Design and Development of Hydro Pressure Testing Machine for Casing

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Abstract— Hydro pressure testing machine is used for testing of products works under high pressure such as gas cylinders, boilers and fuel tanks, filter head, casings etc. Casing is the part used to close the ends of a pipeline; pump etc. casing also can also use to change the flow of fluid. According to its application, it possesses high pressure of fluid on its surface. Therefore it should be tested for deformation and leakages. Testing of component is necessary to ensure the safety. Hydro pressure testing is always preferred when it comes to test a product which going to operate at high pressure in field. Also it is cheap and effective method. For those operators who will be able to use hydrostatic testing, this presentation offers some useful guidelines to help the operator optimize confidence in the test as a means of integrity assurance. In this work application of pressurized water is going to be used for testing purpose. In this work design and analysis of machine structure and clamps is done. Parts of the hydraulic circuit and electrical circuit are bought out and assembled according to system requirements.

Key words: Hydrostatic testing of casing, Analysis of machine structure and fixture, Hydraulics & Electronics

I. INTRODUCTION

Casing is also called as deckle cover which is a part of an oil separator. An oil separator is a device designed to separate hot oil and cold oil. It is used in thermal power plant for the lubrication of turbine. During lubrication the temperature of oil increases. This hot oil is replaced by cold oil with the help of oil separator. This casing is fitted at the end of oil separator to block the flow or to give the direction to the flow. Thus it should be tested before using. The test involves filling the casing with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurization of the vessel to the specified test pressure. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss.

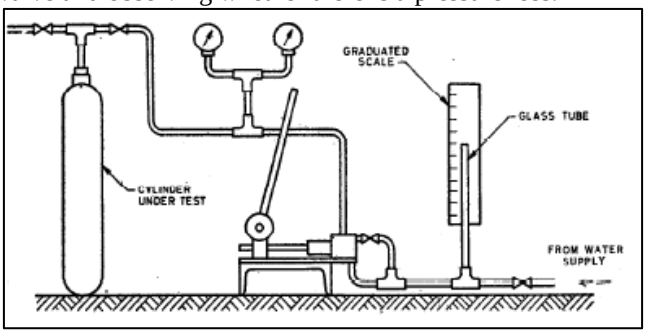

Fig. 1: Schematic of Hydro pressure testing setup

The location of a leak can be visually identified more easily if the water contains a colorant. Hydro pressure testing is done in so many industries such as piping, gas cylinders, automotive etc. This method is always preferred when it comes to test a product which going to operate at high pressure in field. Strength is usually tested by measuring permanent deformation of the container. Hydrostatic testing is the most common method employed for testing pipes and pressure vessels. Using this test helps maintain safety standards and durability of a product over time.

II. METHODS AND MATERIAL

A. General

Hydrostatic tests are conducted under the constraints of either the industry's or the customer's specifications, or may be required by law [1]. The hydro pressure testing is divided into two methods, they are as follows [7]: -

- Water jacket method: - In this method the product under test is covered by jacket. The jacket is filled by water and the product is tested. This method is used for corrosion resistance testing.
- Non jacket method: - In this method jackets are not required. The water is directly supplied to the component which to be tested.

In this case, casing is tested by using non-jacket method.

B. Material

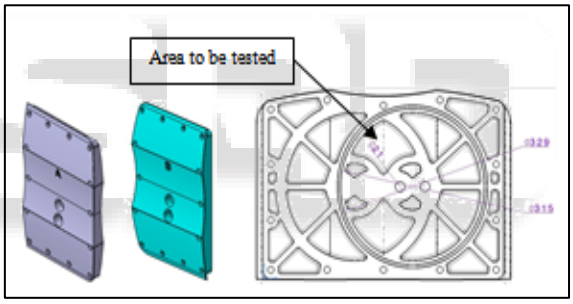

Fig. 2: Geometry of casing A & B

As shown in Fig.1 the area to be tested is within the groove. Mechanical properties of Aluminium casing are as shown in table,[8]

