

Continuous Aluminum Melting and Holding Crucible Furnace

Yusuke Sano*and Masahiro Kuritani
NIPPON CRUCIBLE Co., Ltd.

Abstract

We have developed the continuous aluminum melting and holding crucible furnace which is compact and it has made a continuous melting possible with a graphite crucible. It combines the features of a tower type melting furnace and stationary crucible type holding furnace. It has energy saving, high melt yield, and high quality aluminum aspect and made it possible to adjust temperature easily and eliminate periodical furnace repair. Because of its features for low-temperature melting and ideal temperature for casting and possible to melt different aluminum alloys by replacing crucible for preventing metal contamination, it is used by aluminum die-casters, sand mold and gravity casting users.

1. Introduction

1.1 Outline of furnace and its feature

This continuous aluminum melting and holding crucible furnace is a compact furnace which makes possible to melt and hold aluminum with melting and holding crucible.

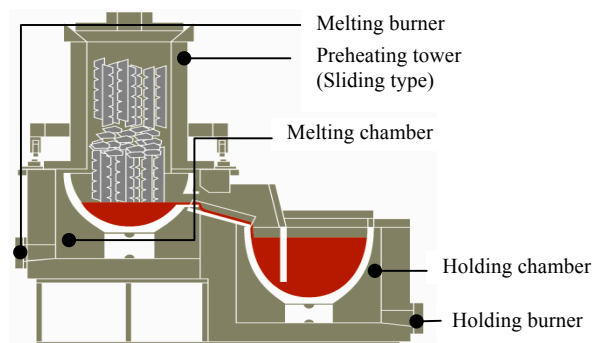
It combines the feature of a tower type melting furnace and a stationary type crucible furnace. It has three major merits, which are energy saving, higher melt yield, and higher quality molten metal, required for this type of furnace. Time of starting up the furnace can be shortened by the light weight and higher thermal insulating furnace lining. In addition, because it is the crucible furnace, it is not necessary to hold the molten metal during night time, weekend, and holiday. As it is not necessary to operate the burner continuously, the huge amount of the energy and CO₂ can be reduced during non operating period. Removing the oxide required for the conventional brick lining furnace and the periodic lining repair are not required. This crucible furnace requires only normal maintenance. By replacing the crucible, furnace returned to the brand new condition and it can be used for the high pressure die casting, gravity die casting, and sand mold casting. By replacing with a new crucible, melting of various alloys is possible and the aluminum alloys cannot be contaminated.

1.2 Structure of the furnace and the melting and holding process of the molten aluminum

As shown in the Fig.1, this furnace consists of the main body, preheating tower (sliding type),

combustion safety equipment, automatic thermal temperature control equipment, material charging equipment and working deck. The outside body shell has the reinforced steel plates with welding structure. High thermal insulating ceramic fiber is adopted inside the furnace in order to improve the efficiency of heat holding. We have designed a special graphite crucible for this furnace. Charged aluminum material is preheated by exhaust gas in the preheating tower, then the metal is melted in the graphite crucible. Then, molten aluminum discharged through the drain pipe that is attached to the melting crucible. Molten aluminum passes through the preheated run out tube and flows into the holding graphite crucible. The run out tube also has a role to raise the temperature that is heated by the discharged heat of the holding burner which is 800 degree Celsius. The temperature of the molten aluminum is raised rapidly to 630 degree Celsius from 600 degree Celsius.

The holding molten aluminum is held in the holding crucible and is regularly held by the indirect heat. Compared with the conventional brick lining furnace that heats the molten aluminum directly, it reduces oxidation which is caused during the heating and the holding, and extremely reduces inclusion of the H₂ gas and the ideal molten aluminum can be secured.



*Main body: Melting chamber + Holding chamber

Fig.1 Furnace structure

2. Experimental Procedure

The furnace was favorably used by many customers and they proposed more efficiency and improvement in environmental aspect. So we conducted the customer's research in both domestic and the overseas markets. After the continuous observation of the operation, we found the following problems to solve.

- 1) Solidification of the molten aluminum

sometimes occurred because the temperature declined at the run out tube that connected the melting and holding chamber.

