MODELLING OF THE PROCESS OF INDUCTION HEATING OF PIPES WITHIN THE WELD ZONE

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Modelling procedure for the process of induction heating of large-diameter pipes before welding is considered. The choice of a software package for modelling is substantiated, and an example of modelling is given. The pattern of temperature field in the weld zone and plots of temperature distribution in the pipe wall are described. An example of embodiment of the induction heating unit is given.

Keywords: *welded pipes, large diameter, weld, induction heating, temperature field, modelling*

Induction heating of the weld zone is widely used now in welding operations performed on large-diameter pipes. The induction heating unit consists of an induction coil and power supply for a medium-frequency (2400 Hz) current. Development of the unit involved mathematical modelling of the heating zone to find geometric parameters of the induction coil and parameters of the power supply for the induction heating unit, and determine the distribution of temperature in the pipe wall. The calculation methods are described in detail in studies [1–3]. The calculation results are temperature field patterns, plots of distribution of power of the heat released in a pipe and temperature, as well as integral indicators, such as power consumption, efficiency, cos φ, etc.

The calculations were performed in two stages.

At the first stage it was assumed that the pipe is continuous (has no discontinuity in the future weld location). The calculations were made by using the Universal 2D software. The software is based on the use of numerical methods (finite differences, finite elements, integral equations and their combinations) for a combined calculation of electromagnetic and temperature fields in 2D regions. This stage made it possible to determine the main energy indicators of the unit and plots of distribution of temperature along and across the pipe wall allowing for the assumption made. The calculations were made for a steel pipe with diameter D = 1420 mm and wall thickness h = = 33.4 mm. The unit has an induction coil consisting of two sections, each having two turns. Distance between the sections is 160 mm, which is sufficient to install an external pipe aligner. The calculations showed that the power consumed by the unit is P = 50 kW, time of heating to a preset temperature is t = 10 min, and electric efficiency of the unit is η = 81.7 %. The curves of distribution of temperature along the pipe wall are shown in Figure 1. Width of the pipe zone heated to a temperature of 100 °C or more is equal to 260 mm.

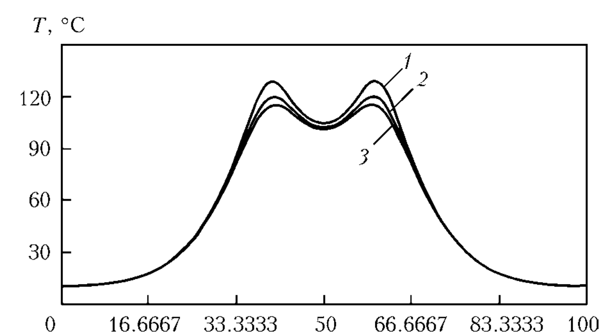

Figure 1. Results of calculations of distribution of temperature along the pipe wall at the first stage: *1, 3* — temperature of external and internal surfaces of the pipe, respectively; *2* — average temperature

The work done at the second stage included checking the calculations allowing for the shape of pipe edge preparation (Figure 2) and solving the electromagnetic and thermal problems. The temperature field pattern, plots of distribution of temperature along the concerned profiles of the pipe, and plots of variations in temperature with time in heating and cooling of the pipe were obtained. The ELCUT software using the finite element method was employed for the calculations [4]. Figure 3 shows the temperature field pattern within the heating zone, as well as location of control point X and profiles A and B. It can be seen from the Figure that the pipe has a maximal temperature of 130 °C in zones of location of the induction coil turns, whereas in the weld zone the temperature is about 100 °C. Figure 4 shows the plots of distribution of temperature along profiles A and B at the end of the heating range. It can be seen that tem-

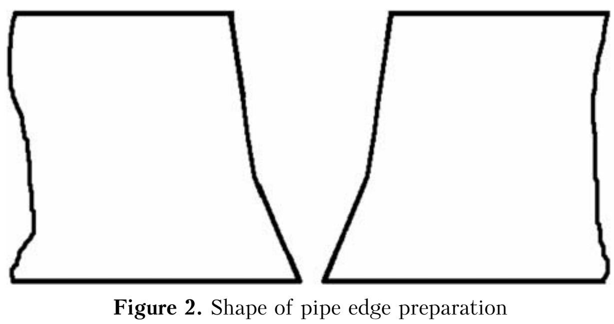

Figure 2. Shape of pipe edge preparation

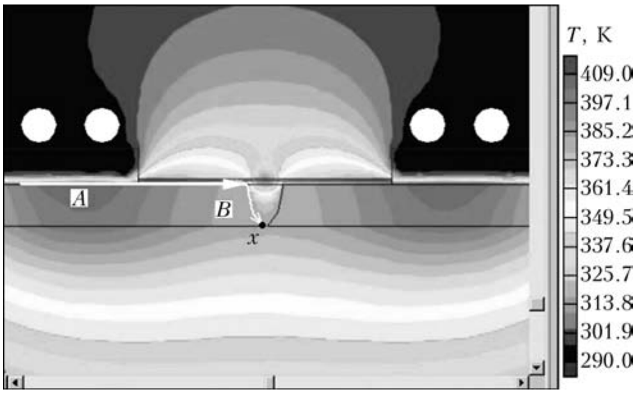

Figure 3. Pattern of distribution of temperature field in the heating zone

perature on the mating surfaces is 100 °C, while on the pipe surface under the induction coil it does not exceed permissible values.