Sr.no.	Mechanical property	Magnitude
1	Density	2800 kg/m^3
2	Tensile strength	340 MPa
3	Shear strength	210 MPa
4	Modulus of elasticity	68.9 GPa
5	Poisson's ratio	0.33

Table 1: Mechanical properties of Aluminium Casing

Casings is made up of Aluminium and manufactured by casting process. There are two casings A & B which are exactly mirror of each other. Both the casings should test on a single machine. Its working pressure is 10 bars. The testing machine should be design to test the casing at 12 bars. The groove can be used for sealing during testing.

Following failure may occur:

- Deformation in shape.
- Leakages and bursting.

Casing is manufactured by casting process. Therefore its testing is necessary to ensure the safety of workers.

C. Objectives

1) To reduce the failure of casing during operation.
2) Testing of casing at a pressure of 12 bars.
3) All the parts must be designed considering factor of safety.
4) It must be easy to detect leakages in casing if any.
5) Valves, pressure gauges should be durable.

D. Scope

This standard describes methods for the hydrostatic stretch testing of casing is intended for the reduction in failure and durability of casing. Hydro pressure testing is done in so many industries such as piping, gas cylinders, automotive etc. This method is always preferred when it comes to test a product which going to operate at high pressure in field. Also it is cheap and effective method.

E. Methodology

1) Analytical Solution

1) Design of L-brackets welded at four corners to lift machine.

2) Analysis by using Ansys

1) Static Analysis of casing at pressure of 12 bars.
2) Analysis of base fabrication on which water tank and hydraulic pump is fitted.
3) Analysis of Strap clamps.
4) Analysis of welding brackets used to lift the setup.

3) Manufacturing

1) Manufacturing of base fabrication which gives support to all parts of machine.
2) Manufacturing of water tank by welding.
3) Manufacturing of fixture plate
4) Manufacturing of strap clamps
5) Deciding a hydraulic circuit and locations of valves & pressure gauges.
6) Manufacturing of protective cover for safety of worker during testing.

4) Testing

1) Testing of pressure switch, valves and fitting for leakage & pressure drop.
2) Testing of electrical components such as timer.
3) Actual testing of machine with casing at workshop.

III. MACHINE SETUP

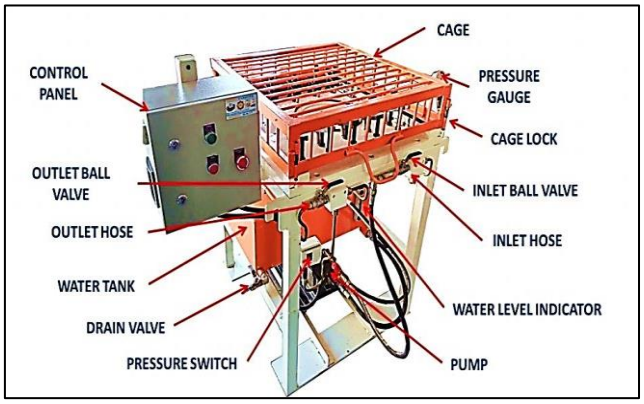

Fig. 3: Hydro pressure testing machine for casing

The machine structure is designed such that both the casing A & B can be loaded and tested on it. The structure of hydro pressure testing machine is like single vertical column of assembled parts. Structure is mainly consists of base fabrication and fixture plate. Strap clamps are assembled with fixture plate which locates and fix the component. The purpose of the analysis is to check the design for failure before manufacturing stage. This helps to eliminate the defects in the design and reduced the cost and also helpful aesthetically and ergonomically. For Finite element analysis of the machine components, the components are modeled in CATIA P3 V5R21 and assembly of components is done. For analysis purpose ANSYS v16.0 WORKBENCH is used.

