Device to support section of major pipeline under repair in trench when doing repair works

A M Akhmedov

Institute of Architecture and Civil Engineering, Volgograd State Technical University, 28, Lenin Avenue, Volgograd 400005, Russia

E-mail: asvar05@mail.ru

Abstract. The article proposes a multi-functional innovative device for major repairs of main pipelines. The objective is the improvement of several process technologies through designing an innovative device for the “lean” realizing of repair works. The use of the device will enable to exclude the involvement of pipe-layers when carrying out some work processes as a part of major repairs techniques. The device is designed to preserve the environmental situation. With the help of the proposed device, during the implementation of capital repair methods, several technological processes can be performed: support of the repaired section of the pipeline, lifting the pipe section from the laying mark, moving the repaired section to the trench edge, laying the repaired section to the bottom of the trench. All of these processes, it is possible to perform with a full preservation of the integrity of the pipe insulating coating and its "body" along the entire length, without bending stresses, longitudinal and transverse forces in the areas of welded joints. For the implementation of technological processes, the device is installed at a certain distance from each other, which depends on the weight of the repaired section of the pipe, its diameter and ground conditions.

1. Introduction

Annually, the major repair works are carried out by oil and gas companies along the several thousands of kilometers of main pipelines. When performing the major repair techniques, one should strive to minimize the stress strain state in the “body” of the main pipeline under repair [1,2].

2. Importance

Maintaining the reliability of the existing pipeline network is important. The preservation of the spatial position of the section of the main pipeline in the trench during the overhaul is very relevant.

3. Formulation of the problem

To date, in the implementation of methods of major repairs of main pipelines, it is simply necessary to support the repaired section of the pipeline. Currently, the production support is carried out by various devices and technical means that are not perfect and have a number of significant shortcomings. The issue of preserving the pipe wall and the condition of the welds is an important problem that needs to be addressed. The issues of reducing stress-strain state is an important problem.

4. Target

The aim is to develop an innovative device that will eliminate damage to the pipe wall in the performance of repair work, laying and lifting of the pipeline section.

5. Method of scientific research

As a method of scientific research the method of modeling is used. A 3D simulation model of the proposed technical solution is developed, which gives a good visual concept.

6. Theoretical part

Out of the existing technical level, it is known that to preserve the integrity of weld joints and the "body" of the section under repair especially on big diameters, special supports are used, for instance, "Atlant" [1,3,4], or features special earthen prism [2]. Apart from that, there is a technology [5] which foresees building special jumpers under the lower generating line of the pipe in the trench made of biodegradable sacks with sand.

As a matter of experience, the scientists [6] work reveals that the actual period of pipeline exploitation is 40-50 years and the operating life of contemporary insulation is not exceeding 15 years which results in the multiplication of break-downs. It should be noted that the contemporary insulation put onto the pipes factory prepared is claimed for 40-50 years of service life. By so doing, if using the same coating under the field conditions, its durability will not exceed 15 years.

Regrettably, this result is obtained due to the fact that the field techniques of putting insulation coating are not perfect nowadays, and the existing technical means do not ensure the needed quality level of operating practices for insulation coating. To improve the situation, new technical means and the introduction of new methods are needed [7,8]. It is only these that can improve the technical and economic performance [9].

However, it should be noted that in different climatic regions of our country, different temperature and soil conditions [10] requires the use of special technologies, machines and technical means that will be adapted to the environment. Hence, when developing techniques and technical means, it is needed to create engineering solutions that can be used everywhere. Only in this way, one can achieve a "breakthrough" in major repairs of the pipeline system in this country.

The paper [11] deals with a mathematical model for strain stress state of the main pipeline section in heat treating, during major repairs. When heating a pipeline section, there appear rather severe bending; hence the issue of using special engineering solutions to carry out the work process of support for a long time period plays a very important role in preserving the integrity and safety in further exploitation. Many factors impact the reliability of a main pipeline [12] after building and repairing among which a quality of the performed works has great significance.

