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Design, Fabrication and Performance Evaluation of Test rig of Oil Pump in Tata Motors

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Abstract: ***The aim of this project is to modify the Oil pump test rig available in the Tata motors, Chinchwad plant. The oil pressure generated in most engines should be about 10 psi per every 1000 revolutions per minute (rpm), peaking around 55-65 psi. All pump pressure does is "fill in the hole" and refresh the oil in the annular space faster than the leak expels it. Low pressure indicates that leakage from the bearings is higher than the pump's delivery rate. The oil pressure at the pump outlet, which is what opens the pressure relief valve, is simply the resistance to flow caused by the bearing clearances and restrictions. Low oil pressure, however, can cause engine damage. Low oil pressure can be caused by many things, such as a faulty oil pump, or simply low oil volume. Low oil pressure is a problem that must be addressed immediately to prevent serious damage. Too much oil pressure can create unnecessary work for the engine and even add air into the system. To ensure that the oil pressure does not exceed the rated maximum, once pressure exceeds a pre-set limit a spring-loaded pressure relief valve dumps excess pressure either to the suction side of the pump, or directly back to the oil pan or tank. Hence, it is very important to inspect every oil pump for its proper functionality and to ensure that oil pump is working as per required conditions of speed (rpm) and oil flow rate (lpm) within prescribed pressure conditions and to do so oil pump test rig is needed.***
Keywords: Oil pump test rig, oil pump in Tata motors, oil pump

I. INTRODUCTION

The oil pump in an internal combustion engine circulates engine oil under pressure to the rotating bearings, the sliding pistons and the camshaft of the engine. This lubricates the bearings, allows the use of higher-capacity fluid bearings and also assists in cooling the engine. To avoid the need for priming, the pump is always mounted low-down, either submerged or around the level of the oil in the sump. A short pick-up pipe with a simple wire-mesh strainer reaches to the bottom of the sump. For simplicity and reliability, mechanical pumps are used, driven by mechanical gear trains from the crankshaft. At 3,000 rpm, the pistons inside your engine are moving up and down violently, the crankshaft is spinning swiftly, and the rocker arms are rapidly doing the two-step with each respective valve. But whether your engine is just idling in drive or at full-throttle, it takes a good lubrication system to keep everything from turning into molten metal. To prevent this unsavory transformation, oil is directed to all of the metal contacting surfaces by a full-pressure lubrication system comprised of an oil pan, an oil pump.

A. Need For An Oil Pump In Engine

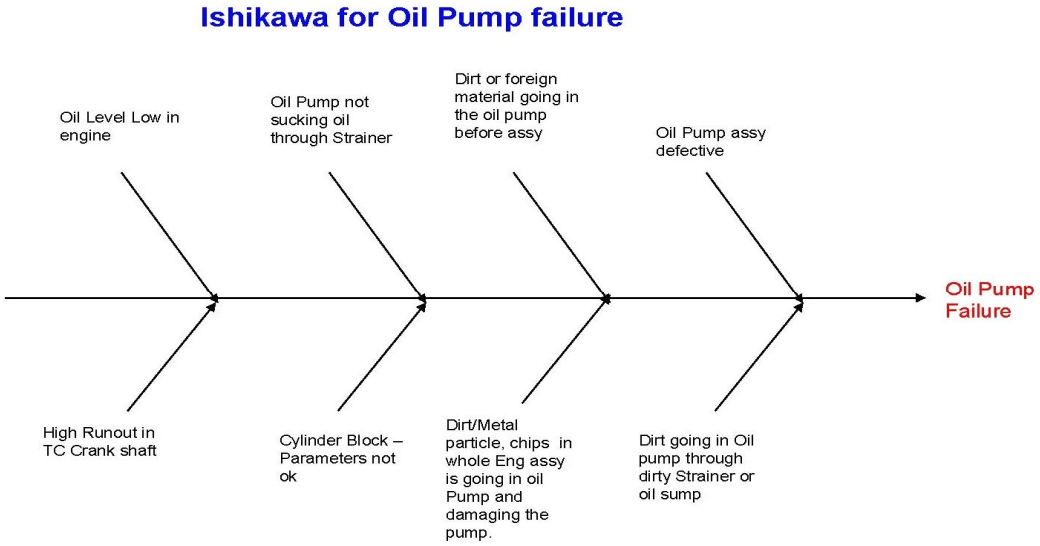
The oiling system addresses the need to properly lubricate an engine when it's running. Properly lubricating an engine not only reduces friction between moving parts but is also the main method by which heat is removed from pistons, bearings, and shafts. Failing to properly lubricate an engine will result in engine failure. The oil pump forces the motor oil through the passages in the engine to properly distribute oil to different engine components. In a common oiling system, oil is drawn out of the oil sump through a wire mesh strainer that removes some of the larger pieces of debris from the oil. The flow made by the oil pump allows the oil to be distributed around the engine. In this system, oil flows through an oil filter and sometimes an oil cooler, before going through the engine's oil passages and being dispersed to lubricate pistons, rings, springs, valve stems, and more.

