DESIGN AND FABRICATION OF HYDRAULIC TEST BENCH

PROJECT REPORT

DE-40 (DME)

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DECLARATION

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ACKNOWLEDGEMENTS

We are thankful to Allah Almighty, the most merciful for the blessings, courage, and the intellect He has bestowed us with, because of which it became possible for us to accomplish such remarkable goal. We are thankful to our parents and the family for their constant support and encouragement through each thick and thin. We are much obliged to our supervisor Asst. Prof Saheeb Kiyani for their continuous guidance and the valuable time they spent on providing us the support and encouragement through each stage. Without their efforts we would never have been able to achieve that much. Moreover, we are grateful to all our fellows, friends who supported us intellectually and emotionally. Tones of thanks to all those who contributed to it, without all that support and appreciation things would have been different. We are hopeful that this project will add value to the peoples' lives and will be developed further to adopt this technology on a massive level.

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ABSTRACT

Hydraulic power control systems are a common and important part of mechanical and agricultural systems. In hydraulic power system design, power, pressure, flow rates, and mechanism of circuitry are all important factors when analyzing any hydraulic system. Pumps, electric motors, reservoirs, working fluid properties, hydraulic circuitry, and a large variety of valves make up a functional hydraulic system. Applications for hydraulic systems vary widely from automotive, agricultural, mechanical etc. It is the engineers' job to design a hydraulic system that will be functional, efficient, and safe. Failure of the hydraulic components while they are being operated can be very hazardous given their wide range of applications in many industries. To ensure them to be in proper working condition, (be it hydraulic pumps, valves, or motors) which is not only necessary for the sake of avoiding any financial damage but also to avoid any kind of potential human injuries or even human loss before it happens, test benches are used to check the operational capability and working condition of hydraulic components. The idea to develop a hydraulic test bench will not only be a viable solution for testing of hydraulic components but also provide an easy to operate conditions with maximum output and accuracy.

CHAPTER 1: LITERATURE REVIEW

1.1 Introduction

The Hydraulic test rig which is also known as second line test rig will be used by the second line servicing bay for conducting the pre-installation (PI) checks for the line re-placement units (LRUs) with landing gear, flight control system and electrical LRUs which are operated by hydraulic power. Hydraulic Test Bench (HTB) allows users to perform comprehensive testing of pumps, motors, double or single-acting cylinders, and valves (relief and manually operated) **[1]**.

The Hydraulic test rig will also have provision for delivering high pressure at lower flow rates for conducting proof pressure testing of LRUs and very high pressure at low flow rates for conducting static pressure testing of hydraulic tubes and hoses **[2]**. LRUs are used in the aircraft for proper flight and motion control. There are many small valves, flow control valves, pressure control valve, direct operated or pilot operated valves used in aircraft. Apart from these, there are temperature sensors, pressure gauges and flow meter devices. These all type of valves and sensors are mounted in between the pressure lines.

1.2 Background

The transmission and control of power by means of fluid under pressure is becoming increasingly used in the field of mechanical engineering. Over half of all industrial products have fluid power systems or components as part of their basic designs **[2]**. The creative aspect of hydraulic system design is to develop a circuit that is capable of performing the required task. Usually, the basic functions of a hydraulic system are determined by the circuit configuration, while the circuit's performance mainly relies on the components sizes and characteristics **[8]**. The extensive use of hydraulics and pneumatics to transmit power is due to the fact that properly constructed fluid power system possesses a number of favorable characteristics. It eliminates the need for complicated systems of gears, cams, and levers **[16]**.

Hydraulic power control systems are a common and important part of mechanical systems **[7]**. In hydraulic power system design, power, pressure flow rates, and mechanism of circuitry are all important factors when analyzing any hydraulic system. Pumps, electric motors, reservoirs, working fluid propertied, hydraulic circuitry, and a large variety of valves make up a functional hydraulic system. Applications for hydraulic systems vary widely from automotive, mechanical etc. It is engineers' job to design a hydraulic system that will be functional, efficient, and safe.

1.3 Motivation

There are many fuel pumps in market which need testing from time to time but there is no proper equipment to test those pumps same goes for the valves. Fittings and other hydraulic components which are to be tested.

So, what has been going was that if a technician were to test a pump, he will take the drive from a car's engine and check if the pump is functioning or not if not, he will again try to fix the pump and install it again get the drive from the engine and check the pump but that lead us to an "Allied Problem".

The problem is testing the pump using the drive from the vehicle's engine is not an engineering solution as it doesn't identify whether the fault is in pump or the fittings or pipes attached. This allied problem led us to work on the first hydraulic test bench that will be available in the Pakistan's market **[9]**.

Also, we're interested in making 3D models and manufacturing work. It gave us an opportunity to learn about various softwares. One of the reasons for selecting this project is that it is a Millitary project which is related to our field and will be helpful in near future. With the help of this project, we were able to learn a well-known software Solidworks.

1.4 Objectives

A test bench could prove to be a useful tool in illustrating the functionality of pressure reducing, and directional control valves. The effect of different system pressures and resulting operational pressures for various circuits. By analyzing the fluid mechanics by the hydraulic system, we can apply hydraulic power and fluid analysis theoretically and validate experimentally with the test bench **[1] [2]**.

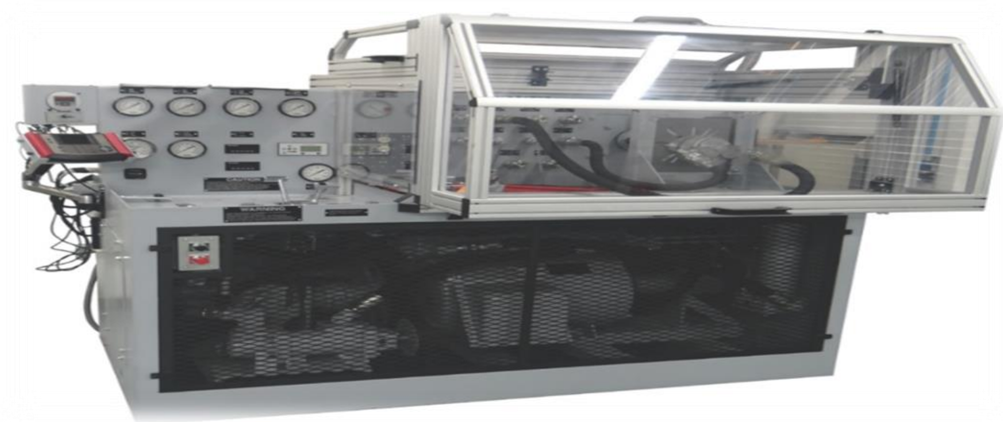


Figure 1: Hydraulic test rig system

A test bench can shorten troubleshooting time, take guesswork out of the diagnoses, and let you thoroughly test new or rebuilt components and sub-assemblies prior to installation in a working system. Hydraulic Test bench system is used to test incoming hydraulic components to identify problems. One of the major uses of HTB is that it can test all rebuilt parts for proper operation **[1]**. Carefully “break in” components with rotating parts (pumps and motors) using clean, filtered hydraulic fluids to give rebuilt pumps and motors a long service life. This prevents warranty claims and help customers solve hydraulic system problems. HTB conducts performance test on rebuilt hydraulic components for proper operation before they are reinstalled on equipment, preventing additional expensive production equipment downtime **[14]**. Can be used to check components removed from production equipment. Parts can be tested for proper operation and unnecessary repair work can be eliminated **[2]**. HBT used hydraulic components before they are sent out, preventing unnecessary expensive repair work. In many instances, we may find that only on inexpensive shaft seal or housing O-ring is necessary to put a component back in operation. Ensures highest quality components and prevent expensive additional production equipment downtime by performance testing components **[16]**.

Figure 2: Horizontal System

System equipment could allow for complete testing of new equipment, from pumps to end components like compressors, transfer pumps pneumatic and hydraulic, even cranes with remote mounting, without ever using a truck chassis **[13]**. The system can be configured to remotely store different drums of various fluids outdoors to simulate different viscosities, at different temperatures.

1.5 Industrial applications

1.5.1 Unmet needs

There was many unmet need of previous hydraulic test rigs **[10] [11]**. Hydraulic test benches are used to measure the performance and test the endurance of many components: sanitary taps, pumps, fittings, valves, pipes, heat exchanger etc. these tests are conducted to ensure proper functioning and compliance with the most important international standards. Test bench can eliminate the trouble shooting time and take out the diagnosis and thoroughly test new assemblies and sub-assemblies before there installation in a working system. It is also useful tool in checking the functionality of pressure reducing and directional control valves. Also test the new parts for proper operation for customer satisfaction. It checks the components that are removed for production equipment so that the unnecessary repair work can be eliminated. It also benefits the industrial companies that are receiving new components by checking their hydraulics. Working system equipment also allow for a complete testing of new components like transfer pumps compressors, **[15]** even cranes with remote mounting, without ever using a truck chassis. As it is very costly to check the hydraulics of the industrial components so it will save large amount of money for the companies.

1.5.2 What is new?

Our Hydraulic test bench is designed for use in local industry for the testing of hydraulic components being manufactured and used inside the country. This would be a better alternative in all sorts of ways considering the simplicity of the equipment and the economic feasibility of the bench Financially Hydraulic test bench can be a profitable project, Due to high demand and scarce availability, hydraulic test bench can be of high value for the developers. Hydraulics companies in Lahore, Gujranwala and Islamabad were surveyed Also, some firms were shared by the project supervisor that are in Japan, China, and Hong Kong.

The testing of hydraulics of a component almost cost Ten thousand rupees (RS 10000) and the time taken for this task is almost 30-35 minutes. And in a day a test bench can check approx. 25 to 30 components. So, it will save the company up to 250000 rupees. Our project can be a huge success financially.

1.5.3 Use of HTS in market

Hydraulic power control systems are a common and important part of mechanical systems. In hydraulic power system design, power, flow rates, and mechanism of circuitry are all important factors when analyzing any hydraulic system. Pumps, **[16]** electric motors, **[16]** reservoirs, working fluid propertied, **[6]** hydraulic circuitry, and a large variety of valves make up a functional hydraulic system. Applications for hydraulic systems vary widely from automotive, mechanical etc. It is engineers' job to design a hydraulic system that will be functional, efficient, and safe.

A test bench could prove to be a useful tool in illustrating the functionality of pressure reducing, and directional control valves. The effect of different system pressures and resulting operational pressures for various circuits. By analyzing the fluid mechanics by the hydraulic system, we can apply hydraulic power and fluid analysis theoretically and validate experimentally with the test bench**. [4]**

A test bench can shorten troubleshooting time, take guesswork out of the diagnoses, and let your company thoroughly test new or rebuilt components and sub-assemblies prior to installation in a working system. Listed are some more specific uses for a test bench system.

1. Test incoming hydraulic components to identify problems **[17].**
2. Test all rebuilt parts for proper operation to ensure customer satisfaction **[19]**. Carefully "break in" components with rotating parts (pumps and motors) using clean, filtered hydraulic fluids to give rebuilt pumps and motors a long service life.
3. Prevent warranty claims and help customers solve hydraulic system problems **[17]**. Conduct performance test on rebuilt hydraulic components for proper operation before they are reinstalled on equipment, preventing additional expensive production equipment downtime.
4. Check used components removed from production equipment. Parts can be tested proper operation and unnecessary repair work can be eliminated for **[17]**.
5. Test used hydraulic components before they are sent out, preventing unnecessary expensive repair work. In many instances, we may find that only on inexpensive shaft seal or housing O-ring is necessary to put a component back in operation. Ensure your company is receiving quality components and prevent expensive additional production equipment downtime by performance testing components **[16]**.
6. System equipment could allow for complete testing of new equipment **[17]**, from pumps to end components like compressors, transfer pumps pneumatic and hydraulic, even cranes with remote mounting, without ever using a truck chassis.
7. The system can be configured to remotely store different drums outdoors to simulate different viscosities, at different temperatures. various fluids.

CHAPTER 2: COMPONENTS

Hydraulic test rig includes several components including the foundation of the bench, different electrical components, their assembly through linkages, hydraulics etc. The components used in the project are as follows:

1. Platform
2. Reservoir
3. Isolation valve
4. Hydraulic pump
5. Low or High pr switch.
6. VFD
7. Filter
8. Selection valve 1
9. Selection valve 2
10. Pressure gauge (HP)
11. Suction line 1
12. Suction line 2
13. Stand by pressure line
14. PRV (low pressure)
15. Pressure gauge (LP)
16. Gear Box
17. Pressure line
18. RPM sensor

2.1 Platform

To create a base for the motor or all the system we created a platform or base which is made up of C- Beams. All the C- Beams were drawn in Solidworks software and using real dimensions we created a base.

