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Development of Flux Structure for Processing of Aluminium Casting Production Wastes

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Abstract

The objective of research is to define aluminium and its production wastes melting modes in electric unit while applying protective fluxes layer. This article cites the results of researches on development of flux structure for melting of aluminium production wastes. Melting unit diagram and results of research defining aluminium production wastes melting temperature regime are exemplified. Modes of metal charging, heating-up and melting of aluminium and its production wastes are exemplified for the electric unit with movable upper and immovable lower electrodes. The article describes the results of researches and recommendations that smelting chamber temperature to be maintained in the range of 1000-1100 ^{0}C, with melting zone temperature at 1400-1500 ^{0}C. It is recommended that charging of production wastes slag was carried after flux melt and reached 700-750 ^{0}C. Tables cite fluxes compositions that allow conducting aluminium melting process in various units. In the conclusion it is stated that application of a corresponding design of melting unit in aggregate with graphite electrodes and protective fluxes provides:
- reduction of irretrievable metal burn-off losses;
- savings on energy expenditures;
- quality upgrade of liquid smelt due to decrease of oxide inclusions and occluded gas concentration.

Keywords: Aluminum, Flux, Melting, Temperature, Burn-off loss, Method, Electrode, Coke, Structure, Mechanical properties, Flux bath, Impurities

1. Introduction

Foundry, as well as other industries, pays special attention to the quality of production. However one of features of remelting of metals and alloys, and in particular aluminium, is its natural burn-off losses. Aluminium has strong relationship with oxygen that results in higher losses at melting and overheating before pouring into forms. Liquid aluminium gets covered with a 0,2 mm thickness kish film in 0,1 seconds. Considering that melting process progresses during 40-50 minutes while metal mirror gets periodically mixed up with newly added metal, aluminium burn-off losses become obvious. To reduce such losses protective fluxes are applied preventing liquid alloy from contact with oxygen. However, applying protective fluxes requires respective remelting technology and use of a corresponding design of melting unit. Scientists of the Machinery-Engineering Faculty of the Tashkent State Technical University developed a method of aluminium alloy remelting under a protective flux and the design of a melting unit for its implementation. During the development of a technology the data of the application of electroslag furnace with a consumable electrode for steel remelting was used. The distinctive principle of work of the given furnace is that it allows to process production wastes in the form of slag.

2. Experimental investigations

Experimental investigations of remelting were conducted on unit presented in Figure-1. It is a single-phase unit, powered by welding transformer TC-500. For the measurements the device K-50 was used, as it allows to measure current strength on a single electrode, as well as on two or three electrodes.

Experimental melting unit (Figure-1) has: a rack (1) which facilitates movement of the upper electrode (3), a lever (2), a casing (4) of 4 mm thickness, which joints to the bottom plate, rammed lining (6), two racks (5) which contain experimental melting unit and enable it to be turned at 180^0. At the bottom of the furnace there is a lower electrode (10) which is isolated by the rammed lining. Copper wires are connected to the lower and upper electrodes (18) and (13) and attached by insulating material (12).

The use of the movable upper electrode is stipulated by the difference of its electrical conductance in various slags, whereby it is necessary to alter a current propagation path, which is carried out by this electrode. In the process of a coke heating-up (7) slag formation is carried out (8). After melting and tapping of metal, unit is shut down and turned at 180^0 to deslag and decoke. In the upper part of unit there are two swinging roof, one of which has gas-escape and chemical analysis sampling hole (16).

To carry out experimental melting it is necessary to produce a temperature regime provided by the arcing of a closed circuit: the upper electrode – coke – lower electrode.

