Development of motor efficiency test setup for direct driven hydraulic actuator

1.Introduction

Today's industry is constantly trying to improve their profit and reduce their impact on the environment. Within different industries, there is a wide use of hydraulic systems. Hydraulic systems are commonly used for industrial applications where a large force or torque needs to be produced. For example, couple large industry sector where hydraulic are commonly used in are construction, landscaping and forestry industries. In these sectors mobile hydraulic systems are most used way to utilize benefits of the hydraulics and typically these are valve-controlled systems.

The traditional valve-controlled systems are not very efficient due to throttled pressure losses and heat losses[1][2][3]. With new technologies and improved affordability of electric drives, direct driven hydraulic (DDH) systems have become an interesting topic for improving current valve controlled hydraulic systems. In a DDH system valves are not used for controlling the flow rate, but instead the pump's rotation is controlled to change the speed and direction of actuation. DDH systems can be more efficient and compact compared to the traditional systems, additionally they also offer improved controllability [4]. Several major companies have started to incorporate this technology on their products[9][10]. They claim that it improves the efficiency and reduces the emissions. Additional benefit of DDH is that the energy source can be brought close to the actuator to reduce energy losses, whereas in a traditional system the hydraulic fluid might have to travel a long distance between the pump and the actuator.

In this paper the development of a test setup of DDH is presented. The test setup is driven by a brushless DC motor which drives a hydraulic bidirectional motor/pump. The pressure generated from the motor is then used to drive a hydraulic cylinder. The system should be fitted with sensor so that all necessary data can be read from the system, e.g. efficiency, power and temperature. The test setup also is meant to be modular, e.g. the motor can be easily changed to test different motors. This kind of test setup can be used for demonstrations and research purposes.

2. Method

2.1. System description

The system has two sections, one being the mechanical section consisting of the hydraulic components, the other section is the electrical consisting driving and sensing. System is designed to move the cylinder's rod with hydraulic pump/motor which is loaded with counter weight. Purpose of the system is to analyse efficiency of a different hydraulic motors, so the system needs to consist all necessarily sensor and modular design for the hydraulic motor mounting.

The cylinder is a symmetric cylinder with a piston diameter of 63 mm, rod diameter of 43 mm. The hydraulic power comes from a bi-directional hydraulic motor with a displacement of 1,48 cc/rev by Parker. These are the major components of the hydraulic system, besides these there is also a hydraulic accumulator, pressure sensors, pressure relief valves and check valves.

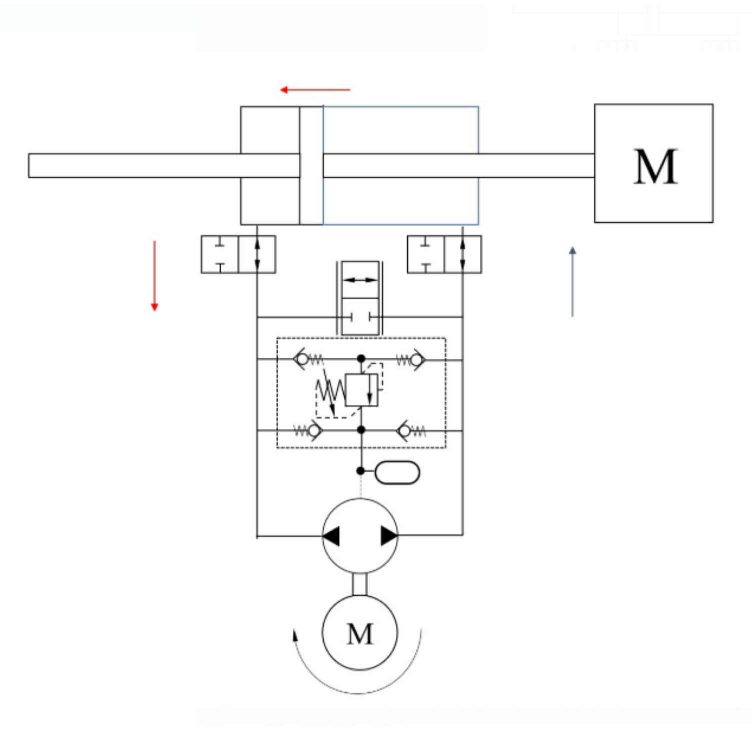


Figure 1 Hydraulic schematic

The electric drive is built around three major components, the electric motor, motor controller and micro controller. The electric motor is a brushless outrunner DC motor with a power of 5300W and max voltage of 44V by Turnigy. To control this motor a programmable motor controller was used. The logic for the system is given by an Arduino Mega. The Arduinos task is to decide how the actuator behaves by setting different outputs to the motor controller. The Arduino also monitor the system by reading different inputs from the sensors of the system and from motor controller to make sure that the system is working within safe margins. The main safety measurements will be temperature of the electric motor, temperature of the MOSFETS on the controller and placement of cylinder's rod. Temperature is controlled with ventilation fan and rod's placement sensor is prevention the piston to be colliding to the end during the driving cycles. For efficiency analysis from tests, necessary data is gathered thought Arduino. To be able to measure the efficiency of the system, torque measurements of the electric motor are needed. This is measured with force sensor which is connected to a bearing-mounted engine mount. Rod's position is measured with magneto restrictive sensor by GEMCO. Pressure is measured from both cylinders' sides with pressure sensors. Voltage and current of the motor are monitored and gathered through motor controller. General overview of the electrical system is seen on figure 2. To power the whole system three 12V batteries in series are used.

