RESEARCH ON THE DESIGNING AND MANUFACTURING OF AN EXPERIMENTAL ROBOTIC ARM MODEL FOR DRILLING RODS HANDLING.

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ABSTRACT: There are a few problems on the drilling market regarding the handling of the drilling rods by the technical operative. There are a few rods loaders on the marked at this point, but they are only accessories of the drilling rigs and can be used only as machinery equipment. The idea of a custom rods loader, who can work with any drilling rigs, has the purpose to create an automated system who can transport, pick and handle the drilling rods to the drilling point, without manually intervention by the operative.

KEYWORDS: holder, pipe, motors, hydraulic, cylinder

1. Introduction

Drill pipes are necessary elements in the geotechnical drilling process and are made of steel or aluminium (see Fig. 1). They are used on drilling rigs and are necessary for auxiliary sampling, such as mechanical coring and layering samples. They are hollow on the inside because they must ensure that the drilling fluid is pumped through the borehole [1].

In the working environment, they are centred in the drill head and screwed to it. Their lengths can be 3000 mm or 6000 mm and the diameter varies depending on the requirements of the working environment. The most commonly used drill rods are 101.6 mm in diameter. For a length of 3000 mm, they reach a weight of about 60 kg [2].

Fig.1. Drilling pipes

At the moment, in most jobs, the pipes are handled manually by the operators. The weight of the pipes can cause health problems for them over time and at the same time manual handling is a disadvantage in terms of flexibility in the working environment. There are several drilling machines on the market that have attached loading equipment for drill pipes. The purpose of this equipment is to create an automatic process of loading and handling drill pipes (Fig. 2.). They are also divided into two categories: the tracked ones for shorter length pipes and the long ones for longer length pipes.

There are a number of disadvantages in using these fixed loader designs:

a. They are fixed elements that have a capacity of a limited number of pipes.
b. They are used only for the machines for which they are constructed and cannot be used outside of them.
c. Involve a larger gauge than that originally used for drilling machinery. The soil and environment do not allow the use of very heavy drilling machine sometimes.
d. The addition of such equipment changes the gauge dimensions of a drilling machine and a too large gauge size can create problems during transport.

Fig.2. The loading equipment for drill rods.

2. State of the art

This machine has a capacity of 49 drill rods (Fig. 4.), each 3000 mm long. The holder in which the pipes are loaded is interchangeable. An advantage is that when the last drill rod is used at the drilling point, this holder can be replaced by an identical one containing 49 more drill rods. The whole system is electrically and hydraulically controlled. The hydraulic pump unit helps to drive the hydraulic cylinders that set certain systems in motion.

The solution is to implement a prototype of an individual loading machine, which has the ability to transport, hold, load and handle rods. This machine is positioned next to the drilling machine and automatically loads and positions the pipes in the rotating head of the drilling machine (Fig. 3.).

The purpose of implementing such a prototype is to create an automatic drilling process using drill pipes.

Fig.3. The 3D model of the drilling pipes machine

Fig. 4. The 3D loaded model of the drilling pipes machine

The assembly is divided in a few mechanical sub-systems. These sub-systems are:

2.1. The holder for drilling pipes (Fig. 5. and Fig. 6.)
2.2. The bridge crane (Fig. 7.)
2.3. The robotic arm (Fig. 8.)

2.1. Holder of the Drilling Pipes

It is a holder in which pipes are loaded and stored. It has a capacity of 49 pieces of 3000 mm length, aligned vertically and horizontally in 7 rows (Fig. 8. and Fig. 9.). The rack weighs 490 kg and the pipes weigh 2900 kg.

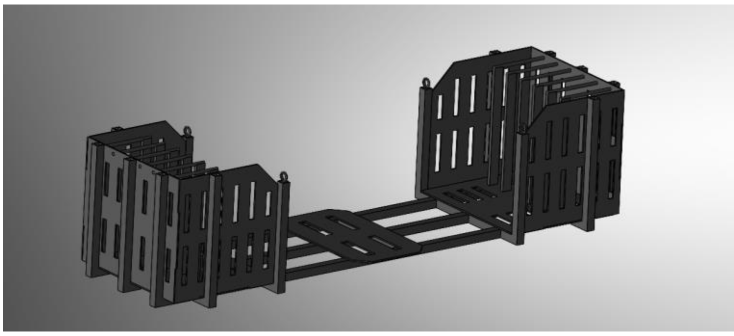

Fig. 5. The holder for drilling pipes

Also, there are 4 rings for the clamp (Fig. 6.) which can be used to lift the holder and replace it with another. The operator can change this holder with another one.