- 2) Energy loss and negative effects to peripheral equipment may occur because of the heat released from the gap between the preheating tower and melting chamber lid.
- 3) A risk that the welding part may come off and fall, which was caused by physical shocks of the charged material inside the preheating tower and the thermal history.
- 4) When preheating tower was shifted aside, rotation of the wheels may become unsmooth and a higher strength was required, because scrap tips may stack in the wheel.
- 5) When such work as removing slag was performed on the working deck, our customers requested to avoid the working environment like a wide stooping down, possibility of stepping foot in a melting area, and the receipt of the released heat to the lower half of the body.
- 6) A larger melting furnace required the frequent charging of ingots by continuous charging. Otherwise, melting capacity will not reach the original capacity.

So improvements were considered in order to solve the problems.

2.1 Solution for the problem 1)

We assumed that the cause of the solidification of molten metal is by the temperature drop. This was because of the long distance between the melting and holding chamber with the run out tube. As a result, it was necessary to reduce the thickness of the wall between the melting and the holding chamber from 240mm to 115mm. The length of the run out tube could be shortened by 125mm.

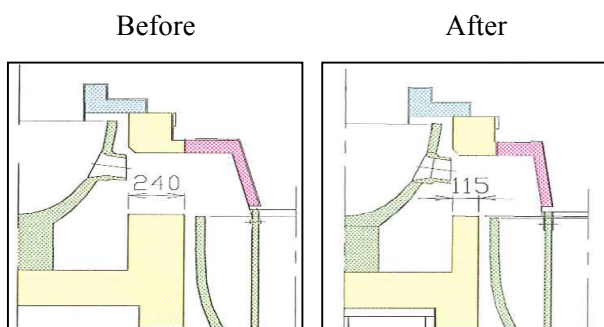


Fig. 2 Solution for the problem 1)

2.2 Solution for the problem 2)

There was an open inclined gap between the

preheating tower and the melting chamber lid. So in order to reduce the gap, we redesigned the gap to the horizontal position and we applied the fire proof cover around the gap.

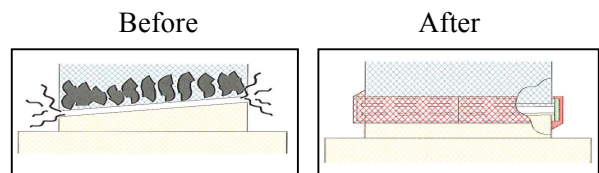


Fig. 3 Solution for the problem 2)

2.3 Solution for the problem 3)

The reinforced rib was designed and installed at the corner of the upper metal plate and the inner metal sleeve in order to withstand the physical shock by charged materials and thermal history.

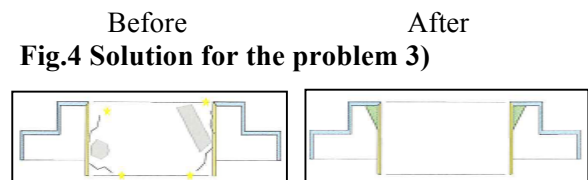


Fig.4 Solution for the problem 3)

2.4 Solution for the problem 4)

The improvement of the rail without spending much cost was considered. In order to reduce scrap tips to stick to the wheel, we changed the cross section of the rail from the mounting shape to the angle L shape. This change could reduce the contacted surface of the wheel and the L shape angle.

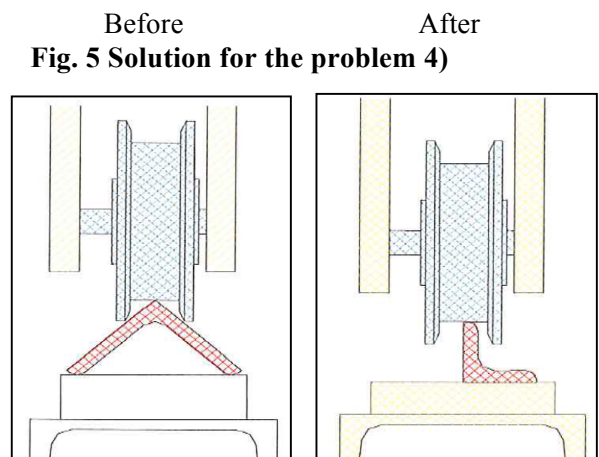


Fig. 5 Solution for the problem 4)

2.5 Solution for the problem 5)

The height of the working deck was considered so that the worker could work easily to avoid unreasonable posture. By the research of the average height of workers and the content of the work, it was decided that the height level of the working deck was lowered by 300mm to 500mm from the original height level.

