INSTALLATION FOR PREPARING GALVANIZED STEEL SCRAP FOR USING AS CHARGE MATERIAL IN INDUCTION MELTING FACILITIES

Leushin I.O., Subbotin A.Y., Geyko M.A.

Nizhniy Novgorod State Technical University n.a. R.E. Alekseev, Nizhniy Novgorod, e-mail: igoleu@yandex.ru

Proposed is construction of installation for removing zinc from galvanized steel scrap in order to prepare it for using as charge material in induction melting facilities. The dimensions of the installation working capacity for processing steel scrap over one work cycle of the installation have been calculated. The installation is designed for removing zinc from galvanized steel scrap by chemical refining. This method consists in chemical drawing of zinc from steel base at the expense of the effect of hydrochloric acid aqueous solution (initial concentration of hydrochloric acid 9 % by weight) on scrap during a set period of time. For protecting steel base from dissolving in acidic medium hexamethylenetetramine (urotropin) in the amount 2,5 % by weight is used as short stopping agent.

Keywords: construction, installation, galvanized steel scrap, zinc coated steel scrap, zinc drawing, chemical refining, induction melting, hydrochloric acid, hexamethylenetetramine

Secondary material resources can reduce the need for constantly rising in price primary materials necessary for the operation of machine-building companies. This is especially true for the foundry sector. A modern approach to the organization of production systems involves recycling (reuse) of recycled materials and products after their operation period for manufacturing useful products according to the scheme: “material – product – secondary materials – secondary products” [1]. So returning galvanized steel scrap generated in large quantities in the automotive industry to its own production chain can significantly improve the production efficiency of the foundry sector of machine building enterprises by reducing the cost of raw materials.

In the modern production of automobile and machine-building industry galvanized steel sheet with zinc coating thicknesses of 20–60 microns is widely used as a basic material. As a result, large amounts of waste galvanized steel sheet (Fig. 1) accumulate, the use of which for iron smelting is difficult in case the melting areas of machine-building enterprises are equipped with induction melting furnaces.

In induction melting facilities remelting of galvanized steel scraps is hindered by a number of factors:

– deleterious effect of emitted during melting fume containing harmful substances on furnace operators as well as the need in expensive refining equipment;

– heavy fume emission restricts visibility in a melting section which may cause factory accidents;

– possibility of weakening of the lining of melting furnace and increased risk of melt leakage connected with the consequences of active physico-chemical interaction of zinc with refractories;

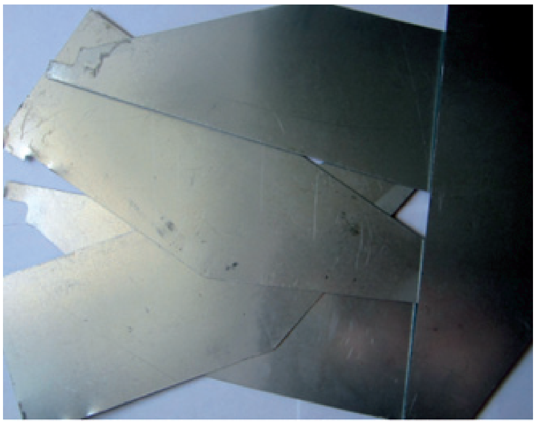

Fig. 1. Galvanized steel scrap

– increased risk of liquid melt discharge from the furnace resulting from boiling which takes place at the contact of galvanized scraps with liquid melt;

– decline in the quality of the obtained alloy due to deterioration of the mechanical properties of the material of castings (hardness, percentage elongation).

Remelting galvanized steel scraps at specialized iron and steel enterprises is also connected with large financial costs primarily of logistics, thus there arises the need for recycling galvanized steel scrap, namely removing zinc from a steel coated base in their own production conditions.

Removing zinc coating from steel scraps

The following methods for processing galvanized steel scraps are used in international practice: [2]

– Remelting in an electric arc furnace;

– Chlorination of galvanized scrap;

– MRI-technology;
– Vacuum evaporation of zinc;
– Electrochemical separation of zinc;
– Chemical separation of zinc.

One of the promising methods of removing zinc from galvanized steel scraps appears to be a chemical method of refining waste in a hydrochloric acid aqueous solution, scheme of which is shown in Fig. 2.

