HUNGARIAN AGRICULTURAL ENGINEERING
No 41/2022 87-93
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print)
HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2022.41.87
Received: 01.09.2022 - Accepted: 25.09.2022

PERIODICAL
OF THE COMMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF THE HUNGARIAN ACADEMY OF SCIENCES
and
HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES INSTITUTE OF TECHNOLOGY

HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES
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DESIGN OF POSITIONING EQUIPMENT FOR WELDING GAS PIPES OF DIFFERENT DIAMETERS

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Abstract: The research involved the design of pipe positioning equipment for the repair of natural gas and oil pipelines. This paper presents the research results of the design of the hydraulic pipe positioning and straightening device and its practical implementation. Several concept calculations and design analyses were carried out during the design. The final design and layout was selected from several possible solutions.

Keywords: natural oil, natural gas, welding, positioning, hydraulic system

1. Introduction

We are designing a gripping device to replace damage to natural gas pipelines due to natural failure. A natural gas pipeline is a steel pipe placed at a depth appropriate to the soil conditions [1]. The failure of the steel pipes used can be caused by three main factors: corrosion, mechanical action, and soil movement [2]. Steel pipes are elastic, and over the years the subsidence of the soil can cause stresses in the pipe [3, 4]. Ageing and thermal expansion of the pipes also cause difficulties in cutting and welding [5]. When cutting tubes, previously stored stresses are released and the tube will snap during cutting [6]. Steel tubes are made of carbon steel [7], so welding is not a problem [8, 9], but the deviation of the joined tube ends should be less than 0.5mm [10]. Various pipe positioning devices are available on the market, and their design can be either internally or externally fixed [11]. In the present work, we plan to design an externally fixed structure, as it is required to be applied in the field. In the soil the pipes deform, for welding deformation must be compensated, the deviation from circularity of the pipe must be less than 0.5mm. Precision cutting equipment that cannot be attached to commercially available pipe positioning devices is only a diamond wire saw [12] or a pipe saw [13]. Pipe gripping devices can be single-arm or double-arm per side [14], but the double-arm design results in a more stable grip and provides more options for positioning [15]. The pipe positioning device we have designed can be used for pipes with diameters of 500-750mm, which are common in the industry.

The structure designed in the project shall be capable of correcting any deformation of the joint surfaces of the pipeline sections joined during the repair.

In field work, the time window available is limited by weather and process time, but this should not be at the expense of quality parameters. The quality factor is a particularly strong constraint, as in a project it is no longer possible to allow for a time margin where several hours of pipe section straightening or re-cutting and the re-design of the weld ends are required. In addition, in many cases these will hold up further work on the pipelines.

Factors to be considered when designing a pipe positioning device with regard to the design of the gripping structure:

- the pipe positioning device must hold the two pipe sections to be welded together in the correct position, so the gripping structure must be robust,
- the right and left pipe clamps should be connected by a common rigid bridge,
- the design of the bridge should take into account the space requirements for additional equipment,

- the bridge structure should be designed to allow the safe installation of hydraulic and electronic lines,
- provide a stable grip up to a pipe diameter of 300 - 650 mm,
- adjustable prismatic top supports should be provided for pipes of different sizes to facilitate installation,
- the gripping device should be openable and releasable,
- when the grips are in the closed position, mechanical locking should be used to prevent any possible pipe bounce,
- the mechanical safety lock should be fitted with an electronic signalling and electrical locking system,
- dual-acting hydraulic cylinders should be used,
- work rollers should be fitted with anti-fall devices,
- the structure must be capable of being lifted, so it should be equipped with lifting points.

2. The concept

The different concepts for the hydraulic unit for the positioning of the pipe ends were developed after several rounds of discussions. During the discussions the following designs were reviewed.

Possibilities of pipe gripping in terms of force application:

- manually driven, spindle design,
- hydraulically operated belt clamp,
- with circularly arranged hydraulic work rollers.

