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Properties Evaluation of Twin Roll Casting Aluminium Strip

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Rolling is a rapid method of metal forming to get the desired thickness. The process essentially consists of passing hot ingots in between the roll rotating in opposite directions at a uniform speed. The space between the rolls could be adjusted to obtain the desired thickness of the rolled section. Twin roll casters are most commonly used machines for the strip casting of aluminium, because they offer low investment and very high operational flexibility. The aluminium strips obtained are subjected to various tests, such as hardness, porosity, visual study, corrosive test, tensile strength, microstructure study and dry abrasion wear test. The aluminium strips are obtained from twin roll casting, strip properties are compared with as cast processed rolled strips. It was found that the most optimal conditions to produce aluminium strips of high integrity were at temperatures of 670 degrees centigrade and rolling speeds of 16 rpm.

***Keywords*:** Aluminium strip, Twin Roll, Casting,

1. Introduction

Twin-roll strip casting combines casting and rolling into a single operation, thus reduces the number of operation compared to conventional continuous casting to produce thin strip ranging from 1 m to 60 mm thickness. Furthermore, due to high cooling rates, it can increase the mechanical properties of the metal. Although the concept goes back to the 19th century with the patent of Bessemer in 1866 and is very simple, its application has proven to be extremely difficult due to strained thermal shredded of the rolls, supplying the liquid metal to the melt pool homogeneously to avoid unsymmetrical solidification of the metal, or avoiding pre-solidification at the edges between the rolls and the dams .If the past two decades of research and development have solved most of the technical problems, very rare results have been published concerning involved in this process. Thin strip casting of aluminium by twin rolling is a new process that utilizes rapid solidification technology. A variety of methods has been considered for production of thin strip of aluminium. This includes single roll melt drag method, twin roll method and two roll melt drag method. Twin roll casters have proven to be the most economical and efficient machines and are in the process of development. In a horizontal type twin roll caster, liquid aluminium is fed from a refractory feed tip into the gap between two counters rotating, air-cooled cylindrical steel rolls. Strip casting process involves solidification of liquid metal and rolling of solidified metal before it leaves the kissing point, which is the point of least roll separation, of two rollers.

2. **Properties of Aluminium – Key to its Utility**

The strength depends on purity, 99.996 percent pure aluminium has a tensile strength of about 49MPa, rising to 700MPa following allying and suitable heat treatment. The electrical conductivity of 99.99% pure aluminium at 200^0C is 63.8% of the International Annealed Copper Standard (IACS). The very good electrical properties of aluminium have made it an obvious choice for applications in the electrical industry, particularly in power distribution where it is used almost exclusively for overhead transmission lines and bus bars. Aluminium and its alloys are very slightly paramagnetic, as it has a magnetic permeability (μ) slightly

greater than one. The thermal conductivity, of 99.99% pure aluminium is 244 W/mK for the temperature range 0-1000^{0}C which is 61.9% of the IACS.

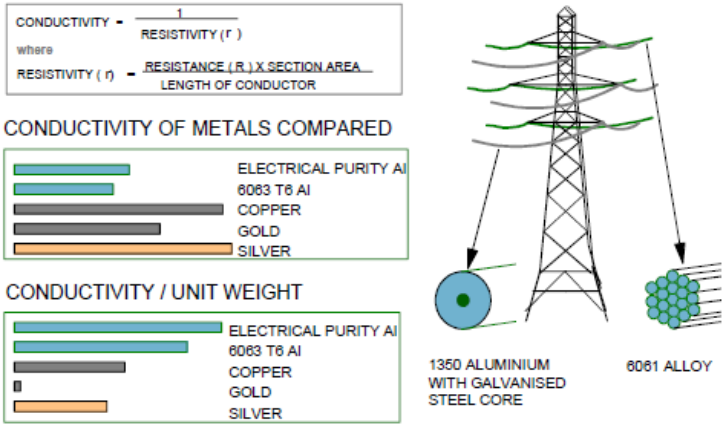


Fig. 1.Comparison of Aluminium with other metals

2. 1. Processing of Aluminium – Conventional Rolling

Twin roll continuous casting has its performance as a major effort on the downstream productivity yields and finished material quality. The process of plastically deforming metal by passing it between rollers is known as rolling. Hot rolling generally does initial break down of ingots in to blooms and billets. This is followed by further hot rolling in to plates, sheets, rods, bars or structural shapes. A cold rolling product produces sheet, strip and foils with good surface finish and increased mechanical strength, at the same time, maintaining closer control over the dimension of the product. In conventional hot rolling or cold rolling, the main object is to decrease the thickness of the metal. Ordinarily, little increase in width occurs, so that the decrease in thickness results in an increase in length.

