Method for Pipeline Section Retrieval for Overhaul with Complete Replacement

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Abstract. Earthworks required for overhaul or reconstruction of underground trunk pipelines with complete replacement of pipeline sections are one of the most labor-intensive. The paper suggests a new innovative method for retrieving a pipeline section to avoid using a single-bucket excavator along the entire section. The method reduces the duration of overhaul involving complete replacement of a worn-out pipeline section. The technology suggested is intended to improve the method of pipeline overhaul with complete pipeline section replacement. The study is focused on a set of devices used to retrieve a pipeline section. Based on a 3D model simulating the process flow of pipeline section retrieval, the related processes were observed and studied in depth, and the suggested innovative solutions were adapted as part of the repair and construction flow. The new method helps to, firstly, simplify the process of overhaul with complete replacement, secondly, improve the ecological situation in the construction area, and thirdly, upgrade the repair and construction flow outfitting. All pertinent equipment and devices can be used multiply, which is an indisputable advantage. The method is environmentally safe and suitable for all climate conditions, including complex ones. This innovative method allows retrieving underground pipeline sections regardless of their diameter. A broad use of this pipeline section retrieval method is ensured by a regular set of machinery and equipment available to nearly all repair and construction organizations and remotely controllable to reduce workforce needed for the above overhaul operations.

1. Introduction
Presently, the “aging” process of main pipelines is increasing with every passing year in our country. In overhaul methods with the complete replacement of the pipe section under repair, there is a need to retrieve the section.

In case of inner examination of the pipe state and trouble-shooting of essential corrosion defects, various sediments and decision on the complete replacement of the section for a new one, as well as major repairs with laying a new pipe parallel to the existing one (looping).

2. Topicality
Today, the “aging” process of main pipelines in our country is increasing with each passing year. When overhauling with the complete replacement of the pipe section for a new one, there appears a need to retrieve the worn-out section out of the ground, which requires earth-movers and lifting machines. The oil and gas industry needs new innovative techniques and devices now that enable to bring the overhaul process and reconstruction to a new level improving technical and economic
performance. To retrieve a pipeline to the soil surface by conventional method with a single-bucket excavator, it is necessary to do a large amount of earthworks, and to lift the pipeline from embedding level by pipe layers which increases the duration of overhaul works with the complete replacement of the worn-out section. The application of the proposed method in overhauling with the complete replacement of the pipe section under repair enables to retrieve the pipe faster which puts it into operation ahead of schedule.

3. Problem setting
It is necessary to increase the overhauling processes rates for main pipelines. It is needed first of all for the service ability of pipelines and the reduction of incidents and break-downs. The faster and more efficiently is the overhauling process on one of the sections, the quicker the construction and maintenance equipment can be moved to another repairable object. Moreover, the preservation of the environmental situation plays an important role in the zone of overhauling process.

4. Target
The target is to develop a technique for retrieval of a pipeline out of the soil.
   To achieve the set goal, it is necessary to solve the following tasks:
   - to design a device for the retrieval of a pipeline;
   - to develop the device as autonomous, mobile and easy in operation;
   - to exclude pipe layers to retrieve the pipeline to the soil surface.

5. Method of study
As a method of study, the modeling technique has been used. Applying this method, a spatial 3D simulation model of the proposed device was developed, a process flow for retrieval of the pipeline from soil was carried out.

