Mobile Processing of Pipeline Assembly Units

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Abstract. The paper addresses the issues, related to the preparation of pipeline docking elements during the repair and recovery of pipelines in field conditions with a limited scope of technological equipment. It has been shown that the replacement of traditional processing methods by combined types of preparation of replaceable pipeline sections for welding can improve the accuracy of mating elements, preventing the occurrence of burrs at the joint. This enhances the quality of repair, ensures the tightness of pipelines, reduces the cost of operation and the period of pipeline recovery. The application of the electric-contact method of processing assembly units, based on the proposed schemes, makes it possible, without sophistication of mobile servicing means, to timely restore the performance of products, eliminating the causes of emergency situations in construction and during operation of pipelines in hydraulic systems of transport machines, especially when used under operation in high-pressure media.

1 Introduction

During the operation of pipes in high-pressure pipelines and in mechanisms of various equipment types, there is often a loss of tightness, which requires the replacement of damaged metal sections with new ones using permanent joints, for example, through welding or soldering. As a rule, the traditional methods of mechanical removal of damaged parts and adjusting new elements require the use of various types of technological equipment and accessories, as well as the disassembly of units, which is not always possible in the field conditions or when products are used at their operating site. At the same time, the availability of welding in repairing complexes assumes the presence of electric power sources with the parameters, required for combined processing by the electric-contact method and for tool rotation. The new process takes place in an available working fluid, (i.e. industrial water), and ensures high accuracy of surfaces, mating for welding and having no burrs. Herewith, there is no mechanical impact upon mating elements, which retains the desired geometry of joints.

2 The schemes of electric-contact processing of pipeline joints

During repair and recovery, joints can have different geometric shapes. Figure 1 shows the
schemes of electric-contact processing of various types of mating surfaces during their preparation for welding under conditions of repair.

Fig. 1. The schemes of pre-processing electric-contact treatment of pipeline mating surfaces.

a) cutting by a disk electrode
1 – a pipe for pipeline repair; 2 – a disk electrode-tool; 3 – a pipe section for pipeline repair; 4 – electrode rotation; 5 – a nozzle for process fluid supply; 6,7 – low-voltage DC source (+,-).

b) piercing a connecting channel in a pipeline
1 – a pipe of a pipeline for repair; 2 – a tubular electrode-tool; 3 – working fluid; 4 – tool rotation.

c) piercing a joint in a tube 1 for repair;
2 – a tubular electrode-tool; 3 – working fluid; 4 – tool rotation.

Figure 1 represents the scheme of carving a pipe section for pipeline repair.

Here, the lengths of the repair pipe 1 of section 3 are shown, required to replace the damaged and removed part of a pipeline. The electric-contact separation is performed by the disk electrode 2 with its rotation 4 around the axis when fed for incut into the pipe 1. To intensify the procedure, the working fluid 6 is supplied to the zone of separation through the nozzle 5. As a rule, it is industrial water, available in every instance of pipeline repair. During its use, the chemical effect occurs due to anodic process under the DC action, hence, the process of separation becomes an erosion-chemical one, and the separation capacity of pipe sections increases by up to 15-20 times, while the electrode wear decreases by 2-3 times. The low-voltage current (12-32 V) is supplied through a flexible cable from the source 7, according to the scheme of direct polarity, presented in Figure 1.

In the same pattern, a defective pipeline element is removed. The use of the electric-contact method for a segment (Figure 1, a) drastically reduces the labour intensity of the procedure; eliminates the possibility of deformation, edging and burrs; decreases the drive power for rotation and feed of the electrode-tool; gives the opportunity to replace the expensive vulcanite disks with those of low-cost steels; prevents the risk of vulcanite destruction and injury of workers.

If it is required to completely replace the part of a pipeline (Figure 1, b) and make a hole in it to fit the new pipe section, the scheme is used, similar to the one, shown in Figure 1. Here, tubular electrodes are used as a tool, the outer diameter of which can equal the inner or outer diameter of a pipe in a replaceable pipeline section. The electrode 2 is fed during its rotation 4 along the axis. The process liquid 3 is supplied from outside to the site of pipe processing by means of free sprinkling or under pressure. If it is necessary to remove the remnants of the welding roller from the pipeline surface, the scheme is used, presented in Figure 1, a.

In the instance of attaching a new side section 1 during the repair (Figure 1, c), it is
required to form a curvilinear profile at its end, having the diameter of a joint with a pipeline. For this purpose, the outer radius of the tubular electrode tool 2 is selected to equal the radius of the line pipe. The processing is performed in the similar process liquid 3 with rotation 4 of the electrode, being fed along the axis.

3 Technological modes and parameters of electric-contact separation in the industrial water

With all schemes of processing, presented in Figure 1, the efficiency of using electric-contact cutting is evaluated by analyzing the technological parameters in recommended technological modes, under conditions of mobile pipeline repair and recovery. Here, there is a significant change in requirements for parameters (as compared with serial production of pipelines), namely, the reduction in the separation rate is allowed, the requirements for electrode-tool materials and liquid operating medium are eased, and the automation of feeding is simplified. However, it remains essential to stabilize the process, assign a safe voltage and select or adapt the parameters of the available current source.

