

# The device for center adjustment of pipe joints to carry out welding works when building and major repairing main pipelines

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**Abstract.** The device is created to carry out high-quality center adjustment of pipe joints setting a required opening between the joints' edges. The proposed device is totally autonomous and can be applied in all the climatic zones of Russia. The proposed device in the paper is adapted to the conventional method of major repairs with a partial replacement of pipes. The device excludes the use of internal clamps. To visualize the process, simulation 3D models have been developed. The use of the device will enable to improve the equipment for the repair and construction site. The device can be used both in the site and the field conditions. Applying the proposed device enables to weld pipe joints not only in the length but also in the strings. The outriggers are applied to spatially stabilize the device in the working process. The management of the device is done with a remote control console which enables to quickly prepare it for service.

The oil and gas industry today needs “breakthrough” technologies and technical means enabling to bring the construction and major repairs to a new qualitative level. First, devices are needed excluding the unproductive movements of workers and machines. Second, power efficient technical facilities are necessary for saving energy and reducing the harmful impact on the environment. Third, it is necessary to transfer to a more eco-friendly fuel or an alternate fuel.

The objective is to develop a device for center adjustment pipe joints in terms of quality herewith reducing a negative impact on the environment.

In order to support the set objective, it is necessary to solve the following tasks:

- to analyze the existing own engineering solutions;
- to develop design solution of a device enabling to upgrade the working conditions for the personnel involved in welding of pipe joints;
- to reduce the harmful exhausts into the environment compared to the conventional technology;

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- to create the 3D simulation models of the device to more real comprehension of the device within the process flow scheme for the major repairs technique with the partial replacement of pipes;

- to adapt the proposed device into the composition of the conventional repair and construction site.

Out of the existing level of technology, a device [1] consisting of semi-rings suitable for the fixation between them is known. According to the description, it is possible to provide the rigid fixation of two pipes relative to each other with the needed weld gaps for the subsequent joint welding. However, to use the device, it is necessary to first lay down the mating pipes sections onto the special supports which requires the manual labour and the additional preparation of the site.

In the [2], a device fixed in place of a bucket at a single-bucket excavator is suggested. The device enables to center adjust the pipe sections for welding with the help of the cross frames with the transposable elements extra fixed on a beam. The given invention has a drawback – the device cannot be used for all the pipe diameters in a wide range that reduces its countrywide application in the oil and gas industry.

In the invention [3], a device enabling to center adjust the pipe sections is proposed. According to the description, the device consists of a beam with the two fixed supports suitable for fixing the sections fitting for welding using special belts with the driving units. Wherein, the axes alignment of the two pipes is done with the help of a driving unit regulating the belt tensions. However, the given device has a drawback – to make it operational, it is needed to involve manual labor.

One more invention [4] is known, with the pipe-layer using the fixed extra equipment to support the pipe sections and the position fixation when center lining the pipes. The essence of the invention lies in the fact that the fitting pipe section is fixed in the needed position in lining using the pipe-layer boom and an extra boom fixed behind the pipe-layer. As a result, the fitting pipe section is fixed along in two places, which excludes virtual shifts when adjusting.

The drawbacks of the given invention:

- the support of the pipe section should be done by the pipe-layer up to the completion of the joint welding excluding the pipe-layer freeing and using it in some other place for subsequent works;

- to set the gap between the pipe ends it is necessary to bring the sections together up to 2-3 mm, and this is not possible using the given facility at once, since bringing the sections together there will appear inertia forces resulting in collision of and as a result it will lead to defects of the sections ends.

Yet another device consisting of semi-cylinder sections made of metal [5] is known. For spatial rigidity, each semi-cylinder section is made with stiffening plates. Moreover, the device's sections are connected from one side using hinges, from the other side using a clamp. The device is made to fix the joints of two pipe sections to one another for center adjustment and the subsequent welding. The drawback of the given device – for its application, it is needed to involve not only load-carrying devices but also special supports to preserve the gap set between the pipe sections in welding joints.

