Equipment for connecting pipeline elements in oil and gas equipment using induction brazing

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Abstract. The article discusses the use of brazing and induction heating for connecting an oil and gas pipeline. The methodology of creating such compounds within the framework of the given problem is considered. The necessary equipment is considered and a schematic diagram of an induction heating device is created, as well as, as a result, a schematic process diagram of an induction soldering device is developed. An analysis and search for all possible solutions to this problem was made, and it was decided to focus on the use of induction soldering. The rationale for the use of induction brazing for such pipeline joints is considered. The application and development of an induction unit is proposed, which allows connecting pipelines for oil and gas equipment in order to increase the durability of the structure during operation at the facility.

1. Introduction

Soldering is a fast, accurate and controlled process [1,2]. It keeps waste to a minimum. The precision and consistency of results are ideal for automated production. Soldering allows for the rapid production of assemblies from standard components, which is more cost effective than custom-made assemblies. In addition, the relatively low soldering temperature (450 °C - 900 °C) contributes to lower energy costs.

Brazing is an amazingly flexible method. It allows you to connect a wide range of metals, including even ferrous and non-ferrous ones [3-5]. And since brazing does not melt the base metal, it is ideal for joining metals with different melting points.

Soldered joints, like welded joints, are very durable. They are shock and vibration resistant, sealed and electrically conductive. A typical solder joint is as strong, if not more durable, than the base metal to be joined. But, unlike welding, when brazing, the integrity of the metal is preserved, which does not melt [6-8].

Induction heating technology is steadily replacing open flames and furnaces as the preferred heating source for brazing. Its growing use is attributed to seven main reasons [9-11]:

• Speed. Induction heating transfers more energy per square millimetre than an open flame. Simply put, induction heating solves more parts per hour than other processes.
• High productivity. Induction heating is ideal for use in production lines. Lots of parts no longer need to be set aside or sent for soldering. Electronic control and specially manufactured inductors allow induction heating to be integrated flawlessly into production processes.

• Stability. Induction heating can be controlled to achieve stability. Enter the required process parameters into the induction equipment, and it will repeat heating cycles with negligible deviations.

• Unique controllability. Induction heating allows the operator to observe the soldering process, which is difficult when using an open flame. This circumstance and the accuracy of the regulation minimize the risk of overheating, weakening the connections.

• Good working conditions. An open flame creates an uncomfortable work environment. As a result, operator morale and productivity are impaired. Induction heating is silent. At the same time, the ambient temperature practically does not rise.

• Effective use of space. Induction stations can be easily accommodated in production cells and existing installations. And our compact mobile systems allow you to work in hard-to-reach places.

• Non-contact process. Induction heating takes place in the base metal - and nowhere else. This is a non-contact process. The base metal does not come into contact with the flame. Thus, it is protected from deformation, which, in turn, increases productivity and product quality.

2. Materials and methods
As part of the research, it is necessary to develop a schematic flow diagram of the induction soldering installation, which will allow displaying its main parts and their interaction with each other. We know that an element of an induction brazing installation that directly heats up the area to be brazed is an inductor. Since energy does not come from anywhere and does not disappear anywhere without a trace, a power source is needed. Can be used as a power source:

• Power frequency network 50 Hz.
• Machine frequency converters, from which a current with a frequency of 500 to 8000 Hz is obtained.
• Lamp generators.
• Current sources with frequency from 70 kHz to several megahertz.

The most widespread in industry are installations powered by machine frequency converters. The heating mode is controlled by an electric machine or a magnetic amplifier.

The switching on and off of heating by a contactor is used when several heating devices are supplied in parallel from one generator. With individual power supply of the heating device, the heating can be switched on and off both by the contactor and by switching on and off the generator excitation. A set of measuring instruments with current and voltage transformers is used to monitor the operating mode of the device. A high-frequency autotransformer is used to regulate the voltage supplied to the inductor and, therefore, the power transmitted to the heated workpieces. An autotransformer is installed in the case of centralized power supply. With individual power supply of a single heating device, the voltage supplied to the inductor is changed by regulating the excitation current of the generator.

The dimensions and shape of the inductor are determined by the dimensions and shape of the workpiece, as well as the required performance of the device. A photopyrometer with an amplifier is used as a sensor for the automatic heating control system. The heated workpieces are fed into and out of the inductor for further processing using a special mechanism. The first four elements of the circuit are usually located in separate rooms - the generating station.

