Rotary tilting furnace is the most efficient installation for recycling of dispersible metal wastes of any alloy. Several constructions have been designed for chips heating and melting, scale recovery, ets.

S. L. ROVIN, Research and Development Enterprise «TECHNOLIT»,
L. E. ROVIN, V. A. ZHARANOV, T. M. ZAYATS, GSTU Named after P. SUKHOI, Gomel

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ONE–STAGE METAL WASTES RECYCLING

Metallic waste, such as calx, light scrap, chips and dust is formed at all stages of a work cycle, from melting to finishing processing. The immense amount of waste formed at metallurgical and machine-building factories, creates a salvaging problem toughened by the requirements on environment protection.

Salvaging or recycling waste represents a problem to which constantly increasing attention is paid in the world. The tendency of cost increase of metals, scrap metal and power supplies, stimulates activity in this direction.

The practice has proved that traditional melting furnaces usage in handling foundry departments for chips recasting is irrational.

Since the 60th years of the past century, various searchings on pig-iron chips recasting in cold blast cupola furnaces have been carried out. Chips was inducted with a positive blast through lances, straight into the melting zone, or loaded into the cupola furnace in the form of cakes, etc. Besides, test chips injection into cupola furnaces through lances by compressed air or by means of a screw feeder was tried.

In such conditions no more than 15% of chips were utilized. The rest of it goes into slag in the form of oxide FeO and into waste gases, in the result of which the of oxides Fe_2O_3 and Fe_3O_4 concentration in cupola aerosols is increased.

Opportunities created with a hot-blast cupola furnace, do not provide conditions for oxidated scrap, such as calx or aspirating dust, salvaging. Estimation of kinetic characteristics of oxides reduction process proves that in order not only to prevent oxidation (waste) but to realize the above it is necessary to increase the time of its staying in the reduction zone by an order (i. e. up to 10-fold). Thus, it is necessary to increase the time of staying in the reduction zone for oxidized cakes (briquettes) even more, up to tens of minutes. Cakes should be specially prepared for cupola melting: be of the specific size and density, contain active reductant and fluxing agent. The cake containing oxides should stay in the reduction zone at the temperature not less than 1000–1100 °C during 30 minutes.

Usage of chips in charging crucible furnaces of production and medium frequency requires to overcome various technological difficulties. Since the chips is poorly heated up at low frequency, the efficiency and productivity of rotary furnaces drops. The chips bulk weight is 1250–1850 kg/m^3, therefore it floats and is retained in cold charge. The oxides introduced by chips cause decarburization of the alloy, accumulation of non-metallics inclusions, gas saturation, etc.

Expansion of single-stage methods of steel processing from ore bypassing the blast-furnace conversion, became the basis for creation of similar processes for ferrous waste recycling, considering that calx contains about 75% of iron, while chips, even oxidated, still more. At present four main methods of crude ore processing, which are applicable also for recycling of scrap-metal, are used: deriving of prereduced pellets or sinter, production of sponge iron in a solid state (prereduced pellets), refined iron in a lamellar condition, hot metal or an intermediate product.

Dispersible scrap-metal recycling without preliminary crowding or agglomeration is technologically more simple. Research works in this direction resulted in creation of Redsmelt, Hismelt, Russian Romelt systems and similar ones. The above systems provide deriving molten metal (pig-iron or an intermediate product). Minimum annual production rate of similar type makes up 300000–500000 tons.

Thus, existing methods do not provide complex solution of a problem at the stage of processing of ferruginous dispersible lump materials: cakes, sinters, pellets, etc.; thus, their subsequent use in traditional electric and fuel melting furnaces appeared ineffective, especially in case of producing branded cast iron

Fig. 1. Rotary tilting melting furnace

and steel. Substitution, even fractional, of high-quality materials for low-grade ones (oxidated, polluted, with inconsistent chemical composition) results in decreasing all melting characteristics, including power inputs and quality of molten metal.

The preferable solution, in our opinion, is scrap-metal recycling at those factories where they are generated. It suggests development of effective installations of low capacity for recasting.

Accordingly, designing of specialized rotary furnaces and installations with the purpose to get liquid or solid intermediate product which can substitute expensive charge materials is actual. Besides it is preferable to have an opportunity of multiple-purpose use of similar wastes processing plants for both black, and non-ferrous metals.

Unitary enterprise «Technolit» has developed rotary furnaces (Fig. 1), enabling to recycle any raw material due to heat and mass transfer carried out in a dynamic layer (the Patent of Byelorussia 2428 and 2770).