Out of the existing technical level, a device [13] is known for supporting a pipeline section under repair consisting of anchor stays joined by cross-beams. The anchors for spatial stability are screwed into the soil. The drawback of the device is the fact that it enables only to support a pipeline section, and there is no possibility of its fast release in the design, for instance, when moving repair machines along the pipe for the re-insulation process.

To carry out lifting and supporting of pipeline section, there is another device [14] consisting of movable lifting mechanism constituting inflatable bags joined by belts and a compressor.

A device is known consisting of wood lumps in each of which there are six gutters. The gutters are laid one on another in mutually perpendicular directions. However, the device is not perfect and manual labor is needed to use it [15].

There is a device [16] to support a pipeline the design of which enables to exclude a digging machine. A system of hydraulic jacks is fixed on the device that supports the pipe in place. However, the mounting and subsequent dismounting of this device is simply impossible without some manual labor in the trench itself.

There is also another device to support the pipeline in the implementation of capital repair methods [17], which consists of a frame with mounted gripping parts, moving relative to each other by means of threaded connections. The device will allow to fix the pipe rigidly, but it is not possible to quickly

remove the device from work, which will lead to a forced stop of technological processes during major repairs. However, there are other technical solutions that allow to support the repaired section of the main pipeline [18-20].

The aim of the work is to improve the technological processes included in the technological sequence of the methods of overhaul on the main pipelines.

To achieve this goal it is necessary to solve the following tasks:

- develop a design that will allow the device to be used in all climatic regions of our country;
- provide the possibility of supporting the pipe section for a long time;
- develop a device that is environmentally friendly to the environment;
- develop a mechanism to reduce bending stresses arising in the" body " of the pipeline when performing methods of overhaul;
- develop a multi-functional device to be able to perform multiple processes.

The novelty of the work lies in the fact that for the first time a device with an original design solution is proposed, which will allow to improve several technological processes included in the technological sequence of traditional, currently used methods of capital repairs on the main pipelines.

For implementation of technological processes in the implementation of repair on the main pipeline 1 (Figure 1), an innovative device is offered, which is installed on the bottom of the trench 2 with the help of a lifting device. The device consists of 3 trenches 2 twisted into the ground on both sides, screw piles 4, on which two spatial metal frames 5 and 6 are rigidly fixed, with guiding casing 7 attached to them (Figure 1).

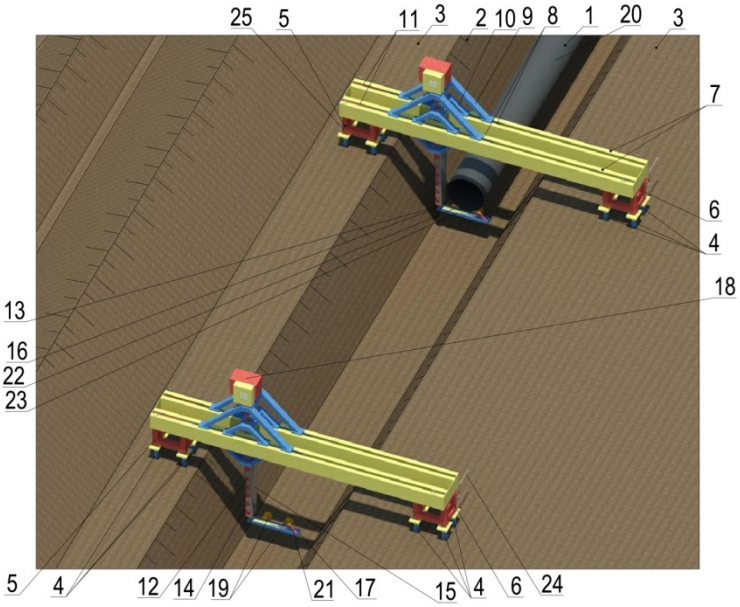

Figure 1. Spatial view of the proposed device for supporting a pipeline section under major repair: 1 – main pipeline, 2 - trench, 3 – lateral sides of the trench, 4 – screw pile, 5, 6 – spatial metal frame, 7 – guiding casing, 8 – system of guiding rollers, 9, 10 – spatial movable frames, 11 – hydraulic jack, 12 – the vertical support bearing element, 13 – rod with thread, 14 – telescopic shaped pipe, 15 – rubber coating, 16 -loops , 17 – horizontal support bar, 18 – actuator, 19 – two rollers, 20 – insulating coating, 21 – fixator, 22, 23 - hydraulic jack, 24 – lever, 25 – technological opening.

