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Yu. I. Shadrin
Vector LLP, Republic of Kazakhstan, Pavlodar,

FEATURES OF ALUMINUM DISC PRODUCTION TECHNOLOGY

The technology features of cast aluminum discs production in the conditions of «Vector» LLP are presented. Aluminum alloy AK-12 smelting process in induction crucible furnaces is described in detail. Results of industrial experiments conducted to reduce the melting time are presented. Initially, the task was set to find the optimal permissible metal residue (swamp) in the furnace after the melting was drained. Based on the results obtained, the optimal mass of the swamp was revealed to be 100 kg.

A series of experimental melting was also carried out in order to identify the difference in the melting duration of the heated billet and the billet at room temperature. In the conditions of production of the enterprise «Vector» LLP, a reduction in the duration of melting by 25 minutes was achieved by using the melting method «in the swamp». Also, the preheating of charge materials in the space of the heating furnace contributed to the reduction of the melting time by 10–15 minutes. Before making changes to the technology, a maximum of 12 melts were carried out per day, taking into account the time for cleaning the furnace crucible and the process of draining metal from the furnace space. After the changes were made, the melts number and volume being metal smelted increased almost twice. This allowed the company to simultaneously put into operation four casting machines, which are supplied with metal by only one induction furnace with a capacity of 700 kg.

Keywords: aluminum alloys, alloy wheels, melting, induction furnace, productivity.

Introduction

Foundry production has been actively developing recently, new enterprises are emerging. For example, in Krasnoyarsk there are three well-known enterprises engaged in the production of cast car wheels.

K&K is one of the most famous and popular Russian brands engaged in the wheels alloy manufacture based on aluminum alloys. Scad is so popular in Russia that its products are regularly used on many cars. The production is fully equipped with high-tech devices and devices for the manufacture of high-quality products. Japanese and European production lines operate at the plant. Ifri is a fairly young company for creating high-quality discs. The brand has received high reviews from motorists thanks to unique design solutions and high durability of finished models.

Not so long ago, the owners and investors of K&K decided to open a production branch in the territory of the Republic of Kazakhstan to establish a sales market and increase production capacity [1–4].

The enterprise «Vector» LLP was founded in 2017 in the city of Pavlodar. The territory of this production is the rented premises and the adjacent territory of the

enterprise «Gissen Haus». The lessors were also suppliers of liquid aluminum, namely AK-12 alloy. In 2021, two induction furnaces with a volume of 600 kilograms were installed and launched on the territory of Vector LLP. The company has started processing its own waste in the form of chips and defective discs.

The technology of production of cast aluminum alloy wheels is simple and has six main stages [5–7].

Preparation of molds. In the workshop there is a site where molds are stored, processed and repaired. In case of premature receipt of an order for the production of a certain model of alloy wheels, the working staff of this site prepares the mold, its complete cleaning with the help of a sandblasting unit. Next, the mold is transported to the heating furnace by means of a loader. Within 2 hours, the mold is heated. After heating the mold to a certain temperature, it returns to the mold repair site for further painting.

Installation of the mold on the casting machine. After reheating the mold in the furnace, the loader driver pre-installs the so-called «cart» in close proximity to the casting machine. The «cart» is a rack with rail tracks fixed on top and a cart mounted on them with a horizontal plane for the molds to be installed. The casting machine also has grooves for installing rail tracks that are closed with the tracks of the «cart». After fixing the rail tracks, the mold is installed on the cart. Next, the working staff rolls the cart along the rail tracks and begins the installation. First of all, the mold is attached to the upper part of the casting machine equipped with hydraulic drives. After successful fixation, the cart returns to its original place, the rails are dismantled. The mold is lowered hydraulically to the lower part of the casting machine, after which wedges are clogged, eliminating the possibility of the mold displacement. After fixing the mold on the casting machine, the air cooling of the mold is connected by sectors. Then, after the successful installation of the mold on the casting machine, namely, the casting machine is put into operation, and the mold is heated to operating temperatures due to the liquid metal entering it [8].

Materials and methods

Metal melting is carried out in induction crucible furnaces. Before the furnace is put into operation, the operability of the main and auxiliary equipment is checked. then the furnace lining is heated by placing steel/cast iron products in the furnace space and gradually heating them. After the end of holding a certain temperature in the furnace, metal products are removed and the furnace is loaded with charge materials [9–10].

After melting the metal and filling the furnace by 85–90 %, a sample of liquid metal is taken to determine the chemical analysis. The analysis of the sample of the prepared alloy is carried out on a spectrometer. In case of unsatisfactory analysis, the smelter brings the alloy to the desired chemical composition (Table 1) by adding alloying elements or diluting with primary aluminum.