In terms of force application to eliminate tube deformation, the structure can be:

- wedge spindle design,
- wedge type, with direct hydraulic movement,
- wedge design, with indirect hydraulic movement,
- with radially mounted hydraulic cylinders,
- axially mounted hydraulic cylinders and a lifting device.

In terms of power supply, the structure can be:

- a structure with its own hydraulic system from an external power source,
- a structure with its own hydraulic system powered by a diesel engine,
- a structure connected to the hydraulic system of an implement,
- hybrid system (electrohydraulic drive),

Opening-closing of the structure in terms of design of the structure can be:

- self-steering,
- with its own hydraulic actuator,
- mechanical spindle design,
- a system with a self-locking mechanism,
- a hybrid system (hydraulically operated with gravity control).

2.1. Planning

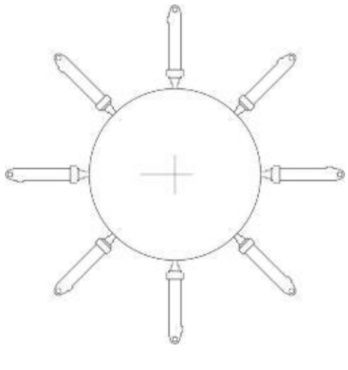

Figure 1. Fingers for pipe positioning and pipe repair

From the literature review and analysis of the tools available on the market, it was found that hydraulic working cylinders are the most commonly used to repair potential circular defects in gas and oil pipelines. These cylinders are directly connected to the section of pipe under investigation. Hydraulic cylinders are attached to a stable and rigid belt section with a centre line of axis coinciding with the theoretical centre line of the complex pipe repair structure to be designed. The hydraulic work rollers are stably bolted to the belt section, and the length of the stems of the work rollers is designed to accommodate the dimensions of the gas and oil pipelines in Hungary (300 -600 mm) as specified in the project. The theoretical design agreed in the joint discussions is illustrated in the Figure 1.

The structure consists of a laser-cut, bolted and welded belt of 20-thick boiler plate, hydraulic working cylinders, piping and valves.

2.1.1. The device and its parts

Figures 2., and 3. show the most important parts of the device.