Inside of each of the guiding casing 7, a system of guiding rollers 8 are put which are fixed to the spatial movable frames 9 and 10. Frames 9 and 10 are driven in a reciprocating horizontal motion along the guiding casing 7, with the help of hydraulic jacks 11 installed inside them with hydraulic return of rods. Inside of the spatial frames 9 and 10, a vertical supporting bearing element 12 is rigidly fixed which is made of a vertical shaped rectangular pipe.

To enable an elevation to-and-fro motion for the supported pipe 1, a telescopic shaped rectangular screw-threaded pipe 14 moves inside the element 12 with the help of the screw-threaded rod 13 (Fig. 1). To prevent the insulation damage of the supported pipe 1, the rubber coating 15 is fixed on the vertical support bearing element 12 and telescopic shaped pipe 14. A screw-threaded rod 13 is put inside the telescopic shaped pipe 14 to the end of which loops 16 of special design are attached. A horizontal support bar 17 is rigidly fixed to the lower part of the loop 16. The actuator 18 (Fig. 1),

electrically powered, is fixed on the top of the rod 13, it allows to turn the horizontal support bar 17 through a full 360. As a result, we can put the rod 16 both in the longitudinal and crosswise direction relative to the repaired pipe 1.

To fixate the position of the pipeline section under repair, when supporting it, there are two rollers 19 on the horizontal support bar 17 excluding the damage to the pipeline wall and insulating coating 20. For a safe and reliable support of the repaired section of the main pipeline, there is fixator 21 on the horizontal support bar 17, which moves with the help of hydraulic jacks 22 and 23.

For the true horizontal position of the guiding casing 7, when bringing them in position, there are mechanical jacks inside the spatial metal frames 5 and 6 that move in vertical to-and-fro motion with the help of the lever 24 which is put into specially technological opening 25 to turn it. The management of the device's movement is done by an operator with a distant controller.

The device works as follows.

The proposed devices are put at the intervals from one another specified by the design, the interval depending on the diameter, weight, and length of the repaired section. The screw piles are driven in the places pre-marked by surveyors. After that spatial metal frames 1 are fixed on them. Further, the alternate installation of guiding casing 7 with the help of a lifting device and then perform the installation of the remaining parts of the device.

After bringing all the devices into working condition, the repaired section of the pipeline near each of the devices is lifted from the laying mark by one pipelayer, with the help of tick. After that, using a remote control a vertical support bearing element 12 is brought to the pipe from the lateral side. Therein, the telescopic shaped pipe 14 with the horizontal support bar 17 is smoothly lowered. When sinking the telescopic shaped pipe 14, horizontal support bar 17 is brought into the parallel to the pipe position by the actuator 18.

After the lifting of the pipe section in the area of the supporting device position to 30-40 cm by a pipe-layer, the horizontal support bar 17 is brought under the pipe by the drive element 14 located at the upper end of the rod with thread 13. The turning of the horizontal support bar 17 is at an angle of 90 degrees. As a result of the movement, the horizontal support bar 17 is put across the pipe 1 axis. Further, moving the hydraulic jacks 22 and 23, up to the pipe the fixator 21 is brought which is necessary for the additional fixation of the pipe under repair. Upon completing all the above operations, the tongs are released, and the pipe section is smoothly given for the further support by the device. The pipelayer with the tongs comes to the next supporting device and puts it into operation in the same manner. The pipe-layer finishes its work after putting all the supporting devices into operation.

7. Practical importance

The practical significance of this development lies in the fact that the device is specially designed for field conditions when performing techniques in the overhaul of the main pipelines.