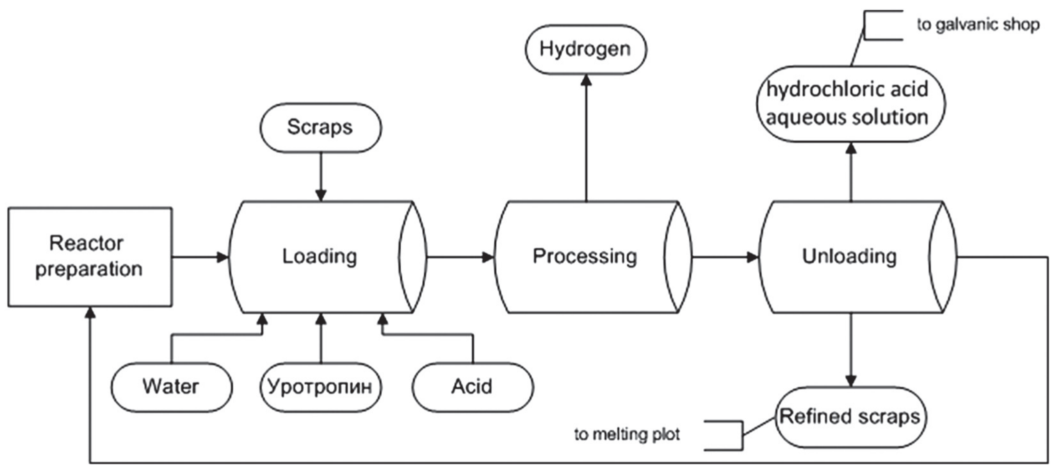

Fig. 2. Diagram of refining of galvanized steel scraps

The method is based on a chemical reaction between zinc and a hydrochloric acid aqueous solution. As a result of a chemical reaction of zinc and hydrochloric acid interaction steel scraps are completely cleaned from the zinc coating and can then be used as charge material for iron smelting in induction furnaces. For the refining process technical hydrochloric acid [3] and technical hexamethylenetetramine [4] are used.

For protecting steel base from dissolving in the interaction of acid and iron a small amount of technical hexamethylenetetramine (urotropin) is added to the solution as short stopping agent. The following original data have been established experimentally: initial concentration of hydrochloric acid 9 % (250 g/l of technical acid), the concentration of hexamethylenetetramine – 2,5 % (2,5 g/l). Temperature of the solution is 20 °C. The ratio of acid to water is 1:3, which allows to exclude the effect of "vapouring acid" and to ensure the removal of the zinc coating from the steel base with an initial velocity of 5–10 microns per minute.

The technology is implemented as follows. Galvanized steel scraps are placed in a tank with the capacity corresponding to one processing cycle. The required amount of water at a water temperature of 10–30 °C is added. Then hexamethylenetetramine at a rate 2,5 g/liter is added to the water with scraps. Next, technical hydrochloric acid in the amount of 250 g/liter is poured into the water. The amount of processed waste is calculated in such a way that the processing cycle at an average temperature of 20 °C does not exceed 30 minutes. During processing waste it is necessary to provide for the withdrawal of evolved gases (hydrogen). For this purpose alloys-absorbents of hydrogen based on TiFe and titanium or Zr(Fe, Mn, Cr, Fe, V, Ni)$_2$ can be used. Also to remove hydrogen from the reaction zone a production hood can be used [5]. After a specified time the solution is drained and sent for further recycling, and steel scraps can be used as charge material for iron smelting in induction furnaces in foundries of machine-building enterprises.

Installation for removing zinc coating

It is proposed to use the refining installation of following construction (Fig. 3). The installation represents a container of the drum type consisting of stationary part 2 fixed on base 1 and the movable part of mesh 3, which is driven in rotation by an electric motor through a reducer (not shown). For the purpose of protection from aggressive acidic solution, the reactor is made of corrosion-resistant alloy, for example KHN65MV or H70MF [6]. The dimensions of the movable and stationary parts are calculated based on the volume of waste to be processed in one cycle of operation. The percentage of filling the installation with waste and the reaction solution seems appropriate to be 70–80 % of the total installation for a more complete reaction between the zinc coating and the acidic solution. The distance between the inner surface of the stationary part and the outer surface of the movable part should be minimal. It is advisable to take it equal to 50 mm. On the basis of the average density of the loaded waste 3000 kg/m^3 and the amount of waste that is processed per cycle 100 kg with filling the working cavity at 80 %, overall dimensions can be taken as follows: the inside diameter of the stationary part D = 900 mm, external diameter of the movable part of the d = 800 mm, the length of the working container l = 800 mm.

