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알루미늄 연속주조 용탕의 탈 가스 일체화 장치 개발

이용중*

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An Implementation of an Integrated Degasing System for Aluminum Molten Metal in Continuous Casting

Yong-Joong Lee*

Abstract

There are some methods that have been used to manage a degasing process in recent years, such as an injection method that uses aluminum molten metal powder and chemicals supplier and input method that supplies argon and nitrogen, or chlorine gas by using a gas blow-tube. However, these methods show some problems, and it shows that it is a difficult process to handle, pollution due to producing a lot of toxic gases like chlorine and fluoride gas, irregular effects, and lowering work efficiency due to the excessive processing time. The problems that are the most fatal are the producing a lot of sludge due to the reaction of aluminum molten metal with chemicals, loss of metals, and decreasing the life of refractory materials. In order to solve these problems, this paper develops a technology that is related to aluminum continuous casting molten metal and monolithic degasing apparatus. A degasing apparatus developed in this study improved the existing methods and prevented environmental pollution with smokeless, odorless, and harmlessness by using a new method that applies argon and nitrogen gas in which the methods used in the West and Japan are eliminated. The method developed in this study decreases the molten metal processing and settling time compared to the existing methods and improves the workers' health, safety, and environment because there is no pollution in processes.

Key Words : Degasing process, Aluminum molten metal powder and chemicals, Productivity, Pollution, Temperature decreasing, Factory

1. Introduction

The industry of nonferrous metals has largely extended to semiconductors, aerospace, high speed transportation, from the beginning of major infrastructures, such as electrics, electronics, vehicles, constructions, steels, and

* 한국폴리텍VII대학 창원캠퍼스 자동화시스템과 (leeyj@chol.com)
주소: 641-772 경남 창원시 중앙동 110 교육단지2길28

ship buildings. In order to establish an international competitiveness in nonferrous industries according to the increase in the nonferrous metal, it is necessary to reduce the energy required during the production processes and to minimize defection rates.

In addition, a much-needed rationalization in the improvement of material production processes is required to reduce operation costs [1].

In recent years, a degasing process of aluminum molten metal has been required according to the high grade of aluminum and aluminum alloy products. An injection method, which injects gas using aluminum molten metal powder and chemicals supplier, and an argon and nitrogen, or chlorine gas supplying method have been used in the existing degasing method [2]. However, these methods present some difficulties in their implementation process and consequently produce a high level of toxic gases, such as chlorine and inert gases. In addition, these methods present a low working efficiency due to the excessive processing time. The most fatal problem in these methods is the production of a high level of sludge due to the reaction between the aluminum molten metal and the chemicals, including the loss of metals and reduction of the life span of refractor materials [2].

This study developed an integrated degasing device in a continuous aluminum

casting process in order to improve these problems. Several devices, which eliminate hydrogen gas in the aluminum molten metal by injecting nitrogen, and argon gases as a bubble state and process nonferrous metals simultaneously, have already been used in Europe, America, Japan, and other countries, which have developed their own technologies [2]. The degasing device developed in this study improves some problems existing in the current method and applies a new method, which excludes the method used in Europe and Japan, in order to prevent environmental pollution using argon and nitrogen gases with smokeless, odorless, and harmless properties.

The developed method can significantly reduce gases and defections due to the use of the chemically treated metal, in addition to minimizing the metal losses by reducing sludge by about 60~80% compared with the existing method. In addition, this method can reduce the processing and settlement time of the molten metal and improve the safety of workers and working environments compared with that of the existing method [3].

The requirement of nonferrous metals in Korea has increased continuously over time. In addition, the production line of nonferrous metals have increased and subsequently been replaced by improved facilities [1]. In this situation, the results acquired in this study can respond to the change in the increase of the nonferrous metal use due to the development of vehicle industries and light-weighted products, and contribute to the international competitiveness.

2. Subjects

2.1 Process improvement

It is known that the following six steps presented in Fig. 1 and 2 in a continuous aluminum production processes should be applied to the existing production line.

