EQUIPMENT FOR HEAT TREATMENT OF WELDED JOINTS ON PIPELINES

E.A. PANTELEJMONOV
E.O. Paton Electric Welding Institute, NASU, Kiev, Ukraine

Mobile system MKT 1420 of the equipment for heat treatment of welded joints on pipelines is described. Its capabilities are shown for optimization of the preset modes of heating using flexible electrical resistance heaters. Peculiarities of design are considered, and comparative characteristics of sectional resistance heaters intended for heat treatment of welded joints and local heating of pipelines are presented.

Keywords: *heat treatment, welded pipelines, mobile system of equipment, resistance heaters*

Heat treatment (HT) of welded joints on pipelines is sufficiently complex and labor-consuming technological process. Severe requirements on power, safety, transportability and service simplicity are made to the equipment and heating devices used for HT performance.

Special attention is made to issues of meeting and maintaining of accuracy of HT modes since the latter affect stress relaxation in the welded joints and their properties. Besides, nonuniform distribution of the temperature fields along the pipe length character for local heating of the pipeline can result in appearance of stresses higher than residual ones in a near weld zone [1]. A uniform heating of the welded joint is to be provided along the perimeter of pipe at minimum temperature difference on thickness of wall, especially, at its large thickness, for elimination of such an effect. This can be provided by means of maintaining or changing of the main parameters of HT, i.e. speed of heating, duration of holding at heating temperature and speed of cooling on specific program.

The mobile systems of the equipment, which should consist of power supply with start-up equipment, systems for measurement, control and regulation of technological parameters of HT, staff protection facilities and heating devices, can provide realization of regulated modes of HT of the welded joints. Self-contained operation and relatively small dimensions allows using mobile systems in a workshop at supply from stationary electric mains or under conditions of construction site at supply from mobile power stations.

Mobile system MKT 1420 of the equipment (Figure 1) designed for performance of HT of horizontal and vertical welded joints on the pipelines of up to 1420 mm diameter, heating of joints on pipes before welding and accompanying heating in welding [2] was developed at the E.O. Paton Electric Welding Institute. Method of radiation heating is used at that. Works can be performed simultaneously by three channels on stand-alone program. Maximum distance of system removal from the heating devices makes 20 m. Rebuilt transformers TDFZh-2002 (heating channels 1 and 2) and TDFZh-1002 (heating channel 3) are used as heaters' power supply. Control of the system is performed from a single control panel by operator (heat-treater) in manual and automatic modes. Digital device TRTsO2P makes basis of a system for regulation of heating channels. There are 12 channels for connection of the thermoelectric converters for temperature measurement. Visual control of temperature on device indices and recording on data carrier are provided for. Indicators of failure of elements of the equipment, and devices for continuous and remote control of insulation resistance of the electric mains are imbedded in a scheme of the system. Equipment of the system including power cables for connection of the heating devices are mounted at open vehicle with rigid hitch haulage attachment. Control panel, heat-ventilation unit and working place of the operator are located in a warm block. Storage facility is organized for storing of heating devices. Engineering tools provide secure servicing of the system at supply from stationary electric mains or mobile electric station.

Peculiarities of operation of MKT 1420 system can be observed at local heating of pipes of ∅1420 × 18 mm (steel 17G1S) and ∅325 × 9 mm (steel 10). Flexible

Figure 1. Mobile system MKT 1420 of the equipment

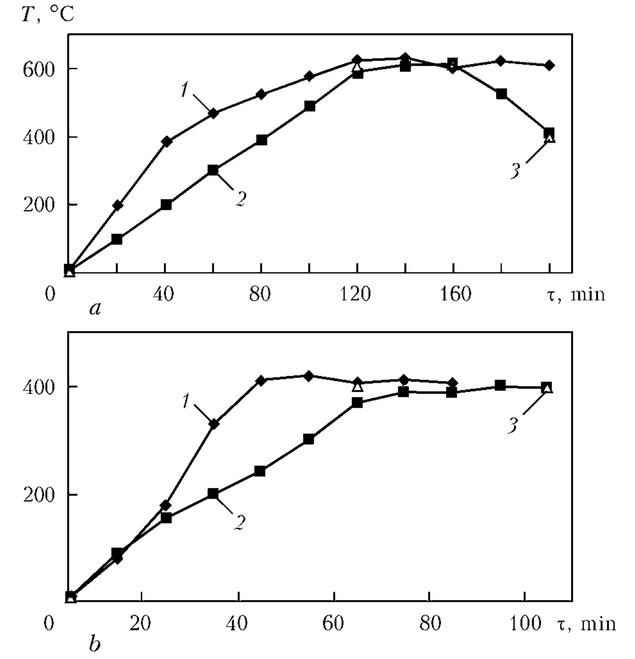

Figure 2. Dynamics of local heating *T* of pipes of ∅1420 × 18 (*a*) and ∅325 × 9 (*b*) mm at operation of MKT 1420 system in manual (*1*) and automatic (*2*) mode of control relative to preset mode (*3*)