6. Theoretical analysis
Let us consider the existing technical solutions on the retrieval of pipeline sections from soil.
   A method of pipeline retrieval is known [1], the essence of which is that the end of the pipeline is stripped at first and put under its bayonet joint which is linked by cables through a special cross-beam with the hauling plant equipped with the ripper arrangement. When the towing machine moves along the section which is to retrieve, the ripper fixed behind it makes the soil ripping over the upper line of the pipe, and the bayonet joint when moving creates a lifting force that pushes the pipeline to the soil surface.
   There is another method of the pipeline retrieval [2], the pipeline is stripped at the beginning of the retrieved section and put a bayonet joint and rollers under it that are linked by platforms with a towing machine. When moving the towing machine with the devices fixed behind it, the pipeline is retrieved to the surface.
   In [3], it is proposed to cut pits at a certain distance from each other with the subsequent ripping of soil over the upper line with the help of a ripper tooth and the retrieval of the pipe with pulling rope loop embracing the pipeline. According to the invention description the given method enables to cut earthwork volumes in the retrieval of the pipeline to the surface.
   According to the method [4], to retrieve a pipeline section, it is proposed to strip the working trench in the beginning of the retrieved section and to fully strip the pipeline and to cut the pipe in it. Moreover, along the whole length of the retrieved section, according to this method, it is needed to rip the soil over the upper line of the pipeline. Further, a special device in the form of cable loop is fixed in the beginning of the section under the lower line and it is linked with the towing machine. Pipe layers are put behind the towing machine, their hooks are connected to the pipe by pipe lifting devices. The towing machine and pipe layers move in synchronicity which enables to lift the pipe to the surface.
In all the given methods, the retrieval is performed with the full soil ripping over the upper line of the pipeline section which will aggravate the moving of towing machine, and this is a considerable drawback of these methods.

A device is known for retrieving pipelines from the soil [5], which is composed of a spatial framework with pipe centering clamps and hydraulic cylinders track-mounted. To retrieve the pipe, the catch pits are cut along its length. The retrieval starts from the first pit. The pipe end is lifted and pulled through the centering clamps. As a result of hydraulic cylinders’ action, the device moves along the whole section of the pipeline, and the pipe is drawn from the soil.

In [6], a device is proposed consisting of a body-frame with a wedge cutting the soil over the upper line and the lifting beam behind it is for lifting a pipe from the embedding level. The device is joined to the base machine creating a pulling force.

There exists a device [7] applying which a pipeline can be retrieved, composed of a wedge-like ejector attached to the base machine. Behind the ejector, there is a pipe layer with a lifting beam for the finishing lifting of the pipe to the soil surface. The operation of the device is done as follows. In the beginning of the retrieved section, a base machine is put for pulling force. The device is connected to the base machine. Then, the pipe section is lifted and the wedge-like ejector is brought under the lower line of the pipe. After that, the movement along the pipeline section starts, at that the lifted section is connected to the pipe layer thought the lifting beam.

A complex is known for disassembling a main pipeline [8], composed of a pulling device joined with a tow car. The pulling device is brought under the pipe when disassembling and when moving ahead the pipeline is drawn from soil to the surface. However, this complex has a drawback lying in the fact that in order to disassemble it requires to create great pulling force, so a high-powered machine with good ground contact is needed. Moreover, the machine creating pulling force will eject a great amount of harmful substances, thus polluting the environment.

There exists another device for stripping a pipeline [9] including a trailing frame with support in the form of carriers with running wheels on which a special plow is fixed with a pin hinge. This trailing device is attached to the machine which creates pulling force, for example, to a bulldozer. To retrieve a pipeline with this device, several passes are needed along the retrieved pipeline, and this is a considerable drawback.

Aside from the above mentioned devices, another one is known [10], consisting of a plow and lifting mechanism with rollers and a leveler in the form of bulldozer blade. This device is also imperfect, as it is not to be used for pipelines of big diameter.

In [11], a device is proposed to retrieve an embedded pipeline with the help of a plow enveloping it. At that, the plow is designed resting on the pipeline through carriers. Apart from the plow, there is a ripper in front of the plow in operation. This device is attached to the hauling plant.

There exists a device [12] consisting of an unpowered tracked chassis with longitudinal and cross beams. There are two I-shaped portals on the frame on which a monorail is fixed with a running roller and a mechanism for pipe clamp and its drawing. The drawback is that in operation, the device is to be moved which requires extra machinery.

In [13], a special device is proposed composed of a wedge-like hollow shell which is put under the pipeline at the beginning of the section. At that, it is needed to cut a pit with a complete cleaning of pipeline from soil, according to the patent description. The wedge-shaped device is attached to the base machine creating pulling force by a cable loop.