Additionally, parameters of natural cooling of the pipe after switching off of the induction coil from the power supply were calculated at the second stage. As follows from Figure 5, surface within the weld zone remains heated to a temperature of 100 °C for about another 10 min.

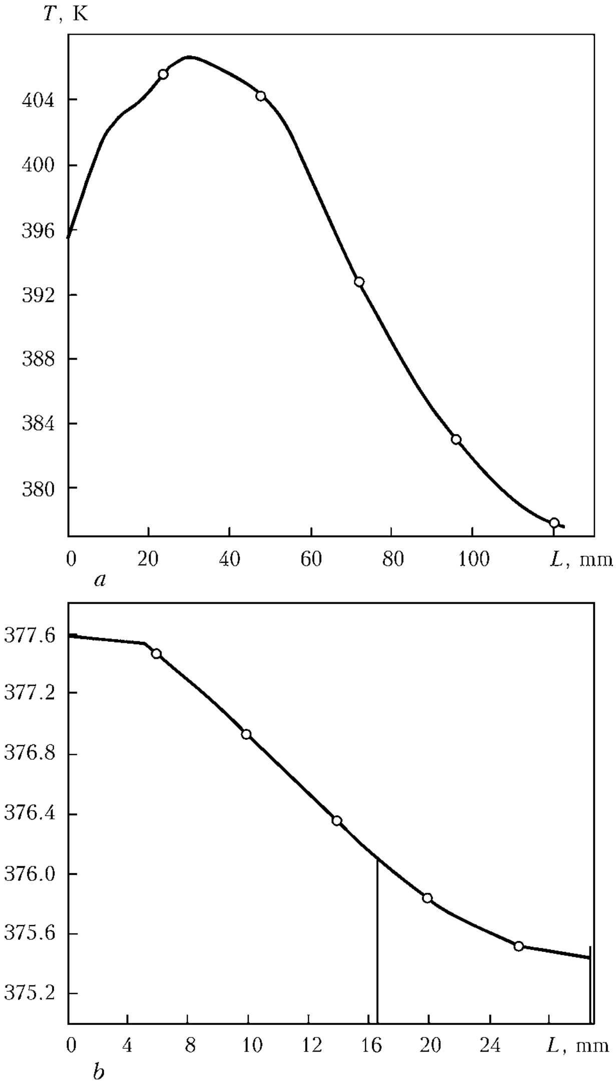

Figure 4. Distribution of temperature at the end of heating range along profiles *A* (*a*) and *B* (*b*)

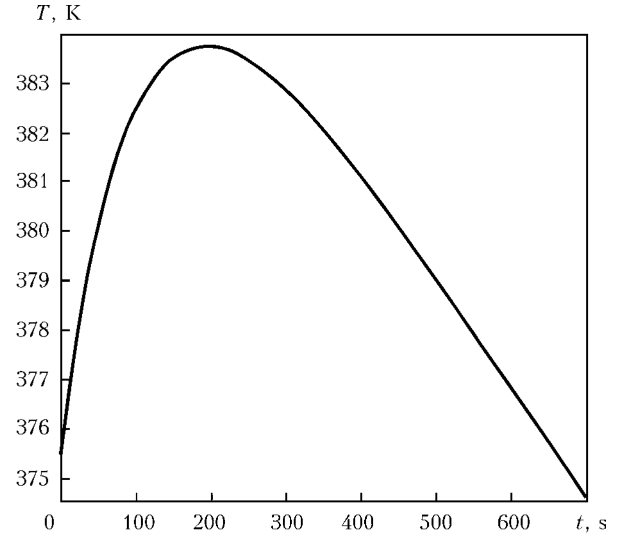

Figure 5. Variations of temperature at control point *X* in cooling

Figure 6. General view of induction heating unit ELTERM-S UINT-50-2.4

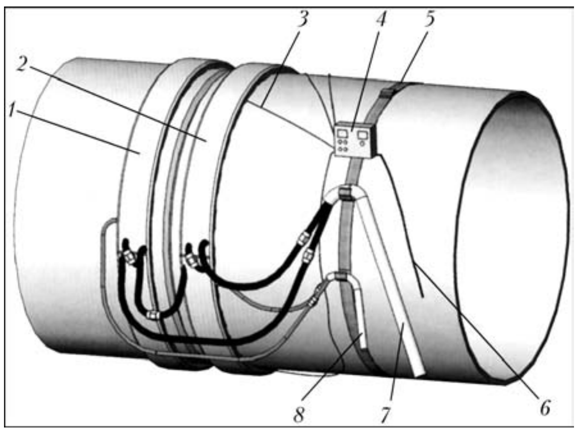

Figure 7. Scheme of arrangement of soft flexible induction coil on the pipe: *1*, *2* — 1st and 2nd induction coils, respectively; *3* — connection of thermocouples (4 pcs); *4* — remote control panel; *5* — assembly belt from a set; *6* — control cable; *7* — electric cable; *8* — water hose

Design parameters and operation conditions of induction heating unit ELTERM-S UINT-50-2.4 were optimised using the calculation results. General view of the unit is shown in Figure 6, and arrangement of the induction coil on the pipe heated is shown in Figure 7. Several types of the induction coils were designed on the basis of modelling.

The induction heating units developed and mass produced by ELTERM-S, which were optimised based on the calculation results, are high-efficiency technological units for induction heating to be used prior to and during welding.

The authors suggest using the experience accumulated from electromagnetic and thermal calculations to develop units for induction heating of different objects (pipes, fittings, shafts etc.).

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