Rotary tilting furnace for melting dispersible and lumpy materials with a chamber, designed with the ability to rotate and having cylindrical section connected to the conic section at its bigger base; with a cover closing the chamber from a smaller base of a conic section; with a burner device and a pipe for combustion gases, built-in in a cover.

The chamber and cover are fixed on the common inclined carriage. Gas staying in the rotary furnace is twice longer than at the rotary drum furnaces, and at feed of the rotating stream its interaction with the material can be stimulated sometimes by the increase of a rotating speed up to 10–15 m/s versus 0,5–1,5 m/s (a forward speed of a stream in drum furnaces). Owing to the its sweeping ability it is easy to load charge into such rotary furnaces and to drain off the pool melt; at that, the capacity of similar rotary furnaces is limited only by technological requirements. Rotary furnaces make it possible to keep continuous operating mode by temperature and furnace atmosphere composition, i. e. at the initial moment to realize the recovery process at temperatures of 900–1100 °C and the CO content at 25–35% then to increase temperature up to 1750–1850 °C due to use of an enriched blast and to get the melt. Rotary furnaces allow, in case of need, to realize finishing alloy and its refining before pouring out. Rotational furnace can work on pool and gas fuel, and to use any carbonaceous materials as reductants, including, wastes.

Research of gas flows and heat interchange in working space of the furnace is carried out by methods of a numerical modeling with the purpose of optimization of a construction of rotary tilting melting furnace and melting techniques (Fig. 2).

Speed components, pressure and temperatures values were defined on the basis of Laws of mass, momentum and energy conservation. For whirl estimation equations of continuity and an impulse were used. As a derivative result the following parameters were evaluated: Mach number, pressure ratio, common pressure and functions of a stream for mobile medium, as well as heat flux and coefficient of a surface heat dissipation for problems of heat and mass transfer.

As a result of a numerical modeling optimal ratios of diameter, lengths and angles of inclination of the rotary furnace, as well as peripheral speed of a body rotation, were calculated. Also the opportunity of application of gas-oxygen burners is estimated.

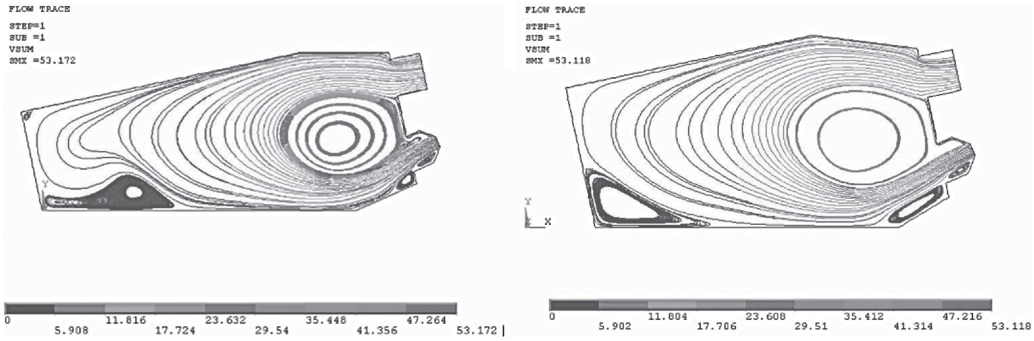

Fig. 2. Scheme of gas streams in working space of the rotary furnace: *a* – at a ratio $D/L = 0,43$; *b* – and $D/L = 0,64$, $\alpha = 25^\circ$ angle of gas direction $\alpha = 5^\circ$

Recycling technology includes 2 stages which are realized in one unit – rotary tilting melting furnace:

- metal oxides recovery (sulphides and etc.) in non-corrosive media under recovering agent;
- melting of reduced metal and refining of liquid melt in accordance with the required chemical composition.

Advantages of rotary furnace usage for scrap-metal recycling in comparison with traditional crucible, reverberatory, boiler kettle and drum-type furnaces:

- decrease of specific power consumption by 20–25%;
- flux expenditure reduction by 10–15%;
- increase of capacity by 30–35% under equal heat rates;
- possibility of carrying out practical recycling without any preliminary material preparation;
- possibility to conduct all metallurgical processes;
- possibility to recycle any ferrous and nonferrous metal alloys, without exception.

The designed equipment and technology perfectly adapt to conditions of working production and allow to recycle any dispersible metallic waste, including chips and scale of non-ferrous and iron-carbon alloys.