The [6] proposes an external clamp consisting of two joined rings forming a spatial frame. Wherein, each ring consists of two semi-rings connected by hinges. A beam is fixed on the frame enabling to move a pipe section up and down, as well as sideways bringing the sections together. Wherein, the guide brackets are put from all four sides along the pipe section area relative to which the adjustment is done of the three dimensional position of pipe sections. The alignment of the pipe sections to be joined is carried out using special brackets.

The invention [7] is known, in which the pipe center adjustment is done with the device containing special support frames on which of each there are guide plates providing for a pipe section to be lifted and brought together.

From the existing technical level, we know the device [8] consisting of two rings each of which is fixed in the area of the future welding joint. Herewith, locking rings are put on one ring for the exact registration of pipe section axes, and on the opposite ring there are special rods to fix the three dimensional position. The drawback of the given invention is in order to make it operational a lifting machine is needed for bringing the sections together.

Another device is known [9], to center adjust the pipe sections for welding consisting of two rings joined between one another. Wherein, there are special threaded rods, which enable to align the axes of the abutting sections. The drawback of the device is that the regulation of the pipe sections with this device is done manually and that requires time and a measure of manual labor.

The invention [10] proposes a device to align pipe section axes. The device consists of the two metal rings each of which is fixed on a pipe section. In the upper part, the rings are joined by an adjustment mechanism enabling to bring shoulders of pipe sections together to the required gap. However, the given device has a drawback: the abutting sections should be put on special reusable supports without which the device operation is impossible. Besides, when bringing pipe sections together with this device, special supports are needed excluding tearing and the insulation faults in places where sections are laid on the supports and this is overlooked in the proposed device.

The device [11] is known, consisting of the movable space frame and the center adjustment mechanism for welding. The given device can be moved along the pipe with no need for readjustment. However, when using this device, it is necessary to string all the abutting sections for easy movement of the device. Herewith, all sections are laid in one line with the minimum shoulder gap which additionally increases the processing time for the pre-welding assembly.

The device [12] is known, for center adjustment of pipe sections mounted inside the abutted pipe sections. The device consists of a body with clamps using which the alignment of axes is done. The drawback of the given device is that it is put inside the sections. After the joint is welded, the device should be taken out of the pipe body, with no damage to the inner pipe surface.

Apart from the above mentioned devices, yet another engineering solution for center adjustment is known consisting of a metal frame with the mounted pipe straps [13]. For the alignment, the pipe sections are rigidly restrained with the straps, after which the joint is welded.

The invention [14] proposes a device for center adjustment designed as a three dimensional frame consisting of two rings joined by clamps. The regulation of each of the clamps is done manually when center adjusting the pipe sections. The application of devices of this type requires time to make them operational and for alignment of pipe section axes, and this is a considerable drawback.

Out of the existing level of technology, internal clamps are known [15, 16, 17, 18] which are put inside the pipe body when center adjusted. The drawback of these is that to make them operational, it is needed to involve a lifting facility, a crane or a pipe-layer as well as the riggers. Moreover, the drawback of these devices is the fact that after the center adjustment and welding it is needed to fully extract the devices out of the pipe body with the help of a vehicle creating a traction pull.

The device [19] is known that consists of a three dimensional frame with fixed in radial directions special hoisting jacks on it. With the help of the radially-set hoisting jacks, the center adjustment of two pipe sections between one another is provided. The drawback of

the device lies in the fact that it is needed to use extra reusable supports to hold pipe sections when center adjusted.

Out of the existing level of technology, a device [20] consisting of several trailer units connected in one line is known. On the frame of the trailer units, the processing equipment is mounted to center adjust and weld-up the pipe sections. The considerable drawback of it is in order to make it operational, some extra machines and a measure of manual labor are needed which increases the labor hours and non-productive movements of machines and workers.

There exists a center adjusting device [21] consisting of a semi-mobile trailer unit. There is a special frame on the trailer's frame to support pipe sections and their adjustment with one another with the subsequent welding. The drawback of the given device lies in the fact that it is possible to adjust pipe sections only of definite diameter which considerably decreases the application of the device in oil and gas industry.

Today, the devices used to center adjust the pipes for welding are imperfect and have considerable drawbacks. Therefore, an innovative device has been developed to center adjust pipe sections for welding.