B. Causes of oil pump failure:

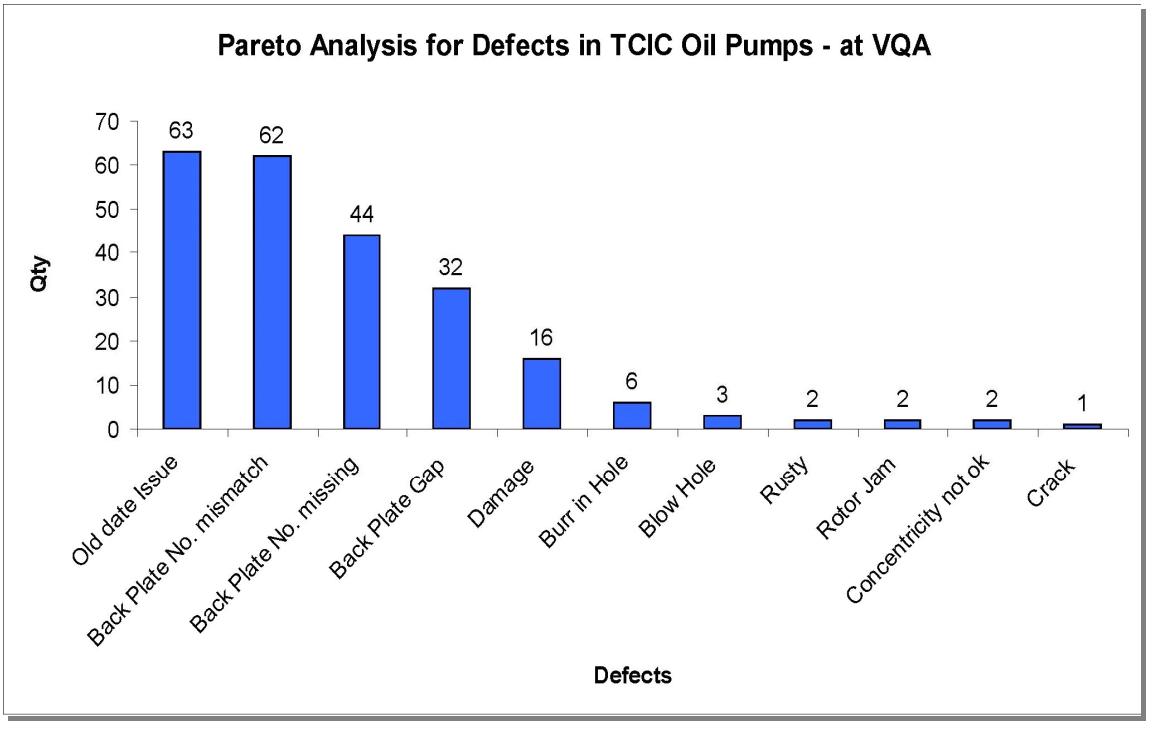
1) Dirt or foreign materials in theassembly of Oil pump.
2) Metal particles remaining while assembly at supplier end.
3) Dirt or metal chips entering while transit.
4) Metal particles with size more than 0.1 mm is major contributor in oil pump failure.
5) Low discharge of oil at outlet at specified pressure conditions.
6) Relief valve doesn't open at peak pressures.