However, the procedure developed in this study consists of three steps and performs the rationalization of

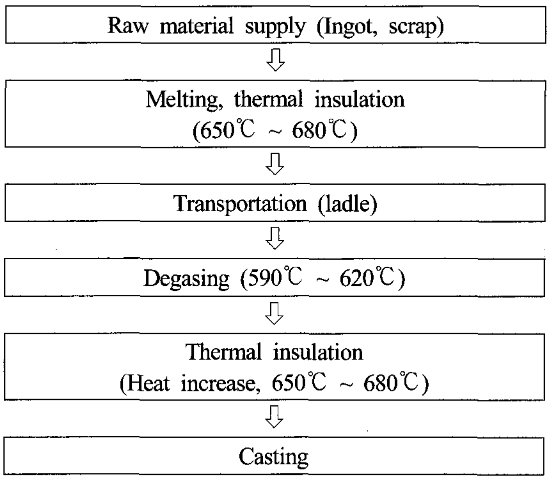


Fig. 1 Procedures of the existing continuous aluminum production

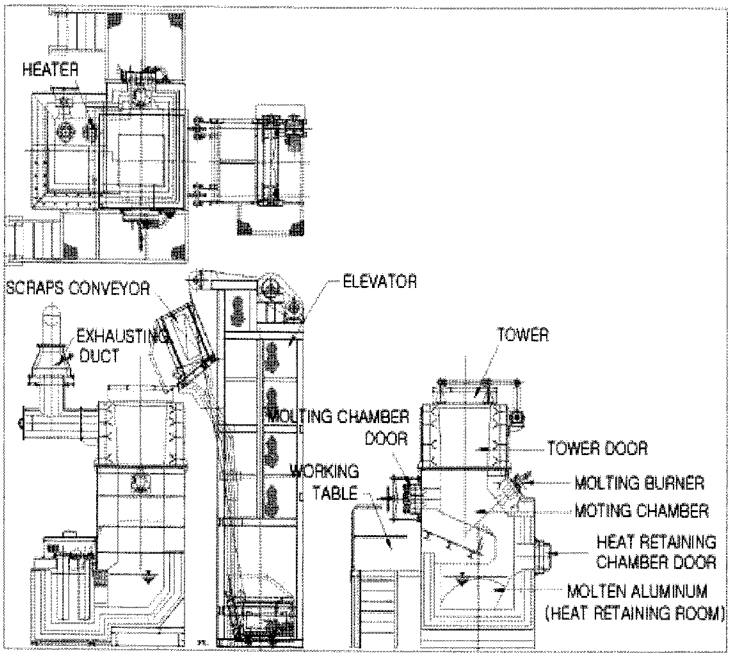


Fig. 2 Existing continuous aluminum production system

Raw material supply (Ingot, scrap)
⇩
Melting, degasing, and thermal insulation (650℃ ~ 680℃)
⇩
Casting

Fig. 3 Improved procedures of the continuous aluminum production In addition, the improved system presented in Fig. 4 consists of a furnace body,

the continuous aluminum production process using these three steps as presented in Fig. 3 and 4 [2].

exhaust system, ingot return scrap filling system, working bench, hood and duct, and other control parts.

Because this system was constructed as an integrated system with a degasing device, the objective of this system was configured to design and develop a control system for temperatures and other devices in order to compensate for the temperature decrease, which was about 60℃, due to the movement of molten metal. In order to achieve this object, the system was designed to apply standard H/W models that operate control panels and related devices and switch packages.

2.2 Degasing device

In the application of a degasing device, a degasing process can be performed in a holding furnace, which contains molten metal, by applying one rotor to the molten metal that is passed through the holding furnace. A melting chamber separates sludge using a chemical supplier and partially treats impurities and flowage, and a thermal insulation furnace supplies argon and nitrogen gases using a rotary fan in order to apply degasing and flowage processes. In addition, this furnace controls the minimum use of Ar and N2 gases [3,4,5]. Fig. 5 presents the degasing device produced and applied in this study.

Because the degasing device was produced to eliminate gases and nonferrous flowage, which were produced in the aluminum molten metal, this device can satisfy the requirement of users. The device consisted of mechanical parts, a rotor system, thermal insulation furnace system, and control system [3,5].

