CHAPTER 4

DEVELOPMENT OF FACILITIES

4.0 DEVELOPMENT OF TWIN ROLL CASTING PROCESS

FACILITIES

It is observed that the machine for producing twin roll casting aluminium is not available in the market. Therefore it was essential to design and fabricate a basic twin roll casting facility. In the first phase the following facilities were developed and are described in the present chapter;

- Twin roll casting machine
- Shell Moulding facilities
- Furnaces
- Stirring mechanism
- Pre-heating facility

The first two items are designed and developed for the production of twin roll strips and the last three equipments are directed towards the making of liquid metal and its respective MMC.

4.1 TWIN ROLL CASTING MACHINE

The objective of this project was to build a twin-roll caster capable of producing thin aluminium strips with high productivity. It was hoped that the results could be used later for developing commercial casters. Two machines were developed, the first one is to receive liquid metal and roll a strip vertically downwards, and four rollers help to achieve it. The second one was developed to pour the liquid metal between
Development of Facilities

rollers and send solid strip at an angle over conveyor belt. The constructional detail of both the rollers is described in the following chapter.

4.1.1 Development of Twin Roll Casting Machine for Making Aluminium Strip in the Vertically Downward Direction

In this setup the molten metal is poured vertically between the top rollers, the basic outline diagram of this caster is as shown in Fig. 4.1.

4.1.1.1 Design and Development

The twin roll casting machine as the following components.

a) Top twin rollers

b) Bottom twin rollers

c) Adjustable structural frame for having item a and b along with variable speed control, high torque low speed motors.

d) High rise floor mounted on a high strength vibrational resistant structural platform.

e) All round protection and safety grill works.

f) Ladder

g) D.C motor speed control electrical rectifier cum tacho feed balls unit.

a) Top twin rollers

The twin rollers are the basic and significant element in twin rolling caster. These rollers made of cast iron of suitable diameter and length 200 mm. These two rollers are independently mounted on high pre radial roller ball bearings. these two rollers are coupled to high torque low rpm D.C. motor of 0.746 KW.
Figure 4.1 Line diagram of twin roll caster
b) Bottom twin rollers

Right below top twin rollers one more pair of similar rollers are mounted to the same frame. These two rollers are also coupled to a variable speed a high torque low rpm D.C motor of capacity 0.746 KW

c) Adjustable structural frame for having item a and b along with variable speed control, high torque low speed motors

The top and bottom pairs of roller is mounted on a high strength structurally stable steel frame. The front roller is permanently fixed to a frame made out of mild steel. The two rollers along with its bearing are mounted to this frame in such a manner that by moving it to end fro the gap between the rollers can be varied from 0.5 mm to 10 mm. the assembly line diagram is shown in Fig. 4.2.

d) High rise floor mounted on high strength, vibrational resistant structural platform

The complete frame carrying D.C motor, gear box and roller are mounted to a stable steel structural high rise floor. This complete assembly carefully mounted on to a high strength vibrational resistant platform. The floor or platform is 2.5 m from the floor level.

e) Allround protection and safety grill works

The platform along with its flooring D.C drive facility and roller is left open to have a safety point for the person working in the floor all round steel grill work is made along rails.
Figure 4.2 Roller Assembly
f) Ladder

The roller is mounted above the ground level at a height 2.5 m the liquid metal has to be poured on to the roller from this height since the melting furnace is at ground level. The liquid metal has to be carried to the platform manually with the help of a steel ladder.


g) D.C motor speed control electrical rectifier cum tachofeed balls unit

It is critical to maintain the same rpm for all the four rollers (top pair and bottom pair rollers). In order to achieve this a D.C controlled panel with complete speed control unit is fixed above the steel platform, with help of this controller all the four high torque motors are made to run at constant rpm. The specification of motor and power panel shown in table 4.1 and 4.2.

The complete twin roller assemblies, platform with ladder cum protection grill and power control unit for the roller is shown in Fig. 4.3, 4.4 and 4.5 respectively.

4.2 DEVELOPMENT OF TWIN ROLL CASTING MACHINE TO REDIRECT STRIP AT AN ANGLE

The vertical strip twin casting machines discussed in 4.1.1 has the following limitation.

a) The maximum strip length is limited because the ground clearance between center of the roller and the floor restricts the strip height to 2.5 m.

b) During rolling the strip own weight results in hot tearing of the strips, hence it was essential to produce strips of continuous length.
### Table 4.1 Specification of high torque D.C motor with gear box

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Item</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Voltage</td>
<td>180V</td>
</tr>
<tr>
<td>2</td>
<td>Gear box</td>
<td>Spur gear with reduction speed ratio 1:17</td>
</tr>
<tr>
<td>3</td>
<td>Power</td>
<td>1hp</td>
</tr>
<tr>
<td>4</td>
<td>Current</td>
<td>4.5 Ampere</td>
</tr>
<tr>
<td>5</td>
<td>RPM</td>
<td>1500</td>
</tr>
<tr>
<td>6</td>
<td>Motor type</td>
<td>DYNAFULX permanent magnate DC motor</td>
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</table>

### Table 4.2 Specification of power panel

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Item</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Input</td>
<td>220V AC</td>
</tr>
<tr>
<td>2</td>
<td>Output</td>
<td>5 to 60 DC</td>
</tr>
<tr>
<td>3</td>
<td>Controller</td>
<td>Reduction type magnetic flux controller</td>
</tr>
</tbody>
</table>
Figure 4.3 Twin roller assembly

Figure 4.4 Twin roller platform with ladder cum protection grill
Figure 4.5 Power control unit for the twin roller motor
By changing the direction the strip movement by an angle of $30^\circ$ with the help of strip guiding stationary metal conveyor system as shown in Fig. 4.6. Functionally this unit is similar to one described under section 4.1.1.

