NEW MELTING and SQUEEZE CASTING SYSTEM FOR HIGH QUALITY AL CASTING

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ABSTRACT Aluminum die-casting product quality depends primarily on molten metal quality. In particular, molten metal transfer techniques after degassing are very important to keep the molten metal clean. By using two types of transfer systems, clean molten metal can be supplied from the melting furnace to the holding furnace for casting. One is a tapping system for the molten metal in the melting furnace. The other is a vacuum transfer system by siphon pipe. This system is used for transferring from the holding furnace to the holding furnace of casting machines. In high-pressure die-casting processes, clean molten metal was also found to be necessary, and the metal level in the holding furnace was kept constant by a float. Further, the metal was supplied smoothly and quickly from the holding furnace to the plunger sleeve with nitrogen gas pressure.

Keywords : *Melting, Degassing, Melt carrying, Squeeze casting, High-quality*

1. INTRODUCTION

In recent years, a great variety of aluminum products have been manufactured by die-casting. Although the requirements vary depending the uses, shapes, and dimensions of products and the degree of working required, a high standard of internal quality is strongly demanded. Trouble arises because the oxides contained in the molten metal appear on the working surface in products requiring working of the whole surface or to a limited extent. Pinholes occur on the coating (plating) surface in products with a clear coating or chrome plating if the concentration of hydrogen gas in the molten metal is high. The occurrence of oxides and the increase in hydrogen gas concentration are apt to be caused by turbulence during the transfer of molten metal, and improvement of the melt transferring method is necessary to prevent the increase of oxides and hydrogen content.

A melting system and a new high-pressure die-casting machine, ADQAST(Advanced Quality Casting Machine), are introduced to solve the above problems and are described in this report.

2. MELTING SYSTEM

2.1 Outline of melting system

The top view of the melting plant is shown in **Figure 1**. The return materials, the master alloys, and other ingredients are first thrown into the melting furnace and the chemical composition is confirmed to be within the standard limits after melting down. Subsequently, the molten metal passes through the tap hole and is transferred to the holding furnace without touching the air by lifting the tap dipped in the molten metal.

The molten metal is then dosed automatically from the holding furnace to the distributing furnace

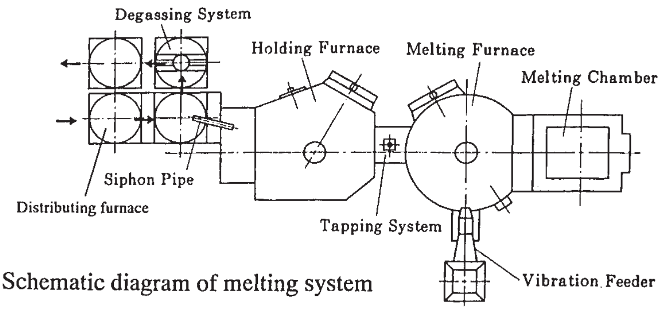


Fig.1 Schematic diagram of melting system

by the siphon dosing apparatus with a vacuum mechanism when the signal for the molten metal is given by the casting machines. The molten metal, having been dosed to the distributing furnace, is transferred to each casting machine with the melt carrying equipment (trunker system) after the degassing process, and is then dosed to each holding furnace attached to the casting machine by the siphon dosing apparatus.

2.2 Tapping by tap dipped in molten metal

The usual tapping method form the melting furnace to the holding furnace has mainly consisted of a system in which the molten metal coming out of the tap hole goes through a groove. Because the molten metal touches the air in this method, oxide films are formed on the molten metal surface. If turbulence of the molten metal occurs in transfer, the oxides are apt to be mixed into it. In the tapping method using the tap dipped in the molten metal, mixture of oxides into the holding furnace can be prevented because the molten metal does not touch the air during its transfer. At the same time, it is possible to transfer the molten metal without disturbance of the molten metal surface of the holding furnace. The melting furnace is equipped with a dam to prevent dross formed during melting from accumulating in the vicinity of the tap dipped in the molten metal. It is possible to remove the oxides contained in the molten metal of the melting furnace by installation of a cylindrical ceramic filter around this tap.