A. Base Fabrication

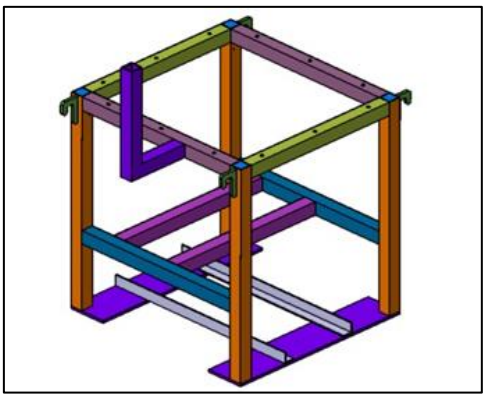

Fig. 4: Design of base fabrication

Base fabrication is the most important part of machine structure. It is manufactured by welding Sq. Tube 50X50 mm together. It supports almost all the parts of the machine such as top plate, cage, water tank, pump, hydraulic fittings and control panel. L-brackets are welded on four corners of fabrication for lifting purpose. All the forces and vibrations of motor are acting on the base structure. Therefore static analysis of base fabrication is done by using Ansys workbench.

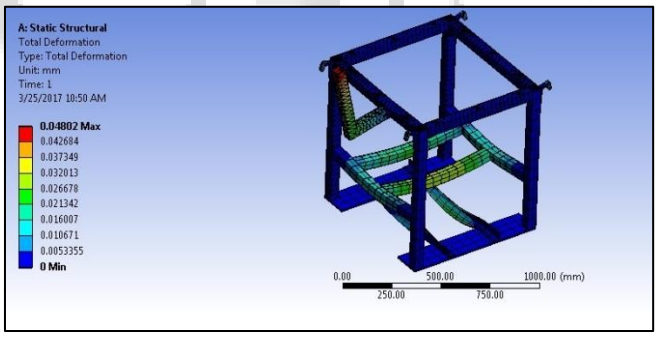

Fig. 5: Analysis of base fabrication

After entering the material properties, we started with base fabrication. The CAD model is imported in geometry then, the boundary conditions loads are as follows,

- Two bottom plates are selected as fixed support.
- Two L-angles welded on bottom plates on which motor and pump is mounted weighs 30kg (300N approx.)
- Water tank of capacity 82 liters weighs 100kg rest upon 4 Sq. Tubes.
- Four L-brackets welded at top corners for lifting the machine weighs 400kg (i.e. 100kg each).
- L-shaped Sq. Tube carries control panel weighs 5 Kg.
- After solving, the maximum deflection in plate is 0.04802 mm which is negligible.

B. Fixture plate

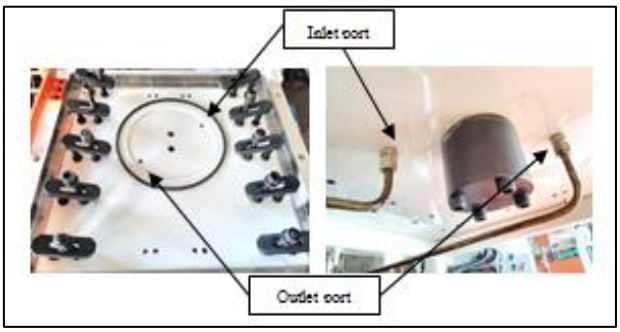

Fig. 6: Fixture plate top view and bottom view

Fixture plate is mounted on base structure with six M12 screws at both the strap sides. It is designed such that the loading and unloading of component will be easy and perfect. The groove is provided for mounting of seal before testing. Thickness of the seal is divided equally in grooves of plate and casing. Inlet and outlet valves are provided within the testing area. Holes on the casing perimeter as shown in Fig.2 are used to locate and equally distribute clamping force over the surface.

