Innovative assembly line for building and major repair of main pipeline

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Abstract. The article proposes an innovative assembly line for pipe sections under field conditions excluding pipe layers. With the suggested assembly line the alignment of pipe sections can be done for welding works. Apart from this, the proposed line can help in insulation works, support of pipeline section, and laying of the finished pipe section onto a special supports along the trench. can be performed. The assembly line is equipped with hoists enabling to lift pipe sections and finished strings without lifting facilities used in conventional technique which will considerably improve environmental situation and cut financial expenditures. The offered assembly line will considerably improve the equipment of the repair and construction site as well as improve the working conditions of the personnel. The assembly line is fully electrically powered which makes it ecologically friendly. An innovative assembly line is treated in the article that is adapted to operate on the construction site. The line was developed as multi-functional one. With the help of this proposed line, there is the opportunity to fully automatize erecting and sheathing and laying works. The application of special anchor-type supports will make it possible to provide a spatial stability while performing the jobs.

1. Introduction
In order to perform installation works in realizing the contemporary conventional building technology or the major repairs techniques for main pipelines, the pipelayers are used as lifting facilities. These machines are commonly used due to their structural design and peculiarities of lifting equipment. However, while operating in the general construction train, in laying the string welded pipeline into the trench, there appears a risk of stability loss and turning over which can result in a big economic damage.

2. Topicality
The main pipelines in this country in their length are laid in different nature and climate conditions. Presently, oil and gas industries need new innovative solutions which can be used everywhere. Moreover, innovations should be fully automatized, self-supporting, cutting the workforce as well as decreasing the negative environmental impact. Given the fact that there are some difficulties in pipeline exploitation in wintertime not only in the moderate climate of this country but also in northern areas, it is necessary to bypass liquid fuel and to switch to cheaper and alternative energy sources.
The proposed inventions will enable to improve all the drawbacks mentioned above. The topicality lies in the fact that the offered invention enables to provide a complex improvement of all the building operations both in construction and in major repairs.

Let us consider the existing technical solutions on the topic under discussion.

There is the invention [1] for assembling pipe sections in building where all the technological operations are done on a specialized site on which all the equipment is located for the work. The pipe sections are transported by special driven rolls. The essential drawback of this invention is that the special assembly line is designed in static mode and cannot be quickly moved to the other location.

A line is known for assembling and welding pipe sections [2] consisting of a framework with special pack racks on which all the technological processes are done from preliminary up to insulation works. The metal frame is put on wheels which facilitates its moving the line from one place to another.

Work [3] proposes a method enabling to lay the finished pipeline onto the trench bottom without pipelayers. Two single bucket excavators are needed processing the trench under the pipeline along the whole length. Under the gravitation force, the pipeline will stepwise be lowered to the project level. However, this technique has a drawback – it is impossible to provide a flat surface of the trench bottom to lay the pipe.

To execute assembling works in [4,5], it was suggested a front-gantry stacker with which assembling of pipe sections can be done in building and major repairs. The adjustment of lifting facilities to work together with the control panel that is in the operator's cabin requires experts and manual labor which maximizes the assembling and activation time.

There exists a pipelayer of another design [6] US 4108317 with two booms from both lateral sides. At that, there is no counter weight absolutely, there is a boom instead. For the spatial stability of the pipelayer, there is a machine with a fixed boom from the side where there should be a counter weight. The essential drawback of the known pipelayer is the fact that as a result of the counter weight exclusion and its substitution for a boom connecting to another machine results in enlarging the width of the surplus land for building a main pipeline which increases the costs.

There is a technical solution where a hook is fixed to the bucket of an operational head of the single bucket excavator that lifts and moves a pipe section and lays it onto the trench bottom[7]. However, despite the design flexibility all the units of the working head of the excavator should be extra enforced which requires additional plant modernization and that results in extra financial expenditures.

The invention [8] proposes a technical solution for assembly works where tractors are fixed on the both sides of the trench which are connected to one another by a beam with cantilevers. Moreover, there is a cargo boom on the beam from one of the sides by which all lifting operations are done. To use this technical solution on the construction site, it is necessary first to move the vee block of the mineral excavation soil farther from the trench edge in order to move machines unchecked enlarging the working width for building or major repairs. Moreover, it is necessary to provide conformity and synergy of the machines tied with one another.

Another technical solution is known [9] in which a special complex is proposed for assembly works consisting of two machines located on both sides of the trench that are united by a special horizontal structure on which there is a hanger for fixing and supporting a pipe.

A pipelayer is known the construction of which is done in such a way as to wholly exclude its turning-over in assembly works [10]. For this purpose, a special base mounting with a removable caterpillar track is foreseen in the design which enhances the stability in cross direction. Moreover, the design according to the description provides moving the facility on automobile and railroads with no need for its disassembly.

To assemble pipe sections, there is still other technical solution [11] where a whole complex is fixed to the working head of the excavator instead of a bucket, which not only supports the connectible pipes but also lines up the pipes for the following welding.

To line up the pipe sections in joining pipes in a single string in [12], a pipelayer is proposed to which an extra boom is attached from the rear side which supports a connectible pipe.
The essential drawback of the given technical solution is the fact that in lining up there appear inertial forces which will hamper the concentricity (alignment).

Out of the existing level of technology, a device [13] is known to perform a quality lineup of pipe sections for the further welding works.

To lineup pipe sections, another device [14] is known where pipe sections are lined up by a special mechanism. However, the device cannot be used without supporting pipes.