2.1.1 C-Beams

The structural channel, also known as a C-channel or Parallel Flange Channel (PFC), is a type of (usually structural steel) beam, used primarily in building construction and civil engineering. We used C-Beams as it is very good for overall stress distribution and was good for the support of Motor and other components.

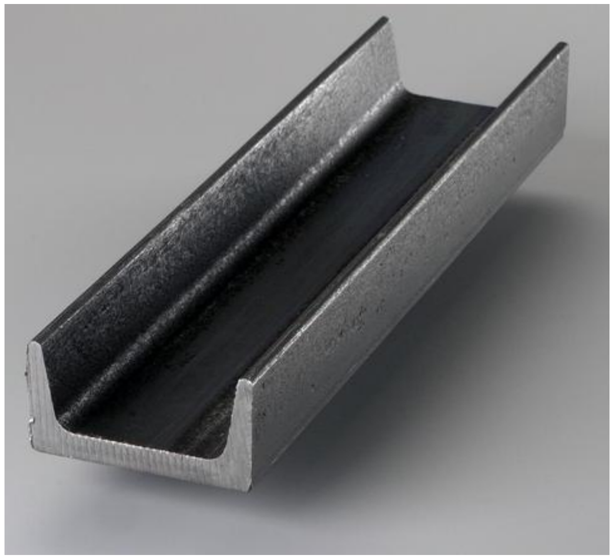


Figure 3: C-beam

We combine several C-Beams and built a structure. After completion of C-Beam structure we made a platform above the base to place Motor on it. As the Motor weight is 335kg platform for the motor was necessary to avoid any accident to worker while working. We decided to lift the platform for motor for easy access of worker if something happens to the motor.

2.1.2 I-Beams

For the base for motor, we used I-beams for better support of motor. I beam is a shape of structural steel used in buildings and it is also known as H, W, wide, universal beam, or rolled joist. They are designed to play a key role as a support member in structures.

Figure 4: I-beam

Final Picture of the Base is given below:

2.1.3 Solid-works design

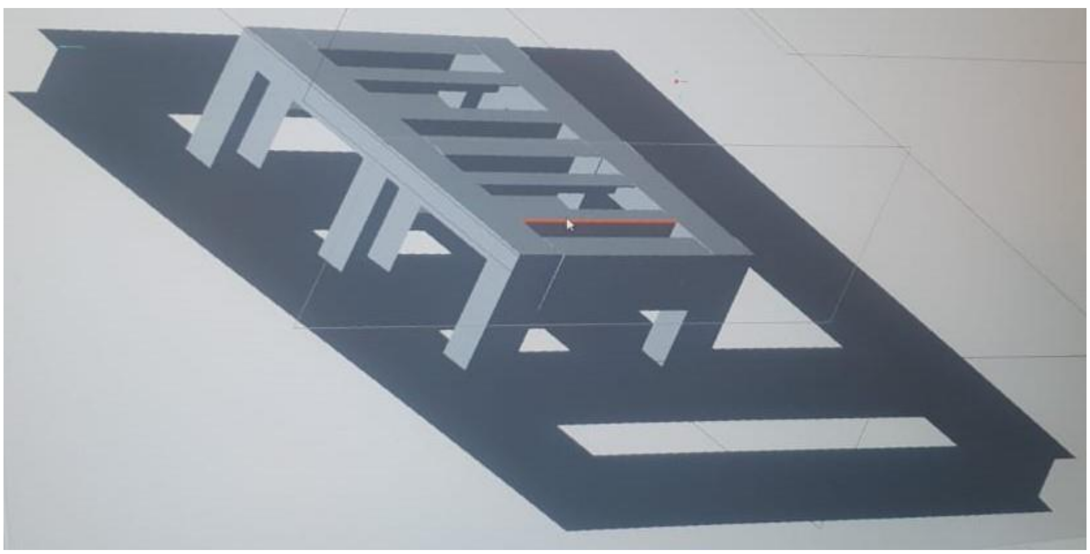


Figure 5:3D model of base

2.1.4 Actual model

We covered the actual model base with steel sheets.

Figure 6: Actual model of base

2.2 Hydraulic Reservoir

We created a steel welded hydraulic reservoir with a capacity of 200littre. This reservoir is divided into two parts. One side is for filtered fuel before using the oil and the other side is for the unfiltered fuel. Oil or fuel after its cycle will go to the unfiltered portion and after filtering it will move to the other side. Filtered oil is used so it does not affect the Pressure of pumps and other components. The Hydraulic reservoirs are storage tanks that hold liquids used in fluid power applications. They are usually:

- Rectangular
- Cylindrical
- T-shaped
- L-shaped

Figure 7: Rectangular hydraulic reservoir

2.3 Hydraulic Filter

Palmer High Pressure Filter: The main high pressure filter assembly comprises of four sub-assemblies and is capable of filtering OM-15 to a degree of 5 microns' absolute.

2.3.1 Filter Head

This houses four threaded ports, of which, only three are in current use. It receives an inlet and outlet adaptor union, a pressure loss indicator assembly, and the fourth port blanked off, but it can be utilized to „hand" the filter for an outlet/Filter Head.

2.3.2 Pressure Loss Indicator

Often referred to as the Clogging Indicator Assembly and consists of a magnetic piston held against a pole piece by a spring. On the other side of the pole piece is a RED warning button held onto the pole piece by magnetic force (North and South Pole together) **[9]**. A light spring tends to push the button away from the pole piece, and a bi-metallic, sleeve around the RED warning button prevents it from moving when the oil temperature is below a pre-determined figure.

2.3.3 Filter Bowl

The filter bowl houses the filter element, and screws into the filter head. Fitted between the filter head and bowl are two sealing rings **[12]**. Due to the construction of the filter element, it should only be necessary to hand tighten the filter bowl into the filter head for servicing procedures.

2.3.4 Filter Element

The filter element is made up of finely woven stainless steel wire cloth pleated across its length to form fins. The fins are welded together and secured in end plates forming a cylinder. One end plate accommodates a threaded made portion allowing the element to be screwed into the filter bowl and the opposite end plate has a hollow boss to allow a flow of filtered fluid into the system.

2.4 Services Isolation Valve

The body of the unit houses two valves i.e., a piston type valve and a pilot valve, both connected by fluid ways to pipe adapters which provide for connection purposes **[12]**. The valve is spring loaded against a sealed seat to close off the flow of fluid to connection P2 when the solenoids is de-energized, and is housed in a guide which is provided with holes for the passage of fluid and retained in the body by a sealed end cap.

The pilot valve assembly comprises of a spring, filter, two sealed valve seats and a spacer shimmed for fitted spring length and ball movement **[10]**. A push rod locates through the spacer and the outer valve seat to contact a ball valve which operates between the seats. Centrally surmounting the pilot valve assembly is a solenoid retained by four cap screws, with its armature screw abutting a spring-loaded rod which it depresses to contact the pilot valve push rod and actuate the pilot valve when energized.

2.5 PRV Valve

PRV stands for Pressure Relieve Valve. A pressure Relief Valve is a safety device designed to protect a pressurized vessel or system during an overpressure event. The primary purpose of a pressure Relief Valve is protection of life and property by venting fluid from an over pressurized vessel. Many electronic, pneumatic and hydraulic systems exist today to control fluid system variables, such as pressure, temperature and flow.

Each of these systems requires a power source of some type, such as electricity or compressed air in order to operate. A pressure Relief Valve must be capable of operating at all times, especially during a period of power failure when system controls are nonfunctional.

Figure 8:PRV valve

The body of the unit comprises a center bore which accommodates all the basic components **[2]**. Externally, it features two taped orifices for its connection, on one hand to the hydraulic system to be protected (orifice A), on the other hand, to the installation reservoir.

2.6 Non-return Valves

Non-return valves are all basically similar, varying mainly in size of thread for pipe connections in order to cater for different diameter piping. Each unit comprises a spring-loaded poppet valve housed in a body and an end fitting, external fluid leakage at the joint being prevented by a trapped "O" ring seal. Arrowheads on alternate flats of the body indicate the direction of fluid flow. A label affixed to the end fitting bears the cure date of the seal fitted.

2.7 Pipe Couplings and unions

The joint is obtained by the swaging action of the nut which compresses the collar and forces the projections into the surfaces of the pipe. The conical ends of the collar engaging with the corresponding countersinks of the union body and nut, ensures the rightness of the joint.

The first operation in making the joint is the anchorage of the collars on the pipes. The penetration of the projections on the collars requires an initial swaging action by the nuts. The torque required to remake the joint is considerably less than the initial swaging action. When the joint is broken the collar remains fixed to the pipe and retains the nut on the pipe.

Figure 9: Pipe couplings & unions

2.8 Pumps

Pumps are driven by the variable speed bi-directional hydraulic motor on the test bench. Pumps are mounted on the universal mounting bracket supplied with bench. The physical connection between test pump and bench motor is accomplished with a universal driveshaft and adapters between the drive shaft and test pump shaft **[15]**. The test pump receives oil from the bench reservoir.

ÖZELLİKLER / SPECIFICATIONS	
Yer Değiştirme / Displacement	85 cm³/dev.
Sürekli Çalışma Basıncı / Working Pressure	250 bar
Mak. Aralıklı Çalışma Basıncı / Max. Intermittent Pressure	300 bar
Maksimum Azami Basınç / Max. Peak Pressure	330 bar
Maksimum Sürekli Çalışma Devri / Max. Continuous Speed	900 1/dak
Aralıklı Maksimum Çalışma Basıncında Maksimum Devir Max. Speed At Intermit. Pressure	1300 1/dak
Hidrolik Yağ Sıcaklığı / Oil Temperature Range	-20 & 80 °C
Yağ Giriş Çapı - C / Oil Inlet Diameter - C	M45x2
Yağ çıkış çapı - D / Oil Outlet Diameter - D	R 3/4"
Ağırlık / Weight	20 kg

Figure 10: Pump and its specifications

Discharge flow from the test pump is measured by a flow meter and restricted by a load valve before discharge flow is returned to the bench reservoir. Pumps are checked for efficiency at a rated working pressure and for external leaks **[2]**. The standard test bench tests only one pressure port at a time, we are adding a second pressure port for the use of a tandem pump arrangement. Figure 10 shows all the specifications of the integral pump which we have used in our main hydraulic test bench including its working pressure, maximum intermittent pressure, maximum peak pressure, oil temperature range, weight of the pump, oil inlet diameter, oil outlet diameter etc.

Dimensions of Pump are shown in the figure 11 as below:

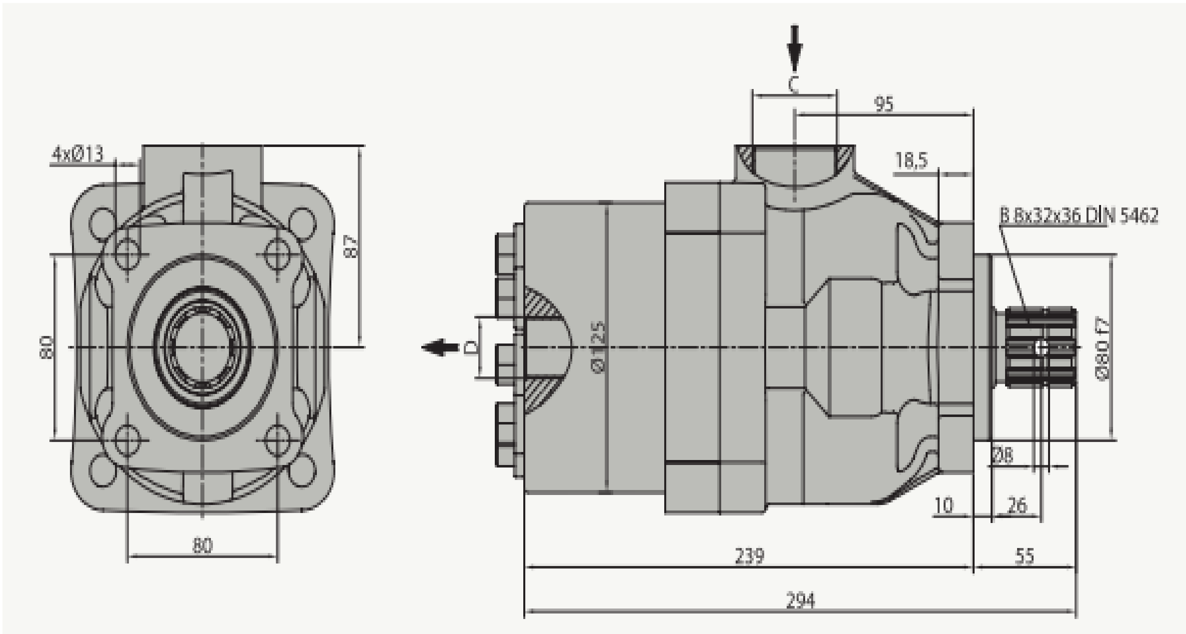


Figure 11: Dimensions of the pump

2.9 Motors

Motors are driven by the variable volume hydraulic pump on the test bench. The test motor drives the hydraulic motor on the bench (therefore, we are using the test bench motor as a pump). Mounting the test motor and the physical connection between the test motor and the bench motor is the same as described the "pump test" above. The discharge flow of the bench motor is restricted with a load valve thereby putting the test motor under a workload. Motors are checked for efficiency at rated working pressure and for external leaks **[15]**. The motor we have used is of 60 horsepower (60 hp), 45 kilowatt (45 KW) of Siemens. It provides enough power to give the drive to the integral pump which allows the pump to extract the oil from the oil tank and pressurize it throughout the hydraulic line and after passing through the components being tested it feds back to the oil tank.

