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Design and Development of Leak Testing Machine for T-Connectors

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Abstract: *The present work is focused on 'Design and Development of Dry Leak Testing Machine'. Proper selection and implementation of a product leak test method starts with an understanding the need of the test being performed, followed by establishing what the leak rate limit is, and finally a determination of how the leak test will be performed. The product to be tested is Quick connectors of hoses used in cooling system of the vehicles. The part will be tested as per given conditions of the automotive manufacturer. This machine is manufactured as per the customer's requirement and standard testing parameters. It is based on Fixture Technology with latch mechanism. The part under testing is pressurized with air and hold with the help of fixtures. The operator looks for pressure drop with the help of pressure sensors (Arduino Programming). One way Solenoid valve is used for rejection, where the component is rejected the solenoid valve operate and spray the colour on Component. If the part passes the test the batch will be approved for the dispatch. And if it fails, then the whole lot will be inspected. As it is moulding component not a machined component, if a crack is detected on a moulding component then it is of no use as it can't be welded on machined to fill the crack. As customer just needs to notify that the component has crack. He is not interested to where the crack is. For this purpose Dry Leak test method is appropriated.*

Keywords: *cooling system of automotive, quick connectors, leak testing, dry leak testing, fixture, pneumatic circuit, Arduino.*

I. Introduction

1.1 Cooling System

A system, which controls the engine temperature, is known as a cooling system. It helps to remove heat from the engine with the help of the coolant and the radiator.

1.1.1 Necessity Of Cooling System

The cooling system is provided in the IC engine for the following reasons:

• The temperature of the burning gases in the engine cylinder reaches up to 1500 to 2000°C, which is above the melting point of the material of the cylinder body and head of the engine. (Platinum, a metal which has one of the highest melting points, melts at 1750 °C, iron at 1530°C and aluminium at 657°C.) Therefore, if the heat is not dissipated, it would result in the failure of the cylinder material.

• Due to very high temperatures, the film of the lubricating oil will get oxidized, thus producing carbon deposits on the surface. This will result in piston seizure.

• Due to overheating, large temperature differences may lead to a distortion of the engine components due to the thermal stresses set up. This makes it necessary for, the temperature variation to be kept to a minimum.

• Higher temperatures also lower the volumetric efficiency of the engine.

1.1.2 Requirements Of Efficient Cooling System

The two main requirements of an efficient cooling system are:

1. It must be capable of removing only about 30% of the heat generated in the combustion chamber. Too much removal of heat lowers the thermal efficiency of the engine.
2. It should remove heat at a fast rate when the engine is hot. During the starting of the engine, the cooling should be very slow so that the different working parts reach their operating temperatures in a short time.

1.1.3 Types of Cooling System

There are two types of cooling systems:

(i) Air cooling system.
(ii) Water-cooling system.

(I) Air Cooling System

In this type of cooling system, the heat, which is conducted to the outer parts of the engine, is radiated and conducted away by the stream of air, which is obtained from the atmosphere. In order to have efficient cooling by means of air, providing fins around the cylinder and cylinder head increases the contact area. The fins are metallic ridges, which are formed during the casting of the cylinder and cylinder head

The amount of heat carried off by the air-cooling depends upon the following factors:

(i) The total area of the fin surfaces,

(ii) The velocity and amount of the cooling air and

(iii) The temperature of the fins and of the cooling air.

Air-cooling is mostly tractors of less horsepower, motorcycles, scooters, small cars and small aircraft engines where the forward motion of the machine gives good velocity to cool the engine. Air-cooling is also provided in some small industrial engines. In this system, individual cylinders are generally employed to provide ample cooling area by providing fins. A blower is used to provide air.

Advantages of Air Cooled Engines Air cooled engines have the following advantages:

1. Its design of air-cooled engine is simple.
2. It is lighter in weight than water-cooled engines due to the absence of water jackets, radiator, circulating pump and the weight of the cooling water.
3. It is cheaper to manufacture.
4. It needs less care and maintenance.
5. No risk of damage from frost, such as cracking of cylinder jackets or radiator water tubes.

(II) Water Cooling System

It serves two purposes in the working of an engine:

A) It takes away the excessive heat generated in the engine and saves it from overheating.

B) It keeps the engine at working temperature for efficient and economical working.

This cooling system has two types of systems:

(i) Thermo-Syphone system,

(ii) Pump/forced circulation system.

Though the present tractor has a forced circulation system, it is still worthwhile to get acquainted with the other system.

Thermo-Syphone Water Cooling System

This system works on the principle that hot water being lighter rises up and the cold water being heavier goes down. In this system the radiator is placed at a higher level than the engine for the easy flow of water towards the engine. Heat is conducted to the water jackets from where it is taken away due to convection by the circulating water. As the water jacket becomes hot, it rises to the top of the radiator. Cold water from the radiator takes the place of the rising hot water and in this way a circulation of water is set up m the system. This helps in keeping the engine at working temperature.

Disadvantages of Thermo-Syphone System

1 Rate of circulation is too slow.

2. Circulation commences only when there is a marked difference in temperature.

3. Circulation stops as the level of water falls below the top of the delivery pipe of the radiator.

For these reasons this system has become obsolete and is no more in use.