Fig-1.1: Causes of oil pump failure

C. Ishikawa for oil pump failure



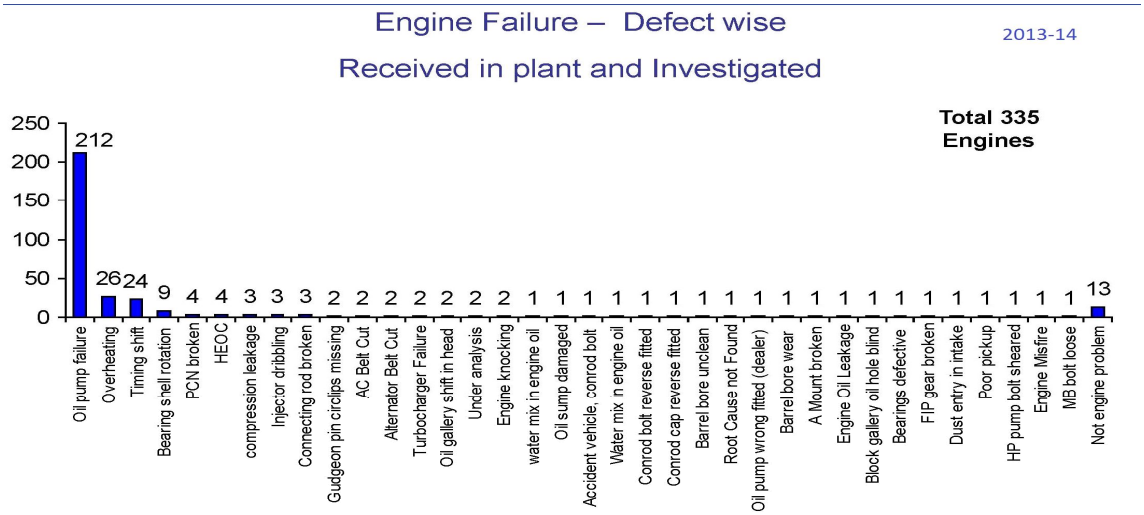
1) Pareto analysis for defects in oil pumps



II. NEED FOR OIL PUMP TEST RIG

The oil pressure generated in most engines should be about 10 psi per every 1000 revolutions per minute (rpm), peaking around 55-65 psi. All pump pressure does is "fill in the hole" and refresh the oil in the annular space faster than the leak expels it. Low pressure indicates that leakage from the bearings is higher than the pump's delivery rate. The oil pressure at the pump outlet, which is what opens the pressure relief valve, is simply the resistance to flow caused by the bearing clearances and restrictions. Low oil pressure, however, can cause engine damage. Low oil pressure can be caused by many things, such as a faulty oil pump, or simply low oil volume. Low oil pressure is a problem that must be addressed immediately to prevent serious damage. Too much oil pressure can create unnecessary work for the engine and even add air into the system. To ensure that the oil pressure does not exceed the rated maximum, once pressure exceeds a pre-set limit a spring-loaded pressure relief valve dumps excess pressure either to the suction side of the pump, or directly back to the oil pan or tank.

Hence, It is very important to inspect every oil pump for its proper functionality and to ensure that oil pump is working as per required conditions of speed (rpm) and oil flow rate (lpm) within prescribed pressure conditions and to do so oil pump test rig is needed.In current scenario it can be seen that when oil pumps are checked at supplier then they are OK but due to absence of oil pump test rig in VQA, they are unable to inspect the pump and after installation of pump in engine during final testing or at an customer end oil pump fails resulting in the failure of the oil pump. The approximate cost to manufacture one engine of Tata Motors is Rs.1,00,000 and in an financial year total no. of engines fail due to oil pump are 212. Hence due to absence of test rig, total loss to the company in a year is Rs.212,00,000 with unsatisfied customer.