In [14], it is proposed a technique of disassembly for a worn-out pipeline section by means of pipelayers. To perform this method, a sump (catch pit) is made at the beginning of the retrieved pipeline section. After that, trolley hangers are brought under the lower line of the pipeline and the pipe retrieval is started. The method has a drawback, when in operation, there is a risk of pipelayers overturning, that decreases the operational safety.

A device is known [15] for pipeline retrieval from soil consisting of a trailing frame with the support, a plow fixed on the frame with blade the cutting edge of which has an oval form to envelop
the pipe from above, as well it has a special lifting trolley to support the retrieved part. This device is connected with the base machine by a trailing appliance.

A method of trench opening and underground pipeline retrieval is known in disassembly and overhauling, including ripping and disposal of vegetable soil with subsequent re-cultivation and mineral earth backing beyond the trench [16]. The drawback of the known method is the fact that when retrieving the pipeline and its lifting to the trench edge, there occurs the pipeline bending and, therefore, misalignment, which results in buckling and weakening of welding joints, as a result, the risk of mechanical damages increases, hence, decreasing the reliability of the method.

In [17], a special device is proposed representing a plow of special form which enables to strip a pipeline. The plow is tied to the base machine by a cable loop. The soil in stripping is laid onto lateral sides along the trench which causes difficulties for workers and for machine in doing subsequent operations.

Apart from this, there exists a system for retrieval and stripping (cleaning) of the pipeline consisting of a tracked chassis, trolley hanger [18] and a rope joint enveloping the pipe. For its operation, the device is put on the pipe and joined to the base machine. The drawback of this method is the fact that it is needed to create big pulling force for the movement of the device along the pipe.

A technique of disassembly of a main pipeline is known [19], the essence of which is that assembly pits are made at certain distances from one another with the complete stripping of a metal pipeline surface and its cutting, soil ripping over the upper line of the pipe, and pulling a cable loop along the pipeline. Moreover, to retrieve the pipeline a tip chute is made, and after that a horizontal pulling of separate pipeline sections is performed. The drawback of this method is the necessity of a repeated ripping of soil above the pipe, high energy costs, and labor intensity of the pipeline retrieval. One more drawback of this method is also a great resistance that a towing machine must overcome, which results in critical load of cables and their breaking. Still another drawback is that in realizing the technique, mechanisms and equipment connected with one another are used simultaneously which requires a high maturity of the process. One more drawback is that when only one part of the equipment is out of order, for instance, a cable, it results in a full stop of the pipeline retrieval.

A device for pipeline retrieval is known [20] which consists of tandem parts tied together. In front, there is a base machine with a ripper and after it go trailers that retrieve the pipe.

The method of retrieval of the worn-out pipeline section 1 is carried out with the help of a specially designed device. The device (Fig.1) is composed of two trailers 2 and 3, as well as air cushions 4, put in pits 5. The trailers 2 and 3 are mounted with both lateral sides from the pit along the path of the service string. Each of the trailers is equipped with outboard supports 6 securing a spatial stability in operation. The outboard supports operate from the power generator 7. Trailers 2 and 3 are connected with one another in operation by metal links 8. Guide rails 9 are fixed in the longitudinal direction on both trailers. On trailer 2 on rails 9, a carrier 10 is fixed suitable for reciprocating movement. On the carrier 10, a bearing part 11 is put to which a spatial framework 12 is linked inside which four couples of rails 13 are fixed for movement of two extra carriers 14 along them. On each carrier 14, the hauling winches 15 are mounted. The movement of carriers 10 and 14 is done with the help of hydraulic cylinders 16 and 17. Framework 12 can turn to 90°, using cam rails 18, a bearing part 11, and pulling winches 19, 20 mounted on both trailers. To easily turn the framework 12, special guide rollers 21 are mounted on its lower surface. Mounting loops 22 are put on the spatial framework 12 from two lateral sides for the connection with the winch’s hook. A compressor 23 operating from power generator 7 is mounted on the trailer 3 for the work of air cushion 4. To fill the air cushion, a compressor 23 is mounted on one of the trailers. The compressor 23 is linked to the air cushion 4 by rubber hoses 24 for air injection. A video-camera 25 is mounted on the lower side of the spatial framework 12 for the positional checking of the retrieved pipe 1 in operation.

