METHOD AND A CONTROL DEVICE FOR OPERATING A POLYPHASE ELECTRIC FURNACE

ABSTRACT: A control device for operating a three phase electric reduction furnace includes a two-point controller responding to departures of the furnace power actual values from the furnace power nominal values for obtaining from an integral controller variations of the electrode current nominal values. Other two-point controllers compare the varied electrode current nominal values with the electrode current actual values and respond to departures of the varied electrode current nominal values from the electrode current actual values to provide adjustment signals for the output controls for corresponding phases of the furnace transformer. Differential controllers sense the differences between the actual currents flowing through the said electrode and the electrodes disposed nearest thereto on the two sides of it, and additional differential controllers activate the transformer output control drive in response to the adjustment signals for adjusting the furnace transformer phase which lies between the two electrodes having the least sensed current difference.
FIG. 2.
METHOD AND A CONTROL DEVICE FOR OPERATING A POLYPHASE ELECTRIC FURNACE

This invention relates to a method of operating a polyphase electric furnace, particularly a three-phase reduction furnace, in which with a substantially constant power input the furnace current is kept substantially constant.

As shown by the equation \( W = f(V, R) \), the power input of a polyphase electric furnace is a function of the square of the voltage applied to the furnace and of the resistance of the charge within the furnace. As shown by the equation \( I = f(V, R) \), the current passing through such a furnace is a function of the voltage applied to the furnace and of the resistance of the charge. Thus of the four quantities mentioned above, namely power, current, voltage, and resistance, only two are independently variable; the values of the remaining two being fixed once values for any two of the four have been chosen.

It is convenient for the power and the current to be selected as the two independent variables. It is then technically good practice for a given non-independent variable to be associated with only one of the two independent variables, that is to say either to associate the voltage with the power, and the resistance with the current, or to associate the voltage with the current, and the resistance with the power. In each case the variable is to be treated as a deviating variable.

When the current is kept constant, the furnace voltage, as a deviating variable, will vary only within the framework of the furnace current programme, but the resistance of the charge within the furnace, on the other hand, will vary as a result of various external occurrences, e.g. charging, tapping or electrode displacement, and also as a result of unpredictable internal occurrences, e.g. movements of the charge, movements of gases, changes of temperature, and changes of the state of the charge.

In one known method of operating polyphase electric furnaces of the type described above, operation is based on the equation \( R = \rho \cdot A \), and upon impedance control; more particularly, variations of the specific resistance \( \rho \) of the charge are compensated by variations, in the opposite direction, of the electrode spacing \( A \) referred to the furnace floor \( A \). In this manner the ohmic resistance of the charge within the furnace can be kept substantially constant, and in the case of a constant voltage this automatically also results in a constant current. Variations of the ohmic resistance of the charge within the furnace are thus compensated by variations of the current path. For this purpose it is necessary for the electrodes to be continually raised or lowered in accordance with the electrical conditions prevailing at each moment in the furnace. Expensive lifting equipment is necessary to enable these raising and lowering movements to be carried out. In addition, to secure reliable sealing of the furnace with respect to the electrodes it is necessary to use complicated electrode holders which can follow the movements of the electrodes, and also stuffing boxes. These electrode holders, however, cause frequent operating difficulties. Another disadvantage of this known method is that the electrodes require flexible connections for the current, coolant and measurement cables or pipes.

In contrast with this known method, the present invention has the object of providing a method of operating a polyphase electric furnace which is free from the above-mentioned disadvantages and enables the continual raising and lowering of the electrodes to be avoided. This is substantially achieved by the present invention in the following manner: upon a variation of the charge resistance, the current is kept substantially constant by means of a voltage variation counteracting the variation in resistance. If desired, this is effected manually by an operator at a suitably arranged control point. This provides a fully satisfactory method of operating a polyphase electric furnace. In particular, considerably less mechanical equipment is needed for moving the heavy electrodes rapidly and accurately. The current and coolant connections can be made shorter and more rigid, so that the reactance of the furnace is reduced. In addition, the reactance of the furnace takes place more smoothly without any unevenness which normally makes it necessary for the electrodes, to be continually raised or lowered. In other words, it is only necessary for the electrodes to be advanced, i.e. consistently with the electrode consumption rate.

The invention also includes a control device for use in carrying out the above-described method. The control device substantially comprises a two-point controller, which is arranged to respond to departures of the furnace power actual values from the furnace power nominal values for variation in an integral controller of the electrode current nominal values; a further two-point controller which is arranged to compare the varied electrode current nominal values with the electrode current actual values; a control member which is arranged to respond to departures of the varied electrode current nominal values from the electrode current actual values and to give adjustment instructions to output controllers, such as stepping or tap switch drive means for those phases of the furnace transformer which adjoin the electrode in which the current values are found to vary; a further differential control member which is arranged to show the differences between the actual currents flowing through the said electrode and the electrodes disposed nearest thereto on the two sides of it; and an additional differential control member which is arranged to only release the output control, such as stepping or tap switch drive means for the furnace transformer phase which lies between the two electrodes having the smaller current difference. The control device described above enables the present process to be carried out automatically.

The invention will be further described with reference to the accompanying diagrammatical drawings, in which:

FIG. 1 shows the circuit of a three-phase-current furnace, and

FIG. 2 is a block circuit diagram for a control device for carrying out the method according to the invention.

In FIG. 1 the circuit of a three-phase furnace is shown as an example. The electrodes 1, 2 and 3 are supplied from the three-phase-current mains R, S, T, through the transformers 7, 8, and 9, which are provided with output controls, such as stepping or tap switch drive means 4, 5, and 6. Y is the neutral line. The transformers 7, 8, and 9 need not consist of a number of single-phase transformers connected together to form a three-phase bank; it is entirely feasible to use a three-phase transformer, each of its phases lying between two electrodes.