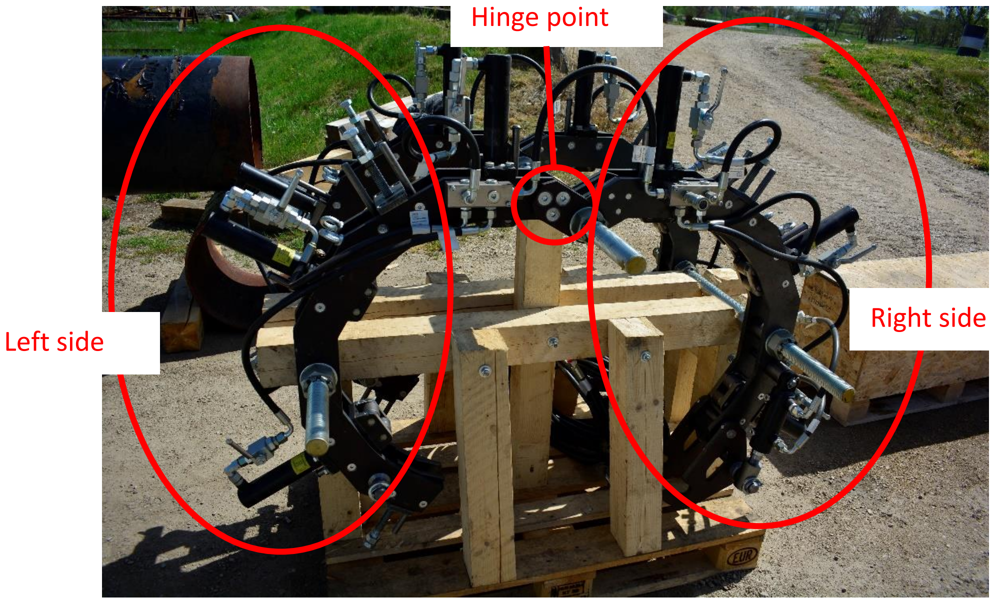

Figure 2. Front view of the structure with 6 hydraulic cylinders

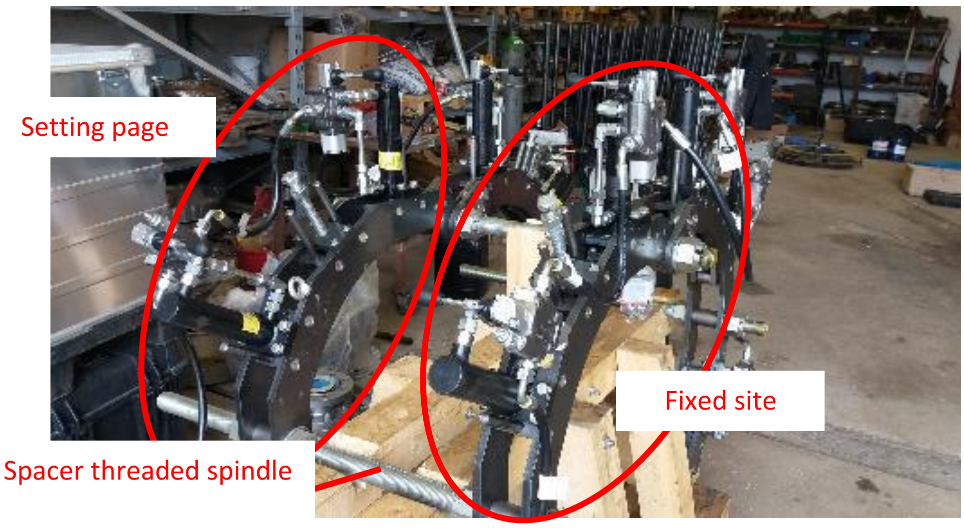

Figure 3. Side view of the pipe clamp positioner

2.2. Positioning of the pipe clamping rollers

Different pipe diameters also have different circumferences, so the device should be designed for the smallest and largest pipes still in use. Due to the varying circumferences of the pipe sizes, the distances between the working cylinder connections also vary. In the case of smaller tubes, the working cylinder stems are closer together, so that they can do a better job of improving circularity. When repairing larger diameter pipes, the attachment points of the working cylinder stems fall further apart, so the pipe shape may be statistically closer to the theoretical circle during the work, but it will be a polygon. To solve this problem, two things can be done, one is to increase the supporting surface by fitting a slipper on the stems of the working rollers to match the pipe size, the other is to increase the number of working rollers.