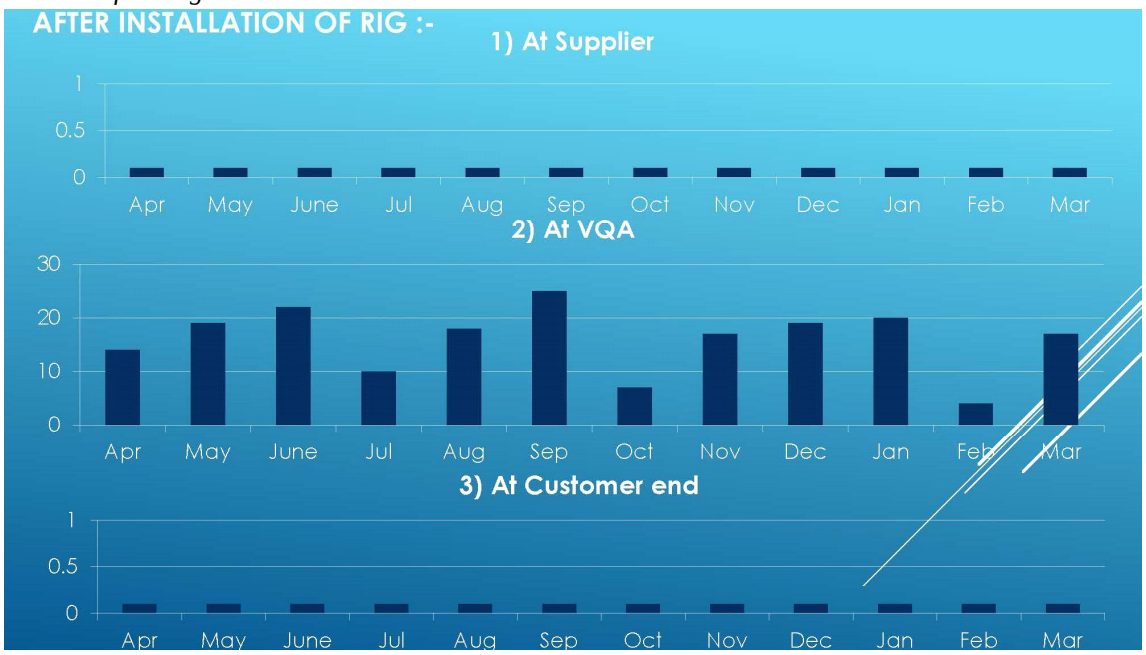


A. Oil pump rejection trend at various stages

1) Current scenerio

To avoid such drastic effects and to save company's Rs.2,12,00,000 as discussed earlier,100% inspection of oil pump is must. Also, this will increase the overall performance of the Tata Motors engine resulting in the increase of car rating in the market. So, it is important to sort out the defective pumps at VQA so that they do not enter the manufacturing line. To achieve following graph it is important to install the test rig.

2) After installation of test rig



B. Cost Analysis

Company sanctioned a budget of Rs.10,00,000 to manufacture the rig.
Total amount spent on the mfg. of rig is Rs.7,00,000.
The savings to the company due to test rig are

1) Total cost saved due to failed engines – Rs2,12,00,000 per annum.
2) Cost reduction in Rework processes.
3) If the defect is found at final testing or at customer end then cost saving in damaged parts which are affected during removing of oil pump from engine.
4) Payment made to workers for removing oil pump, for its inspection could be saved.
5) If the engine is failed due to oil pump then time required to conduct the meetings of all officers, time spent on its failure analysis, time spent to find the remedies of that problem and time required for implementation of the remedy can be saved.

HENCE, as compared to the money spent on the rig, saving to the company in terms of money as well as time is more.

C. Components used in mfg oil pump test rig:

❑ COMPONENTS USED IN MFG OIL PUMP TEST RIG

COMPONENTS NAME	MAKE	SPECIFICATION	NOS
Oil Tank	---	7900x6100x4100 mm	1
Electric Motor	Crompton greaves	50Hz 1.5 HP 415V 2830RPM	1
Solenoid Valve	Avcon	--	4
Electric Heater	Duggal Brothers	5KW	1
Paper Filter	--	5microns	1
RTD	Tech Transducers	OD10mm L250mm	1
Flow Meter	IFM Electronics	0-50lpm 0-80°C temp	1
Pressure Gauge	IFM Electronics	0-100°C, 60 psi;4kg/cm2.	1

