Performance Evaluation of Novel Test Rig of Hydraulic Positive Displacement Pump

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Abstract

The present paper reports the development of a universal test rig capable ofevaluating performance of positive displacement pumps.Hydraulic circuit diagram for the test rig was developed after examining the loading condition on the base frame and L-bracket assembly. The diameter of suction line, return line and pressure line were 79.9mm, 37.6mm and 29.64 mm respectively. While, the directional deformation and maximum stress of base frame at static structural condition were obtained as 2.66 mm and 110.28 MPa respectively, the deformation of L-bracket was0.51 mm and maximum stress induced was 293.11 MPa. The Factory acceptance test revealed that the system can work at a maximum pressure of 315 bar, flow rate of 300 lpm and a speed of 1500 RPM which was at acceptable range.

Keywords: P*umps, Hydraulic circuits, Deformation, Test rig,Stress*

1.0 Introduction

Positive displacement pumpsprovide a set quantity of fluid to the system during each stroke of revolution. The performance parameters of such pumps can be evaluated by constructing a suitable test rig. Recently, the maximum flow rate of external gear pump was achieved as 19 lpm with maximum volumetric efficiency of 95% [1]. Also, the flow efficiency of hydraulic gear was found to be 99.33% at no load maintaining speed of 1500 rpm [2]. Some of the researchers have focussed on constructing hydraulic circuits along with parallel axis test rig [3]. A synthetic hydraulic fluid of UTTO type was adopted and was able to verify the sizing and structure of individual components of pumps [4-5].Additional sealing between the piston and the guide was adopted resulting in an increase in friction [6]. Universal test bench was developed for testing

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valve performance, pressure drop and leakage which made use of aluminium [7]. Some of the researchers developed a test rig to perform endurance test that was capable of considering various safety requirements and handle maximum flow rate of 65 lpm at 22.5 MPa pressure drop and a maximum speed of 810 RPM [8-10]. This research paper aims at reporting performance parameters such as flow, pressure and speed assessed using a novel universal pump test rig capable of evaluating positive displacement pumps. The test pump circuit designs were developed for both open and closed loop conditions. The deformation and stresses for base frame and L-bracket were assessed using ANSYS workbench.

2.0 Design of Hydraulic Circuits

The concepts were developed for open loop and closed loop condition of hydraulic circuit for the pump test rig using AUTOCAD software. The pipe sizing and L-brackets were designed for the modeling of sub-assemblies. The assembly was fabricated and factoryacceptance test(FAT) wasperformed to check whether the system satisfies the requirements. The piston and gear pumps were tested and its performance parameters such as flow rate, speed and pressure capability were determined. The hydraulic circuit diagram developed for universal pump test rig is as shown in Fig 1. The major components used for fabricating the universal pump test rig is as shown in Table 1. Pipe sizing calculations were performed to estimate the size of the pipe to be utilized for suction, return and pressure lines. From the design calculations, the diameter of suction pipe line was obtained as 79.79 mm, diameter of return line pipe was 37.6 mm and diameter of pressure line pipe diameter was 29.64mm. The base frame, L bracket assembly and fabricated model of test rig is as shown in Figure 2 (a) - (c).

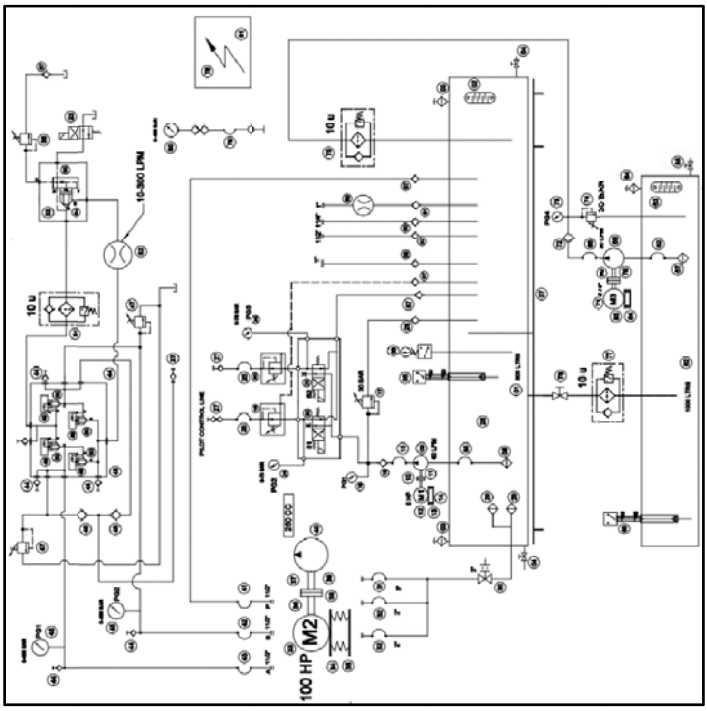


Fig. 1. Hydrauliccircuitdiagramforpumptestrig

Table 1. Major components

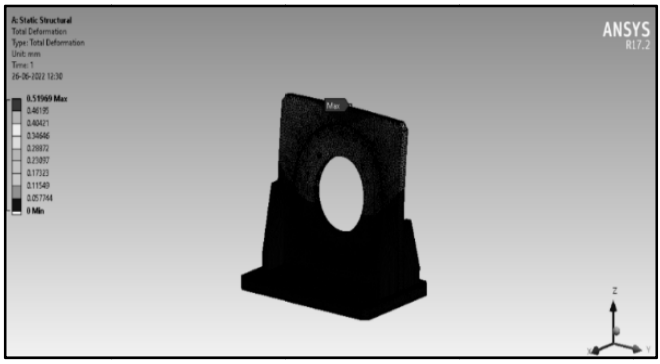
Sl No	Component type	Qty
1	Reservoirs	2
2	Base frame	1
3	Gear pumps	2
4	Electric motor	3
5	Check valves	11
6	Pressure relief valves	5
7	Pressure reducing valve	1
8	Manifold block	1
9	DC valves	3
10	Flow meter	1
11	Pressure gauges	6