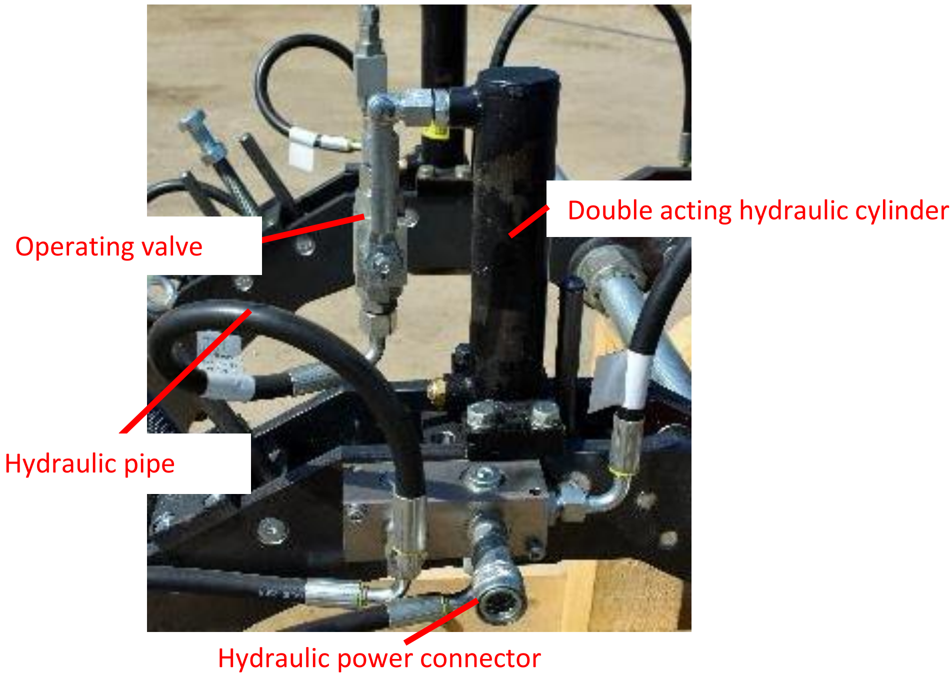

Figure 4. Positioning the hydraulic cylinder on the belt section

The double-acting working rollers are bolted to the belt section and connected by flexible piping for flexible operation. 2 hydraulic quick couplings are mounted on the belt section to ensure the hydraulic fluid inlet and outlet. Figure 4. shows the hydraulic system on the device.

2.3. Connection of hydraulic power cylinders to tubes

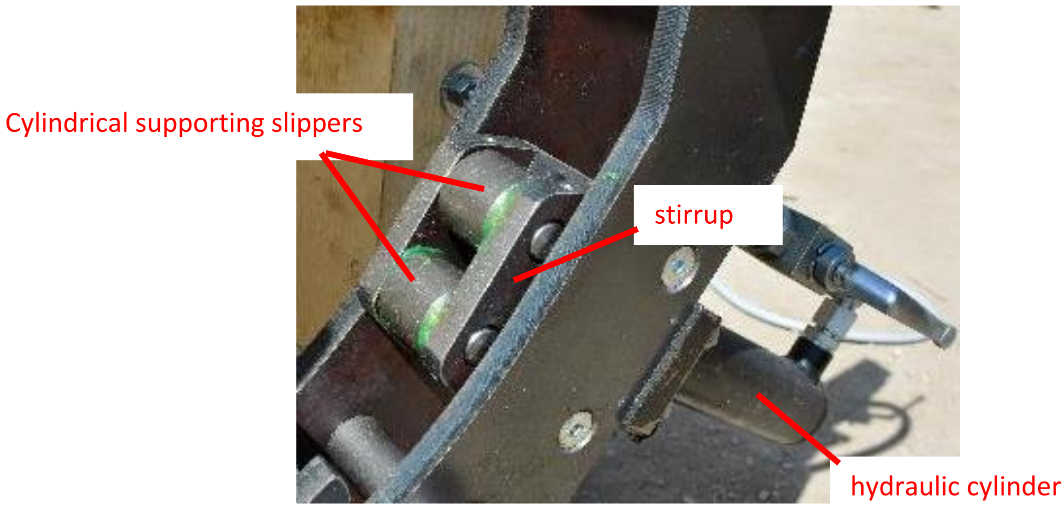

Figure 5. Cylindrical slippers mounted on the end of the working cylinder

The pipe positioning and straightening structure designed for this work is intended to cover a significant size range of gas and oil pipelines in use in Hungary, so the end-mounted slippers on the work rollers are designed to be roller-mounted, which is well suited to the pipe sizes in use.

A "U" shaped stirrup is threadedly attached to the shank of the working cylinder, which holds the cylindrical support shoes on pins. The cylindrical pins allow the support shoes to rotate, which helps in any possible device adjustment. The Figure 5. illustrates the cylindrical support cylinders.

3. Disassembly of the appliance installation on the gas pipe

The part of the belt to be fitted to the section of pipe to be repaired, containing the working rollers, shall be designed to be openable. The structure shall be provided with a sliding pin to allow opening. The hinge point is a threaded stem of size M24 (Figure 6.), on which a bushing is mounted and held in place by two crown nuts. The hydraulic circuit used to power the hydraulic working cylinders on both sides is connected by rubber bushings for opening. The Figure 7. shows the device in the open state.