### 4.3 SHELL MOULDING FACILITIES

The shell moulding facility is used for the preparation of the pouring basin consists of:

- Shell moulding machine
- Details of the metal pattern
- Details of the mould box
- Pouring basin

#### 4.3.1 Shell Moulding Machine

The shell moulding machine consists of a metallic base, which in turn holds the metallic core pattern depicted in Fig. 4.7. A mechanism to bake the shell moulding sand is provided as a unit that consists of heater coils that encloses the entire mould.

An air compressor is used to supply compressed air to the shell moulding machine which has capability of pneumatically ejecting the shell core pouring basin. The complete shell moulding machine is shown in Fig. 4.7 and its specification are given in table 4.3.

#### 4.3.2 Metal Pattern

The metal pattern alone can be used in a shell moulding process because the process is possible only at $120\, ^\circ \text{C}$ to $180\, ^\circ \text{C}$. The detail of the pattern made of high grade cast iron is given in Fig. 4.8 & 4.9.
Figure 4.6 Tray to receive strip at angle

Figure 4.7 Shell moulding machine
Table 4.3 Shell moulding machine specification

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Item</th>
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<tr>
<td>1</td>
<td>Table size</td>
<td>300x300</td>
</tr>
<tr>
<td>2</td>
<td>Curing temperature</td>
<td>150 °C – 200 °C</td>
</tr>
<tr>
<td>3</td>
<td>Pressure of air</td>
<td>0.0006-0.0020 bar</td>
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</table>
Figure 4.8 Metal Pattern

Figure 4.9 Metallic pattern details

All dimensions are in mm
4.3.3 Pouring Basin Ejector System

The core box is made up of high grade cast iron as shown in Fig. 4.10. The cavity formed between the core and the moulding boxes when the latter are placed around the pattern is filled up using the shell sand. The details of the core boxes are as follows. The drawings depicting the top, front and side views of core box are shown in Fig. 4.11.

4.3.4 Pouring Basin

The pouring basin is prepared by shell moulding in accordance with the required dimensions as shown in the Fig. 4.12 and 4.13 given below.

It is made of sand coated with thermosetting resin which on heating binds the sand particles together.

4.4 MELTING FURNACE

The electric furnace used for melting the aluminium ingot is of resistance type as shown in Fig 4.14. Two furnaces, a tilting type and a stationary high capacity type are used. The main structure of the furnace is made of mild steel. The inner walls of the furnace are made of refractory material. The walls contain grooves to carry the heating coils made of super kanthal wire. The base of the furnace is 150 mm high and forms a step so that the crucible containing the aluminium block rest on it. The specification details of the furnaces are given below:

- Furnace type : Resistance type
- Maximum temperature : 800 Degrees Celsius
- Voltage rating : 440 V; 3 Phase
- Power : 10.5 kw
- Length of the thermocouple used : 360 mm
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Figure 4.10 Core box

Figure 4.11 Core box details

All dimensions are in mm

Figure 4.11 Core box details
Figure 4.12 Pouring cup

Figure 4.13 Pouring cup details

All dimensions are in mm
Development of Facilities

Figure 4.14 Meltig Furnace

a) Furnace with temperature controller

b) Crucible inside the melting zone

Figure 4.14 Meltig Furnace

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4.5 STIRRING FACILITY FOR MAKING METAL MATRIX COMPOSITES

The stirring facility is used to promote mixing of silicon carbide and molten aluminium metal. The tilting furnace and the stirring equipment form one complete setup as shown in Fig. 4.15 & 4.16. The equipment consists of the stirrer made up of cast iron rod carrying triangular tapered blades coated with fire clay. A motor with speed controlling unit mounted on a metal frame structure and belt drive mechanism. The stirrer is supported by a bearing in a block that is bolted to the frame. The stirrer can be dipped into the crucible in the furnace or lifted up by using the square threaded screw spindle. The entire arm of the stirrer can be swung around in a horizontal plane by 360 degrees.

The specifications of the stirring mechanism are:

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<tr>
<td>Length of the stirrer</td>
<td>635 mm</td>
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<td>Distance between the screw spindle centre and the stirrer</td>
<td>440 mm</td>
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</table>

Motor specifications

<table>
<thead>
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<th>Parameter</th>
<th>Specification</th>
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<tbody>
<tr>
<td>Type</td>
<td>PM-454</td>
</tr>
<tr>
<td>Voltage</td>
<td>220-180 V (With dimmer stat voltage control)</td>
</tr>
<tr>
<td>Power</td>
<td>180 watts</td>
</tr>
<tr>
<td>Rated Speed</td>
<td>300 rpm</td>
</tr>
</tbody>
</table>
Figure 4.15 Stirrer

Figure 4.16 Stirrer setup
4.6 PRE-HEATING FACILITY OF ROLLERS

The pre-heating facility is used to prevent chilling effect that is created when molted metal comes in contact with cold surfaces. The components that need to be pre-heat before the liquid metal from the furnace is poured are mainly the rollers and the pouring basin. The pre-heating equipment consists of a gas torch which is a flame burner, a hose pipe and an LPG cylinder, shown in Fig. 4.17. The torch consists of a regulator knob which is used to control the intensity of the flame by regulating the rate of flow of LPG.
Figure 4.17 Preheating equipment