Figure 12: Siemens 45 KW Motor

Electrical data:

Frequency	50 Hz	
Rated motor voltage	380-420D/660-725Y V	
Rated motor power	45 kW	
Rated motor speed	2960 rpm	
Rated motor torque	145-145 Nm	
Wiring connection Rated motor current Max motor current	- 78/45 A 81,9/47,3 A	-
Efficiency class	IE3	
Full load Efficiency %	94.0-94.0 %	
Power factor	0,89	
Starting- / Rated motor current (50/60 Hz)		690 /
Breakdown- / Rated motor torque (50/60 Hz)		330-330 / %
Starting- / Rated motor torque (50/60 Hz)		240 /

Mechanical data:

Noise measurements (50/60 Hz)	67 dB(A)
Moment of inertia	0.265 kg m²
Drain holes	Yes (closed)
Bearing DE	7313.BP
Bearing NDE	6313.C3
Bearing arrangement	DE-locked
Type of bearing DE	-
Bearing seal DE	-
Characteristic of grease DE	-
Type of bearing NDE	-
Bearing seal NDE	-
Characteristic of grease NDE	-
Regreasing device	No
Type of lubrication	-
Relubrication interval	-
Quantity of grease for relubrication	-
External earthing	-
Colour/type	Black

Explosion protection:

Type of protection	-

Ambient conditions:

Ambient temperature	-20°C to 55°C
Altitude above sea level	1000 m
Approvals and specifications	IEC 60034, CE,EAC

General data:

Frame size	SIEMENS
Type of construction	IM B5 Flange size FF400
Weight, without optional accessories	335 kg
Frame material	-
Degree of protection	IP IP55
Method of cooling, TEFC	IC 411
Vibration class	
Insulation class	155(F) to 130(B)
Duty type	-
Direction of rotation	CW /

Terminal box:

Material of terminal box	-
Cable entry	-
Cable gland	-

Protection:

Built-in protection	-

Figure 13: Table of technical details of motor

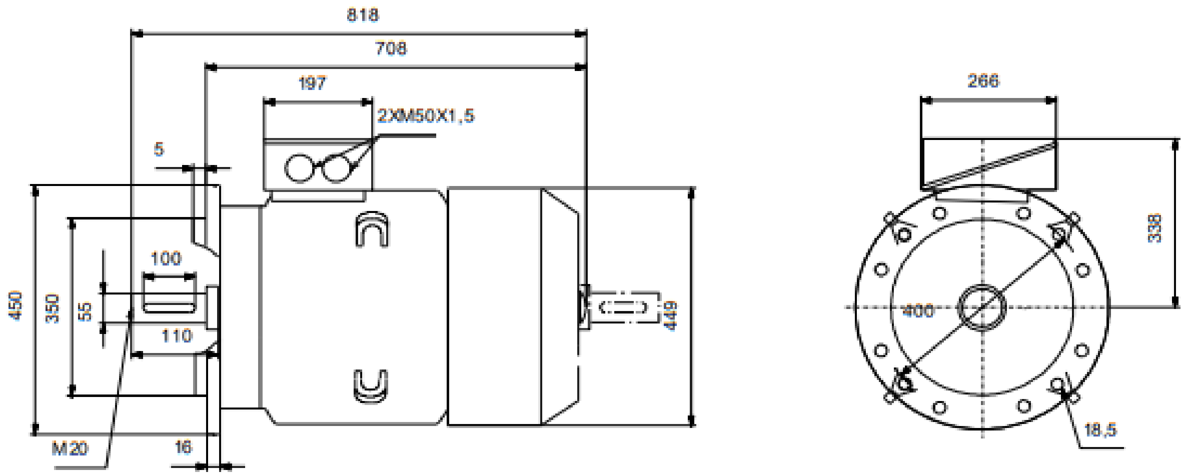


Figure 14: Dimensions of motor

2.10 Cylinders

Cylinders are pressurized and operated by the variable volume hydraulic pump on the test bench **[16]**. Flow is directed to and from the cylinder by a manual operated four-way valve. Cylinders are checked for scored cylinder bores, worn piston packing and external leaks.

2.11 Valves

Relief valves are pressurized and operated by the variable volume hydraulic pump on the test bench. Flow returning from the valve to the bench can be measured by the bench. Relief valves are checked for internal leakage, external leakage, “cracking” pressure, pressure setting and resetting pressure **[19]**. Four-way valves and valve banks are pressurized by the variable volume hydraulic pump on the test bench **[2]**. Generally, the valve spool is shifted to a direct oil to a blocked valve port and leakage past the spool is visually checked at the non-pressurized adjoining port. Valves are checked for external leaks **[19]**.

2.12 Pressure Gauge

200 bar pressure gauge that indicates the operating pressure of the main test bench pump. This gauge also indicates the test pressure applied to motors, valves and cylinders being tested on the test bench **[13]**. The pressure is controlled by the main pump pressure control

valve or by the horse power demand to drive the test pumps. 200 bar pressure gauge that indicates the working pressure being applied to a pump being tested on the test bench. Pressure on this gauge is controlled by pump test pressure control valve. 200 bar pressure gauge that indicates the amount of load being applied to the discharge port of the test bench hydraulic motor when being used as a load pump when testing hydraulic motors. Pressure on this gauge is controlled by the test pressure control valve **[3]**.

Figure 15: Analogue pressure gauge

2.13 Temperature Gauge

Temperature gauge which indicates the test bench reservoir oil temperature. The test bench should not be run if this gauge exceeds 160° F. Digital flow meter (0-100 gpm) measuring the amount of oil flow in gallons per minute being returned to quick disconnect ports on the test bench **[13] [16]**. Pressure control valve and pressure gauge are located in series with port. Main pump pressure control regulates the operating pressure on the main test bench pump between 200 and 250 bar. Circuit selector valve is a two position (either open or closed) valve located between the main test bench pump and the test bench hydraulic drive motor. In the open position it allows main pump flow to turn the hydraulic drive motor which I turn drives the test pump. In the closed position, it blocks off oil flow to the hydraulic drive motor for valve, cylinder, and hydraulic motor test.

This is a standard piece of equipment of a tried a true test bench, used across the industries for hydraulic component testing and relief valve setting process. It comes with a full operating and maintenance manual and factory replacement parts and support.

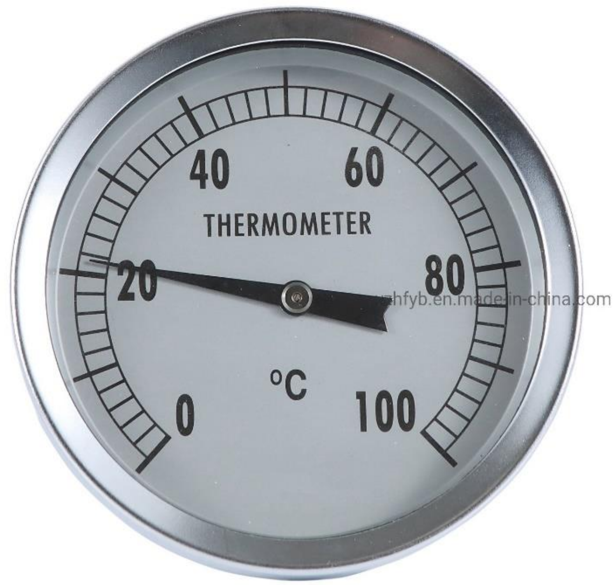


Figure 16: Analogue temperature gauge

2.14 Air-Cooled, Eddy Current Load Stand

The Air-Cooled, Eddy Current Load Stand allows for the output of Transmissions, **[16]** Torque Converters, Torque Converter/ Transmission Combinations and Hydraulic Motors to be loaded **[10]**.

2.14.1 Transmissions

While shifting, the eddy current loading function can load the output shaft as opposed to an unloaded shaft. This simulates more closely the actual condition as if installed in a machine.

2.14.2 Torque Converters

Before spinning, the stall brake is applied then the stall torque can be measured as the input shaft speed is increased. Torque Converter/Transmission Combinations - see the above tests that can be performed.

2.14.1 Hydraulic Motors

While motor is spinning, the eddy current loading function can load the motor. Before spinning, the stall brake is applied and the stall torque can be measured while pressurizing the motor. The Load Stand is vertically adjustable, travels in and out in relation to the driveline on the Hydraulic Test Center (HTC) Worktable and stores out of the way, on the Extension Table, when not in use. The eddy current loading function can be applied at any rpm. The stall brake is a static brake designed to be applied at zero RPM **[10]**.

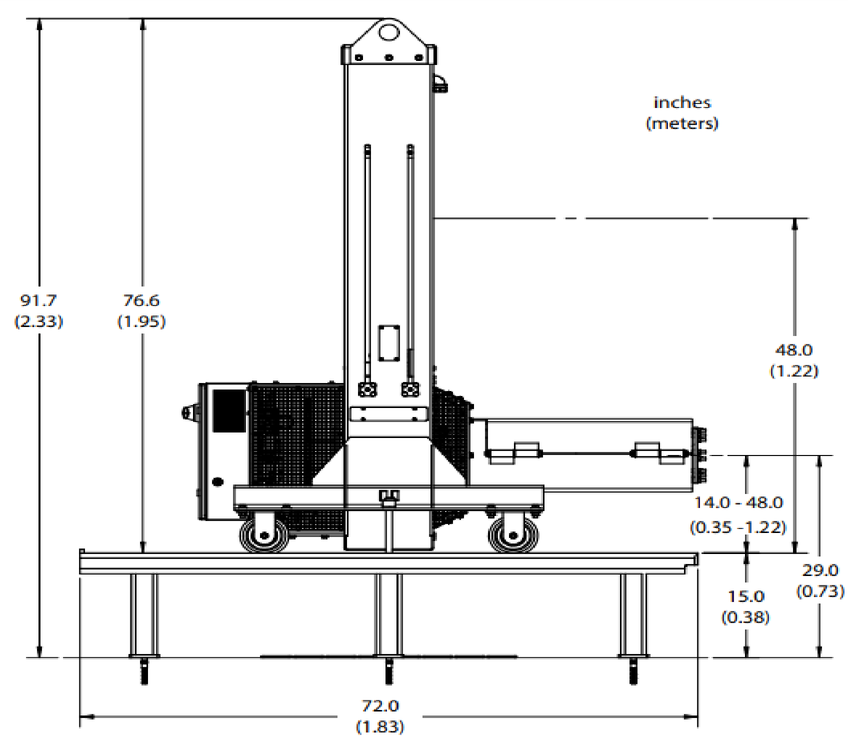


Figure 17: Eddy Current Load Stand

2.15 VFD

We have installed a VFD which a variable frequency drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage of its power supply. The VFD also has the capacity to control ramp-up and ramp-down of the motor during start or stop, respectively **[19]**.

A variable frequency drive is an electronic device we use to control the speed of AC induction motor. The improving performance of the VFDs has resulted from rapidly evolving semiconductor technology. Among the improving performance characteristics are improving electrical characteristics, ability to handle higher power levels, easier programming of desired control response, steadily increasing reliability and ruggedness and smaller size of units.

The frequency of power source applied to a motor and the number of poles designed into a motor determine the motor based (synchronous) speed. You could adjust motor speed by adjusting the number of poles, but this is a physical change to the motor. It requires rewinding, and result in only in a step change in the motor-based speed. Contrast, you can conveniently to adjust the speed of a motor smoothly by changing the frequency applied to the motor.