2.3 Degassing processing

In the melting and the casting processes of aluminum alloys, the melting process is the essential process in removing hydrogen gas and inclusions contained in molten metal. This includes the flux feeder method, the vacuum degassing method, the porous plug method, the rotary degassing method for the degassing process concerned. The degassing process is put into operation by rotary degassing equipment (Bub Clean) developed originally at Kobe Steel.[1)]

This rotary degassing method generates fine bubbles of inert gas blown into the molten metal by rotating the impeller blades, and removes the hydrogen gas and the oxides contained in the molten metal with these bubbles. This equipment was commercialized in 1987.

The schematic diagram of Bub Clean is given in **Figure 2**. The pipe for gas blowing is rotated by a compressive air driving mechanism and blows the inert gas bubbles into the molten metal through its tip. It is important the bubbles of inert gas are made as fine as possible and are scattered uniformly with high density to improve the efficiency of degassing and oxide removal. In the Bub Clean, the big bubbles are first formed at the tip of the pipe for gas blowing and then divided into fine bubbles by the impeller blades in the course of floating. The fine bubbles are scattered uniformly throughout the

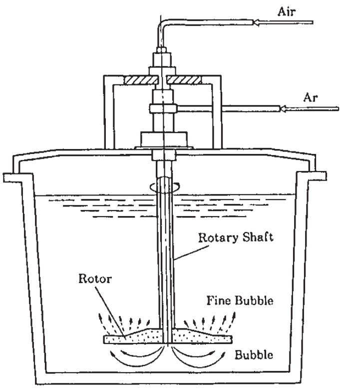
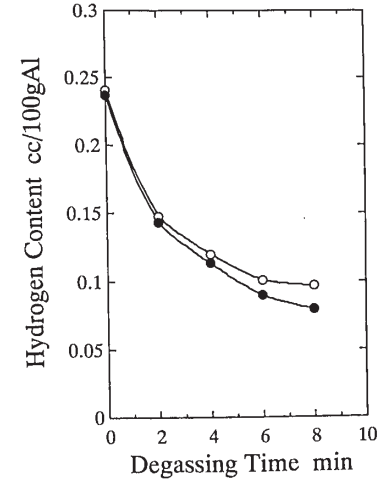


Fig.2 Bub Clean system



Frg.3 Hydrogen content after degassing

crucible by the flow of molten metal.

The relationship between the hydrogen content and the processing time is shown in **Figure 3** in the case of degassing with nitrogen gas and argon gas. The hydrogen content drops below 0.1cc/100gAl by the degassing process with Bub Clean for about 8 minutes. The processing efficiency with argon gas is found to be slightly better than that with nitrogen gas to remove the hydrogen gas in molten metal. The relationships between the mechanical properties and the hydrogen content, in samples taken from sand mold castings, are shown in **Figure 4**. The tensile strength and the elongation are improved with the lowering of the hydrogen content. The yield strength is also improved, but the degree of improvement is small.

2.4 Melt carrying system and siphon dosing apparatus

The tilting method of the distributing furnace for dosing is primarily used for that method which doses the molten metal from the distributing furnace to the holding furnace for casting. Troubles such as the mixing of oxides and the increase of hydrogen content in the course of melt dosing are inevitable in this method. This dosing process also relies largely upon manipulation by workers and is an obstacle to automation.

At Kobe Steel, a siphon dosing apparatus with a vacuum mechanism[2)] is introduced for the dosing method of molten metal and melt carrying equipment incorporates a siphon pipe for melt dosing. As a result, operation is conducted automatically from the carrying process to the dosing process of molten metal after degassing. When the signal for molten metal is given by the casting machines, the molten metal is dosed automatically from the holding furnace to the distributing furnace by the siphon dosing apparatus. After degassing, it is carried to a place in front of the casting machines by the melt carrying equipment (trunker system). The siphon pipe is then dipped in the holding furnace for casting, and the molten metal is dosed from the distributing furnace to the holding furnace for casting.

