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A vertical full-continuous casting method for aluminum alloy billets

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The conventional methods used for casting aluminum alloy billets have been the vertical semi-continuous casting method and the horizontal continuous casting method. We have developed a vertical full-continuous casting method with the combined benefits of the aforementioned methods. Our method improves the production yield rate by approximately 15% compared to the vertical semi-continuous casting method and by approximately 10% compared to the horizontal continuous casting method.

Keywords: *Aluminum alloy, Continuous casting, High-speed casting, Billet for forging*

1. Introduction

The vertical semi-continuous casting method and the horizontal continuous casting method have been used to cast aluminum alloy billets. The vertical semi-continuous casting method suffers from poor productivity. Because the length of the cast billet is limited to the depth of the pit, the casting must be interrupted for each predetermined length. In addition, because the ratio of end materials in non-stationary regions during the initial and final stages of casting is large, the cutting yield of this method is poor. However, the peeling yield of this method is good because of the uniform casting structure of the billet surface, which is a consequence of the lack of any influence of gravity on the distribution of the cooling water. The horizontal continuous casting method features good productivity; the casting is not stopped whenever a billet having a predetermined length is cast because the cutting and casting of the billet are performed simultaneously. The peeling yield of this method is poor because the surface structure of the billet is likely to become heterogeneous; this heterogeneity is a consequence of the difference in the amount of cooling water at the upper and lower surfaces of the billet, which, in turn, is caused by the effect of gravity. Therefore, incorporating the advantages of both technologies into a vertical full-continuous casting method would result in improvements in the yield, quality, and productivity compared to the other two methods. However, realization of such a casting method has been thought to be impossible because the cooling-water facilities are complex and the counterplan of vibrations at the time of cutting is inherently difficult. In this work, we aimed to substantially improve the production of aluminum alloy billets by implementing the vertical full-continuous casting method by developing specialized equipment.

2. Development of the vertical full-continuous casting machine

A schematic of the vertical full-continuous casting machine is shown in Fig. 2. The machine comprises five primary components:

(1) High-speed casting mold: the casting speed when using this mold is 2–3 times more than that when using a general mold. Thus, this mold provides versatility in production and improves productivity.

(2) Guide for suppressing the bending: vibrations generated during cutting and pulling of the billet can be suppressed by using this guide, thereby suppressing the bending of the billet.

(3) Seal: this is placed at the bottom of the water tank in order to separate other equipment from the cooling water of the casting sections.

(4) Pulling machine: this device controls the casting speed.

(5) Synchronized cutting machine: this machine cuts the billet while moving synchronously with the casting speed to cut the billet exactly to the standard product length.

3. Production results

Since the beginning of production, our casting machine has produced ≥10,000 tons of billet in total. This technique can be used to cast billets stably and continuously for >100 h, which is a more than 50-fold increase compared to the continuous casting time achieved with the conventional vertical semi-continuous casting method. The production yield of this method represents a 15% improvement over that obtained using the vertical semi-continuous casting method and a 10% improvement over that obtained using the horizontal continuous casting method. Furthermore, in our developed casting method, variation of the mechanical properties of the billet is reduced. Presumably, this reduction is because of the microstructure of the billet becoming fine and homogeneous as a result of the stable high-speed casting. As an example, the Charpy impact values and variations for 6061 alloy billets cast using our method and each of the conventional methods are shown in Fig. 4.

Fig. 1 An aluminum alloy billet.