Figure 18:VFD (variable frequency drive)

2.16 RPM sensor

The observing of turn can include such sensor types as vicinity, photoelectric, resolvers, encoders, and tachometer generators. Most decide the heading of pivot, speed, and precise situation of their turning focuses by creating a progression of heartbeats. Tachometer generators and other traditional pivot screens require an actual association with the driving component. Closeness sensors, conversely, do not.

The appropriate size and setup of vicinity sensors utilized for estimating turn rely upon whether the sensor is or is certifiably not an embeddable sort. For embeddable sensors, the separating of every tooth and hole, should rise to or surpass the distance across of the sensor, D. For non-embeddable kinds, M should rise to or surpass D or 3 Sn, whichever is bigger.

Figure 19: RPM sensor

2.17 Gear Box

We decided to use a gear box because we were facing power transmission problem during coupling of motor and pump. A gear box is installed across the motor to increase the output torque or to change the speed of a motor. A motor shaft is attached to one end of the gearbox and through the internal gearbox configuration, empowers an output torque and the speed determined by the given ratio.

2.18 Ports for worktable

The Port for Worktable is tooling that allows a drain from a component under test to be plumbed into the worktable as opposed to it draining over the work table grates on the Hydraulic Test Center (HTC). This tooling provides for a safer and cleaner work cell. The Port for worktable allows for the connection of a 5, 4 and 2 in. (127, 102 and 51 mm) female cam lock (ANSI A-A-59326D) hose assembly.

Figure 20: Ports for worktable

2.19 Summary of All components:

1. 60 hp (45 kW) electric motor
2. 200l oil tank capacity
3. High capacity 20,000 Ib (9,072 kg) work support with integral sump
4. Rpm range: 0 - 2960
5. Peak torque: (145 Nm)
6. Includes torque load cell
7. Two (2) variable flow supply circuits
8. Reduced voltage soft-start motor starter
9. Cooling tower cooling: 20 gpm (75 lpm) at 90°F (32°C), inlet water at 40 psi (3 bar) and 120°F (49°C) oil temperature (40% of installed hp capacity)
10. 20 hp (15 kW) heater in component reservoir

CHAPTER 3: DESIGN AND SIMULATION

Solidworks, Creo and PI&D software were used for designing purpose and their progress is shown below:

- PID Diagram
- 3D CAD Model
- Solidworks
- Software development on LABVIEW
- Fabrication of a full-scale working model

3.1 Creo work

The project is about designing of Hydraulic Test Bench, a hydraulic system in which we need detailed knowledge of hydraulics. The product which is going to be fabricated has already been studied previously, which gives reference to build the new test bench with various new function and sub-function.

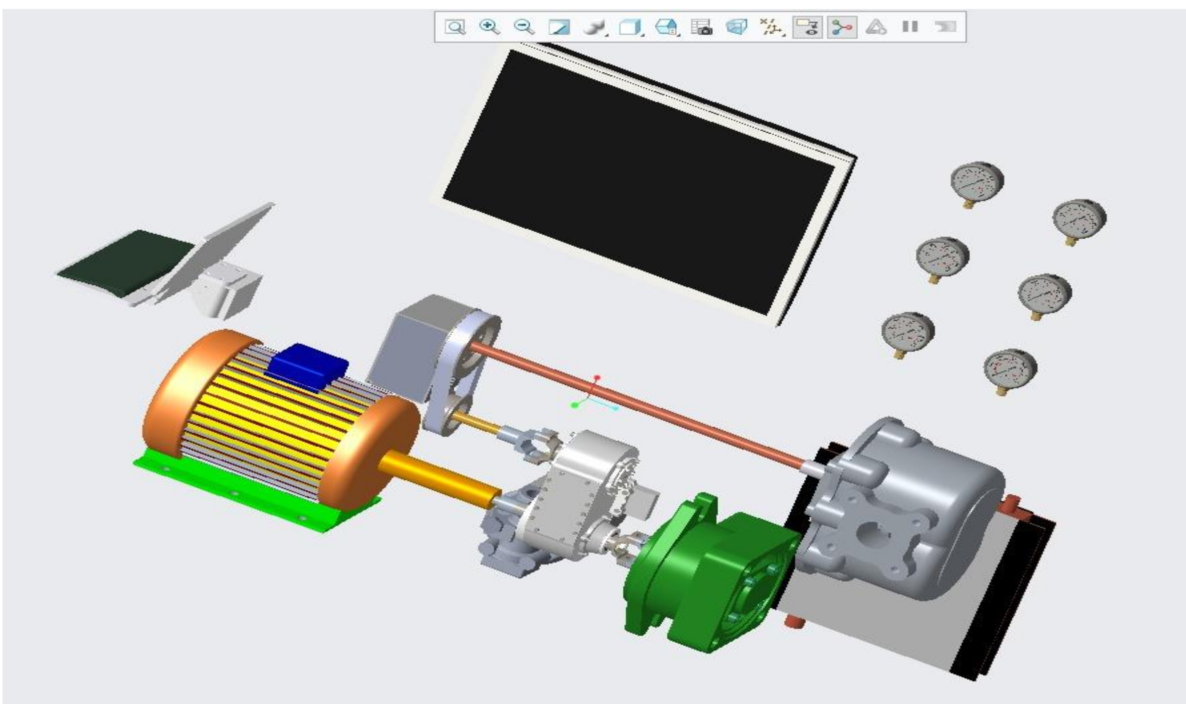


Figure 21: Components on creo

The feasibility study of the Hydraulic test bench has already been performed. The test bench is combination of various components and specification, which tests the hydraulic valve. The new design was developed by taking the reference of the model shown earlier. The design was made with help of CAD software. “CREO” software will allow us design, assemble and join different components of Hydraulic Test Bench.