Table 1 – Chemical composition of AK-12 alloy

The norm	Mass fraction of the main components, %				
	Si	Mg	Ti	Sr	Fe
Melting furnaces	11.0–11.8	≤0.14	0.1–0.15	–	≤ 0.18
Foundry machines furnaces	11.0–11.8	0.05–0.14	0.1–0.15	0.025-0.035	≤ 0.18

The norm	Other impurities						
	Mn	Cu	Zn	Sn	Ca	Na	Li
Melting furnaces	≤0.02	≤0.07	≤0,02	≤ 0,0015	≤0.001	≤0.001	≤0.02
Foundry machines furnaces	≤0.1	≤0.02	≤0.07	≤0,02	≤ 0,0015	≤0.001	≤0.001

In case of full compliance with the required chemical composition, the metal is heated to the required temperature. Then the smelter uses hydraulic cylinders using the control panel and releases metal from the furnace space into the casting ladle for further processing of the alloy at the metal degassing plant. The filler, driving the loader, transports and installs the filling bucket with metal on the scales to fix the mass of the metal merged from the furnace. A graphite rotor for mixing metal with a built-in Argon inert gas supply route is installed above the scales. During the mixing process, alloying elements such as strontium and titanium are added in the form of cut wire.

After the end of the degassing process, the filler uses a loader with a rotary mechanism to transport the filling bucket with metal to the foundry site. Foundry workers suspend casting machines to carry out metal pouring and filling the furnace capacity of the casting machine. Having alternately filled all the casting machines in operation with metal, the filler re-weighs the filling bucket. After casting the discs, they are cooled and transported to the machining site using a conveyor belt. First of all, each disk passes through an X-ray, which helps to identify visually invisible defects (shells and pores). After passing the X-ray, the disk enters the drilling rig, where the gate is drilled. Next, the disk is sent to the first operation performed on an automated machine. After the first operation, the disk is sent to the workplace to the sawdust, where the burrs and obloy are removed from the front side. After successful completion of all these operations, the disk is sent to the second operation, where the final groove of the disk rim is made to the required parameters. After the grinding is completed, the operator cleans the front side of the disc with a grinding machine and performs measurements with a measuring tool in order to prevent the appearance of inconsistencies with the requirements of the certificate of this disc model.

In case of successful completion of all stages of mechanical processing, the disk is checked by the controller for visual and technological inconsistencies. The control is carried out with the help of measuring instruments. If not one of the types of defects has been identified, then the disc is marked with its own QR code and packed in a cardboard box. Next, documents are drawn up for all packaged car wheels, after which they are sent to the paint shop, where the products are brought to marketable appearance and sent to warehouses and stores.

Results and discussion

At the moment, the main problem of production is the lack of mass of the metal being smelted. The reason for the shortage are two main parameters of furnaces used for the

preparation of the melt, namely their volume and duration of melting. The volume of the furnaces is 600–700 kg and in order to safely carry out work on the furnace, it cannot be increased. The duration of melting varies between 80–90 minutes. The beginning is the moment of starting the furnace, and the end is the discharge of metal from the furnace space. The task of reducing the melting time of metal is an urgent and quite feasible task.

The task was set to find the optimal permissible metal residue (swamp) in the furnace after the melting was drained. By conducting experimental melting, the optimal mass of the swamp was determined, presented in Table 2.

Based on the results obtained, the optimal mass of the swamp was identified, which is 100 kg. But this duration of melting still does not allow to significantly increase production volumes. During the period of using primary aluminum in the form of ingots as the main charge material, it was decided to conduct a repeat series of experimental smelting. the purpose is to identify the difference in the duration of melting of heated ingots and ingots at room temperature.

Table 2 – Experimental melting data (Stage 1)

Melting	Furnace volume, kg	Merged metal mass, kg	Swamp mass remaining from the previous melting, kg	Swamp mass left for the next melting, kg	Duration of melting, minutes
1	700	610	0	90	110
2	700	590	90	110	90
3	700	600	110	100	85

A number of measures were carried out to obtain the most accurate values. Measurements were made of the temperature of the pig that had been in the room for more than two days. Measurements of the temperature of the pig imported from the street were made. The temperature in the space of the heating furnace was measured. The staff of the smelting site was tasked with special control of the parameters of experimental melts.

At the moment of the beginning of metal melting in the normal mode, a muld filled with a pig of primary aluminum in the amount of 16 pieces (320 kg) was installed in the heating furnace. Prior to the start of this experiment, the heating furnace was idle due to the lack of the need to use all four heating chambers. As a rule, no more than two or three cameras were used at the same time. The experimental data are presented in Table 3.

Table 3 – Experimental melting data (Stage 2)

Melting	Piece weight, kg	Heating time of the piece, min	Initial temperature, ºC		Temperature after heating, ºC	Duration of melting, minutes
			workshop	street		
1	320	85	15	-	356	68
2	319	70	-	8	349	70
3	398	72	16	-	335	70

Conclusions

According to the experimental melting data, the result was achieved by reducing the duration of melting the alloy in an induction furnace with a volume of 700 kg.