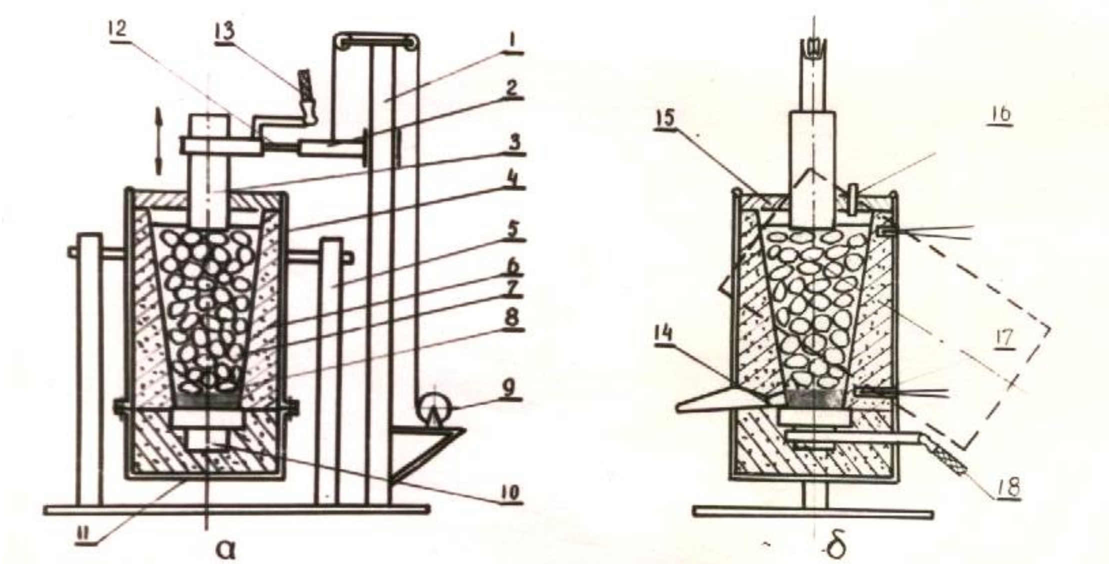

Fig. 1. Aluminium wastes melting unit diagram

Since the specific resistance of coke is high, under the current effect coke heats-up and it is brought to white heat. But the coke burns only on a surface, which result in incomplete burning. Thus combustion materials are formed on a coke surface. In the process of a coke heating-up and as its surface is burnt the burden level is reduced and upper electrode pulled down. When the coke temperature reaches adequate levels (for aluminium slag 700-750^0C) respective components flux is charged. The use of such fluxes is efficient only in conjunction with respective technology. So for example, the use of saline allows in fluxes (NaF+NaCl) results in structure grinding and improvement of mechanical properties. But such effect is achieved by the use of special device (plunger) based flux infeeding technology. Bimetal casting «an aluminium alloy – cast iron», «an aluminium alloy – steel» is used to combine durability, wear resistance and improve heat-sink cooling. Transition layer (for example, cast-iron bushing with aluminium webbing) plays here an important role.

For aluminium alloys refining refiner salines (zinc chloride $ZnCl_2$, magnesium chloride $MgCl_2$) are used, which results in formation of gaseous $AlCl_2$ on a surface of liquid melt. In the result of aluminium alloys melting experiments conducted in the constructed furnace finding obtained defining various size flux structure charged on smelting surface. To prevent flux burn-off losses, the arcing in the unit was created using coke in a contact mode. Smelting chamber temperature was maintained in the range of 1000-1100^0C, with melting zone temperature at 1400-1500^0C. Charging was carried through the loading gate in the upper part of unit. Charging of production wastes slag was carried after flux melt and reached 600-650^0C, 700-750^0C, 800-850^0C, and 900-950^0C. Mode of melting influence on quality metrics finding obtained in the result of carried out experimental melting. Table-1 cites data on fluxes composition, and Table-2 cites data on remelting technology.

To remove detrimental impurities same principle of remelting of metals is applied. But slag bath resistance in this case would become released heat source, which is heating-up the slag temperature to predetermined levels under the current effect.

Table 1.

№	Function of flux	Flux components in weight percent						
		NaCl	KCl	CaF_2	$MgCl_2$	$CaCl_2$	NaF	$BaCl_2$
1	For wastes remelting	50	30	20	-	-	-	-
2	For wastes remelting	50	20	20	-	10	-	-
3	For wastes remelting	40	20	5	-	-	35	-
4	For wastes remelting	50	30	10	-	-	-	10
5	For wastes remelting	50	45	5	-	-	-	-
6	For wastes remelting	40	40	10	-	-	10	-
7	Covering flux	40	-	20	10	30	-	-
Melting heat								
1	Specific melting heat, cal/g	123,5	74,1	–	70	54,2	27,8	–
2	Melting heat, ^{o}C	804,3	790	1330	712	772	962	577
3	Density, gr/sm^3	2,163	189	3,18	2,32	2,152	–	1,85

Table 2.