8. Conclusion

The following results were obtained owing to the development of the innovative device and the analysis of its possibilities:

- the negative impact on the environment is reduced, due to the exclusion of pipelayers in the implementation of technological processes;
- there is a possibility of "careful execution" of the technological process of supporting the pipeline section;
- it excludes the occurrence of bending stresses in the areas of welded joints and the pipe body during the entire time of technological processes (Figure 2);

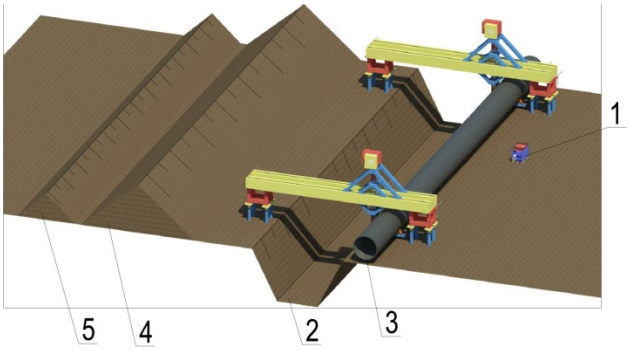

Figure 2. Spatial flow-chart of movement of the main pipeline repaired section with two devices to the trench edge: 1 – electric generator, 2 – trench, 3 – the pipeline section under repair, 4 – dump of inorganic backfill soil, 5 – dump of vegetable soil.

- the need to involve pipe-layers is avoided when moving maintenance machines along the pipe during the major repairs technique with re-insulation, for instance (Figure 3);

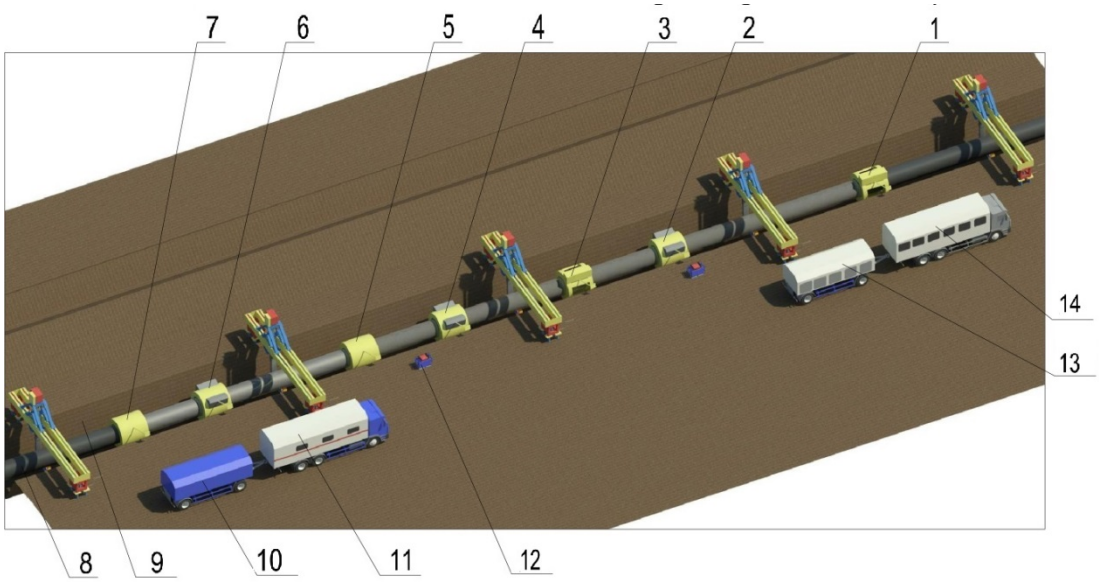

Figure 3. Spatial flow-chart for the major repair technique of the main pipeline section with re-insulation using the innovative supporting devices: 1 – cleaning machine, 2 – machine for secondary cleaning, 3 – cleaning machine for the final purification, 4 – machine for heating a pipe surface for the application of prime coating, 5 – machine for the primer application, 6 – machine for the heating the primed surface of the pipeline, 7 – insulation machine, 8 – pipeline section under repair, 9 – trench, 10 – maintenance trailer equipped for the primer regeneration and storing of insulation materials, 11 – mobile laboratory for weld inspection and insulation works, 12 – electric generator, 13 – container with the insulation stuff, 14 – maintenance crew vehicle.