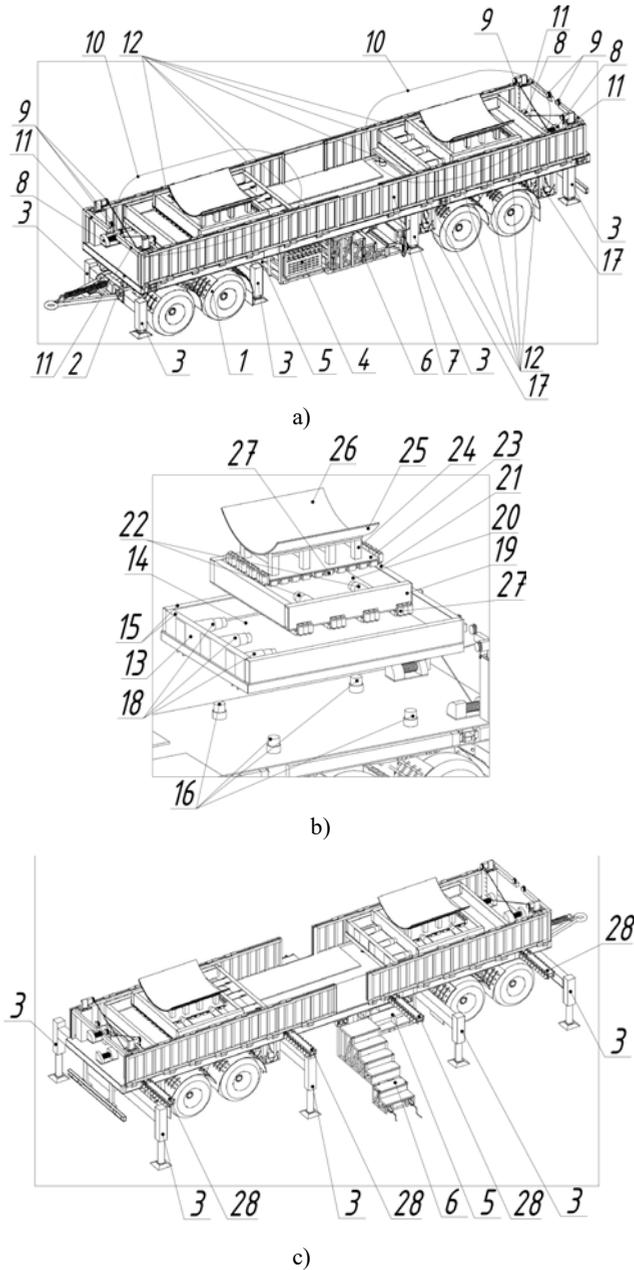
The device for the center adjustment of pipe sections for welding (Fig.1) consists of a trailer unit 1, on the frame 2 of which there are outriggers 3, an oil pumping station 4, and a power generator 5. Apart from it, the folded stairs 6 are mounted on either side on the frame 2. The trailer 1 sides 7 are made collapsible suitable for their back return into the transport position with the winch system 8 and tandem rope pulleys 9. Two mechanisms 10 are fixed on the trailer's frame 1 to center adjust the pipe sections. To fold the sides 7 of the device, there are winches 8 fore and aft on the frame 2 of the trailer unit 1 with the system of pulleys 9 and rods 11 enabling to exclude manual labor when folding the sides 7 and assembling them into the original (transportation) position. By means of using collapsible sides 7 in the design when welding, it is possible to provide easy movement of workers along the abutting pipe sections from either sides. Wherein, a complete operating safety is guaranteed.

For layout of the folding side 7 are connected to each other and to the frame of the trailer 2 by means of hinges 12.

Mechanism 10 [22] for the center adjustment of the sections for welding is presented in (Fig.1b). The mechanism consists of a metal lower tray 13 in the base of which there is a metal plate 14 along the contour of which a limiting device from the channel bar 15 is rigidly fixed. The plate 14 is rigidly connected to vertical hydraulic jacks 16 suitable for up-and-down motion.

Wherein, each of the vertically put jacks 15 is fixed on its own frame 17 located below the frame 2 of the trailer unit 1 for more stability and safety in operation.