Figure 6. The pipe positioning and pipe shapes repair structure hinge point

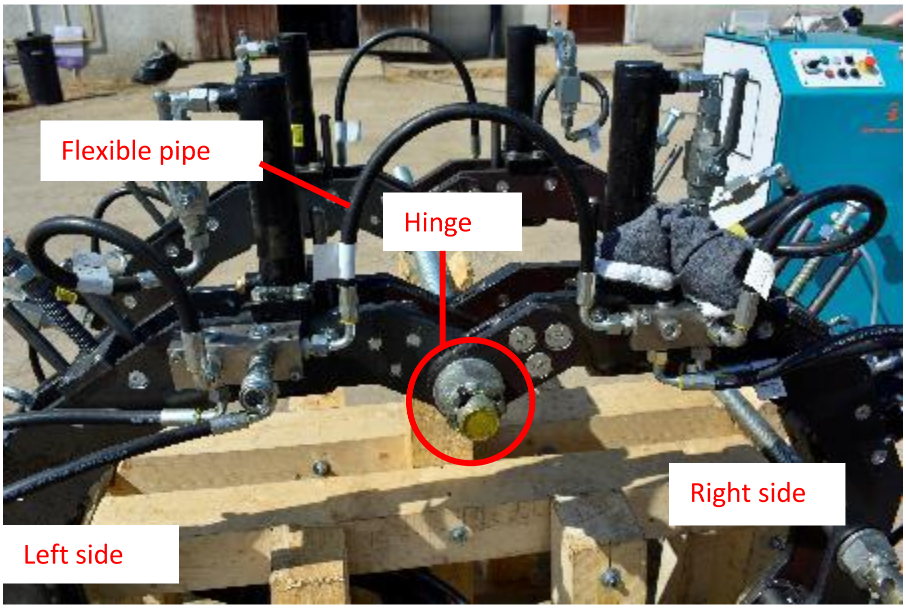

Figure 7. The pipe positioning and pipe repair structure in the open position

The structure of the weight load brakes open and close. It opens automatically when the structure is lifted by gripping the right and left sides of the structure via a lanyard and closes when the structure is placed on the tube.

Figure 8. Installing the pipe positioning device

4. Conclusions

In the course of the work a complex field pipe cutting, gripping and positioning structure was developed, as part of which a hydraulic pipe gripping, positioning and straightening device was designed. Based on the literature research and market demand analysis, a construction design was formulated to be implemented in the POC phase of the project. The Figure 8. shows when the device was tested in practice. During the research, a number of solutions were investigated for positioning pipe ends for welding during the repair of gas and oil pipelines, and for the correct geometry (root voids and circularity). During the research, it became clear that the working conditions (mud, temperature, time to repair) of the repairs were to be considered in order to design a structure that was as simple and robust as possible.

The research led to the production of a structure capable of:

- hold the pipe to be cut firmly,
- to hold the complex system in a central position on the pipeline,
- adjust the circularity of the pipe section if it is defective,
- it is capable of holding the required root gap in a stable manner.

The hydraulic pipe gripping, positioning and straightening device consists of two belt sections whose distance can be adjusted by means of threaded spindles. On the belt sections are mounted the hydraulic working cylinders, which have a double function, on the one hand to position the complex device centrally and on the other hand to repair the pipe end, which may have been damaged in terms of circularity, to the correct shape. The hydraulic working cylinders are connected to a stable and rigid belt section with an axial centre line coinciding with the theoretical centre line of the complex pipe repair device. The hydraulic work rollers are stably bolted to the belt section, and the length of the stems of the work rollers is designed to accommodate the dimensions of the gas and oil pipelines in Hungary (300 -600 mm) as specified in the project.

Acknowledgements

The research was funded by the project "Development of mobile mechatronic industrial applications using laser and structural stress measurement technologies" and "KFI 16-1-2017-0216".

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