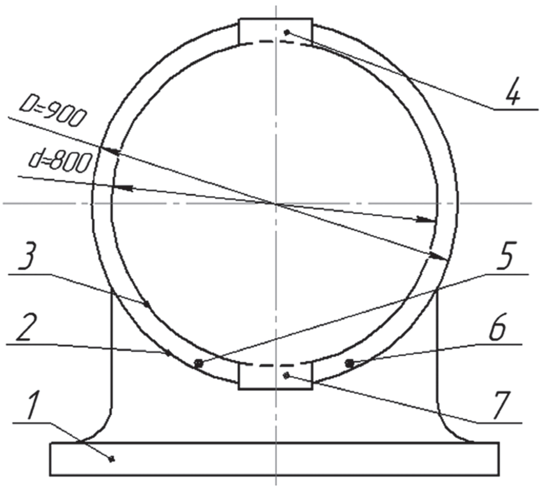

Fig. 3. Installation for removing the zinc coating from galvanized steel scraps

The process of refining steel scraps is as follows: through the loading hatch 4 in the movable part of the installation 3, made of steel mesh, galvanized steel scraps are loaded. Then with the help of the pump 5 and the system a hydrochloric acid aqueous solution with hexamethylenetetramine is supplied, after which the movable part is driven in rotation. After finishing the refining process with the help of the drain pump 6 of the working chamber of the installation the processed solution is removed, then the cleaned steel scraps are discharged through the discharge hatch 7. After drying, they can be used as charge material for iron smelting in induction furnaces. The aqueous solution of zinc salt as the result of the reaction can be used as electrolyte in zincification, i.e. returned to the productive chain of the enterprise, if its structure has electroplating shops or sent for recycling to other options.

Conclusions

Analysis of the results obtained from laboratory experiments shows that processing 1 tonne of galvanized steel scraps requires about 70 liters of hydrochloric acid and 0,8 kg of technical hexamine (dry substance). With the cost of technical hydrochloric acid up to 90,000 rubles per 1 tonne (approximately 10 rubles per 1 liter) and the cost of hexamine up to 60,000 rubles per 1 tonne, the estimated cost of materials for processing 1 tonne of steel scraps will amount to 750 rubles [7]. Based on the value of secondary materials for cast iron smelting (from 12000 rubles per 1 tonne), the costs of materials for processing galvanized steel scraps and the costs of producing and maintaining the installation it can be concluded that using the proposed installation for withdrawal of the zinc coating from galvanized steel scraps at the amount of at least 20 tonnes per month is economically feasibile.

References

1. Disposal of industrial waste: Manual / V.D. Vinokurov, A.V. Kozlov, V.P. Stupnikov and others; edited by V.D. Vinokurov. – M.: Bauman Moscow State Technical University, 2008. – 60 p.: il.

2. Leushin I.O., Subbotin A.Yu., Geyko M.A. Use of galvanized steel scrap in induction melting // Russian foundryman. – 2015. – № 6. – P. 17–21.

3. GOST 857-95 Synthetic hydrochloric acid for industrial use. Specifications. – Moscow.:Standartinform, 2008.

4. GOST 1381-73 Hexamethylenetetramine for industrial use. Specifications. – M.: Standartinform, 2005.

5. Leushin I.O., Subbotin A.Yu., Geyko M.A. Preparation of galvanized steel scraps to induction remelting // Proceedings of the XII Congress of Russian foundry. – Nizhniy Novgorod, 2015. – P. 115–119.

6. GOST 5632-72 High-alloy steels and corrosion-resistant, heatresistant and heat-proof alloys. Brands. – M.: IPK Publishing house of standards, 1997.

7. Leushin I.O., Subbotin A.Yu., Geyko M.A. Recycling of galvanized steel scrap for use in cast iron melting in induction melting facilities // CIS Iron and Steel Review. – 2015. – № 1. – P. 19–22.