To spread sides 7 and to safely fix them in the spatial position inside the frame 2 of the trailer 1, the retractable guide plates 28 are mounted (Fig.1c). The guide plates consist of the channel bar with the rollers fixed along its length using which they can easily move along the metal body where they are put. For more stability of the collapsible sides 7, they rest upon not only the retractable rods 28 but also upon the outriggers 3, which considerably enhances the stability.



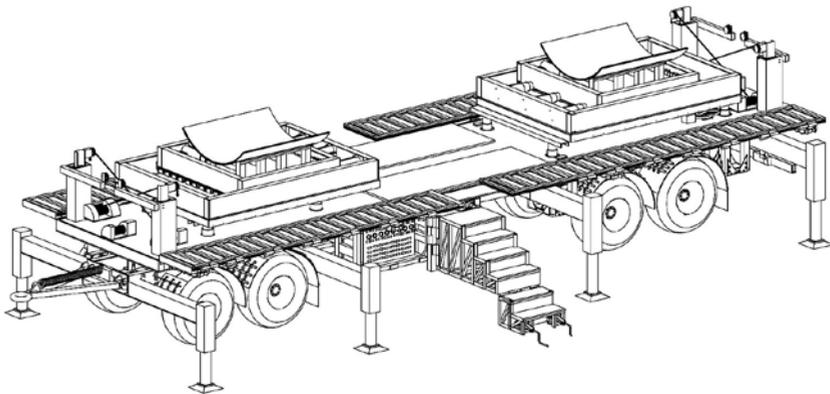
**Fig.1.** The three dimensional simulation scheme of the proposed device , a – the trailer unit is shown in the transportation position, b — the spatial simulation scheme of the pipe section center adjustment mechanism, c – the device is shown with the laid-out outriggers and retractable guide plates

1 – trailer unit , 2 – frame of the trailer unit, 3 – outriggers, 4 – oil pumping station, 5 – power generator, 6 – folded stairs, 7 – folding side, 8– winch, 9 – pulley, 10 – mechanism for pipe section center adjustment, 11 – connecting rod, 12 – hinges, 13 – lower metal tray, 14 – metal plate, 15 – contour limiting device from channel bar, 16 – vertically put hydraulic jacks, 17 – frame of a vertically put hydraulic jack, 18 – horizontally put hydraulic cylinders on the lower tray, 19 – upper metal tray, 20 — metal plate of the upper tray in the base, 21 – contour limiting device of the upper tray, 22 – hydraulic cylinders of the upper tray, 23 – metal plate bearing a spatial frame , 24 – spatial frame, 25 - stand, 26 – rubberized material, 27 – polyurethane rollers, 28 – retractable guide plates

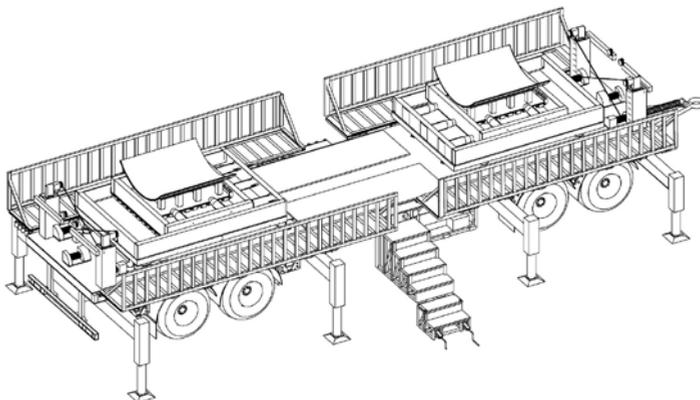
The operation of the device. To start mounting works, the devices are aligned along the trench. The operator switches the power generator 5 and using the operation console on the oil pumping station 4 puts in motion the outriggers 3 setting them up for the job. Further, the worker pressing special buttons on the console puts the retractable guide plates into position (Fig.1c). After that, for ascending and descending workers onto the level of the trailer's frame, the operator sets both stairs 6 on the flanks into position.