C. Strap Clamps

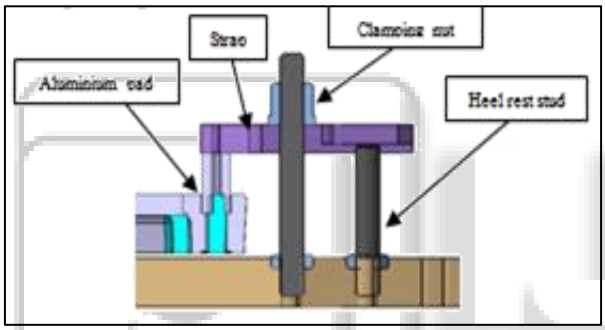

Fig. 7: Design of strap clamp

[6]It is also called edge clamp. This type clamping is done with the help of a lever pressure acting as a strap on the work piece. To release the work piece the nut named as clamping nut is unscrewed. Strap clamps are used for locate and clamp component. Strap clamps consists of two studs one for clamping and another for resting. Aluminium pad of same diameter as that of holes on the perimeter of casing is fitted on strap which locates and applies force for clamping.

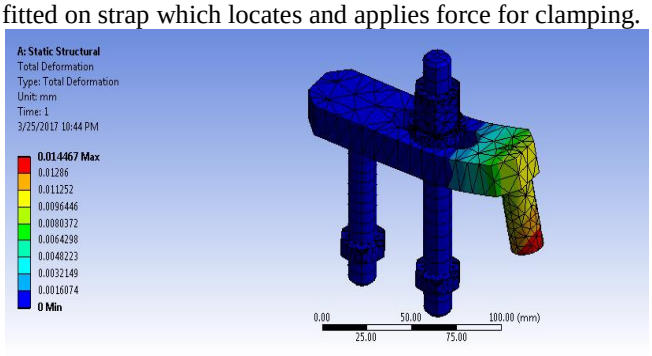

Fig. 8: Analysis of Strap clamp

After entering the material properties, we started with Strap clamp. The CAD model is imported in workbench. The boundary conditions are as follows,

– Two lock nuts at plate are considered as fixed supports.
– Clamping force is applied at middle stud and Aluminium pad.

We have,

F = force applied by a person = $200N$ to $400N$

L = length of the lever or spanner = $270mm$

D = thread dia. = $16mm$

Torque applied,

$$L = \frac{T}{F}$$

$$T = L \times F = 270 \times 200$$

$$T = 54000Nmm$$

Clamping force,

$$T = \mu WL$$

$$W = \frac{T}{\mu L} = \frac{54000}{0.18 \times 270}$$

$$W = 1111.11N$$

Clamping force = 1111.11 N

After solving, it is seemed that due to stress concentration the maximum deformation is occurring in Aluminium pad. The maximum deflection in strap is 0.014467 mm which is negligible.

D. Hydraulic components

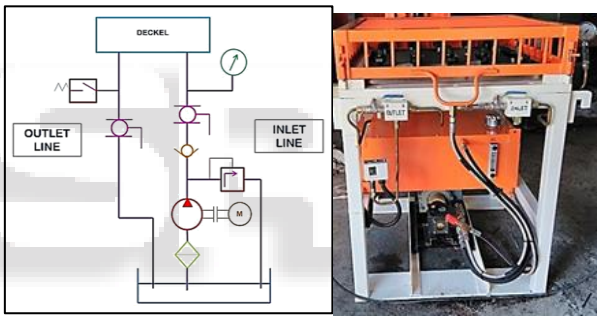

Fig. 9: Schematic and actual hydraulic circuit of machine

The hydraulic circuit shows two lines inlet and outlet. Inlet line consists of filter, pump, PRV, check valve, ball valve and pressure gauge, outlet line has pressure switch which signals the hooter in case of excess pressure. Initially both inlet and outlet ball valves are kept open.