The appearance of the siphon pipe and the trunker system is shown in **Photo 1**. The siphon pipe is moved as it after it is dipped in the molten metal of the distributing furnace, and the opposite side of the pipe is inserted in the holding furnace for casting. The siphon pipe is preheated at the waiting

Table 1 Comparison of siphon system and tilting system

		Siphon System	Tilting System
Charging Speed	kg/s	10	3
Quantity of Dross	kg/500kg charging	0.8~1.0	1.3~1.5
Hydrogen Content after Charging	cc/100gAl	0.13~0.18	0.25~0.30

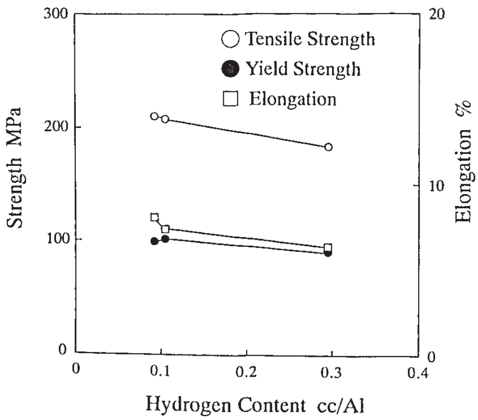


Fig.4 Relation between hydrogen content and mechanical properties (Sand mold sample)

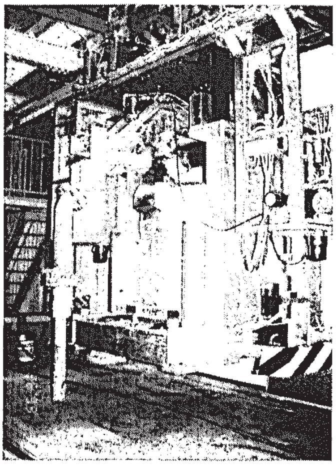


Photo 1 Siphon pipe and trunker system

position. When the molten metal is successively dosed to each casting machine, subsequent heating is not necessary.

A comparison of dosing time and the molten metal quality between the siphon system and the tilting method for dosing is shown in **Table 1.**

In the siphon system, a charging speed of 10kg/s is possible and this is 3 times as fast as that of the tilting system. Because the molten metal surface is not disturbed during its dosing in the siphon system, the dross quantity occurring in the furnace of the receiving side can be decreased to the level of 2/3 as compared with the tilting system, and this results in a reduction of material loss. The rise of hydrogen gas concentration by the melt dosing process in operation is also able to be restrained to the minimum.

With this system, clean molten metal is always able to be supplied to the furnace on the side near the casting machine, due to siphon dosing system being used during transfer. Also being manufactured are the low-pressure die casting machine and the high-pressure machine for the casting machine concerned, as well as the wheel hub, scrolls for air conditioning, engine parts for automobiles, and suspension systems.

In recent years, demands for products by high-pressure die-casting have increased with the need to obtain castings with high strength and high quality, and the vertical high-pressure die-casting machine developed at this facility is described in the following paragraph.

3. HIGH PRESSURE DIE-CASTING MACHINE (ADQAST)

High-pressure die-casting is a method that restrains the occurrence of shrinkage cavity by maintaining a high pressure condition as the molten metal solidifies in the die mold. As a result, the mechanical properties of products are considerably improved. Application of this process to suspension parts for automobiles and pressure proof airtight parts has recently increased.[3),4)]

The new high-pressure die-casting machine (ADQAST : Advanced Quality Casting Machine) was developed at Kobe Steel and this machine makes it possible to cast products with excellent mechanical properties close to the forging process by dosing the clear molten metal and by solidifying it in a high-pressure condition.

The characteristics of this die-casting machine are presented below.

3.1 Structure

As shown in **Figure 5**, ADQAST is composed of the clamping device, the dosing which maintains the temperature of molten metal and supplies the molten metal to the sleeve directly under the lower die mold, and the injection device which transfers the molten metal from the sleeve to the die cavity and maintains it in a high-pressure condition.

3.2 Casting method

1) Melt dosing with laminar flow

The dosing furnace is connected to the casting machine through the delivery tube. The dosing furnace maintains the molten metal surface at a constant level by the float method, and doses the molten metal to the sleeve through its lower part in the laminar flow condition by the nitrogen gas pressure mechanism while the molten metal surface is maintained at a constant level in the delivery tube connected to the injection sleeve. This laminar flow restrains the occurrence of oxides as shown in **Figure 6 ① and ②**.

