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DESIGN AND OPERATION OF A SYSTEM WITH AN IMMERSIBLE ELECTROMAGNETIC PUMP FOR RECASTING ZINC FROM A HOT GALVANIZING SPELTER POT

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A system with a high-temperature immersible induction pump for zinc as its main component has been developed and built at the MHD Laboratory (Khar'kov, Ukraine) in 1985. The system is meant for pumping molten metal out of a hot spelter pot into a reserve container in an emergency or when there is a need to inspect the spelter pot. The system has worked since 1986, i.e., for more than seven years, at the machine-building plant at Pervomaisk, Ukraine. The melt elevation height is 3.8 m and the pump capacity 350 tons/h; the spelter temperature is 460°C.

Larger spelter pots for hot galvanizing, or similar pots for hot covering with other metals (zinc–aluminum, tin), are used in industry. It is necessary to inspect the pot walls periodically since emergency situations can arise. In these cases, the melt must be pumped out of the working pot into a reserve container. In practice, this is done using ladles, during a time period as long as 24 h or longer. There were attempts to employ mechanical pumps; however, these proved to be not sufficiently reliable. An MHD pump allowed us to solve the problem.

The system is shown in Fig. 1, and Fig. 2 shows a photograph of it. The system consists of 1) an electromagnetic three-phase immersible induction pump cooled by the molten spelter; 2) a heated melt transportation tube; 3) a cross arm for lifting the pump and tubes and for control of their position(s) in the pots; 4) the power supply control devices (an induction regulator, control devices, control desk).

Before the beginning of development of the MHD system, the resistance of the duct wall material in molten zinc was tested. A cube of stainless steel sheets (X18H10T; American equivalent, steel 316), 6 mm thick, was made, filled with iron filings, submersed into molten zinc in a bath with temperature 460°C, and kept there for 206 h. The cube wall thickness decreased to 3 mm except the weld zone; consequently, the rate of thickness decrease was 0.014 mm/h. This result was assumed to be satisfactory because the pump is used 1-3 times per year, every time for 1.3 h. A decision to manufacture the pump duct of stainless steel sheets 10 mm in thickness was made which would warrant a reliable lifetime of the pump 100 h. Since the system is used rarely, this ensures reliable operation in the course of some 30-40 years.

When designing the pump the following factors were taken into account: 1) nonuniformity of the velocity profile both along the width and height of the duct; 2) both transversal and longitudinal end effects; and 3) the effect of conducting walls of the duct and the molten zinc around the duct.

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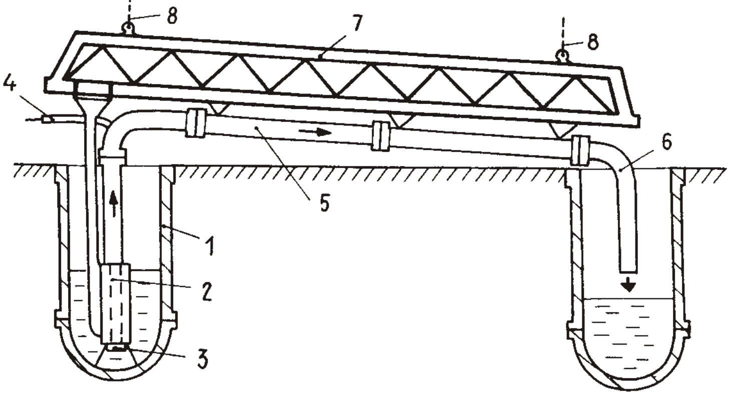

Fig. 1. System with an immersible induction pump for emptying a pot for hot galvanizing. 1) Pot for hot galvanizing; 2) pump; 3) inlet nozzle; 4) power supply cable; 5) metal transport tube (heated); 6) outlet tube; 7) cross arm; 8) ropes to cranes.