FIG. 2 is a block circuit diagram for a control device with the aid of which, in the event of a change in the resistance of the charge within the furnace, the furnace current can automatically be kept substantially constant, by means of a variation in voltage counteracting the variation in resistance. Five controllers A, B, C, D, and E, are used as control units, and these are known in themselves, the invention is not concerned with them but with the connection of the controllers together to form a control device as a whole.

In the event of the deviation of the actual power \( P \) from the desired power \( W \), the two-input controller A varies the desired current \( I_a \) in the integral controller B. The altered desired current \( I \) is compared in the two-input controller C with the actual current \( I_a \), flowing through the electrode 1, and is also compared in the two-input controller C with the actual current \( I_a \), flowing through the electrode 2, and is also compared in the two-input controller C with the actual current \( I_a \), flowing through the electrode 3.

On the basis of the comparison of the respective currents, an adjusting instruction is produced in each of the three controllers C, C, and C. The adjusting instruction produced in the two-input controller C acts on the output control, such as stepping or tap switch drive means 4 and on the output control, such as stepping or tap switch drive means 6. This is necessary because it is not yet determined whether the voltage \( V \) between the electrodes 1 and 2, or the voltage \( V \) between the electrode 1 and 3, is to be varied, that is to say whether the output control, such as stepping or tap switch drive means 4 or
the output control, such as stepping or tap switch drive means 6 is to come into operation. Only that voltage which is associated with the currents which are least different from one another is in fact to be varied. The same is true of the adjustment instructions produced in the two-input controllers C2 and C3. The adjustment instruction of the two-input controller C2 thus acts on the output control, such as stepping or tap switch drive means 4 and on the output control, such as stepping or tap switch drive means 5. Similarly, the adjustment instruction of the two-input controller C3 acts on the output control, such as stepping or tap switch drive means 5 and on the output control 6.

In the differential controller D1, the actual current $I_a$ flowing through the electrode 1 is compared with the actual current $I_b$ flowing through the electrode 2, in the differential controller D2 the actual current $I_a$ flowing through the electrode 3 is compared with the actual current $I_b$, flowing through the electrode 1. The absolute amount of the difference $I_a - I_b$ determined in the differential controller D1 is compared in the differential controller E1 with the absolute amount of the difference $I_a - I_b$ determined in the differential controller D3, in order to ascertain which of the two amounts is larger. In the event of the absolute amount of the difference $I_a - I_b$ being smaller than the absolute amount of the difference $I_a - I_b$, a release instruction is given to the output control 4, such as stepping or tap switch drive means. In the opposite case, in which the absolute amount of the difference $I_a - I_b$ is smaller than the absolute amount of the difference $I_a - I_b$, a release instruction is given to the output control 6, such as stepping or tap switch drive means. The same applies to the differential controllers E2 and E3. Thus the difference $I_a - I_b$ determined in the differential controller D1 is compared in the differential controller E2 with the difference $I_a - I_b$ determined in the differential controller D2 to determine its absolute amount. In the event of the absolute amount of the difference $I_a - I_b$ being greater than the absolute amount of the difference $I_a - I_b$, a release instruction will be given to the output control 4, such as stepping or tap switch drive means. In the opposite case, where the absolute amount of the difference $I_a - I_b$ is greater than the absolute amount of the difference $I_a - I_b$, a release instruction will be given to the output control 5, such as stepping or tap switch drive means.

Again, in the differential controller E3, the difference $I_a - I_b$ determined in the differential controller D3 is compared with the difference $I_a - I_b$ determined in the differential controller D3. Here again, in the event of the absolute amount of the difference $I_a - I_b$ being greater than the absolute amount of the difference $I_a - I_b$, a release instruction is given to the output control, such as stepping or tap switch drive means 6, while in the opposite case, that is to say if the absolute amount of the difference $I_a - I_b$ is greater than the absolute amount of the difference $I_a - I_b$, a release instruction is given to the output control, such as stepping or tap switch drive means 5.

We claim:

1. A control device for automatically operating a polyphase electric furnace having electrodes and current supplying transformers, comprising a control circuit, a two-point controller, an integral controller, said two-point controller being connected in said control circuit to respond to departures of the furnace power actual values from the furnace power nominal values and being connected to said integral controller for obtaining variations of electrode current nominal values, a plurality of additional two-point controllers connected in said circuit for comparing said variations of electrode current nominal values with electrode current actual values, said additional two-point controllers being connected in said control circuit to respond to departures of said variations of electrode current nominal values from said electrode current actual values and to provide adjustment signals in response thereto, output control means operatively connected to said transformers for varying the current supplied to said electrodes, said control circuit connecting said additional two-point controllers to said output control means whereby said adjustment signals are provided to said output control means, a plurality of differential controllers, said control circuit connecting said differential controllers to sense the differences between the actual currents flowing through one of said electrodes and the electrodes disposed nearest thereto on the two sides of it, a plurality of additional differential controllers, and said control circuit connecting said additional differential controllers to operate said output control means for said transformer disposed between the two of said electrodes having the least current difference between them in accordance with said adjustment signals for adjusting the current provided thereby.

2. A control device as set forth in claim 1 wherein said electric furnace is a three-phase electric furnace having three of said electrodes and three of said current supplying transformers.

3. A control device as set forth in claim 2 having three primary current supply lines and a neutral supply line, and each of said current supplying transformers being connected across one of said current supply lines and said neutral line.