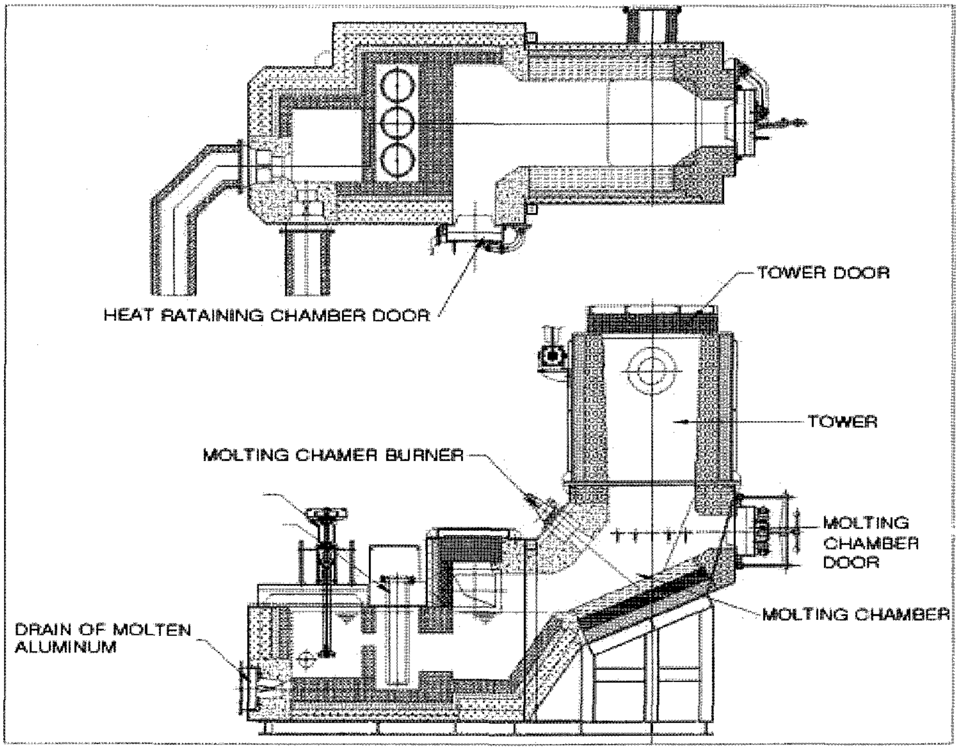


Fig. 4 Improved continuous aluminum production system

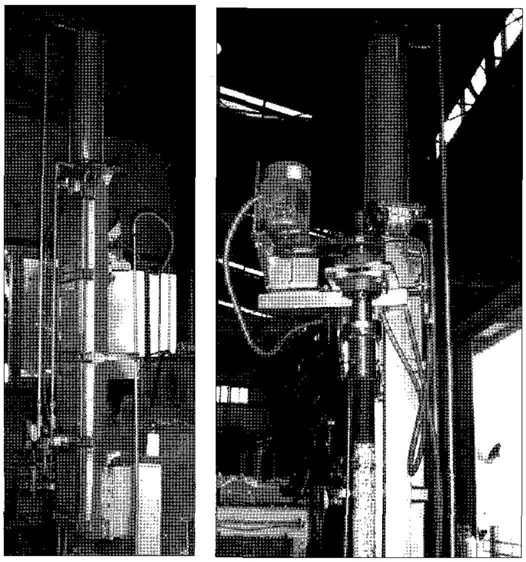
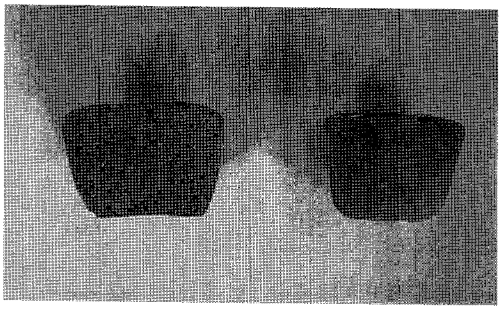


Fig. 5 Installing and operating the actual degasing device

3. Evaluation of the composition and hardness

Quality evaluations in the component and hardness of samples were performed to objectively investigate the molten metal in the melting process that improves the process by integrating aluminum molten metal in continuous casting and degasing devices. The specimen used in this evaluation was obtained from the melting furnace of the 'R' company located in Ulsan where the system developed in this project has been operated. The specimen was collected at a 800 ℃ of molten metal. Fig. 6 illustrates the comparison of pores before and after applying a degasing process.