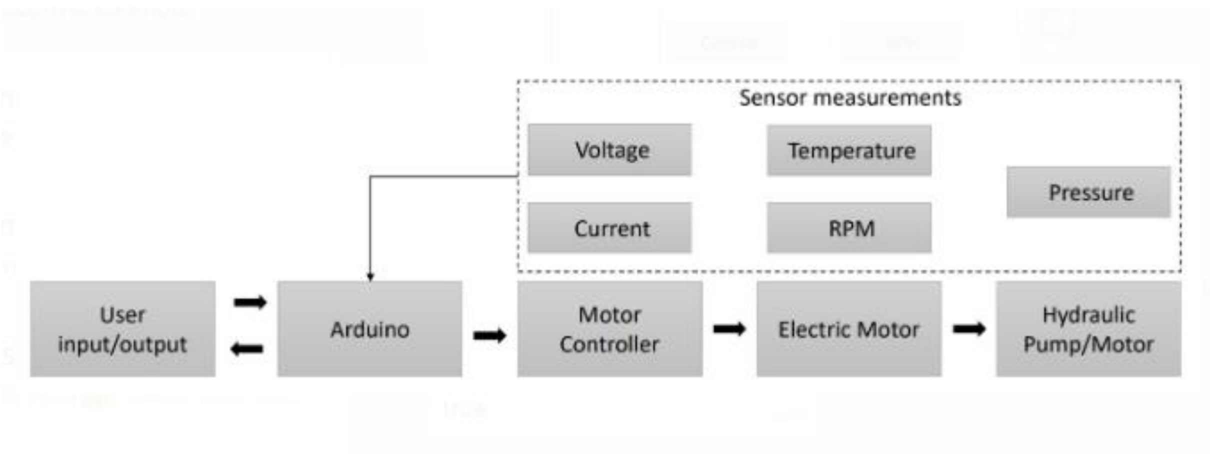


Figure 2 Electrical system

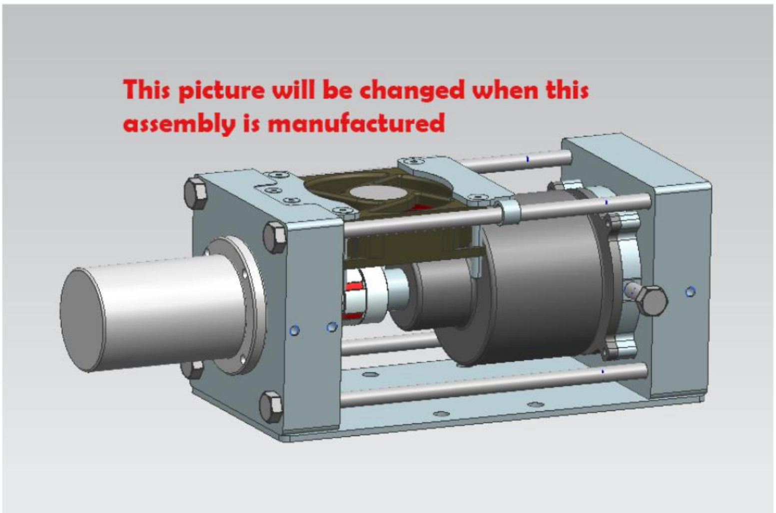
2.2. Programming of Arduino

The Arduino the test setup is done in the Arduino, here the number of operating cycles are defined and the speed of the actuator can also be decided. The Arduino controls the speed by sending a pulse position modulation (PPM) signal to the VESC. The VESC in turn feeds a signal back via the UART port to the Arduino informing about the temperature of the motor, MOSFETS and the electromagnetic rotation speed. The Arduino monitors these values to make sure the system is operating within its limits. In case some limits are exceeded the operation stops.

2.3. System's design and construction of piping

Motor housing need to be modular so the motor housing was designed to be assembled from aluminium block which can be changed and modified to be suitable to different motor types. Hydraulic system is designed to be compact and all components are connected to hydraulic cylinder. Replacing hydraulic hoses with pipes will make the system more compact and cleaner looking.

(There will be more explanation for the system when designing and manufacturing is finished and also couple pictures will be added of finished product.)



3. Results

The setup will be tested by moving the cylinder’s rod first on horizontal direction and then in vertical direction. In this experiment the effect of gravitational force act as counter weight.

Measured data is motor speed and torque and pressure which hydraulic motor is generating. This data is used to determine hydro-mechanical losses which motor/pump crate.

4. Discussion

[possibility of further improvements]

5. References

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