2. 2. Processing of Aluminium – Strip Casting

Strip casting technology is the most recent innovative metal casting technology that integrates casting and rolling, thus re-heating of the metal is avoided. The original root of strip casting technology goes back to the 19th century. Bessemer, one of the classical inventors of the metal industry, applied for a patent in 1857. After renewed interest in strip casting technology arose between 1980 and 1985, a robust and large technology network emerged

2. 3. Twin Roll Continuous Casting

Thin strip casting of aluminium by twin rolling is a new process that utilizes rapid solidification technology. A variety of methods has been considered for production of thin strips of aluminium. This includes single roll melt drag method, twin roll method (both horizontal and vertical type) and two roll melt drag method. Twin roll casters have proven to be the most economical and efficient machines and are in the process of development. In a horizontal type twin roll caster, liquid aluminium is fed from a refractory feed tip into the gap between two counters rotating, air-cooled cylindrical steel rolls. Strip castings process involves solidification of liquid metal and rolling of solidified metal before it leaves the kissing point, which is the point of least roll separation, of two rollers. Solidification of molten metal starts at the point of first metal – roll contact and is over before the kissing point. This requires a strict control on molten metal flow in the roll gap and heat transfer in the roll and strip. Various models have been suggested in literature to predict fluid flow, heat transfer and solidification in twin roll casters various casting defects like centreline segregation, heat line formation, and sticking problems occur during strip casting. Heat

lines are formed when the material leaves the roll bite in a partially molten state. These are semi-continuous longitudinal defects, a few centimetres in width. Sticking occurs because of a high, steep pressure distribution along the arc of roll-strip contact, which is caused by the friction developed between the rolls and the strip.

3. Fabrication

The double roller method of continuous casting involves pouring the liquid aluminium alloy directly into the gap of the two horizontal rolls, which are rotating in the opposite direction. The molten aluminium begins to solidify at contacts with the surface of the rolls since these are cooled to a temperature bellow the solids temperature of the aluminium alloy. The two layers of the solidified aluminium must concur at a point above the narrowest point of the gap between the two rolls in order to ensure a solider strip leaving the gap. The process control must ensure that this condition is well met using the production. On the other hand, the joining point should be as low as possible in order to reduce the forming force acting on the set up. Usually dams are provided on either side of rolls to ensure that the melt does not leave the pool. A typical conventional continuous casting set up is as shown in figure 2.

