

CHEMICAL AND PHYSICAL PROPERTIES OF CONTINUOUS CASTING POWDERS

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Abstract:

The present work's aim is to obtain mould fluxes using recycled materials, with low costs and optimal properties in order to reach good surface quality.

New mixed and prefused powders was accordingly designed taking in consideration the advantage of silica dust recovery generated in ferro-silicon plant.

Laboratory experiments and industrial trials showed that this powders meets the necessary requirements for producing defect-free slabs.

Introduction

The technology of manufacturing the ferroalloys produces large quantities of recycling materials known as secondary products or by-products, and non-recycling materials, known as waste products. Current data shows that, on several countries, the by-products are more and more used as raw materials. The resulting waste products recycling are important for several reasons, the most important being the environment protection and the conservation of natural resources.

The secondary and waste products issued at ferroalloys manufacturing are, in general, slag, dust, lime residue and gases. All of them, if not recycled, lead to environment pollution. It is well known that preventing pollution is less expensive than investments for environment de-pollution (air, water ground). The resulted quantities of by-products and waste products depend on the type of the manufactured alloy.

In several countries, the dust resulted from gas cleaning at silicon ferroalloys manufacturing is known as, "silica powder" (70 - 80% from particles are under 1 mm), micro-silica or silica dust. Its price on the open market varies among \$150 and \$200. The silica powder (with 90% SiO₂) is used for several purposes.

The silica powder can be used for covering dusts manufacturing at steel casting, which, by melting due the contact with liquid steel, will form protecting slag.

Figure 1 shows the behaviour of the mould powders during continuous casting process.¹

The slagging mixtures play the role of:

- lubricant between the mould wall and crust;
- absorbing a part of non-metallic inclusions;
- improving the heat transfer between half- finished material and mould;
- thermal isolator of liquid metal surface in mould and tundish;
- protecting the steel from oxidation in mould and tundish.

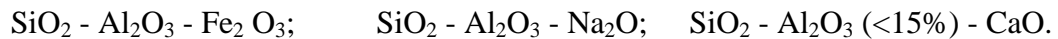
Physical properties of slagging mixtures

The properties that confer the covering dust a good behaviour during steel casting are:

- thermal characteristics (specific heat and thermal conductivity);
- fusibility (the melting temperature);
- viscosity and surface characteristics (superficial tensions and metal - slag inter-phase tensions) of the slag resulted from dust melting;
- granule size;
- specific weight.

All these properties are determined by the chemical composition of covering dusts.

The chemical composition of slagging mixtures is enclosed, generally, in one of the systems:



For a good behaviour of powders designated to mould lubrication, their physical and chemical properties have to integrate in the following optimum fields:

- melting temperature: 1150 - 1200 °C;
- melting rate: $10 \cdot 10^{-3}$ - $40 \cdot 10^{-3}$ kg/m²·s
- viscosity:

1200 °C	1300 °C	1400 °C
0.25 - 0.85	0.20 - 0.45	0.10 - 0.21 Pa
- volumetric weight: <1000 Kg/m³;
- spreading surface: > 400 cm²/220g;
- optimal granule size: min. 70% <0.06 mm; there are preferred the atomised or granular powders, with very good floating and spreading characteristics.

The mixture manufacturing

One of the technological solutions for manufacturing the mixtures with the characteristics described above is by mechanical methods.

For their manufacture, we used the following raw materials:

- blast furnace cinder, fine crushed (95% under 0.09);
- amorphous silica powder, corrector of basicity index (I_B);
- fluxes and fluidizers, such as anhydrous sodium carbonate and calcium fluoride;
- free carbon carrying auxiliary materials (metallurgical coke at 100% under 0.09 mm).

The chemical composition of mechanical mixtures is given in Table 1:

Using mixtures with $I_B \leq 1.00$ and several proportions of fluxes and coke, we measured their melting temperatures, the determining took place in Argon atmosphere. Almost all manufactured mixtures had the melting temperature over 1200 °C.

By free carbon content decreasing, even at variable proportions of fluxes, down to maximum 4.5% we succeeded the integration of melting temperatures under 1200 °C.

The resulting data is presented in Table 2:

To determine the melting rate, we used:

$$V_t = \frac{m}{S \cdot t} \text{ Kg/m}^2\text{s} \quad [1]$$

where:

- m - is the dust melting weight, at the end of the determination, kg;
- S - graphite runner surface, used for determining at the laboratory installation, m²;
- t - time for melting the dust, sec.

We determined the melting rate (Table 3) and viscosity (Table 4):

As we can see, the melting rates of these mixtures are located in the optimal domain:

$$V_{t \text{ opt}} = 10 \cdot 10^{-3} - 40 \cdot 10^{-3} \text{ Kg/m}^2 \cdot \text{s}$$

The viscosity, determined using an electro-vibrating viscosimeter, functioning among 0 - 0.9 Pa, is given in Table 4:

As we can see from Table 3 and 4, only the A4 mixture is enclosed in the optimum domains of viscosity, melting rate and temperature.