In [15-17] propose innovative technical solutions to carry out installation works in construction and major repairs which can find a wide application.

In the device [18], a special gantry system with hoists is proposed to link pipes of big diameter.

Moreover, a pipelayer [19] is suggested with a displaced center of gravity which enables to provide a better spatial stability in installation. However, when transporting, there will be difficulties.

To carry out major repairs, a special mobile repair base [20] is proposed composed of some elements. The given repair base enables to provide restoration of pipe insulation and to reuse them.

3. Statement

When applying conventional techniques for building main pipelines, there is a problem lying in the fact that all the installation works are done by pipelayers and this has a number of following drawbacks:

- the pipelayers cannot be transported fully assembled on the roads because they are bulky and this requires manual and machine labor to assemble and later disassemble them when relocating, hence, it results in the growth of financial expenditures;
- when assembling the pipelayers, it is needed to adjust sensors in lifting ability and their synchronizing with a board computer which results in involvement of experts with software, this too can result in financial expenditures;
- the pipelayers operate on the liquid fuel resulting in the environment pollution;
- the application of pipelayers in installation works and specifically in pipe sections assembly for welding and subsequent laying of the finished string onto the trench bottom do not preclude the appearance of bending stresses in the pipe “body” and at the zones of welding joints which results in defects potentially leading to accidents in the further exploitation of the pipeline;
- when using pipelayers in all the technological process of pipeline laying to the trench, there is a risk to lose the stable position and turning over which results in enormous financial outlay;

In the conventional technology of main pipeline construction, there are a lot of lifting facilities the operation of which has a negative impact on the environment in the working area and this is an essential drawback and a problem.

From the above mentioned, it is safe to say that the assembly works in the construction technology need improvements. The above described problem and confirmed by a number of essential drawbacks is very urgent today.

4. Target

The objective of the research is the complex improvement of the techniques for construction of main pipelines based on the proposed special assembly line.

5. Problems

To realize the target goal, the following problems are stated:

- to develop an assembly line for improving the construction techniques and methods for major repairs;
- to exclude the use of pipelayers when building and major repairing pipelines.

6. Methods of scientific research
When solving the set target, the methods of comparison and modeling were employed. At that, the modeling method was used by way of creating an imitation spatial 3D model of the construction spread.

7. Scientific novelty

The scientific novelty of the study is as follows: a multifunctional innovative device is proposed for the first time to carry out technological processes and the device is transformed into a unique assembly line for construction of a main pipeline as well as for methods of major repairs with a complete or partial replacement of a section excluding the use of lifting facilities operating on liquid fuel compared to conventional techniques.

The assembly line consists of two parts. The first one (Figure 1 a) is composed of two end 1 and one middle special trailer 2 on which sections of pipes 3 with special traveling mechanisms 4 are fixed. The spatial stability of all trailers at lineup is realized with the help of outriggers 5. To improve the working conditions of welders and insulation workers, when doing their job they are not on the ground but on a platform 6 with a stage 7 which can be adjusted in altitude for access to the top generatrix of the pipe in order to visually control the quality of adjoining the pipe edges and of the subsequent technological processes.

![Figure 1a. The first part of the assembly line: 1 – end special trailers, 2 – middle special trailer, 3 – sections of the connectable pipes, 4 – traveling mechanism, 5 – outriggers, 6 – platform for workers, 7 – altitude adjusted stage](image)

The second part (Figure 1b) of the assembly line for the spatial stability is fixed in operating position with the help of outriggers 8 to which conveyor screw 9 is fixed rotating with drive 10. Rotation and windup of shear key 9 into the soil are done with drive 10 put in a special metal box. The second part has been designed to specially exclude the need to use pipelayers in assembly works. On the horizontal part of the frame, two pairs of rails 11 are fixed on which trolleys 12 are positioned driven to to-and-fro motion by hydraulic cylinders 13 with the hydraulic return of rods. The opposite trolleys 12 are connected pairwise to one another with metal spatial leading elements of frames 14 on which there are pulley blocks 15. To move the whole second part, base mounting 16 and draw bars 17 are foreseen.
The assembly line (Figure 2) consists of devices connected with one another in one line by top hitches. The number of devices in the assembly line depends upon the number of pipe sections which are necessary to weld in a string. When operating, the pipe trucks move under the second part of the device where the pipes in them are moved by pulley blocks onto the first part of the assembly line where their lineup, welding, and subsequent welding joints insulation take place. Whereupon, the whole welded string is lifted and the first part of the device is transported forward by a bulldozer and after that the pipe is laid upon pneumatic cushions 7. Whereupon, the whole second part of the assembly line is moved following the first one, and all the technological processes are repeated again.

8. Practical importance
The practical importance of the invention lies in the possibility to use the device in hard to access places as well as in places with harsh climatic conditions. The practicality of the work is to exclude pipelayers from the construction spread which affects favorably the technological, environmental, and economic aspects of construction techniques in general.

9. Conclusion
The assembly line for construction and major repairs of main pipelines is realizing the concept of "lean manufacturing".

The proposed assembly line will enable:
• to improve the working conditions of the stuff when assembling the pipe sections in a string and, hence, to increase the quality of works;
• to cut the number of lifting facilities in the construction spread;
• to reduce nonproductive movements of machines and lifting facilities to improve the environmental situation due to reduction of environmental discharges from operation of pipelayers.

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