3.1.1 Pump and Motor CAD model

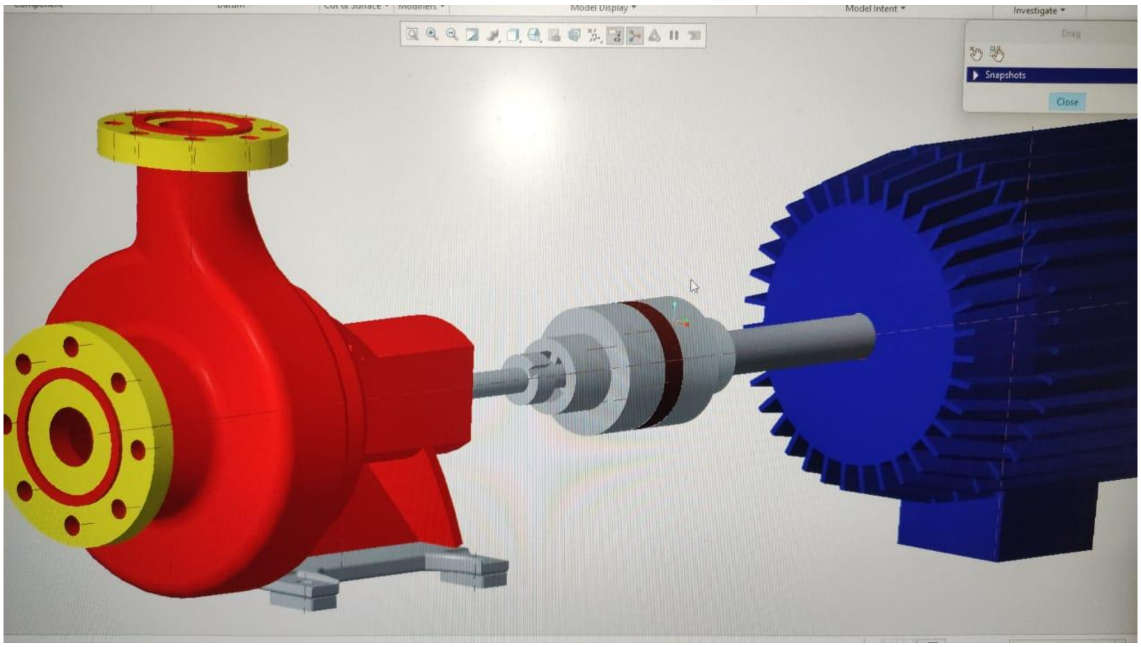


Figure 22: Pump and motor

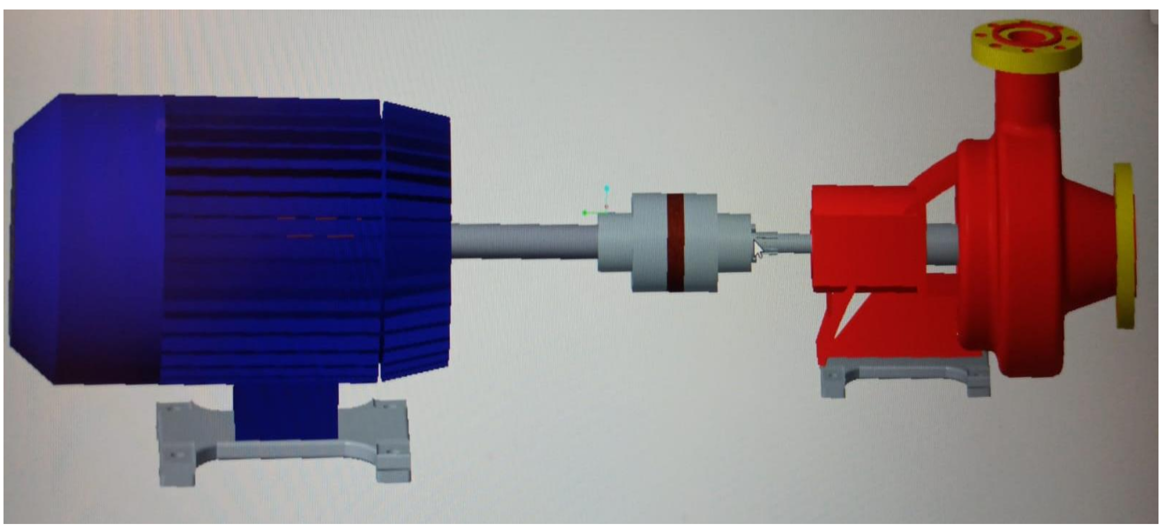


Figure 23: Pump and motor front view

3.1.2 CAD Model of connection Between Pump and Motor

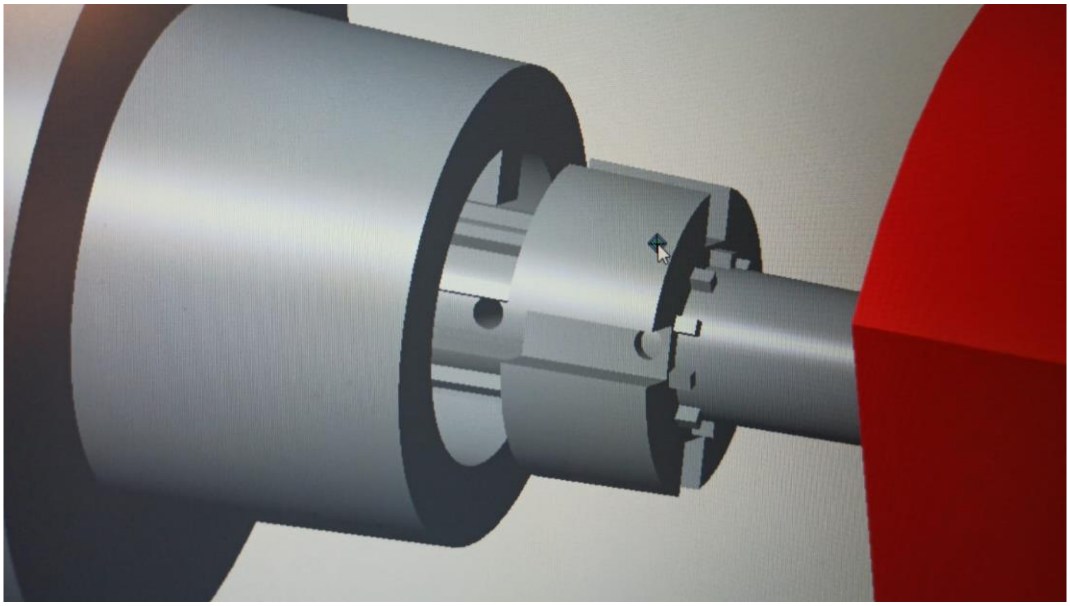


Figure 24: Connection of pump and motor

3.1.3 CAD Model of Foundation

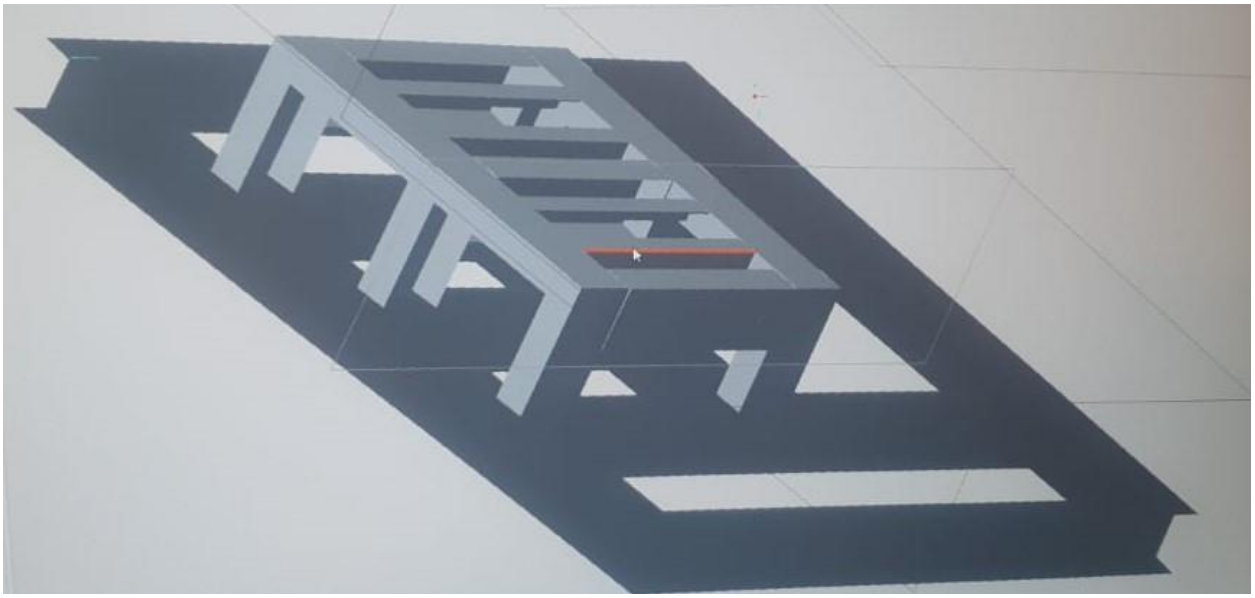


Figure 25: Base of HTC on creo

3.2 SolidWorks

We made the finalized model of hydraulic test rig on Solidworks software and different views of the model are given below:

3.2.1 Top View

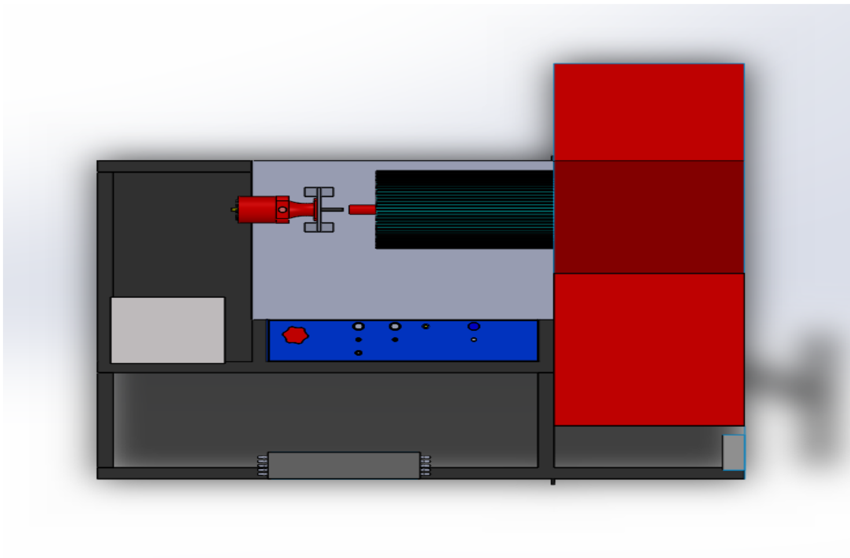


Figure 26: Top view

3.2.2 Back View

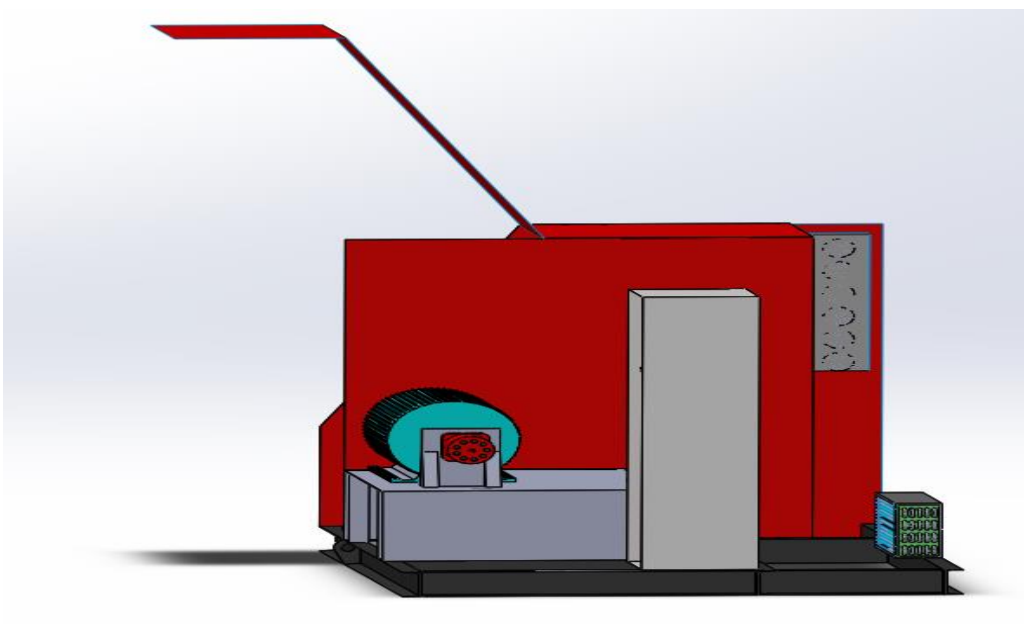


Figure 27: Back view

3.2.3 Left View

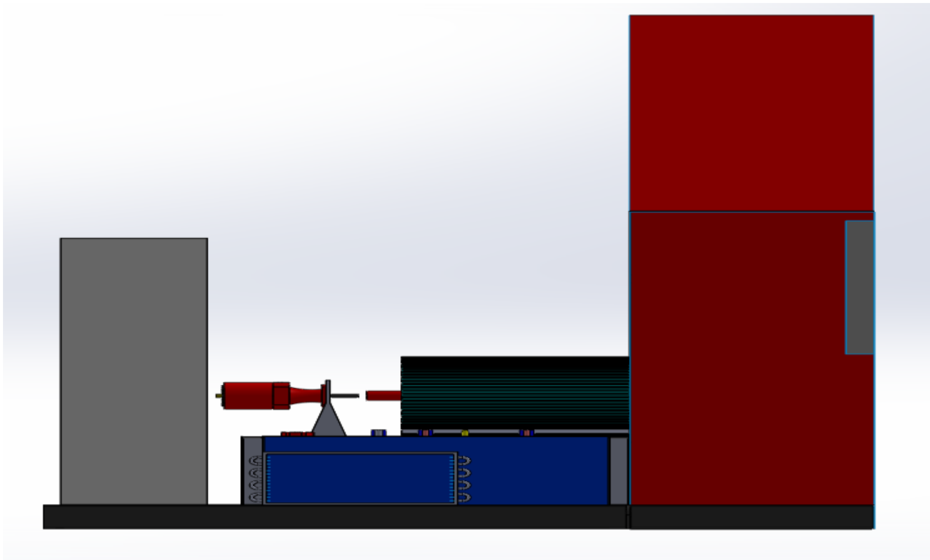


Figure 28: Left view

3.2.4 Right View

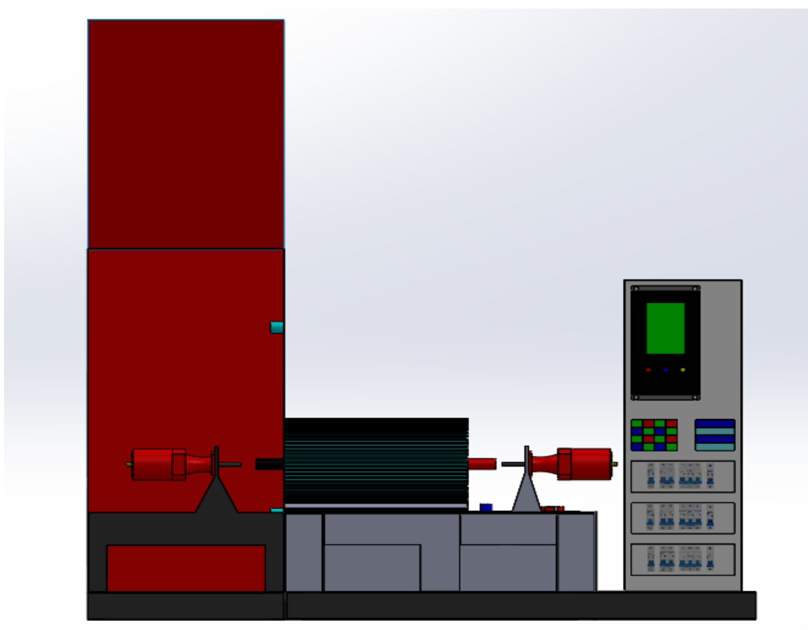


Figure 29: Right view

3.2.5 Front

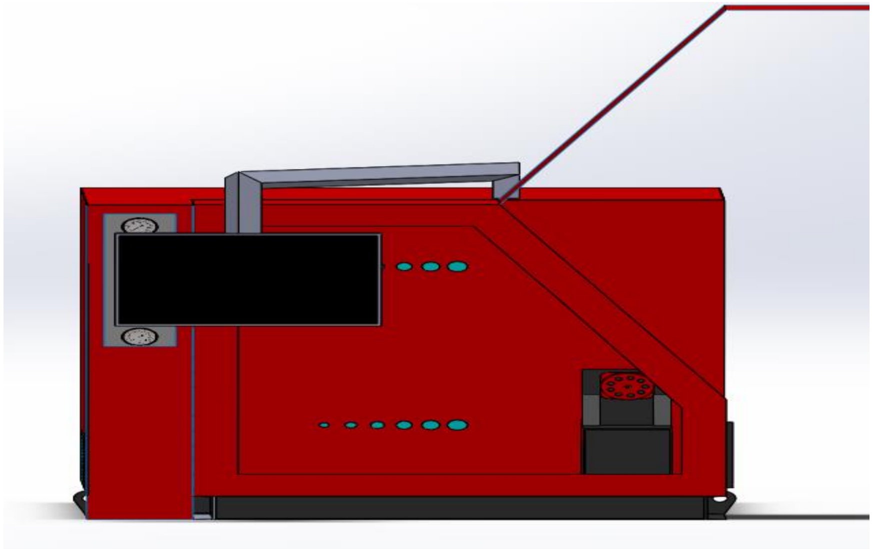


Figure 30: Front view

3.2.6 Isometric View

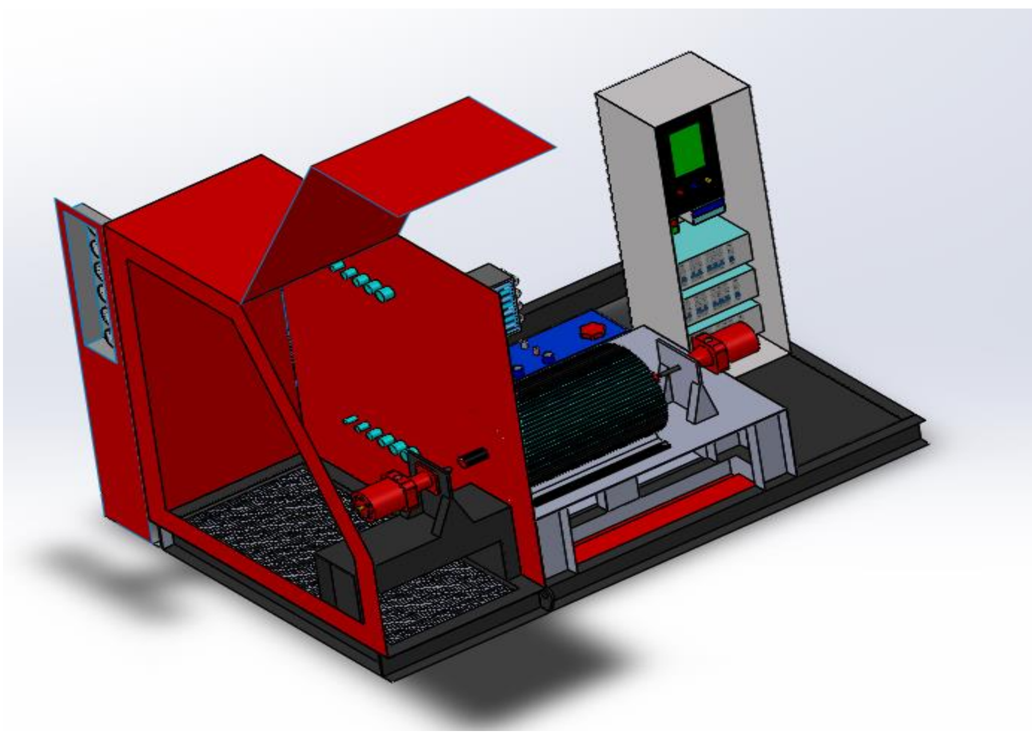


Figure 31: Isometric view 1

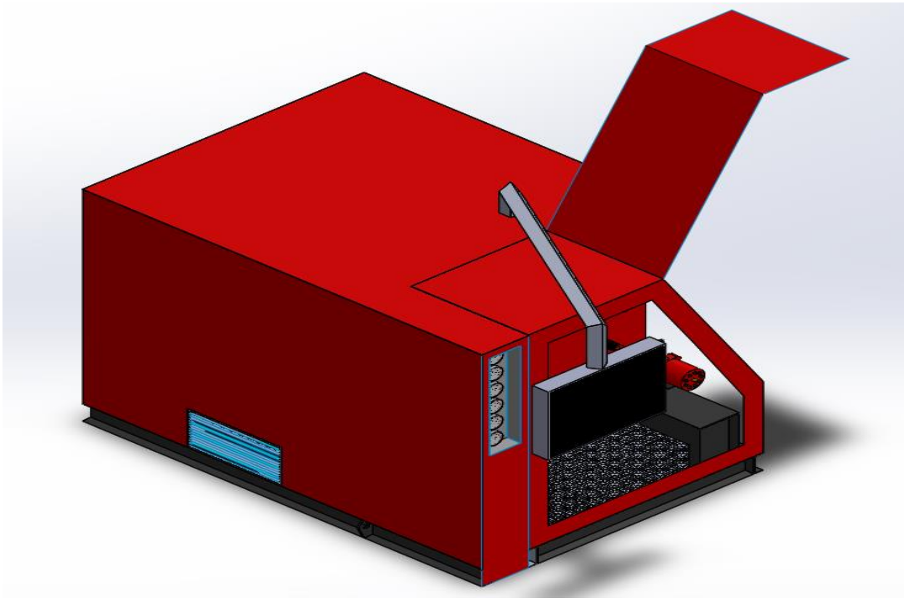


Figure 32: Isometric View 2

3.3 Control Panel Software

We will develop software for the functioning of control panel in Hydraulic Test Bench. We will be using “Lab view” software for the development of software. The software will be controlling Rpm of motor, hydraulic pressure, digital readings from the gauges and will be displaying any kind of warnings or any kind of malfunctions. We will be manufacturing our project in 502 workshops with the help of provided workforce. Our project is military funded.

3.4 PID Diagram

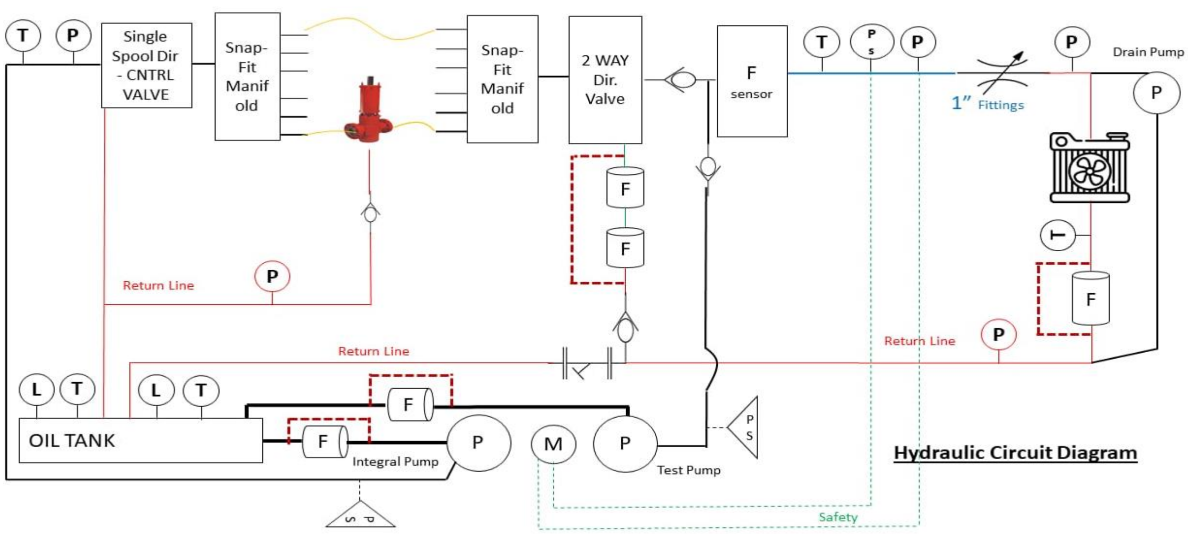


Figure 33: PID diagram

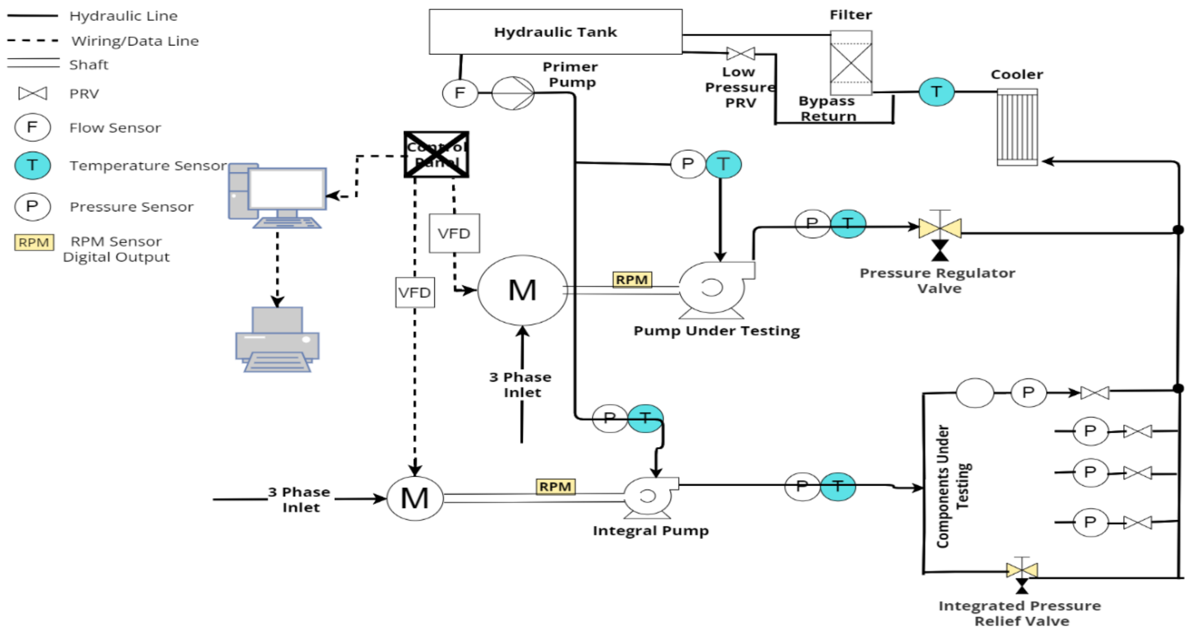


Figure 34: PID diagram

The PID diagram shows the connections of the Hydraulic Test Bench. The motor is connected to transfer case which is further connected to integral pump. The components to be tested are connected to integral pump. The transfer case is used to transfer power in two directions. The cooler is attached with filter and is connected to tank. The filter removes all the impurities, and the remaining is cooled in cooler. The process is repeated **[13]**.

The word hydraulics, in fact, comes from the Greek, hydro, meaning "water" and, aulos, meaning "pipe" **[6]**. The most used liquid in hydraulic systems is petroleum oil. Oil evaporates easily because it is very low in pressure. The hydraulic system is not a power source. A power source is a large conductor such as an electric motor or a pump that drives a liquid with a certain volume and pressure in response to a load need **[13]**. Hydraulic research workers were reported by many researchers and industry groups.

The idea for hydraulic cylinders can be attributed to renowned French mathematician Blaise Pascal (1623-1662), **[6]** who dedicated a large part of his mid-1600s studies to fluids, fluid pressure and vacuums.

3.5 Design Problems faced

During the design phase we faced many problems due which we had to change our design many times. The problems faced by our group was:

3.5.1 Placement of motor

While working on our design the first problem we faced is the position of motor. To place the motor is such a way that it would be easy for the worker to work on motor. We created a platform as shown above for the motor so that the worker does not have to bend down enough.

The position of motor should be in line with the pump so platform for motor was necessary. Due to the larger weight of motor the base should be strong enough so that there would be no chance of any accident. To solve this problem, we used angle beams for the support of motor.

3.5.2 Placement of pumps

We had to place the pumps in line with the motor so that there would be no problem in transmission of torque or power. While selecting the best position for pumps we changed the system many times using gears and belts for transmission. The problem related to belt was that of its lifetime. As gears have more lifetime than belts. we used gears for power transmission. If the pumps and motor are not aligned properly vibrations would be generated and it would cause damage to coupling and the pressure would not be accurate.

3.5.3 Coupling

While coupling the motor and pump we changed the mechanism to sleeves. Sleeves are good for engaging and disengaging the motor and pumps. While working on the tested pump sleeve is engaged and while working on integrated pump sleeve is disengaged. We used sleeves mechanism and picture of this mechanism is shown in creo model.

3.5.4 Oil drainage

Later onwards we faced the problem of oil drainage. As the worker has to go inside the HTB while working on motor and other components we had to design a model which could not endanger the life of worker. Also, to make HTB neat and clean we had to design a model in which there would be no issue of oil drainage. We first made the design with inclined surface so that oi goes straight to the oil tank but this method was not safe. We decided to change the design and made a meshed surface or base so that the worker can go inside HTB without any harm.

3.5.5 Placement of Boom

The Boom is created so that worker could easily get access to the functioning of the HTB system. We needed to design a boom such that worker could easily access at any point near HTB. We created a design in which a worker can rotate the boom at any position near the working bench.

3.5.6 Allocated space for wirings and fittings

To make our Hydraulic test bench (HTB) neat we had to design a model in which there would be no jumble of wires and pipes. All the wires and pipes should be visible properly. To solve this problem, we decided to shift all the piping and wires under the metallic sheet covering the base of HTB.

CHAPTER 4: FABRICATION

4.1 Fabrication of main hydraulic test bench

Fabrication is the process of constructing products by combining typically standardized parts using one or more individual processes. For example, steel fabrication is the production of metal structures using a range of processes such as cutting, bending and assembling.

Fabrication of our project hydraulic test rig has been started and it is currently in progress. It will take a detail supervision, as a small mistake can be responsible for a big accident.

This project is supervised by us and currently being manufactured in 502 workshop. We are checking the progress and fabrication on daily basis.

4.1.1 Methodology

Fabrication of our project is done step by step:

First comes the material selection. As this project is fabricated n a large scale so we need strong base and foundation for it. We are using high Stainless-steel for the foundation. After the selection of material, then comes the process of building foundation. We are going to use I-beams on base. These I-beams are welded together to form a strong structure. After the welding of I-beams, we covered it with steel sheets to give full support to the other components. As the motor being used is more than 300kg, we cannot simply place it on the foundation. So, we created another structure to support pump and motor.

We created a tank covered with steel sheets to accommodate oil which will be used in the system. Tank is placed behind the motor and pump. Both Motor and pump are levitated from the surface of foundation as it cannot give full support to the motor. After the placement of motor and pump we will install VFD (variable frequency drive) controller inside the Hydraulic test rig.