As shown in Fig. 6, the results demonstrate a large difference in pores before and after applying a degasing process. In a chemical component inspection and hardness test, two different specimens were collected.



(a) Before degasing (b) After degasing

Fig. 6 Pores before and after applying a degasing process

Because the height of the chamber of molten metal is 700 mm, the specimen A was collected between the upper and the middle section (300 mm), and the specimen B was collected between the middle and the bottom. The specimens A and B were processed by 2.5 mm, respectively, to apply a chemical component inspection and were polished. Table 1 shows the results of the chemical component inspection [3]. As noted in Table 1, the specimens A and B represents an excellent composition in chemical components because their components are in the standard range of chemical components [6, 7]. The more detailed information on these components are not mentioned in this paper due to the business knowhow. After completing the component inspection as noted in Table 1, the specimens A and B were processed by 0.5 mm for applying a hardness test. Table 2 shows the results of the hardness test. The specimens A and B with a degasing process developed by this study were verified as excellent products

Table 1 Chemical composition

items		chemical composition (wt .- %)								
		Cu	Si	Fe	Mg	Mn	Zn	Ni	Sn	Al
standard spec		4.0 ~ 5.0	13.5 ~ 15.5	below 1.3	below 0.5	below 0.5	below 1.0	below 0.5	below 0.3	others
A	1	4.349	15.058	0.972	0.420	0.323	0.417	0.074	0.012	others
	2	4.469	15.263	1.022	0.476	0.334	0.430	0.080	0.013	others
	3	4.527	15.326	0.977	0.433	0.334	0.438	0.076	0.014	others
	average	4.449	15.216	0.990	0.443	0.330	0.428	0.077	0.013	others
	result	O K	O K	O K	O K	O K	O K	O K	O K	O K
B	4	4.307	14.818	1.0037	0.431	0.326	0.406	0.073	0.008	others
	5	4.366	15.438	1.0434	0.525	0.323	0.415	0.075	0.011	others
	6	4.555	15.319	1.0211	0.452	0.334	0.445	0.077	0.012	others
	average	4.409	15.192	1.023	0.469	0.328	0.422	0.075	0.010	others
	result	O K	O K	O K	O K	O K	O K	O K	O K	O K

Table 2 Results of the hardness measurement

items	Unit	A				B			
		1	2	3	4	5	6	7	8
standard spec	HRB	63	62	62	62	63	63	62	65
specimen hardness	HRB	70	70.5	71	72	71.5	70.5	74.5	75.5
result		O K				O K			

compared to that of the standard hardness criteria [6, 7]. More detailed information on the hardness are not mentioned in this paper due to the business knowhow.

4. Conclusions

The results of the development in the improvement of the productivity and accident prevention effects can be summarized as follows.

(1) Process rationalization : Because this system was constructed as an integrated type, the molten metal, which was moved to a mixer using a ladle, isn't necessarily comparable to that of the existing method. Thus, this will rationalize the process.
(2) Reduction of defection rates : This system presents no flowage, which occurred after a certain level of oxidation, and prevents the inflow of deposited impurities compared with that of the existing process.
(3) Energy saving : Because this system was constructed as an integrated type, it is not necessary to consume extra energies in order to compensate for the decrease in the temperature of about 60℃ due to the movement of molten metal.
(4) Prevention of overlapped facility investments : An additional investment is not necessary to exhaust the gas produced in a degasing process using a mixer.
(5) Improvement of working environments : Because the molten metal is not exposed at the internal space of a factory, the working environment can be improved due to the clean air.

Acknowledgments

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