Fig. 2. a) Base frame, b) L Bracket Assembly, c) Fabricated model of hydraulic pump test rig

3.0 Results and Discussion

3.1 Structural analysis of L-bracket assemblyand base frame

Static structural analysis was performed using ANSYS WORK BENCH finite element analysis package to determine the maximum stress and deformation on the sub-assemblies such as L-bracket assembly and base frame. The maximum deformation of 0.519 mm was obtained at full loading condition and the maximum stress acting on the material was 293.11MPa and the minimum stress was 0.00061 MPa as shown in Fig 3 (a) and (b). For base frame, the maximum deformation of 2.67 mm was obtained at full loading condition and maximum stress was 110.28MPa and the minimum stress was 0.009495 MPa. The obtained stresses were within the allowable stresses of the material and the design was safe.



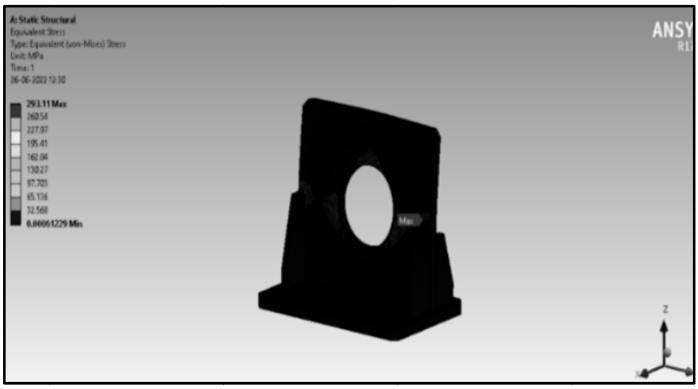
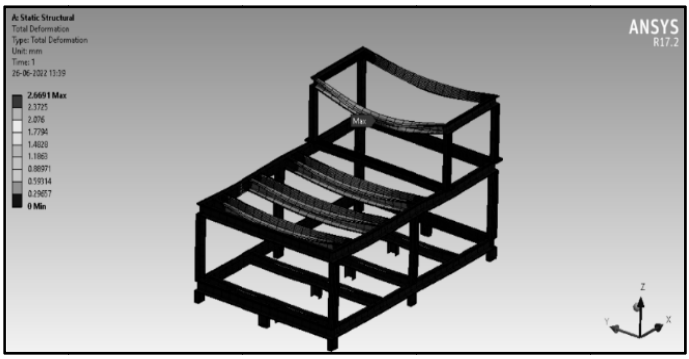


Fig. 3. a) Total deformation and b) Equivalent Von mises stress for L-bracket



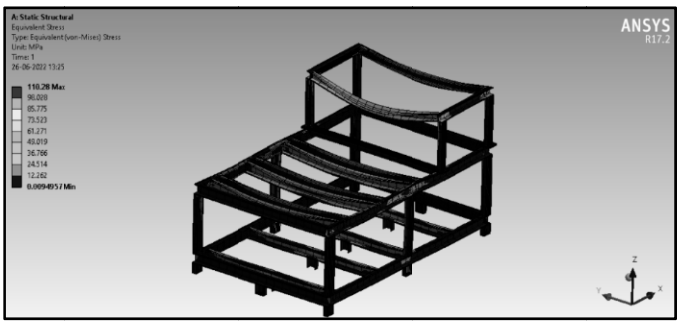


Fig. 4. a) Total deformation and b) Equivalent Von mises stress of base frame

3.2 Test results of A4VG71 closed loop and open loop pumps

The test results of an A4VG71 closed loop pump performed at a fixed speed of 1000 RPM while considering flow in both clockwise and counter clockwise rotation of the pump are as shown in Table 2. At no load, the flow rate was 67LPM and with incremental

loading, the flow rate dropped and at a pressure of 250 bar, the flow ratewas 63 LPM. There was no variation found with change in direction from cw to ccw. Table 3 predicts the test results of an Eton 70423 open loop pump at a fixed speed of 1000 RPM. Since it was an open loop pump, the flow rate reading was considered only in single direction at different loading conditions. The flow rate was observed as 44 LPM at 50 bar and 36 LPM at 200 bar, indicating that as pressure increases, the flow rate decreases.

Table 2. Test results of A4VG71 closed loop pump at 1000 RPM

Pump Speed RPM	Pressure (bar)	Flow rate, lpm (cw rotation)	Flow rate, lpm (ccw rotation)
1000	100	65	66
1000	140	65	65
1000	180	64	64
1000	220	64	64
1000	250	63	63

Table 3. Test results of Eton-70423open loop pump at1000RPM

Pump Speed, RPM	Pressure (bar)	Flowrate, lpm
1000	50	44
1000	100	43
1000	150	38
1000	200	36

4.0 Conclusion

A universal pump test rig was developed to evaluate the flow rate of positive displacement pumps various loading conditions. From the structural analysis results, the total deformation for base frame and L-bracket is obtained as 2.66mm and 0.51mm. Similarly, the induced stress in the frame and L-bracket assembly were within the allowable stresses of the material. From running test observation, the power pack and pumping unit was found perform at satisfactory level and variable pressure test was carried out at a maximum pressure of 315 bar. Factory acceptance test revealed that the system could work at a maximum pressure of 315 bar, a flow rate of 300 LPM, and a speed of 1500 RPM.

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