electrical resistance heaters (FERH) were used as heating devices. Each FERH section is made in a form of flat spiral from two wires of 3.6 mm diameter. Amount of winds in the spiral equals 34 pcs [3], maximum current of the section is 120 A. Eight FERH sections were joined in two belts by four sections in heating of pipe of 1420 × 18 mm. Two FERH sections were used for heating of 325 × 9 mm pipe. Heat insulation of heating place consisted of TK-1 grade cardboard and MTPB sewing heat-insulated mats with cover from silica fabric and filling from kaolin wool.

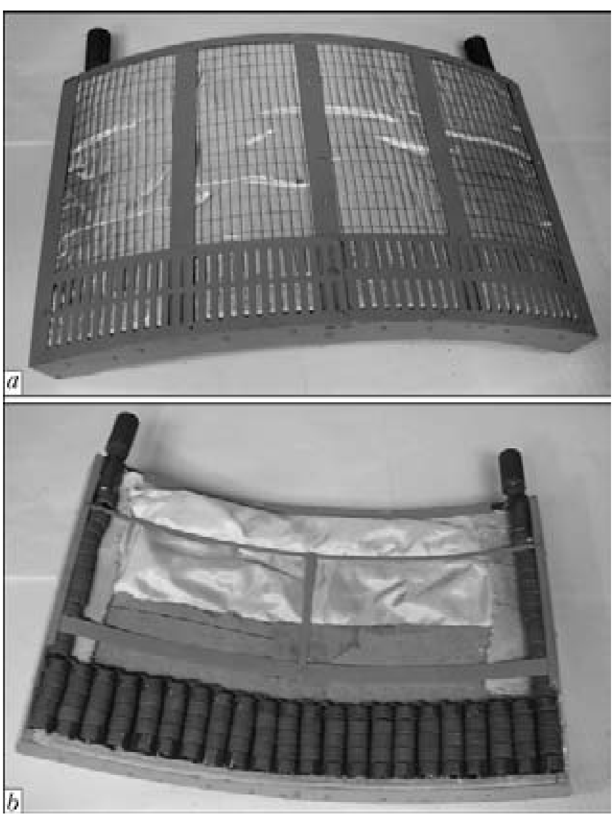

Figure 3. General view of SRH (*a*), and location of heating element (*b*)

Figure 2 shows the dependencies reflecting dynamics of pipe heating. The following parameters, i.e. speed 300 and 400 °C/h, temperature 600 and 400 °C, holding time 40 min, controlled cooling up to 420 °C during 20 min (for 1420 × 18 mm pipe) and allowable temperature deviation ±20 °C set the modes of heating of pipes of 1420 × 18 and 325 × 9 mm. Heating of pipe of 1420 × 18 mm in manual mode was carried out up to the temperature of high tempering 620–650 °C (Figure 2, *a*) at total capacity of heating devices 59.5 kV·A. Average speed of heating was equal 300–320 °C/h. Average speed of heating made 180 °C/h in 400–650 °C range, 200 °C temperature value was achieved in pipe heating for not more than 20 min. This corresponds to the requirements of normative documents on modes of heating at high tempering of welded joints on pipelines [4] and technology of heating of pipe joints before welding.

Accuracy of adjustment of specified mode of heating in manual mode depends on qualification of operator. In this case temperature deviation for pipe of 1420 × 18 mm made 200 °C in the specified interval 10–400 °C (Figure 2, *a*) and for 325 × 9 mm pipe it was 170 °C (Figure 2, *b*). Temperature of pipe exceeded the specified value by 20–50 °C at stage of holding. Temperature deviation for pipe of 1420 × × 18 mm reduced up to ±(5–8) °C including the stage of controlled cooling at transfer of the system in automatic control mode. Temperature deviation for pipe of 325 × 9 mm lied at the level ±25 °C for 10–400 °C range. Pipe temperature was 5–10 °C lower than the specified one at holding stage.