We will create a boom to support the screen which will be used to monitor and control all the function of the system. All the piping system will be installed once components are placed at their places. Free space has been allotted for electrical wiring and piping system in order to ensure clean internal area.

A separate compartment has been designed for the pipes and motors under test so that testing process is efficient. Gauges are also fitted at front side so that it is easily readable. Oil level gauge is also visible at the front for ease of the worker during testing. Colling system is also installed at allocated position.

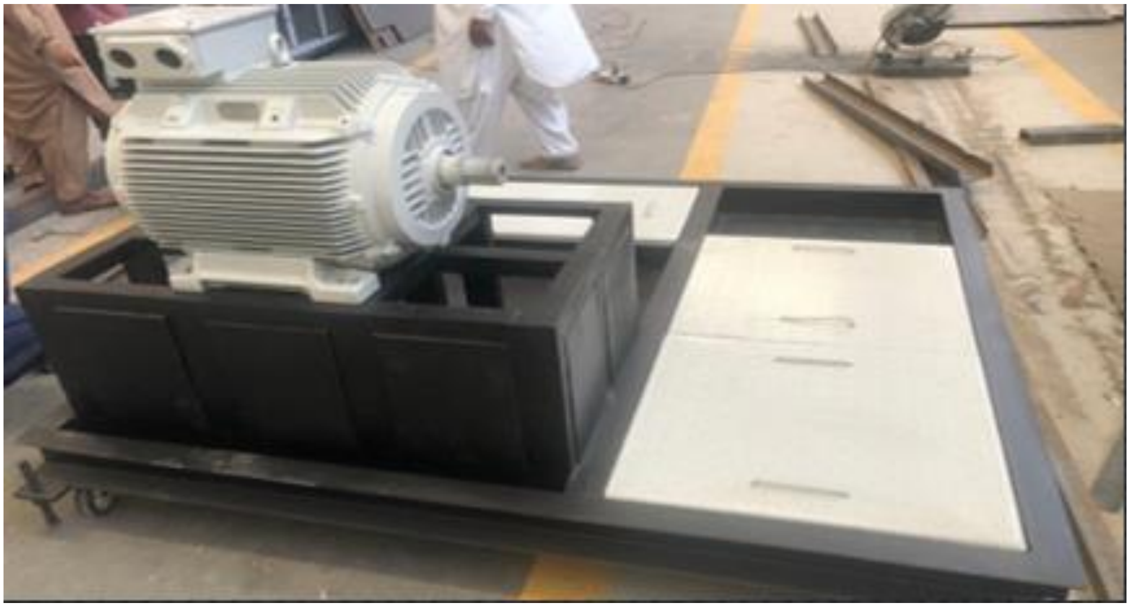


Figure 35:HTB base with motor installed

Figure 36:HTB base

4.1.2 Problems faced and their solutions

During the fabrication of our main HTB we faced many problems. These problems are:

4.1.2.1 Vibration issue

During fabrication of our main HTB when we tested the system it was creating a lot of noise and vibrations. These vibrations were not desirable for our project. These vibrations could easily wear and tear the components. To control these vibrations, we decided to use rubber padding under the vibrating systems like motor and pumps. This greatly reduced our vibrations and canceled the noise generated during working of system.

4.1.2.2 Valve issue

During the working of our main HTB pressure needle was flickering during rise and drop of pressure. For maintain linear rise in pressure and to avoid flickering inn gauge we came up with the solution that we will use a cylinder shape container in which oil would be filled. That filling would be in linear manner so that that the pressure rise will be linear ultimately. To release extra pressure in container we used safety valve to regulate pressure ultimately flickering in the gauge is also avoided.

CHAPTER 5: CALCULATIONS BASED ON SPECIFIED MOTOR AND PUMP USAGE

5.1 Reference Pumps used for the Research Purpose

During our research, we had gone through the study of a wide range of pumps which are being used in a lot of vehicles, lifters, SUVs, tanks, and hydraulic facilities in Pakistan Military which are mostly being sent to the 502 Workshop for being tested. The wide variety of pumps being studied during our research are of the following vehicles:

- APU hydraulic Pump (M-88)
- PTO hydraulic Pump (M-110)
- Hydraulic Pump-VIZOVICE (T-813)
- Spad Hydraulic Pump (T-813)
- Rotary hydraulic Pump (M-110)

The pumps of the above-mentioned vehicles cover almost all the pumps being used in Pakistan Military which needs deliberate testing to avoid any incident during their operation in the ground exercise as the failure of the pumps can cause a lot of the fatal risks as this warning had already been documented on Dec 12, 2020 [21].

In the light of above-mentioned warning, the pumps must be tested after being manufactured or repaired before fitting them into the vehicles to avoid such fatal risks. For this purpose, we worked on the hydraulic facility which will test the above-mentioned pumps and for the testing we need the pump and motor assembly which will undergo the testing of such pumps. So, for the selection of the motor and pump for the hydraulic facility we had conducted a detailed calculation so that the above-mentioned pumps can be safely tested up to their standards.

5.2 Specifications of the Pumps to be Tested

5.2.1 Range of RPM

After studying the above-mentioned pumps, we concluded a range of RPM which covers the RPMs of such pumps. The range of RPM is as follows:

1500-2900 RPM

Keeping in mind this RPM range, the other factors like torque, flow rate, pump size (can be large or small), and shaft diameter can vary for the same RPM. So, we considered these factors as well in our study so that a universally accepted motor and pump can be selected testing a wide range of pumps.

5.2.2 Flow Rates

The pumps to be tested as discussed in topic 3.1 have high volumetric flow rates to lift up heavy loads and bridges. These applications demand high volumetric flow rate, the larger supply diameter piston size of the pump. We categorized the flow rates the pumps into 2 categories as:

High Range: 35-40 gpm (gallons per minute)

Lower Range: 5-10 gpm (gallons per minute)

Ultimately, the flow rate range of the tested pumps were concluded as 5-40 gpm.

5.2.3 Power Requirement

The pumps to be tested as discussed in topic 3.1 are already being run by certain engines. So, after studying the engines of those vehicles we concluded that the maximum power delivered by all those engines is 60 HP or 44.742 KW and the minimum power delivered by one of such engines is 15 HP or 11.1855 KW. This confirmed the required power of the motor to be used to run the pump of the hydraulic test bench to test such pumps. The range of power thus concluded is **15-60 HP or 11.1855-44.742 KW**.

5.2.4 Range of Torque

As, the pumps to be tested have greater flow rates and greater power requirements so using the following relation we determined the torque range of the pumps so that the motor to be used should generate enough power to generate the required torque within the following range:

$$\frac{RPM * Torque}{5252} = \text{HP}$$

As, the maximum RPM is 3000 RPM and the required maximum horsepower is 60 HP so, using above relation the maximum torque being determined is 145 N-m. The minimum torque requirement determined from the wide variety of already discussed pumps is 50 N-m. So, the range of the torque concluded is **50-145 N-m**.

5.2.5 Pressure Range

The maximum working pressure of such pumps observed is **200 bar**.

5.2.6 Summary of the Specifications

- RPM Range=1500-3000 RPM
- Flow Rate Range=5-40 gpm
- Power Requirement=15-60 HP or 11.1855-44.742 KW
- Torque Range=50-145 N-m
- Maximum Pressure=200 bar

5.3 Selection of the Pump being used in Hydraulic Test Bench

In the light of all the specifications of the pumps to be tested as discussed in topic 3.2, after keeping in mind the safety standards and the power losses which can occur in hydraulic line, power loss as heat, leakage of some droplets etc. we concluded that pump which should be used in the hydraulic test bench should be having a working pressure of 250 bar (250-200=50 bar) by considering the power loss factor and environmental factors.

So, using the pump of such pressure it will be possible to test all the mentioned pumps in topic 3.1 up to full rated specifications of those pumps.

5.4 Selection of the Motor being used in Hydraulic Test Bench

Out of all the specifications of the pumps to be tested in section 3.2.6, there is one most important factor i.e., power requirement which is the main factor behind the selection of the motor to be used in our hydraulic test bench which shows that we require at max 60 HP to safely run the pump of the hydraulic test bench taking in consideration all the safety standards, losses and environmental factors; ultimately undergoing successful testing the pumps being discussed in topics 3.1 and 3.2. As per the specifications of the pumps to be tested, we searched for the model of the motor which can fit all the requirements as previously discussed.

Finally, we had come up with the decision of a specific model of the motor which fits all the requirements as per specifications discussed in section 3.2.6 keeping in mind the other factors like power losses, safety standards etc. as well. That specific model of the motor is **Siemens 225 M** with the following specifications:

- Frequency=50Hz ($\frac{RPM}{60}$=Frequency)

- Rated Voltage=380-420D/660-725Y V (Rated for two voltages, the wye 'Y' connection is for the high voltage and delta 'D' connection is for the low voltage.
- Rated RPM=3000 RPM ($\frac{RPM}{60}$=Frequency)
- Rated current=78/45 A
- Rated Torque=145 N-m
- Motor shaft size is almost twice the size of the maximum shaft size of the pump to be tested, keeping the safety factor intact.

The above-mentioned motor **Siemens 225 M** with all such specifications successfully fir all our requirements to run the integrated pump and to test the pumps up to their rated specifications.

5.5 Introducing Variable Frequency Drive VFD to achieve different RPM-Torque Relation

5.5.1 Reason behind using VFD

As using the mechanical RPM-Torque equation does not always give the required result when one of the specifications is locked e.g. our maximum torque is 145 N-m so, if there is 1000 RPM and 60 HP known then, the required torque as per the following mechanical RPM-Torque equation is as follows:

$$\frac{RPM*Torque}{5252}=\text{HP}$$

$$\frac{1000\ RPM*Torque}{5252}=60\ \text{HP}$$

$$\text{Torque}=315\ \text{N-m}$$

But our maximum torque cannot exceed 145 N-m. So, manually adjusting the above specification while locking the maximum value of each specification is complicated. So, for this purpose there is variable frequency drive VFD is used which can alter the voltage and current in a way that it gives the required RPM and torque respectively.

5.5.2 How VFD works to achieve the required RPM-Torque Relation

Basically, the coding is VFD is done in a way that it feeds the maximum and minimum values of each specification like torque and RPM. In our case:

For maximum Torque of 145 N-m:

$$\frac{RPM*Torque}{5252}=\text{HP}$$

$$\frac{RPM*145\ N-m}{5252}=60\ \text{HP}$$

RPM=2173 RPM

For maximum RPM of 3000 RPM:

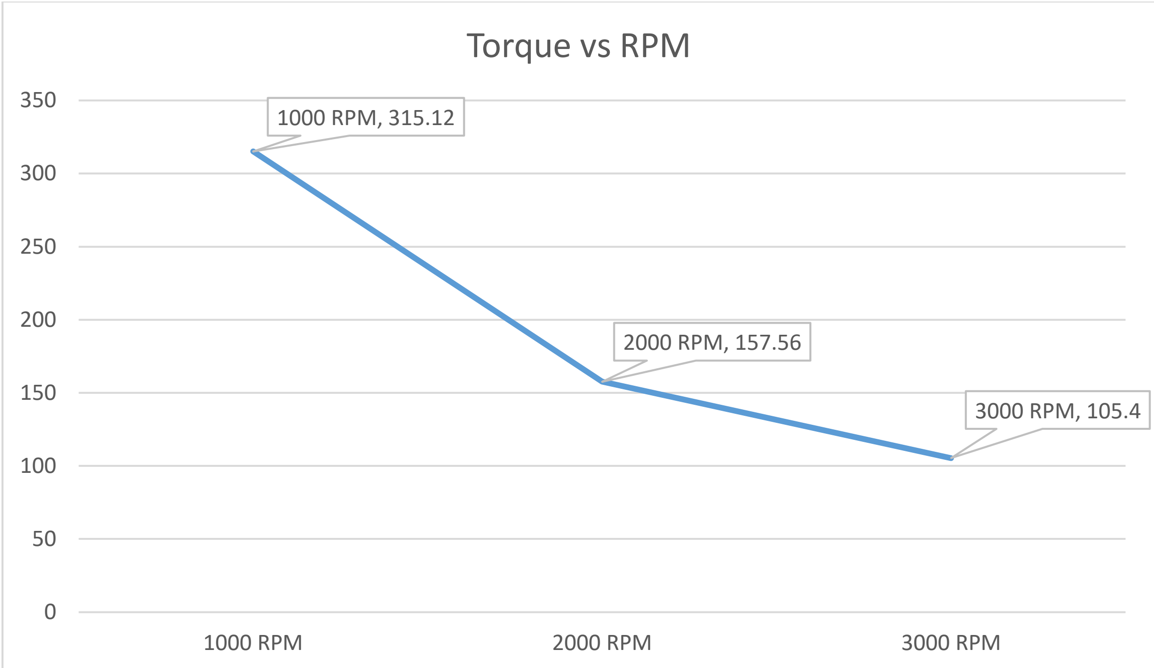
$$\frac{RPM*Torque}{5252}=\text{HP}$$

$$\frac{3000\ RPM*145\ N-m}{5252}=60\ \text{HP}$$

Torque=106.5 N-m

Now, we know that as the RPM will reduce than 2173 RPM then the torque will rise than 145 N-m and if the torque will reduce than 106.5 N-m then the RPM will rise that 3000 RPM using the mechanical RPM-torque equation. Similarly, we also know that the above situation can be faced in which RPM and torque can be reduced than 2173 RPM and 106.5 N-m respectively for different large and small size pumps.