Industrial experiments

We conducted industrial experiments in SIDEX S.A. Galati (LD 1 – Continuous Casting Machine no. 2) with a continuous casting speed of 0.5 m/minute, in order to compare our manufactured powders with Accutherm STC 39/4S. We aimed the following aspects:

- a) the powder behaviour during the casting (it's melting behaviour, the covering of the free meniscus);
- b) the quality of the slab's surface;
- c) the specific consumption of material.

The test results were as follows:

- the covering of the free meniscus by the melted powder was complete and uniform;
- the melting rate for the manufactured powder was comparable to the referenced powder, Accutherm STC 39/4S;
- the formed slag layer didn't stick to the mould wall surface and the solidified shell;
- the specific consumption was 1.19kg per tone (35% greater than for Accutherm STC 39/4S);
- the slab's surface was defect free.

Conclusions

The secondary products represent one of the important problems in the environment protection policy, because neglecting them leads to pollution both on long and short term. Using these products offers great advantage in environment and basic materials resources protecting, reduces the waste stock and the expenses for de-polluting technologies.

The recovery of util metals from slag and dust represent an important source of diminishing the expenses for raw materials and, in conclusion, a lower price for the main products.

The silica powder can be used for covering dusts manufacturing at steel casting, which, by melting due the contact with liquid steel, will form protecting slag.

The manufactured mixture showed good performance in mould without any surface defects and good insulating behaviour.

Despite the greater specific consumption comparing to standard mixtures, their use has a real technological, economic and environmental advantages.

References

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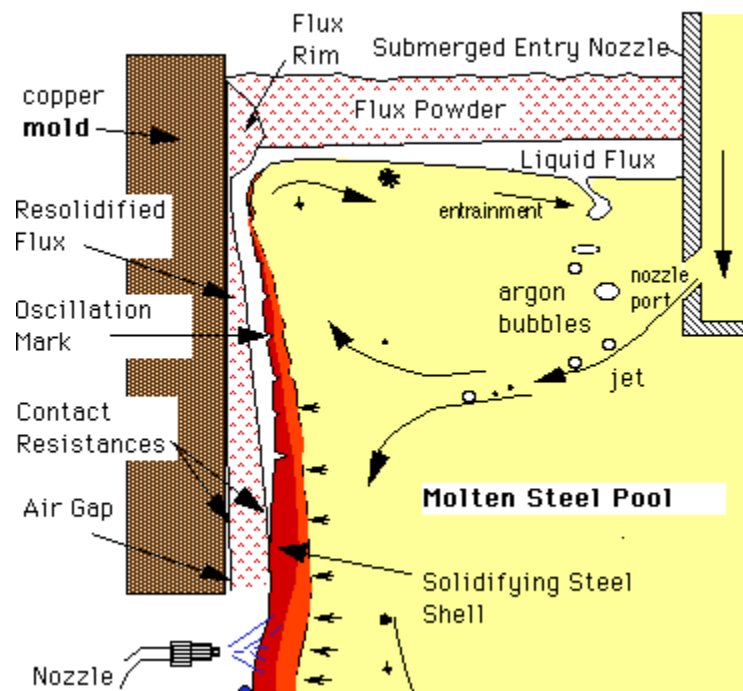


Figure 1. The behaviour of the mould powders during continuous casting process

Table 1. The chemical composition of mechanical mixtures

Samples	a ₁	a ₂	A ₄
SiO ₂	41 - 43	40 - 42	30 - 32
CaO	41 - 43	40 - 42	30 - 32
Al ₂ O ₃	10 - 11	10 - 11	6 - 7
CaF ₂ + Na ₂ O	1 - 2	1 - 2	10 - 15

Table 2. Melting temperatures for different mixtures

Samples	Components		t _{melt} , °C
	Fluxes, %	C _{free} , %	
a ₁	5 - 15	1 - 7	1260
a ₂	slag + silica		1260
a ₄	1 - 10	4.5	1200

Table 3. Melting rates for different mixtures

Samples	Fluxes, %	C _{free} , %	Melting rate, kg/m ² ·s	Medium temperature, °C
a ₁	0 - 1	max. 1	19.1·10 ⁻³	1412
a ₂	0 - 1	max. 2	27·10 ⁻³	1438
a ₄	1 - 10	4.5	11.9·10 ⁻³	1442

Table 4. Viscosity for different mixtures

Samples	Measured viscosity, Pa·s			
	1200 °C	1250 °C	1350 °C	1400 °C
a ₁	over 0.9			
a ₂	over 0.9			
a ₄	0.63	0.455	0.24	0.195