Special attention is made to fixation of sections of heaters and their outputs over the pipe at preparation of FERH or combined electrical resistance heaters to performance of HT. Sectional resistance heaters (SRH) were developed at the E.O. Paton Electric Welding Institute for the purpose of reduction of labouriousness of preparatory works and increase of safety of heating devices. Heating elements, heat-insulated cardboard and few layers of kaolin wool are located in a metal body with vent holes (Figure 3, *a*) in SRH basic design. The heating element (wire from nichrome) is realized based on FERH type. Ceramic insulators of IKN-302 type (Figure 3, *b*) protect the wire and outputs. Removable bushings manufactured from metal strip, with shoulders, limiting the displacement of insulators along the winding are used in the SRH design in contrast to FERH. The limiters are hold by spiral coupling belt. The outputs of heating element are rigidly fastened inside the body and equipped with reducing ceramic bushings for connec-

Technical characteristics of the heaters

Parameter	FERH	SRH-1	SRH-2	SRH-3	SRH-4	SRH-5
Length of spiral of heating element, m	0.72	0.72	0.72	0.72	0.72	0.72
Width of spiral of heating element, m	0.08	0.10	0.10	0.10	0.10	0.10
Number of winds of spiral of heating element, pcs	22	22	22	22	22	22
Number of wires in spiral, pcs	2	2	3	3	3	3
Diameter of wires of spiral of welding element, mm	3.6	3.6	3.6	3.6	3.6	3.6
Area of heating, cm^2	580	720	720	720	720	720
Thickness of pipe wall, mm	18	16	16	16	16	16
Insulation:						
cardboard + mats + mats	+	–	–	–	–	–
cardboard	–	+	+	+	+	+
cardboard + wool + cardboard	–	–	–	+	+	+
Arc voltage, V	44.3	38	36	36	43	46
Current, A	149	134	190	190	225	240
Capacity, V·A	6200	5090	6840	6840	9670	11000
Specific capacity, V·A/cm^2	10.7	7.07	9.5	9.5	13.4	15.3
Volume capacity, V·A/cm^3	5.94	4.42	5.94	5.94	8.39	9.58
Speed of heating in 100–400 °C range, °C/h	780	690	740	800	1200	1370

Note. Here, «+» means presence of insulation, «–» means its absence.

tion to current conducting cables. Setting of the interlocking devices over the SRH body for mutual joining in the belt and fixing around the pipe perimeter is provided for.

The Table shows the characteristics of SRH (version 1–5) and FERH. SRH designs differ in number of wires in the spiral of the heating element and heat-insulation of the device. SRH characteristics were studied at local heating of pipe from 17G1S steel of 1420 × 16 mm. The plugs were set at pipe ends. Temperature of heating was measured at points in outside and inside surfaces of the pipe at the center of heating element spiral. Difference of the temperature did not exceed 20 °C along the pipe thickness at all speeds of heating. FERH design (cardboard insulation and two layers of heat-insulated mats) provided higher speed of heating than SRH-1 (cardboard insulation) and SRH-2 (spiral from three wires, cardboard insulation). Introduction of additional insulation from cardboard and heat-insulated wool in the structure resulted in increase of speed of heating (SRH-3) at 5.94 V·A/cm^3 volume capacity of FERH, SRH-2 and SRH-3 heaters. Further rise of heating speed was achieved at increase of capacity of heaters (SRH-4, SRH-5).

$K = \Delta V / \Delta Q$ relationship, where ΔV is the heating speed increment, and ΔQ being the volume capacity increment (Figure 4), can be used for evaluation of efficiency of SRH structure. Increment of volume capacity by 1.52 V·A/cm^3 resulted in heating speed increment by 90 using FERH, 50 for SRH-2 and 110 °C/h for SRH-3. Current of heating element of FERH, SRH-2 and SRH-3 made not more than 70 A per wire. Some current overload (75 A per wire) is character for SRH-4. Increment of heating speed equaled 510 °C/h at increase of volume capacity of SRH-4 by 3.97 V·A/cm^3 and made 680 °C/h for SRH-5 at 5.16 V·A/cm^3. However, service time of heating element can be reduced due to high load of SRH-5 by current (80 A on wire). SRH-3 has optimum characteristics since spiral of heating element from three wires and combination of heat insulation from cardboard and kaolin wool are used in its structure. The heater provides high speed of heating and possibility of its increment at insignificant current overload.