So, in this case VFD use its coding to alter the voltage and current in a way that it does not cause the RPM and torque to exceed their maximum rated values. As, torque is dependent on current and RPM is dependent on voltage so varying current and voltage in a managed way affect the torque and voltage and ultimately, using VFD can achieve the required specifications without exceeding any of the specification greater than its maximum value, saving the motor and pumps from malfunctioning and avoiding the life-reduction risk of those components.



Graph 1: Torque vs RPM Relation

The above graph shows torque on Y-axis and RPM on X-axis. The curve shows that the RPM and torque have inverse relation. With the increase in RPM, torque decreases and vice versa. Taking in consideration this relation, the relation of current and voltage with torque and RPM respectively and keeping the maximum values of both torque and RPM the higher limit, the VFD is coded in a way that it causes the motor to safely work without the risk of malfunctioning and ultimately getting the pumps being tested safely.

CHAPTER 6: MINIATURE MODEL

We have designed and fabricated a scaled down miniature model of the Hydraulic Test Bench so that we can explain the basic working principle and demonstrate the working of HTB. It is an improvised model in which certain parameters have been ignored such as safety valves, high pressure working components etc.

6.1 Basic Principle

The basic principle of the test bench is to generate pressure ripples in the desired frequency range for different working conditions in mean pressure and mean flow rate. It characterizes passive hydraulic components based on the ISO standard. The discharge flow of the bench motor is restricted with a load valve thereby putting the test motor under a work load. Motors are checked for efficiency at rated working pressure and for external leaks. Cylinders are pressurized and operated by the variable volume hydraulic pump on the test bench.

A test bench can prove to be a useful tool in illustrating the functionality of pressure reducing, and directional control valves. The effect of different system pressures and resulting operational pressures for various circuits. By analyzing the fluid mechanics by the hydraulic system, we can apply hydraulic power and fluid analysis theoretically and validate experimentally with the test bench.

6.2 Components

Following components have been used un the miniature model.

6.2.1 Base

The base of the miniature model has been designed keeping in the view of our requirements. We have changed the design of the base because less stress distribution is required. The motor is not having much weight and simple sheet of mild steel material can withstand the weight of the components. We have used mild steel to make a table for the model on which we have fitted a sheet made of the same material that is mild steel. The dimensions of the table are based keeping in the view that it can be easily operated.

Length	3 ft
Width	2 ft
Height	0.8 ft

Table 1: Dimensions of the base

The base of HTB has been designed using a C-shaped beam. C-shaped gives the most efficient stress distribution horizontally. This means that for flat and wide structures, a C-shaped beam is more reliable and stronger than I-shaped beam. For the miniature model we have not used C-shaped nor an I-shaped because we can easily manage the stress distribution of the components. We have designed and fabricated a table and placed a sheet on top for placing the components.

Figure 37: Base

6.2.2 Fuel Tank

The use of oil for demonstration purpose is very less. We have used a square box made of mild steel which is having a capacity of **6-8 liter**. This is sufficient for our requirement. We have placed the fuel tank underneath the table so that we have a neat and clean outlook of the model. The use of fuel tank is considerably lesser than other components thus it has been placed under the table. We have also fitted a level gauge in the main HTB. But in miniature model the level gauge is not required because of lesser amount of oil present.

6.2.3 Motor

The main component of our model is motor. Motors are driven by the variable volume hydraulic pump on the test bench. The test motor drives the hydraulic motor on the bench (therefore, we are using the test bench motor as a pump). Mounting the test motor and the physical connection between the test motor and the bench motor is the same as described the "pump test" above. The discharge flow of the bench motor is restricted with a load valve thereby putting the test motor under a workload. Motors are checked for efficiency at rated working pressure and for external leaks. We have used a motor that will be sufficient for our needs. The specifications are given below.

Power	2 Hp
Shaft diameter	1 inch
Quarter Pin/Key	
Length	12.7mm = 0.5 inch
Height	3mm = 0.11 inch

Table 2: Specifications of the motor

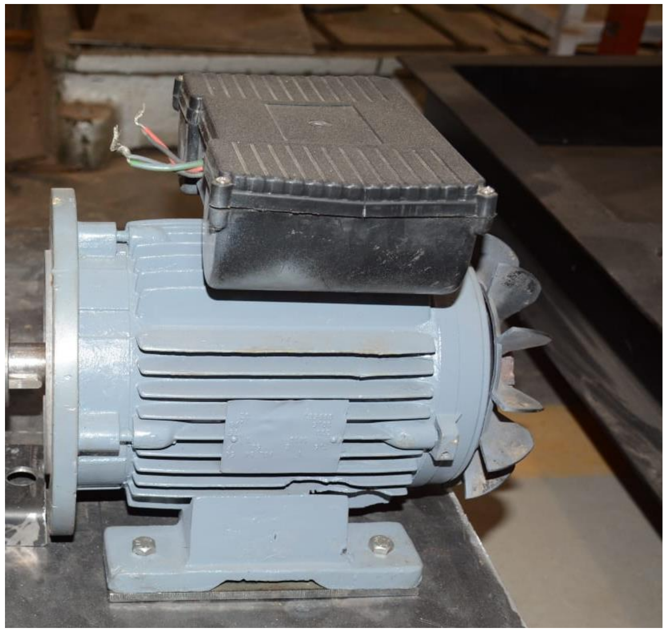


Figure 38: Motor

6.2.4 Pump

Pumps are driven by the variable speed bi-directional hydraulic motor on the test bench. Pumps are mounted on the universal mounting bracket supplied with bench. The physical connection between test pump and bench motor is accomplished with a universal driveshaft and adapters between the drive shaft and test pump shaft. The test pump receives oil from the bench reservoir. Discharge flow from the test pump is measured by a flow meter and restricted by a load valve before discharge flow is returned to the bench reservoir. Pumps are checked for efficiency at a rated working pressure and for external leaks. The standard test bench tests only one pressure port at a time, we are adding a second pressure port for the use of a tandem pump arrangement. The specifications of pump are given below.

Pressure generated	10 bars
Shaft diameter	0.5 inch
Quarter Pin/Key	
Length	8mm = 0.31 inch
Height	3mm = 0.11 inch

Table 3: Specifications of the pump

Figure 39: Pump

6.2.5 Coupling

It is used to connect the rotating pump shaft to drive shaft of motor. This enables motor to transmit power efficiently. Coupling helps us to ignore any other connecting assembly to be attached between motor and pump. We have used a coupling of **2-inch**. This is ideal for the shaft size of motor and pump. For the coupling to be attached between motor and pump, first we bored holes on the opposite sides of coupling so that it can be gripped by motor and the pump. After that we welded the coupling assembly so that it will not be loosely rotating, which in turn can produce vibration, noise etc.

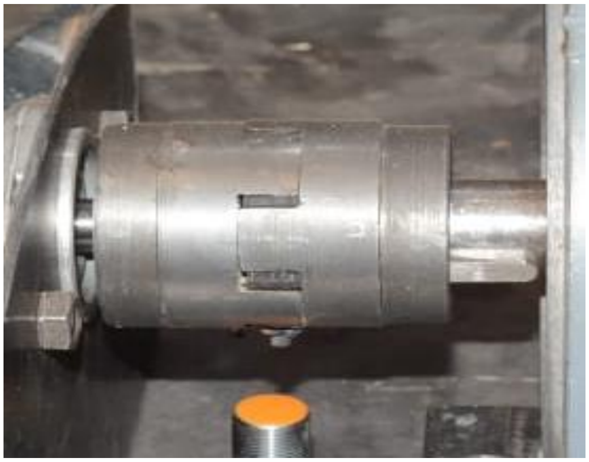


Figure 40: Coupling

6.2.6 Fitting

We designed the miniature model keeping in view that it must accommodate all the components and must look professional. We placed the motor and pump in a corner to use least amount of space. The motor has been rivetted down using bolts. The pump has been elevated from the surface and is fitted on a triangular shaped support. It has been elevated to the height of motor. We have placed a rpm counter under the coupling to read and count number of rotations. The pump and motor have been coupled by the process of slotting. Two keys were made, each for pump and motor. The key grips the motor or pump with coupling assembly.

6.2.7 Sensors

We have used main sensors in this model for demonstration purpose. The most important sensor is pressure sensor. It detects the back flow and normal pressure from hydraulic circuitry. After that we have used temperature and proximity sensors. These both are very important for showing temperature of certain components and circuit line. Many pressure and temperature gauges are also fitted on the hydraulic circuit line. We are also counting rpm using these sensors. Pressure safety valve has also been introduced in the model so that any back pressure is controlled immediately without doing any harm to the pump or motor.

6.2.8 Piping and Hydraulic line

We designed the hydraulic circuit according to the general possible smart utilization of our space. Pressure gauge has been fitted in the start of the circuit. We have given bend in the pipe in front of the motor, the line goes in front of the pump and different sensor have been attached to it at different locations. Pressure safety valve has also been used for restricting back-flow. The working of the model is based upon the linear pressure. The linear pressure generated is increased to test the pump under test.

6.2.9 Electrical Circuitry

The electrical circuitry has been placed underneath the table in order to have a neat outlook of the model. Arduino has been used to process all the values coming from different sensors and display them on laptop. We will be having values of rpms of motor, pressure, temperature etc.

6.2.10 Methodology

The miniature model has been designed to have reasonable working and would be able to demonstrate required function. The table of the model has been welded and a sheet of mild steel has been placed on it. The motor has been rivetted along with the pump. Two supports have been made for the pump to raise to the level of motor. We attached the motor and pump by coupling. Two keys were made by the process of slotting. This key helps grip the coupling with motor or pump. We have made an oil tank of capacity of 6liter by using sheets of mild steel.

The piping and electronic circuitry has been designed and installed according to the placement of the components. All wirings are going underneath the table whereas the hydraulic circuitry has been displayed on the main surface. The sensors, gauges and safety valve has been fitted in the hydraulic circuitry. Arduino has been connected to laptop which has been coded according to the required values. It will be showing us the values like pressure, temperature, rpms of motor etc.

6.3 Difference from main model

We have made some compromises on our miniature model because it will be only used for demonstration purposes. We have used a motor and a pump with less power and torque as we don't have to test components on this model. The basic working principle of both the models are the same. Components like sensors, extra gauges, extra safety valves have been removed in the miniature model. The last factor is the cost which has been kept in view. We were having main funding for the main hydraulic test bench project thus all the components and necessary valves have been used in that main project but in the miniature model due to less budget we compromised some of the safety standards and sophistication level has also been decreased.

CONCLUSION

The overall focus of the project was to develop a test bench. It was achieved in successive stages which started from research domain and literature review and then observation of different models available in the local market as well as global market. The observation phase was carefully carried out in a detailed way to bring out the best possible solution to our task and what we were trying to achieve. Different aspect was kept in mind as well during the whole process to make sure that the core idea and issue is addressed which to develop a test bench and then carrying out the testing of equipment of different sizes with the help of newly designed and developed linking mechanism. The feasibility study and research cover a major portion of the work and provide help in addressing the concern related to the components of the and modeling of the bench. Modeling of the prototype of the bench and the universal linking mechanism covers the design portion of the project which represents the actual built and design of the product that is to be developed. The development of the miniature model gave us the confirmation of the working hydraulic line with all the testing being feasible. The main model will be undergoing testing of the pumps and hoses of the different vehicles for whom those pumps and hoses are very important; otherwise it will lead to the major failures if there is not correctly conducted and ultimately failure in their performance to the rated specifications.

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