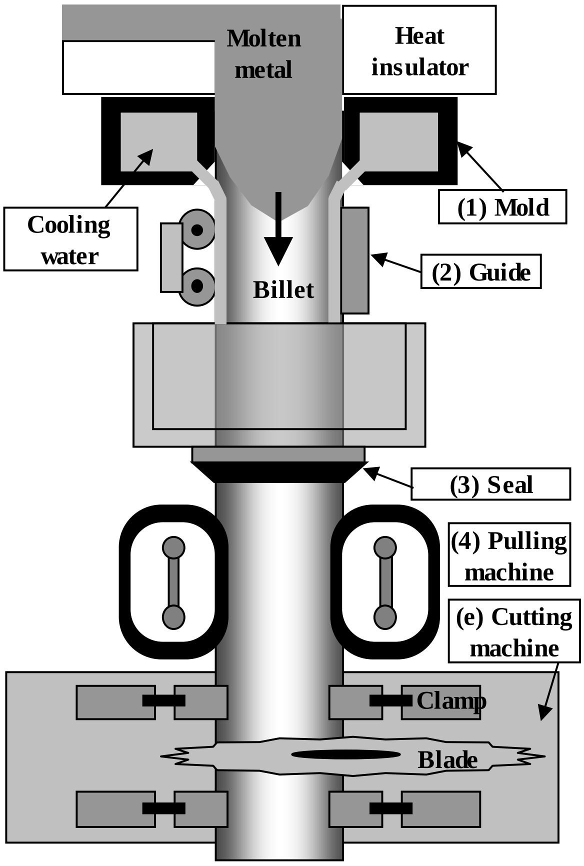

Fig. 2 Schematic of the vertical full-continuous casting machine.

Table 1 Comparison of the casting method developed in this work and the conventional casting methods.

Method	Cutting yield	Peeling yield	Quality	Productivity
Vertical semi-continuous	bad	good	good	bad
Horizontal continuous	good	bad	intermediate	good
Developed	good	good	good	good

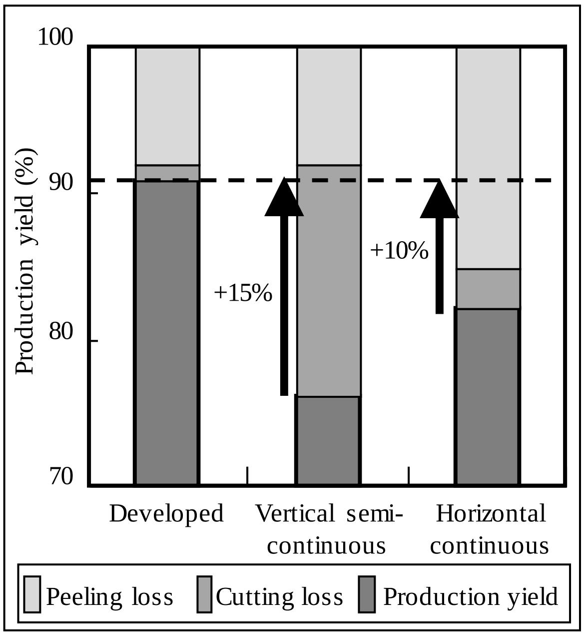

Fig. 3 Comparison of production yields of the casting method developed in this work and the conventional casting methods.

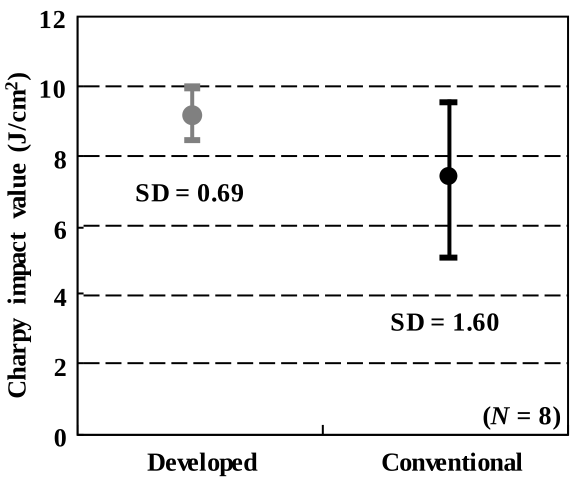

Fig. 4 Comparison of Charpy impact values for 6061 alloy.