1) *The unit consists of following components:*

a) *Oil Tank:* Tank is used to fill the oil which is required for the oil pump testing. Tank with dimensions 7900x6100x4100 mm is used which accommodates approx. 200 liters of oil.

b) *Electric Motor :* 1.5 HP Motor running on electric current is used to rotate the shaft of housing with the help of belt drive which in turn rotates the oil pump for the suction of oil from tank through the strainer. Motor is rotated at different speeds to obtain the required flow rate readings.

c) *SolenoidValve:* These valves possess two distinct states, which are

i. When the coil is activated by an electrical current, and

ii. When the valve is resting (without electricity). When coil is activated it allows entry of fluid through it and when current to coil is stopped then oil flow is restricted. These valves help in automation of cycles.

d) *Electric Heater:* Electric heater with 5KW of power is used to heat the Oil to a temperature of 40±50ºC. Oil is heated indirectly by means of electric heating elements insulated from oil.

e) *Paper Filter :* As oil is often very polluted by the dirt and dust particles from the air, the Unit is fitted with a large sized, easy to open and clean, paper filter. Paper filter has a capacity to filter up to 5 microns.

f) *RTD:* The Unit is equipped with a precise RTD, acting as safety equipment. By means of the RTD, temperature of the oil can be controlled. This safety thermostat is designed to control temperature up to 40±50C, with a construction that allows it both safety and control role.

g) *FlowMeter:* Flow meter is provided to indicate the rate of flow of oil through the pipes. Flow meter has a range of 0-50 LPM working efficiently between the temperature range of 0-800C

h) *PressureGauge:* It is provided to indicate the pressure of oil running through the pipes. Pressure gauge can indicate the readings in various units.

i) *Oil LevelIndicator:* Oil level indicator is provided to denote the level of oil present in the tank. If the level of oil is below the required level then a signal is sent to control panel indicating low oil level.

j) *LimitSensor:* Limit sensor is used to check whether the relief valve is opened or not at required pressure reading. When the relief valve is opened, the oil is collected in the pot and up to certain level of oil the limit sensor is activated which sends the signal to control panel indicating pressure at which valve was opened.

2) *Other auxillary devices*

a) FlexibleHoses: Specially designed flexible hoses are used, suitable for operation in oil with hose connections for 1” tread.

b) Tank Stand: Stand is used to raise the height of oil tank to the required height. Height of the stand is selected such that operator should not have to bent to operate the machine and fatigue free in operation.

c) Flow ControlValves: To regulate the flow of oil through pipe control valves are used having pressure limits 0-30 bar. Four control valves are used for different speeds of the motor.

d) Toggle Clamps: To minimize the time for clamping of oil pump, toggle clamps are used. To exert sufficient amount of force on pump, 5 toggle clamps are used with their arm lengths adjustable.

e) SafetyDoor: To avoid the splashing of oil, safety door is used. Safety door also directs the flow of oil into the tank. To minimize the weight and for aesthetic look, the door is made up of acrylic.

f) Three WayValve: To cross check the rate of flow of oil, a three way valve is provided. Through one end of the valve, oil can be collected in a pot for a minute and rate of flow can be verified.

g) Automatic Detectionof Relief ValveOpening: An arrangement is made to obtain the pressure reading at which the relief valve opens. A limit sensor, Nozzle pipe, Spring, ‘C’ channel assembly is used for the detection of relief valve opening.

h) FixtureforStrainer: For ease of an operator and to minimize the time required for fitting of the strainer to the pump, fixture is designed.

D. *Features of control panel*

1) Entry of operator and oil pump details, serial number, model etc. by touch-screen TFT display.
2) Commands for operating motor at different speeds.
3) Regulate the pressure and temperature at required conditions.
4) POKAYOKE: Ok/Not ok indicator.
5) Three cycles automatic and one cycle manual.
6) Arrangement for data storage.

7) Provided with the USB ports to take out the data with the help of pen drive.
8) Result of the checked pumps displayed in systematic format.
9) On screen instructions and description of stage of test and results.
10) Information regarding the oil pump and the final calibration value automatically saved to Quality control database and label printed showing oil pumps details.