According to [1], the electrode feed rate depends upon the intensity of instrument feed and is regulated by the voltage on electrodes, assigned within up to 36 V and controlled by the value of the current. In mobile auto-repair plants, the DC generators of up to 100 A are mainly installed for welding. On this basis, we review the technological capabilities of using the available sources for electric-contact processing of pipes in steel pipelines. Figure 2 shows the dependence of the checked parameter (current) upon electrode voltage when separating steel blanks by the disk and tubular electrodes.

Fig. 2. The dependence of the scheme of technological current upon the voltage on electrodes. 1 - a steel 3 tubular electrode; 2 - a steel 45 disk electrode

The studies, presented in Figure 2, are conducted when separating 45 sheet steel samples of 1.2 mm in thickness, at a circumferential tool speed of 12-15 m/sec.

The analysis of Figure 2 suggests that the process of separation is possible with currents
of up to 100 A. This value is provided by available generators, however, even with ultimate current loads, the treatment in process water is 2-3 times slower, than in the liquid glass, recommended for the given method of processing in [1; 2; 3].

The modes of electric contact processing in water and the resulting technological parameters for analyzed variants of mobile preparation of pipelines for assembly are presented in the table, in which a disk and a thick tubular electrode act as tools.

Table 1. Modes and parameters of combined electric-contact processing

| No | Patterns of processing                      | Modes               | Parameters                       |
|----|--------------------------------------------|---------------------|----------------------------------|
|    |                                            | Voltag e, V | Curren t, A | Disk speed, m/sec | Disk feed, mm/min | Roughness of cutting, Kα, microns | Average electrode wear, % |
| 1. | Trimming with a disk electrode             | 24         | 60-70      | 10-12              | 20-30             | 10-15                             | 12-15                     |
| 2. | Cleaning with a disk electrode             | 24-30      | 40-50      | 10-15              | 20-25             | 5-10                              | 8-10                      |
| 3. | Piercing a connection channel              | 30-32      | 80-100     | 35-40              | 80-100            | 15-20                             | 10-12                     |
| 4. | Piercing a joint                           | 30-32      | 60-80      | 35-40              | 80-90             | 10-15                             | 10-12                     |

In addition to the parameters, listed in the table, it is necessary to consider the error of extending the contact surface, obtained by electric-contact processing. This parameter depends upon the performer’s skills, however, in any case, the deviation from a plane or a mating surface geometry must not exceed 0.3 mm, which complies with the requirements for pipeline welding and soldering.

It follows from the table that the surface roughness at the junction of elements meets the requirements, established for obtaining hermetically welded seams in permanent joints.

During electric-contact processing, the material is heated in the zone of the electric discharge, which causes the change in the surface layer. Numerous tests and experience of using the combined process, described in [4-6], have shown that the depth of change at the boundaries of steel parts does not exceed 300 µm, which does not affect the quality of a welded seam and the tightness of a joint.

4 The perspectives for using electric-contact processing in the assembly of pipelines of building structures and the recovery of hydraulic systems of products

The repair and recovery of pipelines is part of technological processes, in which combined processing methods can be effectively applied. For this purpose, it is required to improve the technological parameters of the process without a decline in economic results. The studies in this area, presented in [7;8;9;10] have shown that the increased productivity and improved quality of the surface layer and processing accuracy are possible through
replacement with a more powerful source of technological current (up to 4000 A) and switching to a liquid glass-based working fluid with higher concentration of up to 40%. Figure 3 describes the change in machine time with increasing concentration of liquid glass in water.

Fig. 3. The impact of liquid glass concentration upon the time of blank cutting. Material of the part: 1 – stainless steel; 2 – construction steel; 3 – titanium alloy. The diameter of a blank is 90 mm. L – the zone of unstable process flow with low content of liquid glass in water.

The analysis of Figure 3 shows that the replacement of the processing medium with a more expensive and insufficient one (liquid glass) can significantly improve the technological parameters of electric-contact cutting and create the conditions for the process to be used in finishing operations, related to product manufacturing in construction and mechanical engineering.

The separation in processing water is most labour-intensive, in which the increase in cutting depth (more than 5-10 mm) causes mode failures, overheating of tools and sticking of the workpiece material to a disk, resulting in its buckling and the loss of accuracy in mating elements of products.

Figure 4 shows the results of analyzing the efficiency of using electric-contact separation of blanks, manufactured from different metals, in liquid glass, under optimal technological modes, described in [1].

As shown by Figure 4, the traditional method of mechanical processing is adopted as a basic type of separation. It considers the cost of tooling, electricity and labour intensity of the procedure.
Fig. 4. The production cost of a similar procedure of separation, performed by the blade and abrasive tooling. 1 – the basic type of material separation and electric-contact separation of materials: 2 – aluminum alloys (as shown by riser-cutting and sprueing); 3 – cast iron; 4 – construction steel; 5 – stainless, heat-resistant alloys; 6 – titanium alloys.

5 Conclusion

The presented materials make it possible to assert that the combined processing methods [4], one of which is an electric-contact one, can be extensively used not only in the repair and recovery of pipelines, but also during their laying in the period of constructing the building structures. They are also used to replace the accepted procedures of mechanical processing, since they allow to reduce the time of the operation, do not need further cleaning of workpiece joints during their assembly, prevent the possibility of environmental pollution and work safety violation, and do not require the disassembly of pipelines for accessing the operation site.

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