Method No.	Refining methods (increasing density)	Means of metal refining and increasing of density	Refining technology
1.	Adsorptive	Titanium chipping	Mixing of fat-free chipping for 5 minutes
2.		Magnesium chloride	Charging of 0,2% $MnCl_2$ in the plunger
3.		Hexachloroethane	Modification in three batches (0,4%) in the plunger
4.		Argon	Argon blow for 10 minutes
5.		Universal flux	Charging of 2% of flux composed of: 50% NaCl, 30% NaF, 10% Na_3Al6, 10% KCl, soaking for 10 minutes
6.		Active filter	Filtering at tapping from the surface into the dispensing crucible through 100 мм layer of flux composed of: 52,7%, 47,3% NaF
7.		Inert filter	Filtering through glass fabric ССФЗ (?)
8.	Non-adsorptive	Ultrasound	Processing (20 kHz) in 2 stages: first for 10 minutes, soaking for 10 minutes; second for 10 minutes
9.		Vacuum	Vacuumizing at 10 mm of mercury for 15 minutes under the layer of flux composed of: 62% 13% 25% (0,2% of flux)
10.	Combined refining	Filtering through active filter, then vacuumizing	-
11.	Crystallization in autoclave	Pressure 0,5-0,6 MH/ m^2	-
12.	Electroslag remelting	Remelting, overheating in the layer of liquid flux	Various NaCl, KCl NaCl+MnCl+KCl NaCl+NaF NaCl+KCl+NaF NaCl+KCl+NaF

3. General results and conclusions

While conducting aluminium wastes melting process in liquid flux bath at 600-650 ^{0}C, the concentration of oxide inclusions in liquid alloy reached 7-8 %. The amount of hydrogen was at 0,60-0,62 sm3/100 gr. During the second melting mode, conducted under the protective fluxes layer at 700-750 ^{0}C, the concentration of oxide inclusions in liquid alloy came to 2-3 %, with amount of hydrogen at 0,34-0,36 sm3/100 gr. In a melting mode, conducted under the protective fluxes layer at 800-850 ^{0}C, the concentration of oxide inclusions in liquid alloy came to 4-5 %, while the amount of hydrogen to 0,42-0,44 sm3/100 gr. The melting mode, conducted under the protective fluxes layer at 900-950 ^{0}C, the concentration of oxide inclusions in liquid alloy came to 6-7 %, with amount of hydrogen at 0,54-0,56 sm3/100 gr. The researches results apparently indicate that the temperature of liquid flux bath used for aluminium alloys melting has an influence on quantitative measures of oxide inclusions and occluded gas concentration of alloy. This proves the efficiency of melting mode applying protective fluxes layer cover and complying to proper temperature regime.

Table 3 displays all four alloys chemical analysis results obtained after each of melting modes.

Table 3
Chemical analysis results obtained after four melting modes

№	Melting mode	Amount of aluminum oxide in the alloy, %	Amount of hydrogen in the alloy, sm3/100 gr.
1	**2**	**3**	**4**
1	Melting with protective layer at 600-650 ^{0}C	7-8	0,60-0,62
2	Melting with protective layer at 700-750 ^{0}C	2-3	0,34-0,38
3	Melting with protective layer at 800-850 ^{0}C	4-5	0,42-0,44
4	Melting with protective layer at 900-950 ^{0}C	6-7	0,54-0,56

In the result of conducted research following conclusions can be drawn:

The application of protective fluxes layer at 700-750 0C for aluminium and its production wastes melting provides:

- decrease of oxide inclusions amount in liquid alloy;
- decrease of occluded gas concentration in liquid alloy;
- quality upgrade of liquid smelt due to decrease of oxide inclusions and occluded gas concentration.

The advantages of this melting method in the electric furnace with electrodes, are:

1. Necessity in the use of second unit for slag preparation is eliminated;
2. Burn-off losses at easily oxidized charge remelting are reduced;
3. Flus formation allows remelt of any non-ferrous alloys;
4. Different chemical composition and properties alloys could be produced thought the instrumentality of different composition of slag.

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