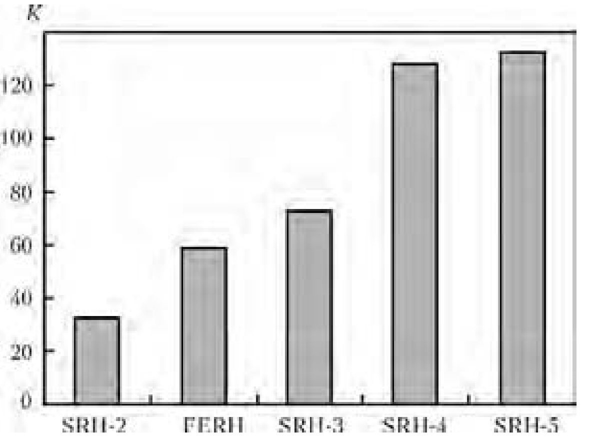

Figure 4. Index of efficiency of various heaters

Number of winds of the heating element, size and amount of SRH sections depend on pipe diameter. 12 sections of SRH-3 joined in two belts by six sections are to be used for local heating of 1420 mm diameter pipes using MKT 1420 system. Four sections should be connected in parallel to each heating channel of the system. Voltage of SRH-3 is lower than the nominal operating voltage of TDFZh transformers, common capacity of four SRH-3 does not exceed 30 kV·A and total consumed power of the system makes not less than 130 kV·A at that. Such a connection of the heating devices allows smooth adjusting of heating temperature along the pipe perimeter and providing equal current loading of all three phases of supply mains of MKT 1420 system.

CONCLUSIONS

1. It is shown that mobile system MKT 1420 of the equipment in assembly with FERH provides performance of HT of welded joint on pipelines of 1420 mm diameter in accordance with the requirements of technical normative documents and high accuracy of adjustment of preset modes of local heating of pipes of ∅325 × 9 and ∅1420 × 18 mm at system operation in mode of automatic control.

2. SRH for local heating of pipelines was developed. It differs in higher efficiency of heating in comparison with FERH and simplifies the process of preparation of heating equipment for running.

1. Rojtenberg, S.Sh. (1982) *Heat treatment of welded joints of pipelines*. Moscow: Energoizdat.
2. Pismenny, A.S., Pantelejmonov, E.A. (2003) Complex of equipment for heat treatment of pipe butts in field environment. In: *Abstr. of Int. Conf. of Current Problems in Welding and Life of Structures* (24–27 Nov. 2003, Kiev, Ukraine). Kiev: PWI, 54–56.
3. Khromchenko, F.A., Korolkov, P.M. (1987) *Technology and equipment for heat treatment of welded joints*. Moscow: Energoatomizdat.
4. *OST 36-50–86*: Technological steel pipelines. Heat treatment of welded joints. Typical technological process. Introd. 01.01.87.

NEWS

HIGH-FREQUENCY WELDING ELECTROCOAGULATOR

E.O. Paton Electric Welding Institute developed a new generation PATON-MED™ EKV3-300 apparatus, intended for performance of various surgical procedures in medicine and veterinary practice. It provides a state-of-the-art solution of problems faced by surgery and enables practical implementation of the technology of high-frequency welding of soft live tissues.

Due to novel engineering decisions, performance of surgery with application of PATONMED™ EKV3-300 apparatus ensures:

- reliability of joining tissues without resorting to sutures, staples, medical adhesives, etc.;
- absence of tissue necrosis or foreign bodies in the wound;
- leak-proofness of the joints;
- decrease of blood losses, as well as shortening of surgery duration (speed of surgery performance increases by 30–40 %);
- absence of suppurations;
- accuracy and precision of tissue dissections;
- reliable hemostasis;
- shortening of patients rehabilitation duration in postoperative period;
- fast, convenient and reliable performance of surgical interventions;
- simplification of surgical procedures;
- absence of smoke during surgical interventions, as well as other factors adversely affecting surgeon’s health.

PATONMED™ EKV3-300 apparatus can be applied to perform operations in many surgical fields, including general abdominal surgery, traumatology, pulmonology, proctology, urology, mammalogy, otolaryngology, gynecology, vascular surgery, operations on parenchymatous organs, ophthalmology, etc.

PATONMED™ EKV3-300 has four main operation modes: cutting, coagulation, manual and automatic welding. Each of the modes provides a broad possibility of selection of operation algorithms and working parameters of the process, depending on specific tasks.

Power source control is performed by microcontroller by special programs, which can be modified by the user preference, and a possibility of entering additional programs as required by the surgeons is also envisaged.

The apparatus is supplied with the basic kit of electric surgical tools (forceps and surgical clips). It can be also fitted with additional tools for open and laparoscopic surgery, which are made to Customer specification.