- due to the design of the device, it is possible not only to perform the supporting work process for the main pipeline section under repair, but also three more processes (laying pipe onto the trench bottom, lifting from the bottom level, as well as the moving it to the trench edge for further cutting up or spool replacement);
- due to the possibility of moving the section under repair to the trench edge, there appears an opportunity to simplify the replacement of defect portions of the repaired section for new ones, and this is especially important in repair works on big diameters;
- when repairing on the edge, a lifting device is required (pipe-layer with lesser load lifting capacity) since the works for back placing of pipe section is done by the proposed devices

only, and the pipe-layer moves equipment and smaller pipe sections in their direct replacement;
- non-productive movements of workers and machines are reduced;
- the design of the device is done so that it can be reusable;
- there is no need to involve pipe layers in order to support repair and technological machines for the implementation of the re-insulation processes.

References

[1] Mukhamedova D C 2011 Modern technical and technological solutions to improve the efficiency of gas pipeline repairs *Young Scientist* **5** pp 86–88
[2] Semin E L 2011 Overhaul of main pipelines using ground and inventory supports *Pipeline transport*m **4** pp 25–27
[3] Abramyan S G 2013 Technological scheme of replacement of insulation during reconstruction and overhaul of main pipelines using GIS technologies *Bulletin of VolgGASU* **30** pp 342–345
[4] Muhammadova D C 2016 Some features of designing the production of works on the overhaul of main pipelines by the flow method *Young Scientist* **9** pp 233–235
[5] Akhmedov A M 2014 Development of environmentally safe way of laying the main oil and gas pipeline *Vestnik MGSU* **5** pp 100–107
[6] Usmanov R R, Askarov R M and Topilin A V 2014 Overhaul of gas mains - the basis for extending the period of their reliable and safe operation *Problems of oil gathering, preparation and transport and oil products* **4** pp 148–154
[7] Filatov A A, Khalliev N Kh and Dubinsky V G 2012 Extension of the period of reliable and safe operation of LPGS is the basis of the concept of stage-by-stage repair of gas pipelines *Gas industry* **9** pp 26–28
[8] Khallyev N Kh 2014 The concept of maintaining and prolonging the period of reliable and safe operation of the linear part of the main gas pipelines *Russian Journal of Management* **3** pp 84–89
[9] Topilin A V 2014 Complex methods for increasing the efficiency of capital repairs of the linear part of the main gas pipelines *Problems of collecting, preparing and transporting oil and oil products* pp 143–147
[10] Mosyagin M N 2012 Analysis and choice of methods for repair of main gas pipelines of Gazprom transgaz Surgut LLC *The gas industry* **9** pp 22–25
[11] Muhammadova D Ch, Khallyev N Kh 2012 Mathematical model for calculating the stress-strain state of LCHM under major repair with preservation of its spatial position in the horizontal and vertical planes *Young Scientist* **7** pp 37–39
[12] Mukhamedova D Ch 2012 Methods of planning the technological processes for the overhaul of main gas pipelines *Young Scientist* 1 pp 22–24
[13] Matveev Yu G 2014 *Supporting centering device for the end section of the main oil or gas pipeline,* Patent RU, no. RU 148090
[14] Aksyutin O E 2010 *Device for raising and supporting a pipeline in a trench*, Patent RU, no. RU 90522
[15] William K 2016 *Support assembly and components thereof.* Patent US, no. US 20160319959 A1
[16] Shlomo Kline 2015 *Pipeline lifting and supporting apparatus for maintenance and restoration purposes* Patent US, no. US 2015/0078832 A1
[17] Tianjin Huibo Pu Pipeline 2017 *Technology Company, Pipe quick repair device,* Patent CN, no. 106838539A
[18] Siegmund Huber 2008 e.a. Patent EP, No. 1703187 B1
[19] Kenneth L 1978e.a. Patent US, No. 4130204 A
[20] Garry Mclvor 2003 Patent US, No. 2003/0039509 A1