1) Water tank (Reservoir)

Water tank is manufactured by sheet metal. Its shape is inclined at bottom to easily drain during cleaning and maintenance. Specifications of water tank are as follows,

Sheet material – Stainless steel

Size – $700 \times 475 \times 250mm$

Capacity – 80 liters

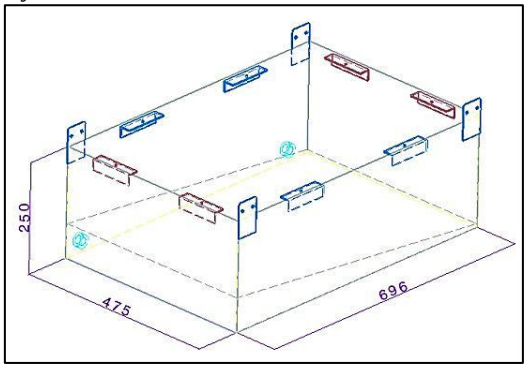

Fig. 10: Design of water tank

Water tank is mounted on base fabrication at middle. It is fastened by using two M6 screws on the base fabrication. Water level indicator is fitted on operator side of the tank. Outlet pipe is transparent which is fitted such that it will easily visible to operator whether the casing is completely filled with water.

2) Hydraulic Pump

Fig. 11: Recipracting pump

Part	Pump
Manufacturer	Annovi Reverberi
Model no.	RC 8.15N
Type	Piston pump
Output	8 Lpm
Pressure	150 bars
Power	3 HP
RPM	1450
Weight	5 Kg

Table 2: Specifications of Pump

[10]A pump, which is the heart of a hydraulic system, converts mechanical energy into hydraulic energy. Reciprocating pumps are very important part of the ships machinery and any other industry which is present in the world. High pressure is the main characteristic of this pump and this high pressure output are being used in places like starting of the engine or you can say the building of pressure in the fluids. But there are used in limited application because they require lot of maintenance. The mechanical energy is delivered to the pump via a prime mover such as an electric motor.

3) Electric Motor

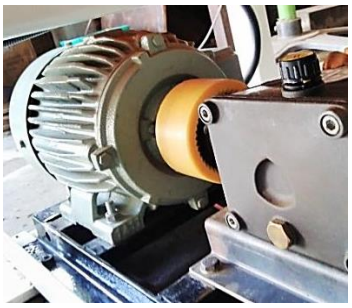

Fig. 12: Electric motor

Part	Motor
Manufacturer	Crompton Greaves
Model no.	ND90S
Type	3 phase induction motor
Output	1.5 hp
Efficiency	78%
RPM	1450
Weight	22 Kg

Table 3: Specifications of Motor

[3]An electric motor which operates on A.C. supply is called as AC motor. These motors are classified as single and three phase induction motors, synchronous motors and some special purpose motors. Out of these, three phase induction motors are widely used for various industrial applications. Induction motor drives with cage-type machines have been the work-horses in the industry for variable speed applications in a wide power range that covers fractional horse-power to megawatts. These applications include pumps and fans, paper and textile mills, subway and locomotive propulsions, electric and hybrid vehicles, machine tools and robotics, home appliances, heat pumps and air-conditioners, rolling mills, wind generation systems, etc. In addition to the process control, the energy saving aspect of variable frequency drives is getting a lot of applications nowadays.

4) Pressure relief valve and Pressure switch

Fig. 13 Pressure relief valve Pressure switch

Part	Pressure relief valve
Type	VR56
Max. pressure	25 MPa
Flow rate	30 Lpm
Hose fittings	1/4" brass

Table 4: Specifications of Pressure relief valve

[10]Pressure relief valve is connected at inlet line to the pump outlet. Pressure relief valve is a most widely used in every hydraulic system. It is normally a closed valve whose function is to limit the pressure to a specified maximum value by diverting pump flow back to the tank.