The rest, depending on the adopted layout method, are assembled in one or several housings, installed in the workshop and form the actual unit, which is commonly called an "induction heater". The heaters are powered both according to an individual scheme, when one heater is connected to one or more
parallel operating frequency converters, and according to a centralized scheme, when several heaters are connected to a central generating station.

Individual power supply circuits are used when installing one heater in the workshop and in cases of installing several heaters, if the power consumed by each heater changes insignificantly during operation. When installing a large number of heaters in the shop with 46 significantly varying power consumption, centralized power supply circuits should be used. In this case, generators can be used better. When the power consumed by several heaters decreases, some of the generators can be stopped. Since normally all heaters do not operate at the same time at maximum load, the total installed capacity of the generators may be less with centralized power supply. With individual power supply, the heating mode is determined by the voltage on the generator, which is maintained at a set level using an automatic regulator with an electric machine or magnetic amplifier. With a centralized supply, the voltage on the busbars, to which all generators are connected in parallel, are automatically kept equal to the rated voltage of the generators. The voltage on each individual heater, and, consequently, the mode of its operation, is set using an autotransformer.

There are two schemes for transferring energy from busbars to heaters with a centralized supply:

- In the workshop, one or two feeders are installed, connected to the busbars. Heaters are connected in parallel to the feeders.
- A separate feeder is laid to each heater from the busbars.

The disadvantage of the first method of energy sewerage is the mutual influence of heaters on each other during operation. In this case, the stability of the temperature of the heated preforms can only be ensured by the use of a photopyrometer; however, the temperature difference between the surface and the core of the preform can deviate from the specified one. The performance of the heater may also change. The second method of energy canalization is free from these drawbacks, but is associated with the laying of a large number of lines, and, consequently, with high capital costs. Despite this, preference should be given to the second method. In this case, the constancy of the temperature of the workpieces can be ensured both with a photopyrometer and with a time relay.

Thus, considering all of the above, we will develop a schematic flow diagram of the installation for induction soldering, the diagram of which is shown in figure 1.

![Figure 1. Schematic diagram of an induction heating device: 1 - high frequency transistor current generator; 2 - electric machine amplifier that controls the heating mode; 3 - contactor for switching on and off heating; 4 - cabinet with measuring instruments and equipment for controlling the operation of the electric machine amplifier 2; 5 - high-frequency transformer for voltage regulation on the inductor; 6 - inductor; 7 - capacitor bank.](image-url)
3. Result and discussion

One of the tasks of this work is the development of the design of the installation, which allows soldering of flanges of fittings, pipes by the method of induction heating. The developed installation consists of an alternating current source, a generator, an industrial computer, a soldering station control unit, an inductor, a control panel, a pyrometer, an ammeter. An industrial source with a voltage of 380 V and a frequency of 50 Hz was used as an alternating current source.

The design of the induction brazing unit will be based on existing units manufactured by Petra. Thus, a schematic flow diagram of an induction soldering plant was developed (figure 2).

![Basic technological scheme of the induction soldering installation](image)

**Figure 2.** Basic technological scheme of the induction soldering installation: 1. Temperature of the measured medium, [°C] from plus 1 to plus 90; 2. Range of flow rates (flow rates) for liquid, [t/day] 15 - 1500; 3. Range of gas flow rates (flow rates), [t] 1500 - 300000; 4. Working pressure, [MPa] from 0.2 to 4.0; 5. The type of current is variable; 6. Voltage, [V] 380/220; 7. Frequency, [Hz] 50 ± 1.
Currently, there are high-frequency transistor generators designed for induction heating and include functions of supplying coolant, programmable operation, control of heating temperature control, control of cooling water flow, and having a touch screen operator panel. Transistor induction current generator of high frequency were selected transistor frequency converters PETRA-0132.

The most common application is in induction melting furnaces with a capacity of up to 400 kg, in induction hardening installations and induction heating installations for high frequency soldering of tools, as well as for induction forging heaters. They replace the previously used frequency converters of the TPCh-160, TPCh-320 type and machine frequency converters of the HPCh type.

4. Conclusion

The use of induction brazing for connecting pipelines in oil and gas equipment was justified. In the course of the work, a circuit diagram of the induction heating device was designed, and an overview of the current state of the soldering was carried out. As a result of this work, a schematic diagram of an induction heating device was designed for an induction installation and a basic technological scheme of the induction soldering installation.

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