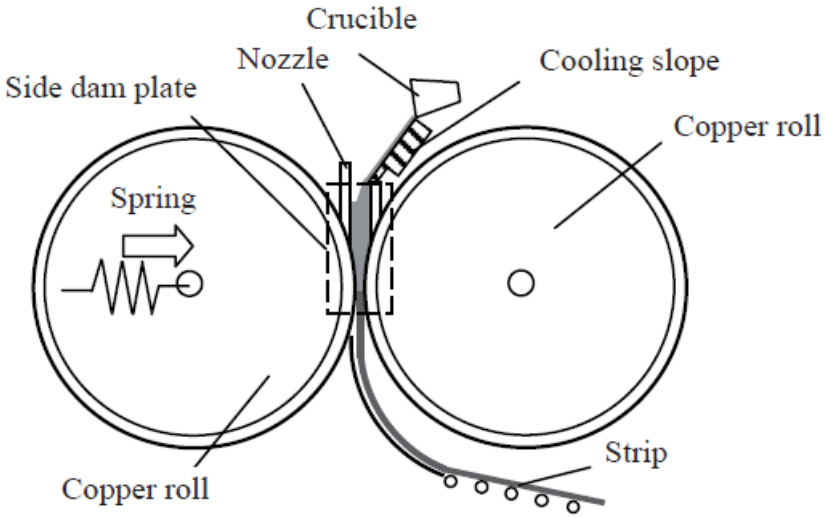


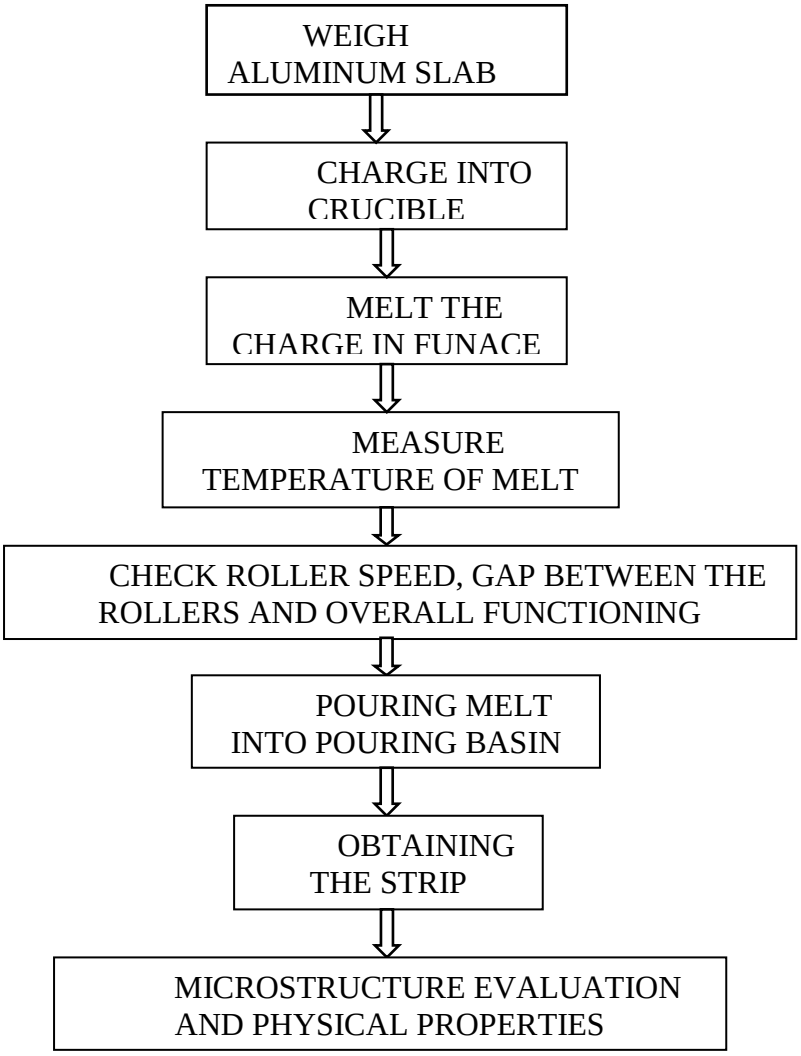
Fig. 2. Experimental Set Up

3. 1. Twin Rollers setup

As the name indicates the twin roll consist of two sets of rollers (4 rollers). These set of rollers placed in collinear to each other, improper alignment of this may cause cracks and breakages in aluminium strips. All the rollers set at same speed and are matched to the strip velocity. Different speed of individual roller causes improper forces to act on aluminium strip, which results in discontinuous strips. The gap between rollers is initially set depending up on the thickness of the strip required. The molten metal taken in a crucible is poured in to the pouring basin, which in turn allows the control flow of molten metal between the roller gap of first set of rollers and rolled strip are directly obtained a sit comes out of second set of rollers. Prior to rolling the aluminium is in the form of an ingot. This ingot is then heated to around 680°C and passed through the hot preheated rollers. This gradually reduces the thickness of the metal to around 1.2 mm as set.

Preheating of the rollers is very essential as the preheating makes the aluminium to flow easily thru the rollers; if the rollers are not preheated then there are al possibilities that the molten aluminium gets stuck in between the rollers instead of flowing between them forming strips of aluminium. The preheating is done using normal gas burner for about half an hour, as soon as the rollers are heated to a good extent the core box prepared is placed on the structure prepared for placing the same, note that even this core box is preheated to a high temperature so that temperature difference between the core box and the molten aluminium is reduced.

3. 2. Flow Chart of the Process



3. 2. Testing and Evaluation

Metal forming process can be classified as hot working and Cold working process. Forming processes that involve working at a temperature above the re crystallization temperature of the metal is termed as hot working while that which involves working below the re-crystallization temperature is termed as cold working processes In the casting process, perfect crystal structure can be obtained only when the crystallization develops under conditions when the degree of super cooling is slight and the metal is of high purity.

3. 2.1 Hardness Test

Before testing the specimen for its hardness, the indenter to be used, hardness scale, and major load to be applied, initial pointer position on the dial are chosen depending upon the material to be tested with the aid of the chart provided by the manufacturer.

3. 2.2 Abrasion Test

Abrasive wear occurs when hard particles slide or roll under pressure across a surface, or when a hard surface rubs across another surface. The abasing particles from the harder object tend to scratch or gouge the softer material. These hard particles may also penetrate the softer metal and cause the tearing off of metallic particles.

4. Steps Involved

- Specimen preparation
- Preparation of the electrolyte
- Setting up of the corrosion cell
- Conduction of Experiment

5. Conclusion

Devising newer and more efficient ways of fabricating aluminium is fast becoming a necessity due to the large number of applications to which the metal may be used in the one hand and its relatively lower cost and high availability vis-à-vis other metals and elements. This research explored the twin roller method of fabricating aluminium strips from liquid aluminium. The main objective was to find those optimal parameters of speed and temperature at which, aluminium strips with high levels of integrity could be obtained. Several devices were adopted to realize rapid solidification of the strip. These included rolling the rollers at speeds from 6 rpm to 20 rpm in steps of 2 at temperatures of 660, 665, 670, 675 and 680 degrees centigrade. Several benefits accrue through use of twin roller technology, which includes cost effectiveness, high quality, flexible manufacturing, and eco friendliness.

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