Manufacturing Processes 2

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Continuous casting processes:

All metal products have to be “cast”, that is, converted from molten metal into a solidified mass in a mold. The result may be a “casting” which is cooled in a specially shaped mold and is generally a finished product in itself, or an “ingot”, which is an intermediate shape which will be further processed into finished products. Ingots can be extruded or forged directly into finished products, or, in the case of sheet and wire products, rolled down to thinner dimensions.

Continuous casting is a faster and more efficient method of producing ingots and related products. It is not employed for producing “castings”. In the traditional ingot production method, molten metal is poured into stationary molds. The cast ingots are then allowed to cool, removed from the molds and then machined to remove surface imperfections, a time consuming and wasteful process.

Continuous casting (Fig.1), converts molten metal into a continuous moving ingot shape with a rectangular or round cross section. Time, energy, and labor are saved. Generally, a water-cooled mold is employed, receiving molten metal in one end and delivering a continuous solidified product out the other. The molds can be vibrating or moving, slow or fast.

Fig.(1)Principle of continuous casting

ADVANTAGES OF CONTINUOUS CASTING:
There are many advantages of continuous casting over conventionally produced materials. Technically, the ability to continuously cast a "semi finished" product close to near net shape minimizes the number of subsequent downstream operations required to produce the finished product. The quality of the semi finished product and its continuous production can significantly improve the production yield.
Commercially, the improved yield and reduced number of operations lowers the cost of production. Also the ability to continuous cast semi-finished products "in house" can provide independence from outside suppliers, avoidance of extended delivery lead-times and close control of metal product quality. Continuously cast strips, inherently have a relatively large grain size. If there is insufficient reduction and recrystallisation of these grains during the processing of the strip.

The conventional way of producing rolling slabs is DC (Direct Chill) semi-continuous casting although some slabs are produced by pouring molten metal into a permanent mould. After DC casting, the rolling slabs are re-heated to about 500°C and hot rolled to a coilable thickness between 4 mm and 6 mm. The biggest advantage of the continuous technologies is the saving of several production steps in the production of strip or foil compared to conventional technologies.

**Conventional technology:**
- Melting
- DC-casting
- hot rolling
- coiling
- cold rolling (possibly including several thermal treatments)
- foil or canstock

**Continuous technology:**
- Melting
- strip casting
- coiling
- cold rolling (possibly including several thermal treatments)
- foil or canstock

*a) Vertical downward*

The first machine for the industrial casting of aluminum strip in the late thirties. It was a twin drum caster with vertical casting direction Fig. (2). The molten metal was cast from the top into the space between two casting rolls. The strip leaves vertically downward between the rolls. The machine was used for the casting of narrow strip.

![Fig. (2) Vertical downward continuous casting](image-url)
**b) Vertical upward**

The casting nozzle is situated beneath the two rolls. By the metallostatic pressure, determined from the level of liquid in the tundish, the molten metal flows through the nozzle and immediately into contact with the rolls. The rolls transport the solidified material in such a way, that the material gets a light deformation. The strip leaves at the top and it is being coiled (Fig. 3). The magnesium content is limited to 2.0%. The temperature of the finished strip is 300°C to 350°C. It is possible to cast strip up to 1700 mm width with 6 mm to 9 mm gauge.

![Fig. (3) Vertical upward continuous casting](image)

![Fig.4 Continuous casting process](image)
Continuous casting of aluminum:

Due to its many economic advantages the continuous casting of aluminium has become more and more important during the last 40 years. These processes are mostly used for the production of a semi fabricated strip, for cold rolling to foilstock building sheet and canstock. They are also used to cast endless wire bar stock. Continuous casting processes converts molten aluminium alloys directly into an endless coiled strip suitable for cold rolling or wire-bars for wire-drawing. They effectively eliminate the operations associated with traditional mould casting (discontinuous process) or D.C. casting (a semicontinuous process) and subsequent hot mill deformation. Therefore the capital investment and operational costs are significantly lower than in a conventional production process. Continuous casting is the preferred casting method in many modern plants because it offers higher productivity. Continuous casting has been employed with increasing commercial success for aluminium as well as other metals.

Five types of casters for continuous casting of aluminium are used. Most of them produce aluminium alloy slab or strip. The principle of operation is as follows:

1. **Twin drum caster**, which has considerable commercial application, especially for the production of foil stock, is shown in Figure 5. It includes a source of molten metal which feeds into the space between a pair of counter-rotating, internally cooled drums (hollow rolls). In a very short time after leaving the casting nozzle the molten metal solidifies due to the contact with the water-cooled rolls. An homogeneous distribution of the melt must already occur in the casting nozzle. The casting direction can be horizontal or vertical (the later type used especially in earlier models). The solidification zone is 10 mm to 20 mm long and is followed immediately by a zone of hot-rolling in the same gap. All such methods are in fact roll casting processes because the strip thickness can be reduced of 5% to 20% in-situ by hot rolling. The strip usually has a temperature between 400°C and 550°C and can be directly coiled at hot temperature.

![Fig. 5 Twin drum caster with horizontal casting direction](image-url)
2. In **single drum casters** (Figure 6), a supply of molten metal is delivered to the surface of a rotating drum that is internally water-cooled. The molten metal is dragged onto the surface of the drum to form a thin strip of metal, which cools on contact with the surface of the drum.

![Fig.6 Single drum caster](image)

3. In **twin belt slab casting** equipment, two moving thin steel belts are provided which create a moving mould for the metal to be cast (Figure 7). The belt is subjected to extremely high thermal gradients, with molten metal in contact with the belt on one side and a water coolant in contact with the belt on the other side.

![Fig.7 Belt caster](image)
4. The **block caster technique** is illustrated in **Figure 8**. A number of chilling blocks is mounted adjacent to each other on a pair of opposing tracks. Block casters require precise dimensional control to prevent flash (transverse metal fins) caused by small gaps between the blocks. Such flash can cause sliver defects when the strip is hot rolled.

![Fig.8 Block caster](image1)

5. A **combination of a rotating steel belt and a water-cooled casting wheel**. Here the mould is formed between the belt and a sector on the outside of the casting wheel (see **Figure 9**).

![Fig.9 Caster with a combination of steel belt and casting wheel](image2)