The proposed method of the worn-out pipeline 1 retrieval goes as follows. Prior to setting-up of the proposed device and the realization of the technique, it is necessary to cut vegetable mold to the width of the right-of-way 26 (Fig.1b) for the overhaul using the bulldozer 27. The vegetable mold should be transferred to the waste pit 28. Further, distance 29 between the pit 5 axes 30 is calculated at
appropriate interval which depends upon the soil type, its physical properties, hoisting capacity of the applied winches 15, and air cushions 4. After that, catch pit 5 is developed using excavator 30. The soil from the pit 5 is deposited to the dump 31. And the pipe section in the pit 5 is completely cleaned from soil from all the sides.

The cutting of the retrieved pipe section is followed at the end pits in order to separate it from the basic string of the main pipeline. Further, along the band 32 equaling the pits 5 width, the soil ripping is carried out above the upper line of the worn-out pipeline 1 using bulldozer 27 equipped with rip teeth 33. Air cushions 4 are laid under the lower line of the pipeline. Further, using any transportation means, for instance, a bulldozer, trailers 2 and 3 are at first moved pneumatic-tired to the pit 5 position, and then, they are put in pairs onto the outboard supports 6 close to each pit 5 stripped by excavator 30. After that, the two trailers are rigidly tied using metal links 8 and cam rails 18. Using winch 20 that is fixed on trailer 3, the spatial frame 12 mounted on trailer 2 is turned by 90° along the cam rails 18 and is rested upon the guide rails 9 of trailer 3. Extra carts 14 with winches 15 inside the spatial frame 12 are mounted above the pipe 1 and are linked to it by special webbing belts. Each belt is fortified by special metal chains from outside for better strength. An air cushion is put on the bottom of each catch pit and is connected to compressor 23 by rubber hoses 24, the compressor working from power generator 7. After all the devices are set-up and connected to the control panel, the retrieval of the worn-out pipeline section starts. After the retrieval from soil, the worn-out pipeline section is cut to pieces and removed from the constructional project.
7. Practical implications

The practical implications lie in the fact that the proposed method is designed for the retrieval of worn-out pipeline sections in overhauling with the complete replacement of a pipe and reconstruction. Moreover, proposed devices can be used in maintenance of pipeline section when performing various technological activities, and namely:
- support of a pipe section when cutting jointed pipe sections for further transportation;
- support of a pipeline in preparatory processing during new pipes stringing;
- replacement of pipe layers when laying new pipeline into the trench.

8. Conclusion

The proposed method of the pipe retrieval enables to facilitate overhauling techniques with complete replacement of the worn-out pipeline section and looping. Due to the totality of the proposed devices, the retrieval method is environmentally safe.

Each of the proposed devices works fully autonomously due to the power generator which enables to realize the technique in all the climatic areas of our country where pipelines are laid underground. This method can achieve:
- partial exclusion of single-bucket excavators;
- reduction of workers, pipe layers operators;
- the need to involve pipe layers to lift a pipe from the embedding level;
- the technological process of pipe section retrieval is performed due to synchronous and simultaneous operation of all devices which accelerates the retrieval rate;
- management of devices is carried out from control panel by an operator who monitors the work of each of the devices using a closed circuit;
- the work of devices in this method is controlled by an operator enabling to fully automate the whole process and exclude superfluous non-productive movements of technicians and engineers when performing the retrieval;
- the proposed method is easy in realization and all components for the assembly of the device are everywhere available;
- due to the simultaneous action of the pulling force from the winches of the proposed device and pushing force of air cushions, a pipe section is equally retrieved from the soil to the surface;
- due to the fact that all the devices work from the control panel, the complete automation of the whole technological process of the pipeline retrieval to the soil surface is achieved.

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