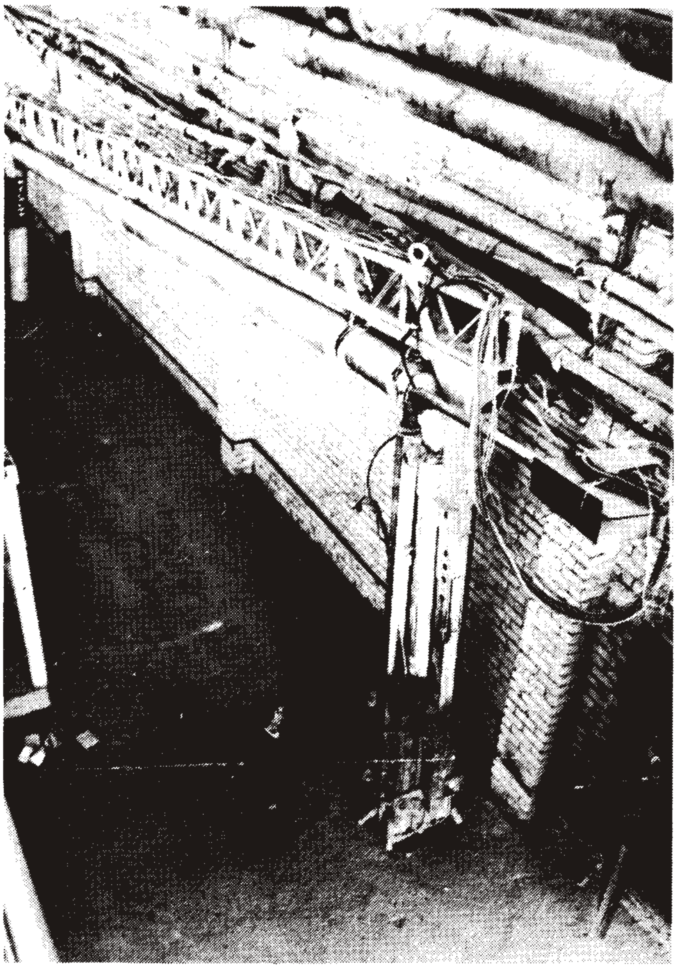

Fig. 2. Photograph of the system.

The main characteristics and parameters (experimental, or design values) were: capacity 350 tons/h; melt temperature 460°C; the working temperature of the windings and the laminated core up to 550°C; number of poles 6; pole pitch 250 mm; nonmagnetic gap 45 mm, duct height 25 mm, width 150 mm; wall thickness 10 mm; phase current up to 420 A; supply voltage

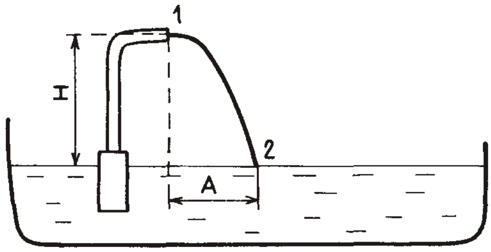

Fig. 3. The pump test scheme. Explanations in text.

220 V, frequency 50 Hz; flux density amplitude 0.3 T at phase current 320 A. The distance between the vessels (see Fig. 1) was 12 m, the pump mass 2.5 tons, mass of the whole system 5 tons, and melt mass in the vessel 500 tons.

The pot emptying duration was 1.3 h, which is essentially less than the ladle operation period (24 h or more). Time reduction was not the only advantage of the electromagnetic pump; there were several others, including savings in zinc (see further).

Once manufactured, the pump was checked in one bath (Fig. 3). The molten zinc left the tube horizontally in 1 and reached the melt surface in 2, at a distance A measured experimentally. Since the height H was known, we could calculate the falling time T and the horizonal velocity v_h in 1:

$$A = v_h T;\ T = (2H/g)^{1/2};\ v_h = A\ (g/2H)^{1/2}.$$

The pump capacity is $Q = Fv_h$, where F is the tube cross-sectional area at 1. In this first experiment, we found that $Q_G \approx$ 300-400 tons/h (Q_G, the mass flow rate, was obtained from Q by multiplication with the melt density). After this test, the system (Figs. 1 and 2) was completed and set in operation. It is operated regularly when there is a need to empty the pot for hot zincing.

Let us recall the main stages of the earlier process: 1) a number of zinc ingots were placed on the bottom of the reserve pot; 2) the pot was filled with water, the latter heated until it evaporated, and the ingots melted; 3) the melt was transferred from the working pot to the reserve one using ladles; this process was unsafe. Moreover, since the work duration was long, a part of the melt in the working pot cooled and froze, and approximately 10-15 tons of the zinc passed over as losses.

The system has worked since 1986 for more than seven years at the machine-building plant at Pervomaisk, Ukraine. As far as we know, the system has no analogues in Ukraine or Russia, nor in other countries.

Similar systems could be used for aluminum–zinc alloy (with another, properly chosen duct wall material), tin, and lead.