In the production conditions of the enterprise «Vector» LLP, by making changes to the technology of metal smelting in induction furnaces, a reduction in the melting time by 25 minutes was achieved by using the «in the swamp» melting method Also, the preheating of the charge materials in the space of the heating furnace contributed to the reduction of the melting time by 10–15 minutes. Before making changes to the technology, a maximum of 12 melts were carried out per day, taking into account the time for cleaning the furnace crucible and the process of draining metal from the furnace space. After the changes were made, the number of melts and the volume of the metal being smelted increased almost twice. This allowed the company to simultaneously put into operation four casting machines, which are supplied with metal by one induction furnace with a capacity of 700 kg.

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Ю. И. Шадрин
«Вектор» ЖШС,
Қазақстан Республикасы, Павлодар қ.
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АЛЮМИНИЙ ДИСКІЛЕРІН ӨНДІРУ ТЕХНОЛОГИЯСЫНЫҢ ЕРЕКШЕЛІКТЕРІ

«Вектор» ЖШС жағдайында құйылған алюминий дискілерін өндіру технологиясының ерекшеліктері көрсетілген. Құйма дискілерді өндіруге арналған индукциялық тигельді пештерде АК-12 алюминий қорытпасын балқыту процесі толық сипатталған.

Балқыту уақытын қысқарту бойынша жүргізілген өнеркәсіптік эксперименттердің нәтижелері келтірілген. Балқытудан кейін пештегі құйылған металдың оңтайлы рұқсат етілген қалдығын (батпақты) табу міндеті қойылды. Алынған нәтижелер негізінде батпақтың оңтайлы массасы анықталды, ол 100 кг құрайды.

Сондай-ақ қыздырылған дайындама мен бөлме температурасындағы дайындаманың балқу ұзақтығының айырмашылығын анықтау мақсатында эксперименттік балқытулар сериясы жүргізілді. «Вектор» ЖШС кәсіпорнының өндіріс жағдайында индукциялық пештерде металды балқыту технологиясына өзгерістер енгізу арқылы «батпақта» балқыту тәсілін пайдалану арқылы балқыту ұзақтығын 25 минутқа қысқартуға қол жеткізілді. Сондай-ақ, балқыту ұзақтығын 10–15 минутқа қысқарту қыздыру пешінің кеңістігінде материалдарын алдын-ала қыздыруға ықпал етті. Технологияға өзгерістер енгізбес бұрын, пештің тигелін тазалау уақытын және пештің кеңістігінен металды ағызу процесін ескере отырып, тәулігіне ең көбі 12 балқыту жүргізілді. Өзгерістер енгізілгеннен кейін балқымалардың саны мен балқытылатын металдың көлемі іс жүзінде екі есеге ұлғайды, бұл кәсіпорынға бір мезгілде бір ғана 700 кг сыйымдылығы бар индукциялық пеш металмен қамтамасыз ететін төрт құю машинасын іске қосуға мүмкіндік берді.

Кілтті сөздер: алюминий қорытпалары, құйылған дискілер, балқыту, индукциялық пеш, өнімділік.

Ю. И. Шадрин
ТОО «Вектор»,
Республика Казахстан, г. Павлодар
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ОСОБЕННОСТИ ТЕХНОЛОГИИ ПРОИЗВОДСТВА АЛЮМИНИЕВЫХ ДИСКОВ

Представлены особенности технологии производства литых алюминиевых дисков в условиях ТОО «Вектор». Подробно описан процесс выплавки алюминиевого сплава АК-12 в индукционных тигельных печах для производства литых дисков.

Приведены результаты проведенных промышленных экспериментов по сокращению времени плавки. Была поставлена задача поиска оптимально допустимого остатка металла (болота) в печи после слива плавки. На основе полученных результатов была выявлена оптимальная масса болота, которая составляет 100 кг.

Проведена также серия экспериментальных плавок с целью выявления разницы длительности плавления нагретой чушки и чушки комнатной температуры. В условиях производства предприятия ТОО «Вектор» с помощью внесения изменения в технологию выплавки металла в индукционных печах было достигнуто сокращение длительности плавки на 25 минут, при помощи использования способа плавки «на болоте». Также сокращению длительности плавки на 10-15 минут способствовал предварительный нагрев шихтовых материалов в пространстве нагревательной печи. До внесения изменений в технологию, за сутки производилось максимум 12 плавок, с учётом времени на чистку тигеля печи и процесс слива металла из пространства печи. После внесения изменений количество плавок и объём выплавляемого металла увеличились практически в два раза, что позволило предприятию одновременно запустить в работу четыре литейные машины, которые снабжает металлом лишь одна индукционная печь ёмкостью 700 кг.

Ключевые слова: алюминиевые сплавы, литые диски, плавка, индукционная печь, производительность.

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«Toraighyrov University» баспасынан басылып шығарылған
Торайғыров университеті
140008, Павлодар қ., Ломов көш., 64, 137 каб.

«Toraighyrov University» баспасы
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
67-36-69

e-mail: kereku@tou.edu.kz
nitk.tou.edu.kz