5) Pressure switch

Fig. 14: Pressure switch

Part	Pressure switch
Manufacturer	Danfoss
Model no.	KPI36
Type	Contact type
Range	4-12 bars
Max. pressure	18 bars
Contact material	Silver

Table 5: Specifications of Pressure switch

A pressure switch is a form of switch that closes an electrical contact when a certain set pressure has been reached on its input. The switch may be designed to make contact either on pressure rise or on pressure fall. Pressure switch is connected to the hooter via contactor in control panel. When the system pressure raises up to 18 bars this switch sends signal to hooter and stops the entire system.

6) Electronic circuit

It consists of contactor, timer, hooter and MCB switch. It is used to turn ON/OFF the system.

- MCB switch: - It is connected to main electricity supply of industry.
- AC Contactor: - [5] Contactors are electromechanical switches employed in applications that require processes of electric circuit "making and breaking", such as starter motors, electric vehicles, heaters, and lighting applications.
- Timer: - [4] A timer is a specialized type of clock for measuring time intervals and performing action according to condition. The electronic timer is a device which has driving circuit and a digital display system with a facility depends on the application for connecting the output to individual machinery/system to control the operation at predetermined time interval. In this circuit timer is used to stop the entire system after 2 min. of excess pressure.
- Hooter: - It is a device which makes noise in case of emergency.

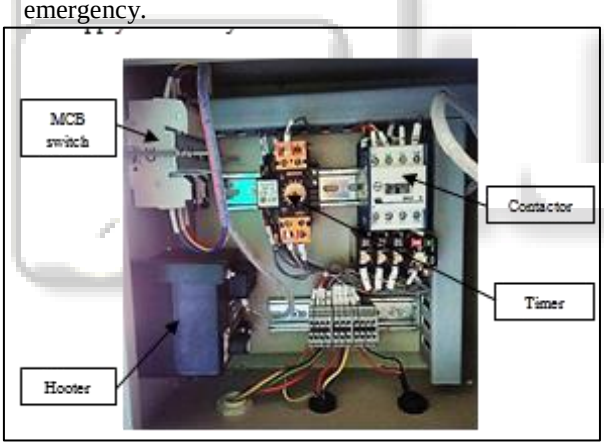

Fig. 15: Electronic circuit

IV. Experimental Procedure

1) Check/set working pressure on PRV. Check water level. Check oil level of pump. The component to be tested must be cleaned from inside & outside. The space and holes within the O-ring should be clean before and after testing.
2) Insert O-ring in groove in bottom plate. Load the component on bottom plate by coinciding axes of holes. Make sure that the O-ring is entered in the groove of component.
3) Insert two M20 screws with seals at center & four M12 screws at LH & RH sides.
4) Locate all the clamps.
5) Tighten the M20 & M12 screws.
6) Tighten the straps in sequence as shown in image.
7) Close & lock cage.
8) Check outlet & inlet ball valve is open.
9) Turn on the MCB switch. Press "start" button on control panel.
10) Check water flow thru transparent pipe at outlet.
11) Slowly close outlet ball valve.
12) Pressure relief valve will keep the system pressure 12bar by transmitting excess water back to the tank.
13) Close inlet ball valve immediately.
14) Press "stop" button on control panel.
15) Hold system pressure for 30 min. & check on pressure gauge for pressure drop.
16) Open the outlet valve & inlet valve.
17) Unlock & open cage. Remove the component & clean it every time after testing.

V. Conclusion

In this work, we have done design as well as manufacturing of hydro pressure testing machine for casing. Analysis is done according to working condition at site. Manufacturing is done as per decided sequence by controlling quality of product. All the bought out parts such as Motor, Pump, Valves and electrical components are suitable for future extensions to the machine. Process of detection of leakage and shape deformation is quick and easy.

Acknowledgement

First and foremost, I would like to thank my respected guide Prof. C. A. CHAUDHARI and H.O.D. Dr. K.B. WAGHULDE (Dept. of Mechanical Engineering) for giving me an opportunity to present this dissertation. Finally, I wish to thanks my friends for being supportive of me, without whom this project would not have seen, the light if day.

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