yield, since it is not necessary to crop the ends of continuously cast slabs and reduced energy costs.
- ✓ The slabs are sent directly to hot rolling and do not require pits for reheating and also the thickness of continuously cast slabs is half the thickness of ingot castings and thus require lower energy for hot rolling.
- ✓ Less pollution and the dimensions produced in continuous castings are more amenable for hot rolling.
- ✓ In continiuos casting process, the ladle has to move short distance i.e. only over the tundish and not over every mould.

- ✓ Continuous casting is perfect for manufacturing semi-finished products (bars, slabs) of long sizes;
- ✓ The microstructure of long semi-finished products is even and due to this there is less possibility for arising of tension in the product and the finished parts made from such products will be more durable;
- ✓ Continuous casting reduces metal cuttings and loss of metal compared to casting in moulds. It is economic regarding the energetic consumption and there are fewer workers needed at the production process compared to casting in moulds.

CONCLUSION

Continuous casting transforms molten metal into solid on a continuous basis and includes a variety of important commercial processes. Continuous casting technology is a metalworking process in which metal is cast continuously, rather than being cast in discrete molds. This process is extremely efficient and cost effective, making it popular for the production of a variety of semi finished metal shapes. Once cast, the metal can be further worked as needed. All operations can be easily automated and supervised. It is easy to modify the quality and properties of the semi-finished products by changing the cast parameters like the pulling speed of the product, the temperature of the crystallizer's water. Continuous casting allows manufacturing metal slabs or bars in large amounts by short time.

Acknowledgement

The author expresses his thanks and gratitude to the School of Mechanical and Building Sciences, SMBS, VIT University, Chennai Campus, Chennai 600127, India.

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