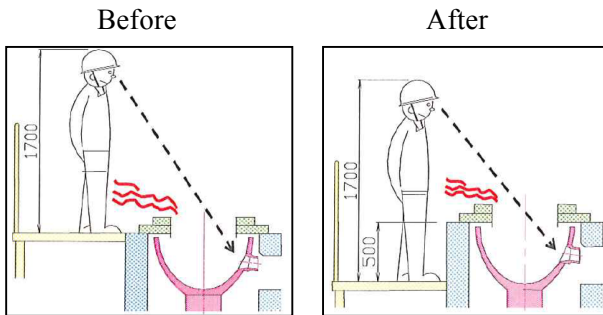


Fig.6 Solution for the problem 5)

2.6 Solution for the problem 6)

The angle of charging the ingots was considered so that ingots could fall smoothly and more ingots could be held in the preheating tower and the melting chamber. It found that when the ingots position was vertical at present furnace with $\Phi 550$ mm diameter, many ingots could not be charged, because the damper could not be properly closed. So after the successive discussion and the experiment, we changed its diameter to $\Phi 650$ mm.

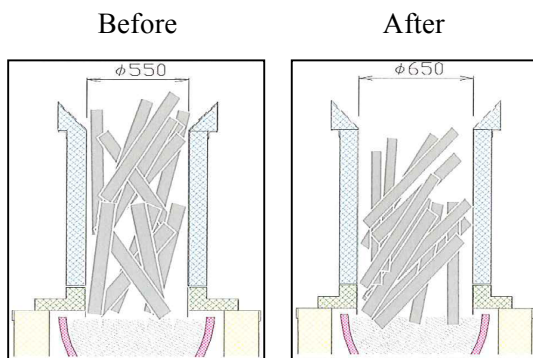


Fig. 7 Solution for the problem 6)

Result and discussion

1) As a result of shortening the length of the run out tube and thinning the wall thickness, the space around the run out tube became three quarter and temperature around the run out tube did not drop. The molten metal solidification was dramatically reduced by following two reasons.

- As thermal storage value of furnace wall was reduced. First melting time was shortened by five minutes.
 - As the distance between melting and holding chamber became shorter, the drain pipe and the cleaning of run out tube became easier.
- 2) Installation of the fireproof cover reduced heat release, which lowered the energy loss. In addition, the leak of the heated exhausted gas reduced and the inhalation of the outside air reduced, because the gap was reduced.
 - 3) Installation of a reinforced rib against the physical shock of the charged material and the thermal history prevented the trouble like the fall of the inner sleeve of preheating tower even if the welding came off, because the structure was reinforced.
 - 4) As a result of the change of the rail cross section shape to the L shape, it had become easier and smoother to move preheating tower manually. Problem of the scrap tips sticking was also solved.
 - 5) The adjustment of the working deck lowering between 300mm and 500mm was very effective. The work with back bent position was reduced. And the danger of stepping the foot into the roof of the melting chamber was reduced by placing the level difference. In addition, the level of heat work was improved very much, because the lower half of the body was released from the radiant and direct heat.
 - 6) The effect for the expansion of the preheating tower inner diameter to $\Phi 650$ mm enabled to locate ingot with angle and to secure to hold sufficient amount of ingots. Continuous material charging within a short time became possible.

It was difficult to realize the problems occurred at customer's site during the planning phase. The effect like energy saving, improvement of molten metal quality, and stable operation were important. At the same time, the labor saving which were not countable could be realized, which was the most important result. We would like to develop a more improved furnace by collecting various customers operating and working conditions.