We've developed the high accuracy melt dosing system (melt amount accuracy 3%) by adopting the float method and gas vent valves in the die mold which stabilize the back pressure of mold cavities.

2) Melt supplied with laminar flow

After the molten metal is supplied to the injection sleeve, the injection plunger rises slowly at a low injection speed below 200 mm/s. The molten metal is supplied to the die cavity in the laminar flow condition.

3) Solidification under high pressure

The occurrence of shrinkage cavities due to solidification contraction is prevented by maintaining a high pressure condition (melting pressure: 800 ~ 1000kgf/cm^2) with the injection plunger.

3.3 Characteristics of equipment

The halfnut method is adopted for the die clamping mechanism, and as a result, reduction of machine height and uniform loading to the tie rod and reduction of machine oil is achieved.

The operation board is equipped with a panel with touch sensors to achieve simplification of the operation panel and improvement of manipulation. Robots take out the products from the die and spray lubrication oil on the surface of the die mold, and as a result, complete automation of casting operation is realized. Kobe Steel has commercialized the vertical type ADQAST system. The standard specifications are given in **Table 2**.

Using this system, we've developed 2-pieces and 4-pieces casting technique for the automobile upper arms and the scrolls for air-conditioners. Typical strength of the casting are given in **Table 3**.

We could get the good mechanical properties from these castings.

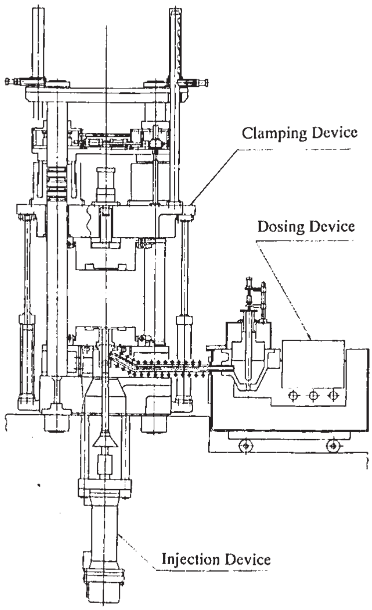


Fig.5 Vartical high-pressure die-casting machine

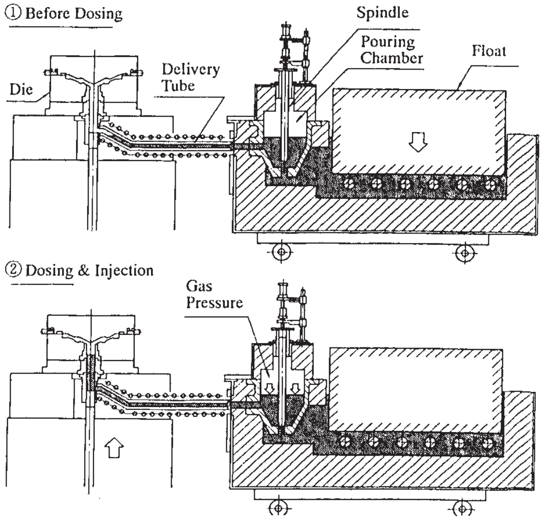


Fig.6 Automatic dosing system

Table.2 Specification table of ADQAST machine

		HP350	HP500	HP630	HP800	HP1000
Clamping Force	tf	350	500	630	800	1000
Injection Force	tf	50	63	80	100	125
Injection Speed	mm/s	50～300	50～300	50～300	50～300	50～300
Tip Dia	mm	60～90	70～100	80～110	90～120	100～140
Casting Weight	max/kg	5.0	7.8	9.4	12.5	15.0

Table.3 Typical strength of the castings (T6 condition)

Products	Material	Tensile Strength MPa	Yield Strength MPa	Elongation %
Upper arm	Al-6.5Si-0.35Mg	310	255	11
Scroll	Al-9Si-2.3Cu-0.5Mg	385	340	1.5

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[2] Japanese PAT.No. 06-39263
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