Development of a robotic system of nonstripping pipeline repair by reinforced polymeric compositions

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Abstract. The article considers the possibility of creating a robotic system for pipeline repair. The pipeline repair is performed due to inner layer formation by special polyurethane compositions reinforced by short glass fiber strands. This approach provides the opportunity to repair pipelines without excavation works and pipe replacement.

A well-developed pipeline network is necessary for the stable and safe extraction of solid minerals by a mining enterprise. In accordance with the purpose mine pipelines are divided into the following categories: fire-irrigation, mine drainage, filling material, compressed air (up to 16 bar), degassing, air conditioning systems.

In mines the pipeline is subjected to a constant negative impact - the mine atmosphere and slightly acidic formation water, oxygen dissolved in the water, and wandering electrical currents, resulting in steel pipes subjected to constant wear, aging and destruction. To replace unsuitable parts of the pipeline and repair the equipment expensive operations are carried out. They are performed to deliver the necessary materials and new sections of steel pipes to the mine field with the subsequent replacement of an unusable pipeline section.

This article presents the idea of a promising technology of pipeline repair by creating an inner layer with special polyurethane compounds reinforced with short fiberglass strands. Unlike traditional means of repair, the proposed approach provides a significant reduction in the cost of work by eliminating the preparation and delivery of pipeline sections. In contrast to relining, cost reduction is achieved through continuous filling of the pipeline interval. There is no need for preliminary blowing of the hose. Inexpensive chemical reagents of Russian and Chinese production are used. Repair can be done directly from the mine field without the necessity to stop the process of mining.

Recently, solutions from polyurethanes are most widely used in comparison with all polymer compositions. These compositions are actively used in underground construction. Also, they are employed in mining in case of high formation pressures and temperatures to strengthen and isolate the wells’ walls, to create anti-filtration barriers from formation water and to isolate the walls of production [1–4].

The employed synthetic resin compositions can be one-component or two-component. In the first case, the polymerization of the composition usually occurs, when it interacts with water. In the second case two components are mixed immediately before entering the working interval, where they polymerize, entering into chemical reactions between themselves and water. The advantage of the first approach is the possibility of using relatively simple pumping equipment. The disadvantages are the limited storage time of the compositions, the complexity of the polymerization control, and high
sensitivity to the water saturation of the medium. The advantages of two-component compositions are their lower cost and dependence on water saturation, the ability to control the polymerization time of the composition by simply changing the concentration of the activator in one of its components.

Implementation of this approach is possible through the development of special technical means (Figure 1).

![Figure 1. General view of the pipeline’s repair device: 1 – two-channel line of the fluid supply, 2 – line of the fluid supply, 3 – polymeric shell, 4 – body, 5 – polymer layer, 6 – hydraulic packer, 7 – preliminary cleaning of the walls, 8 – pneumatic breakdown mechanism](image)

The body 4 must be made of a smooth solid material, for example, a steel pipe in which the holes for formulations’ supply through the 2-channel line 1 are made. For a reliable fixation of the body, a rubber coupling or hydraulic packer 6 can be used. The pressure will be controlled by line 2. The transportation of the device along the pipeline can be performed by a pneumatic breakdown mechanism 8, with preliminary cleaning of the walls 7 [5–6]. This device will make it possible to form a polymer layer 5 that solidifies inside pipeline and creates a polymeric shell 3.

The operation of the pipeline interval’s repair can be performed according to the following scheme (Figure 2).

![Figure 2. Pipeline repair operation.](image)
Step 1. The beginning of the pipe is sealed with a rubber clutch, preventing the polymer from leakage outwards.
Step 2. The packer is being inflated, thus, sealing the work interval and centering the device in the pipe. The polymer composition is placed in the space between the device and the pipe, the pressure is monitored by a manometer.
Step 3. After the polymer is supplied, the time after which the composition will lose its plastic properties is detected. At this point, the pressure in the packer is released and the device is moved further along the pipeline, so that the body is adjacent to the newly created layer.
Step 4. After the device is moved to the next section of the pipeline, steps 2 and 3 are repeated.

The device suggests separate injection of the components of the composition and their mixing in the interval between the inner wall of the pipeline and the repair device. This feature will reduce the requirements for the used pumping equipment, as well as help to avoid problems with the contamination of the operating hydraulic equipment associated with the high reactivity of polyurethanes with water.

The resulting inner layer will be smooth, which will reduce the possibility of pipeline contamination. Reinforcing the composition with fiberglass threads will prevent the destruction of the layer under mechanical loads on the pipe.

Conclusion
The development of the proposed method and the creation of technical means for repairing the pipeline through the creation of an inner layer with special polyurethane compounds reinforced with short fiberglass strands will significantly reduce costs in case of pipeline section’s repair and replacement and will extend its service life.

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