VQA PWT **DATE** - 10/03/2015

Part Name :- Assy Oil Pump CRAIL

Part No :- 279718100104

Supplier :- Sundaram

SR.NO	PUMP NO.	MFG. DATE	OIL TEMP. °C	FLOW RATE	RELIEF VALVE OPENING PRESSURE AT 4000 RPM (bar)	REMARK
1	1720	12-03-2015	40	OK	OK	OK
2	1474	13-03-2015	40	NOT OK	NOT OK	NOT OK
3						
4						
5						
6						
7						
8						
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III. OIL PIMP TEST RIG:

Fig-3.1:Actual fabricated Front view of Test rig

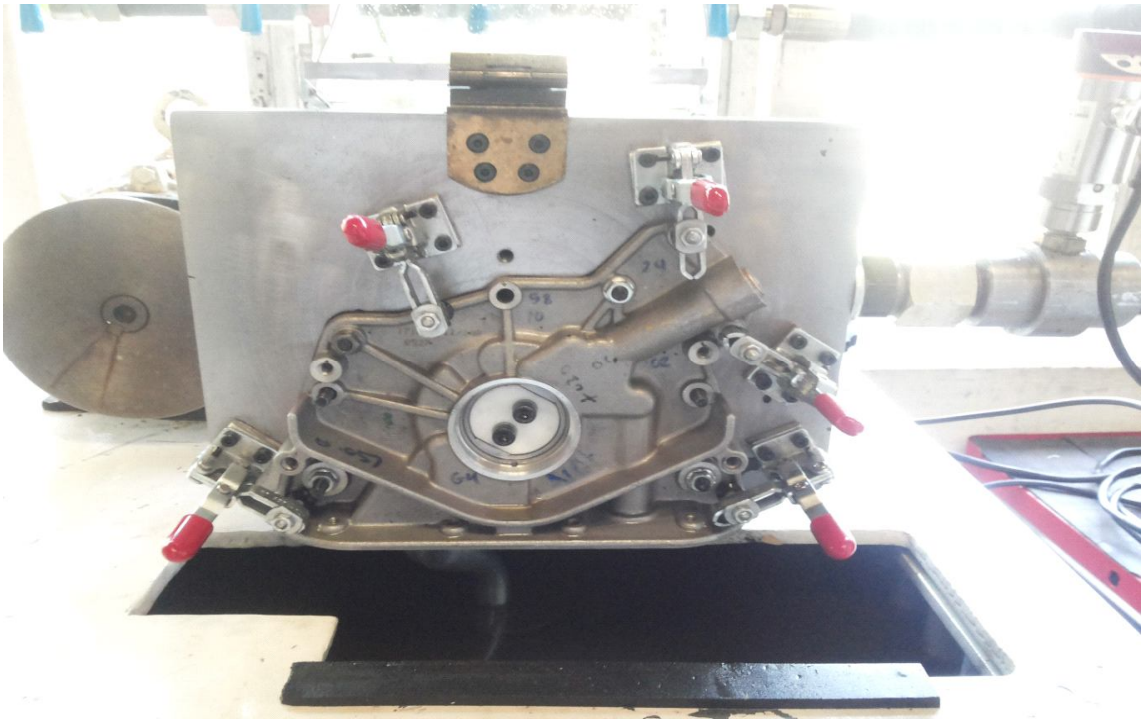

Fig-3.2: Mounting arrangement for oil pump

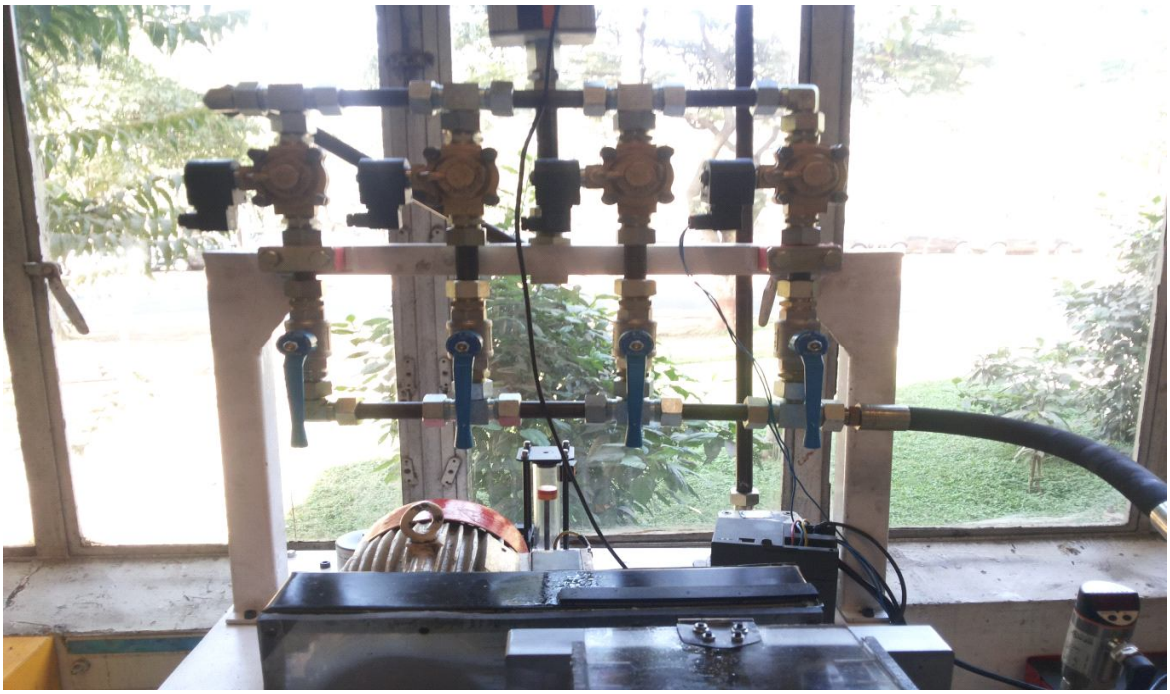

Fig-3.3: Rear view of Test rig

IV. INSTRUCTIONS FOR THE OPERATION

1) Plug the Unit into the power supply source. Turn on the main power switch.
2) Check the level of oil in the tank. It should be up to middle of strainer.
3) Ensure that gasket and 'O' rings are fitted at their respective positions.
4) Fit the strainer to the oil pump. Ensure that the oil temperature is 40±50C.
5) Pour 100 ml oil at delivery port of pump and prime it properly.

6) Clamp the oil pump to the test rig with the help of toggle clamps.
7) Enter the pump details such as model, part no., pump sr. no., mfg. date, etc.
8) Start the test rig motor by pressing 'Motor On' button.
9) Wait until three automatic cycles are completed then increase the pressure up to relief valve opening to record the readings.
10) Stop the test rig motor by pressing 'Motor Off' button.
11) Dismantle the oil pump from the rig, clean it then save the recorded readings.
12) If pump found Ok then issue it to the line.

A. DO'S:-

1) Periodically check the level of oil in the tank.
2) Change the oil after using it for 6 months.
3) Change the filter papers after every 6 months.
4) Calibrate pressure gauge, flow meter periodically.
5) Always ensure that perpendicularity between housing rotor and mounting plate is verified time to time.
6) Always shut down and lock down the control panel after use of the rig.

B. Don'ts

1) Don't turn on the motor until the safety door is at its desired position.
2) Prevent the entry of solid impurities such as burrs, dirt, and dust particles.

V. BENEFITS OF TEST RIG TO COMPANY:

A. Presence of test rig for oil pump in company will ensure that all parts are been thoroughly inspected at VQA level.
B. Oil Pumps do not enter the manufacturing line without 100% inspection which ensures that pump will not fail in engine.
C. So Tata Motors engines will give satisfactory performance to customers hence customers will be happy.
D. Also, this will increase the overall performance of the Tata Motors engine resulting in the increase of car rating in the market.
E. The output from the control panel is designed in a such way that no separate report format have to be prepared which will ultimately reduce the valuable time of the machine operator.