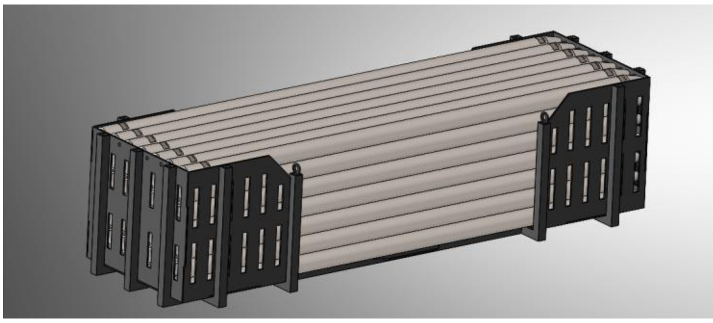

Fig. 6. The loaded holder for drilling pipes

2.2. Bridge Crane

It moves over the 7 rows of the rack by means of linear guides (Fig. 10) and contains a hydraulic shear system that lowers itself to the gripping point of the pole. The gripper is hydraulically operated.

Fig. 7. The 3D model of the bridge crane

2.3. Robotic Arm

Its purpose is to take the pole from the crane gripper and bring it to the drilling point (Fig. 11) and the other way around. It approaches the gripper to grab the pipe which it picks up from the overhead crane via a stepper motor on linear guides. It moves away from the scraper towards the edge of the chassis. The lower boom extends from the bracket outside the machine approx. 1500 mm. The upper arm moves from horizontal to vertical position by means of a hydraulic cylinder. The upper link is based on a joint driven by a stepper motor which will rotate the upper link approx. ±30˚ from the fixed point.

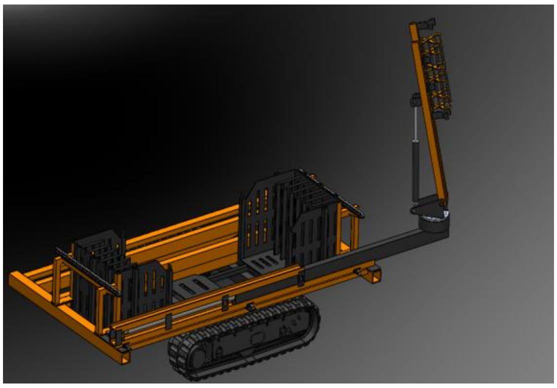

Fig.8. The 3D model of the robotic arm

The movement and functionality of the bridge crane

Movement is achieved by two stepper motors moving symmetrically at the two ends of the bridge. The whole system moves by means of two linear bearings for each bridge base. The bearings move on a linear guide. The gripper descends and ascends by means of a hydraulically operated shear system. The movement of the gripper to tighten the pole is hydraulically operated. During the functional process we encountered a number of problems such as:

a. The bridge crane must constantly maintain a position perfectly parallel to the rows of the fence in order to be able to grab the pipe. Its length is 3620 mm, and at such a size such problems can arise much more easily if the two motors do not move symmetrically at the same time.

b. The gripper must fix the pipe correctly so that it does not cause accidents in the working environment that may affect the machine and operators.

The solution to these problems is to implement an algorithm that ensures the correct functionality of the whole system. This uses two microswitches placed on the inside faces of the gripper that signal that the pipe has been fixed in the gripper when they are pressed against its walls. If this is the case, the hydraulic cylinder will lift the pole through the shear system. When the pipe is at the upper transport point, the bridge crane will start moving. The two stepper motors will start driving the bridge crane at the same time. To check that the movement is symmetrical, the distances of both ends from the starting point are measured and if they are equal the movement is symmetrical. This is measured using two ultrasonic sensors.

3. The solution using LABVIEW

An Arduino Mega board, two 28BYJ-48 stepper motors, two HC-SR04 ultrasonic sensors and two SS-5GL microswitches were chosen for the command and control system.

The user interface (Fig. 9.) contains: a selection area to choose the connection port, two LEDs, which will light up to confirm when the two microswitches are pressed, indicators showing the distance measured by each sensor in centimetres, a control button that operates the two stepper motors and a switch that changes the direction in which the spindle rotates.

