1. Introduction

In automobiles, decreasing weight is one of the most important problems should be solved. Using parts of aluminum alloy instead of parts of steel enables the weight of the automobiles to be decreased. In the body of the automobiles, sheets of 6000 series aluminum alloys are adopted for the inner and outer panel [1-3]. However, sheet products of aluminum alloy are more expensive than sheet products of steel. It is desirable to economically produce aluminum alloy strip, and twin roll caster has this capability. Aluminum alloy strip can be cast directly from molten metal by a twin roll caster. The twin roll caster for aluminum alloy has several advantages, including low equipment cost, low running cost, energy saving and space saving. It is possible that improvement of the ductility of the aluminum alloy for casting by the rapid solidification using the twin roll caster [4] [5]. However, the strip casting using conventional twin roll caster...
has disadvantage, too. It is low casting speed. The low casting speed becomes cause of low productivity. In the present study, the improvement of the low casting speed was tried by increasing the cooling rate at the roll caster. A high-speed twin roll caster [6-11] of vertical type was designed and assembled to cast aluminum alloy strip. Strip casting of 6016 alloy was tried using a vertical type twin roll caster. Properties of the cast strip were investigated by the metallography, a tension test and a bending test.

2. Experimental conditions

Figure 1 shows a schematic illustration of the high-speed twin roll caster. One of most important features of the twin-roll caster is rapid solidification. In the present study, some improvements were implemented in order to increase cooling rate. The conventional twin roll caster for aluminum alloys uses steel rolls. Copper is higher in thermal conductivity than steel, making copper rolls suitable for the twin roll caster. The high-speed twin roll caster adopts copper rolls. When the copper rolls are used, hot rolling under large load is difficult. Load affects the heat transfer coefficient between the roll and the strip. The low load of enough heat transmission was added: the load of the high-speed twin roll caster is 1/10 to 1/100 the load of the conventional twin roll caster. The hot rolling is hardly performed.

Lubricant is sprayed on the roll surface in order to prevent sticking of the strip to the roll in the conventional twin roll caster. The lubricant adds heat resistance, lowering the heat transfer coefficient between the roll and the strip. Therefore, without lubricant, the cooling rate of the strip increases. In high-speed twin roll caster, the strip did not stick to the roll due to the low rolling load and the use of the copper roll. Lubricant is not required in high-speed twin roll caster.

A cooling slope was mounted on the high-speed twin roll caster in order to perform low superheat casting. Low superheat casting and semisolid casting have several advantages, including an increase in the cooling rate of the strip and an increase in casting speed.

The nozzle of the high-speed twin roll caster is assembled from four plates, including two side dam plates and two nozzle plates, the nozzle plates being moveable. A puddle is formed in the space between the four plates. The nozzle of the high-speed twin roll caster is simple and adjustable. The solidification length can be controlled by the position of the nozzle.

Experimental conditions are shown in Table 1. 6016 that is a kind of Al-Mg-Si aluminum alloys were used. Low superheat casting were performed to increase cooling rate. The superheat of the melt poured from crucible was about 5°C. Lubricant was not used. Casting speed was 60 m/min. Tensile test and 180 degrees bending test were operated to investigate the mechanical properties. Microstructures of as-cast strip and T4 treatment condition were observed.

Table 1. Experimental condition

<table>
<thead>
<tr>
<th>Roll material</th>
<th>Copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>size</td>
<td>Diameter 1500 [mm], width 100 [mm]</td>
</tr>
<tr>
<td>speed</td>
<td>60[m/min]</td>
</tr>
<tr>
<td>aluminum alloy</td>
<td>6016</td>
</tr>
<tr>
<td>superheat</td>
<td>5[°C] (pouring)</td>
</tr>
<tr>
<td>Cooling slope</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>Mild steel</td>
</tr>
<tr>
<td>Size</td>
<td>length 300 [mm], width 100[mm]</td>
</tr>
<tr>
<td>inclination angle</td>
<td>45 [degrees]</td>
</tr>
<tr>
<td>Separating force</td>
<td>0.14 [kN/mm]</td>
</tr>
<tr>
<td>Solidification length</td>
<td>180[mm]</td>
</tr>
<tr>
<td>Melt head</td>
<td>100 [mm]</td>
</tr>
</tbody>
</table>

3. Result and discussions

3.1. Surface of strip

Figure 2 shows photograph of the vertical type high-speed twin roll caster. 6016 could be cast to the strip continuously at a speed of 60 m/min. No lubricant was applied, and the strip did not stick to the roll. The twin roll caster of the present study was able...
High speed twin roll casting of 6016 aluminium alloy strip

Manufacturing and processing

3.2 Microstructure of strip

The microstructure of the strips cast by the conventional twin-roll caster for aluminium alloy is usually columnar structure. Figure 5 shows the microstructure of 6016 strip by the twin roll caster of the present study. The microstructure of as-cast strip was not uniform at thickness direction. The microstructure of center area was near to grainy or spherical structure, and the near surface was near to equiaxed structure. Figure 6 shows microstructure of 6016 ingot cast by the insulator mold. The microstructure of 6016 strip by the twin roll caster of the present study was smaller than the microstructure of insulator mold casting. This is the effect of rapid solidification by the twin roll caster of the present study. Figure 7 shows the microstructure of the strip after cold rolling and T4 heat treatment. This non-uniformity of the microstructure became almost uniform after the cold rolling and T4 heat treatment.

3.3 Mechanical properties

Table 2 shows mechanical properties of the 6016 strip. The thickness of the test piece for tensile test was 1 mm. T4 heat treatment was performed the test piece. Tensile strength is 230MPa, 0.2% proof stress is 118MPa, and elongation is 33%. The test piece for 180 degrees bending test was made from same as that for the tensile testing. The thickness of the test piece was 1 mm, and bending was carried out T4 heat treatments. Figure 8 shows the surface and cross section of 180 degrees bending test. When heat treatment was T4, there was no crack on the outer surface, and the strip was not broken. The 6016 showed good ductility by the rapid solidification of high-speed roll casting.
4. Conclusions

Several devices were adopted to realize rapid solidification of the strip. A high-speed twin-roll caster was designed and used in order to increase casting speeds. 6016 could be cast to the strip continuously at a speed of 60 m/min. Strip thickness was 3.4 mm. The microstructure of the strip was not columnar, but near to grainy or spherical structure. Result of tensile test was tensile strength is 230MPa, 0.2% proof stress is 118MPa, and elongation is 33%. When 180 degrees bending test at T4 heat treatment, there was no crack on the outer surface, and the strip was not broken.

References