VI. CONCLUSION

All the major as well as minor faults were detected with the help of Ishikawa and Pareto analysis techniques and necessary actions were taken on them. The modified setup is made leak proof and the motor shaft is aligned properly with the pump, and hence vibrations are reduced. Gauges, bearings, taps, coupling and hose are replaced with new one. The test rig is ready for experimentation. We carried out experiments on test rig and plotted the performance characteristic graphs of oil pump, which are well accordance with theoretical graphs giving satisfactory performance.

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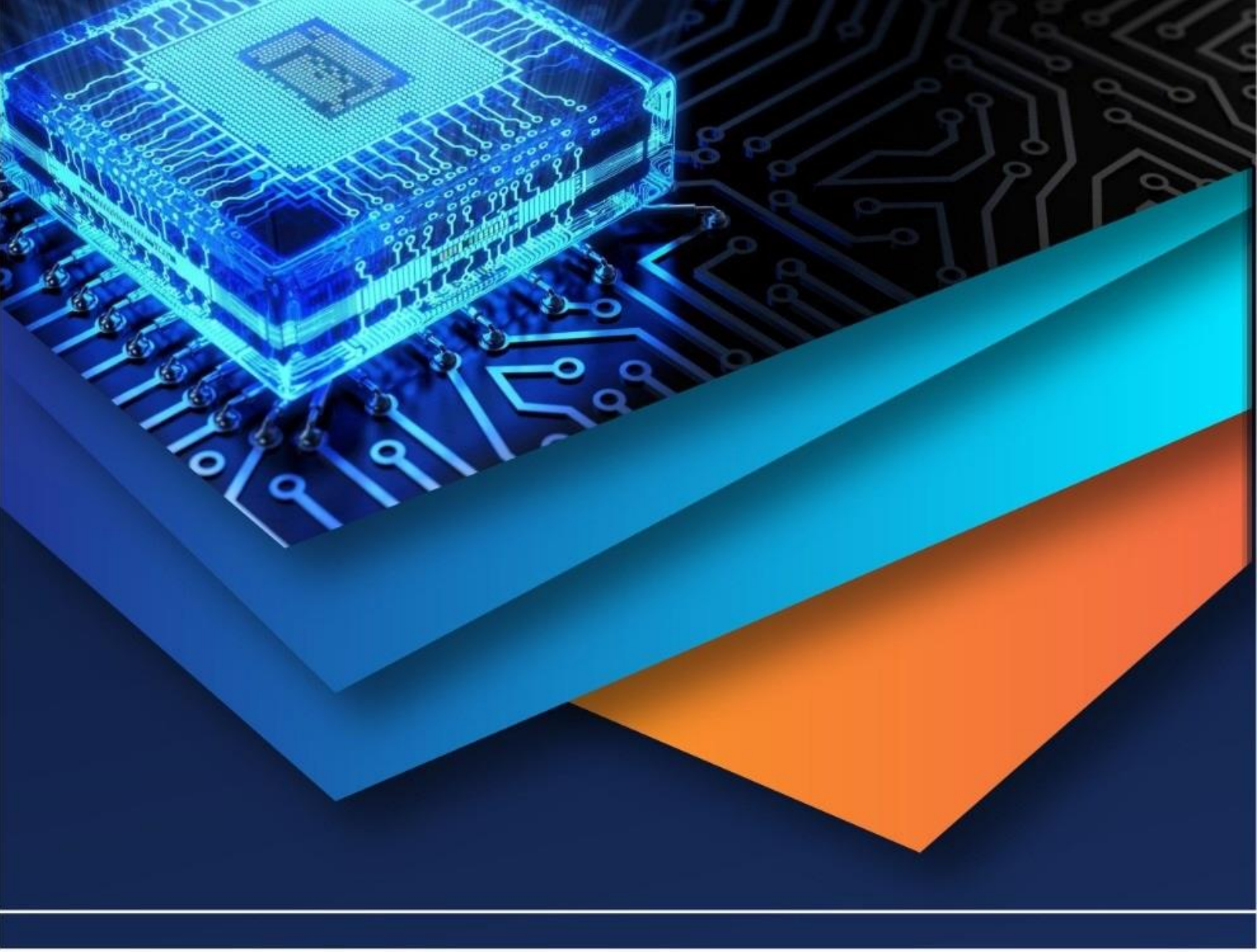

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