In order to finally put the device into position, it is necessary to spread the sides 7 onto the extension leaders 28. To improve the safety level, the sides are made double, enabling to obtain the metal decking and metal railings.

The spreading of the sides is done in two stages. Stage one includes placing the sides from the vertical position to the horizontal one (Fig.2). In order to exclude the manual labor, to lay sides 7, winches 8 and the pulley system 9 are used. After that, stage two follows, the second part of the side is hoisted into the vertical position (Fig.3). The decking for workers is made threaded to prevent the worker's shoes from skidding while moving on it.



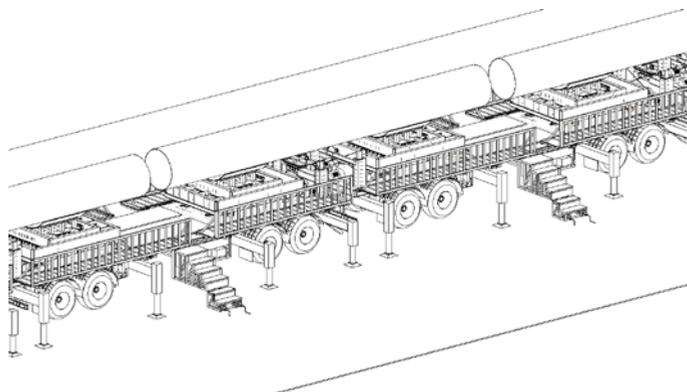
**Fig. 2.** Stage one of spreading the sides of the proposed device



**Fig. 3.** Stage two of spreading the sides of the proposed device

Upon the completion of spreading the sides onto the stands of device 25, the pipe sections are put which should be welded into section.

Fig. 4 presents a three dimensional simulation scheme for pipe section alignment using the proposed device.



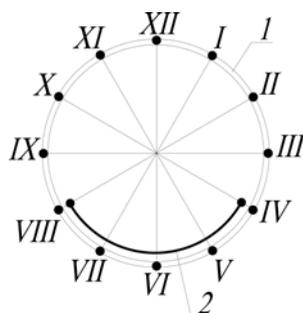
**Fig. 4.** Three dimensional scheme of the device when center adjustment is done.

Loading of pipes onto the device is carried out using any hoisting machine. All the rest technological processes can be done without these. The proposed device enables to perform the following work processes:

- weld preparation of pipe sections ends;
- demagnetization of pipe sections to remove the retained magnetization;
- grit blasting of the metal zone of pipe ends;
- assembling the pipe sections for welding;
- welding of pipe sections;
- insulation of the welding joints with the shrunk-on ring.

Upon the completion of the above mentioned work processes, the pipe sections are moved by a hoisting machine with a cross beam and laid upon the pipe truck or put on the trench edge for the subsequent mounting or putting into the trench.

The proposed device enables to perform welding above ground. When carrying out the overhead manual arc welding from « 8 » to « 4 » hours (Fig.5), the welder will be on the mark of the trailer unit frame, on a special rubber dry pad, not on a moist and damp soil as is usual in field conditions when building and major repair works. As a result the working conditions grow better.



**Fig. 5.** Scheme of the pipe section overhead weld: 1 – pipe section , 2 – overhead weld.

This is especially important in the field conditions, when the works are carried out in the cold period or in wet weather.

The center adjustment of pipe sections is performed due to the mutual perpendicular movement of metal trays 13 and 19 using hydraulic cylinders 18, 22, and 16. The device management is carried out by a control console with one operator.

The application of the proposed device is rather wide, since it can be used in all without exception climatic and soil conditions of this country. The system of outriggers in this device enables to enhance the spatial stability and safety in the process of operation.

Using the device, we can prepare butt welding ends and fix a shrunk-on ring onto the welding joint of the main pipeline. The structural design of the device enables to move along the welded pipe securing the safety of welding works. In case of using the proposed device, there is no need to use extra means of access. The structural design of the device allows to be transported on the regional and federal highways. Due to the joint use of hydraulic jacks and system of winches, a fine motion of folding frames into the operational position is provided. The spatial rigidity and stability is achieved due to the outriggers when arranging additional frames.

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