INDUCTION ELECTRIC FURNACE

Inventor:
Heinz Ilberg

Attorneys:
The majority of the known induction furnaces, in which the melting channels, which form the secondary winding of a transformer, are of relatively small cross-sectional area and terminate in a crucible serving as melting pool or bath, make use either of a "pinch-effect", motor effect, repulsion effect and buoyancy due to heat, or of a combination of these electrodynamic and thermic effects of the electric current.

The melting channels are also constructed accordingly. A common feature in all these furnaces is, that a heat accumulation takes place at a certain point in the melting channel. This point can be located from consideration of the symmetrical construction of the furnace, or is known from experience, because the ceramic lining of the furnaces is generally broken through by the molten metal at this point.

It is obvious that the flow caused by the buoyancy due to heat, hereafter briefly referred to as heat flow, begins at this point and is preferably directed in one direction and is superimposed on the movements in the melting channel caused by the electrodynamic forces.

According to the invention the heat accumulation and therefore the heat flow are influenced to a considerable extent and their detrimental effects avoided, which effects consist in a local overheating of the material and in a strong eating away of the ceramic lining of the furnace which must result in the furnace being quickly rendered unfit for service.

Two embodiments of the invention are illustrated in the accompanying drawings in which:

- Fig. 1 is a longitudinal section through one form of construction of an induction furnace.
- Fig. 2 is a similar view of another form of construction.
- Fig. 3 is a side elevation of a somewhat variant form of furnace from that shown in Figs. 1 and 2.
- Fig. 4 is an end elevation of the furnace of Fig. 3, the view being from the end indicated by the arrow A.
- A secondary winding e, which serves as a melting channel surrounds a primary coil with iron core b and terminates in a melting bath d.

Owing to the electrodynamic forces a strong flow is produced in the melting channel e which is directed uniformly outwards and inwards on both channel arms. The strength of the flow is dependent upon the square of the current strength divided by the cross section. The course of flow is indicated in Fig. 1. It can be seen, that the flow at e has a reversing zone so that the material to be melted can only be moved from this zone with difficulty. Moreover, owing to the frictional resistances the speed of the electrodynamic flow decreases considerably with the length of the path, so that the greatest speed exists near the channel mouths f and g and at the point e. As a result of this the displacement of the molten material from the point e is checked, so that the molten material is at this point subjected to a relatively long time to the heating effect of the electric current and is strongly overheated. As is known, the melting channels of induction furnaces are based on a certain nominal cross section according to the service conditions to be fulfilled. One might endeavor to overcome the above mentioned drawbacks by increasing the constructional nominal cross section of the melting channel. This, however, is open to the objection that, on the one hand the efficiency factor of the furnace is detrimentally affected and on the other hand the drawing effect of the electrodynamic flow is reduced. It is difficult to estimate whether, owing to the reduced frictional resistances, the electrodynamic flow still extends to the same point as in the case of smaller cross sectional area or not. If it does not extend so far, nothing is attained by enlarging the cross sectional area; on the contrary, a greater heat buoyancy effect, that is again a greater overheating, is necessary to shift the material from the point e.

In order to overcome the above mentioned difficulties, it is proposed, according to the invention, to enlarge the cross sectional area of the melting channels along a portion of their length or along their entire length above the nominal cross sectional area of one of the channel arms and to again reduce same to the nominal cross sectional area of the other channel arm. The point, at which the heat accumulation takes place, is situated in the above example (Fig. 1) at the point of the melting channel, which is equidistant from the two channel mouths. The enlargement is designated by a in Fig. 1. It preferably merges gradually into the original cross section, The portion of the junction of the two melting channels to the total length of the channel depends upon the actual working conditions, the material to be melted and the form of construction of the melting channel. It is evident that two limits are possible which, however, are of practical importance. In one instance the cross section is only widened in direct proximity to the point of greatest heat accumulation and in another instance, starting from the mouth of the melting channel...
the cross section of the melting channel is gradually widened to the point where the greatest heat accumulation takes place. The channel cross sectional area will be widest at this point and reduce gradually, reduces towards the other mouth of the melting channel. The latter construction is illustrated in Fig. 2, the individual parts correspond to those shown in Fig. 1 and are consequently designated by similar reference characters.

In the case of furnaces, which utilize the repulsion effect of the primary coil (Figs. 3 and 4), the melting channel is very often made of helical shape or crossed in order to obtain a uni-directional flow in the melting channels. In order to attain this, the repulsion effect ought to be made very strong, so that it overcomes the inwardly and outwardly directed flow (see Fig. 1) caused by the “pinch-effect”. A strong repulsion effect of the coil results, however, in a bad output coefficient. Therefore, one has hitherto generally been satisfied with a lower repulsion effect, which causes a one-sided flow, that is superimposed on the outwardly and inwardly directed flow. Consequently, the point where a heat accumulation takes place is displaced towards the side of the channel arm on which the outwardly directed flow caused by the “pinch-effect” and the flow caused by the repulsion effect counteract each other. The widening of the channel cross section must therefore be arranged at the same point. This point is no longer situated, as mentioned above, equidistant from the two channel mouths but shifted towards one of the channel mouths. The reference characters otherwise correspond to those of Figs. 1 or 2.

The invention has been described in connection with two forms of example. According to the construction of the melting channel and to the object to be attained it can also be employed in another form of construction. It can likewise be employed appropriately when, for example, the mouths of the melting channel have different cross sectional areas, for instance \( g \) and \( f \) according to Fig. 3 and Fig. 4. Particularly it is immaterial what relative position the melting channels occupy with respect to the melting bath, whether they are vertical, horizontal or inclined, and what cross sectional shape they have.

I claim:

1. An induction smelting furnace, comprising melting channels which form the secondary winding of a transformer, the cross sectional area of the melting channels being widened upon the whole length of the channel commencing from the nominal cross sectional area of the one channel arm and again narrowing to the nominal cross sectional area of the other channel arm.

2. An induction electric furnace of the type having a pool for molten metal and walls forming a single submerged channel which forms the secondary of a transformer, in which the cross sectional area of the channel is widened intermediate between the extremities of the channel at the point where excessive heating would otherwise develop.

3. An electric induction furnace of the type having a pool for molten metal and walls forming a submerged channel which forms the secondary of a transformer, in which the cross sectional area of the channel is progressively and gradually widened and then progressively and gradually narrowed from a point near one extremity to a point near the other extremity of the channel, the widened and narrowed portions having progressively curved contours.

4. An electric induction furnace of the type having a pool for molten metal and walls forming a single depending submerged channel below the pool, in which the channel is of horseshoe contour and is continuously and progressively enlarged in cross section from points on either side of the middle point toward the middle point, the enlarged portion having a progressively curved contour.

5. An electric induction furnace of the type having a pool for molten metal and walls forming a single submerged channel, which increases in cross section from one end to the other, in communication with the pool, in which the channel cross section on the side of the channel nearest the largest end of the channel and at the point at which the channel tends to overheat is enlarged with respect to the immediately adjoining channel cross sections.

Heinz Ilberg.