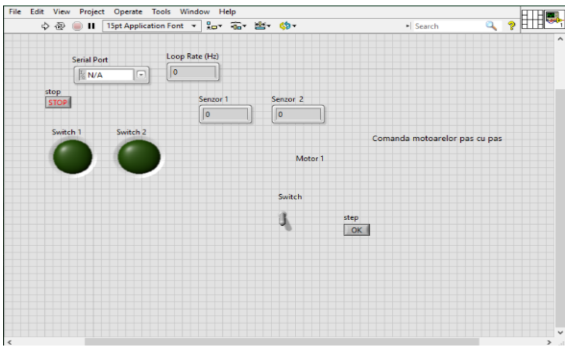

Fig. 9. LABVIEW interface

In the control diagram of the program, when the two switches send a digital signal to the Arduino board, the two sensors will start taking measurements and the two motors will be able to move the crane (Fig. 10.).

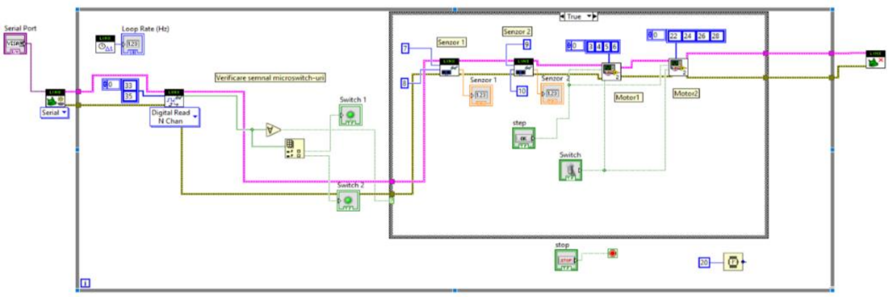

Fig. 10. The algorithm in Labview

A separate program was developed for the motor drives, which was later integrated into the main program as SUBVI for each motor (Fig. 11.). Element 1 of the Case structure will contain the Boolean values for the counter clockwise rotational motion, while element 3 will contain Boolean values opposite to the original ones for the clockwise motion of the motor shaft. In element 0 all Boolean values are False. Since the initial mechanical action of the Step button performs a single step for one press, it changes to Switch when pressed for a continuous movement over a certain period of time indicated in the main VI [3].

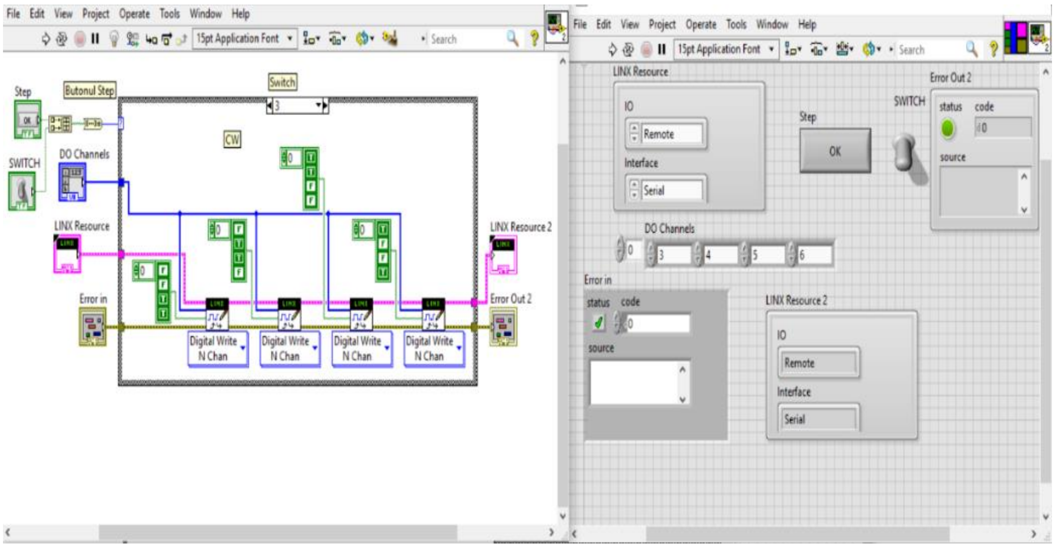

Fig. 11. The algorithm used for the motor drives

4. Conclusions

The own contribution to the implemented system consists both in the adaptation of a model of an overhead travelling crane, used in industrial halls, to create a customized mechanical system on tracks, which aims at automating the processes of handling, loading and transport of drill rods and for the shearing system, which ensures stability in the process of handling the drill rods. Future research consists in the development of an algorithm that ensures good functionality of the robotic arm and an algorithm that ensures correct positioning of the designed prototype in relation to the drilling machines when performing geotechnical drilling.

5. Bibliography

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