Force Circulation Water Cooling System

This system is similar in construction to the thermo-syphone system except that it makes use of a centrifugal pump to circulate the water throughout the water jackets and radiator. The water flows from the lower portion of the radiator to the water jacket of the engine through the centrifugal pump. After the circulation water comes back to the radiator, it loses its heat by the process of radiation. This system is employed in cars, trucks, tractors, etc.

Parts of Liquid Cooling System

The main parts in the water-cooling system are:

(i) water pump,
(ii) fan,
(iii) radiator and pressure cap,
(iv) fan belt,
(v) water jacket
(vi) thermostat valve
(vii) temperature gauge and
(viii) Hose pipes and Connectors

1.2 Quick Connectors

The quick connectors are the part which is to be tested by the dry leak testing method. This part is manufactured by the injection moulding process. The material used to manufacture the part is Zytel (PA66-GF30) which is a 30% glass fiber reinforced, heat stabilized, hydrolysis resistant polyamide 66 resin. The part can sustain upto 120 N load. The inline pressure is upto 2.5 bar but considering the factor of safety the part will be checked at 5 bar pressure.

Fig. 1 Quick connectors to be tested

There are various type of connector materials are available in market. We use Zytel material for connector instead of Metal connectors. The comparison between Zytel and Metal connectors,

Table No. 1.1 Difference between Metal and Plastic connectors

Sr.No.	Metal Connector	Plastic Connector
1.	The metal connectors are heavy as compare to Plastic connectors.	The connectors are light in weight.
2.	The manufacturing process takes time.	The manufacturing process is easy
3.	They are non-corrosive.	They corrosion resistant.
4.	The overall cost of metal connectors is high.	The overall cost is low.

1.2.1 Applications of Connectors

A general purpose automotive fitting for

- Cooling lines/Heating lines
- Engine Cooling
- Intercooler Systems
- Battery Cooling (E-Mobility)
- Voltage Transformer Cooling (E-Mobility)
- Vaccum hose connector.

Fig. 2 Quick connector used in Automotive cooling

1.2.2 Designation

Designation example for a coolant pipe made of PA66-GF30, black.

1.2.3 Properties

The surface and inside of the finished parts must be free of flaws and processing defects (voids, cracks, cold shuts, etc.) That have a negative effect on strength, service life, and the required appearance. Sink marks in the area of the ribs, stiffening elements, and fittings are only permissible if they do not have a negative impact on installability or function. The parts must permit flawless assembly. The glass fibers must be evenly distributed in the material to such an extent that the glass fiber content of specimens taken at three different points on a finished part does not differ by more than 1.0%.

1.2.4. Design of Product:

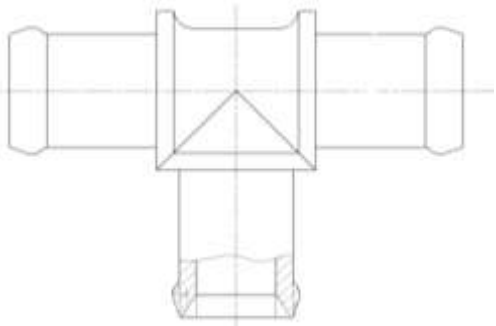

Fig 3 2D diagram of component

1.2.5 Manufacturing process:
Injection molding or a related process (water injection technology).

1.2.6. Testing of component:
Material:

The identity test can be performed by infrared spectroscopy. Ball indentation hardness Measurements must be taken on at least three (20 × 20) mm specimens (2 measurements per specimen). On specimens that have been taken from molded parts with one-sided graining or a paint finish, the grain or paint must be removed using a surface grinding machine. The flat surface created in this way serves as the contact surface. The measurements are taken on the untreated back surface of the specimen.

Leakage Test:

The following parameters apply to the Dry leak test:
Test medium: Air, Test temperature: (23 ±5) °C, Test pressure: 2.5 bar overpressure, unless otherwise specified in the drawing, Hold time after reaching the test pressure: 10 s, Criterion for leak tightness: no pressure drop more than 0.05 Bar.

II. Need, Statement And Objective Of The Work

2.1 Needs to be leak proof

The word Leak proof means not allowing the escape or entry of liquid or gas. The leakage in the quick connectors leads to:

- Overheating of the engine.
- Reduction in system efficiency
- Increase CO_2 emissions
- Increase downtime of the engine due to overheating
- Increase in maintenance cost.

2.2 Problem Statement

Company was neither conducting 100% leak test for quick connectors, nor was they conducting batch wise Leak Testing. Quick connectors failed in vehicles at running condition due to leakage of quick connector. So, the Present work is focused on developing the system on which company will perform leak test of VDA - Quick connectors in batch quantity with different types of shapes and size of connectors.
System-: Development of the system which can used to conduct leak test as per automotive specifications provided by customer.

2.3 Objectives

Steps involved in creating Leak testing machine:-

- To understand customer's automotive standards.
- To select proper leak testing method.
- To design leak testing machine for quick connectors.
- To design fixture for quick connectors such that 2 to 3 components can be tested.
- To fabricate and assemble the components in proposed design.
- To test the quick connectors for leakages.

III. Experimental Setup

3.1 Schematic of Dry Leak Testing Machine

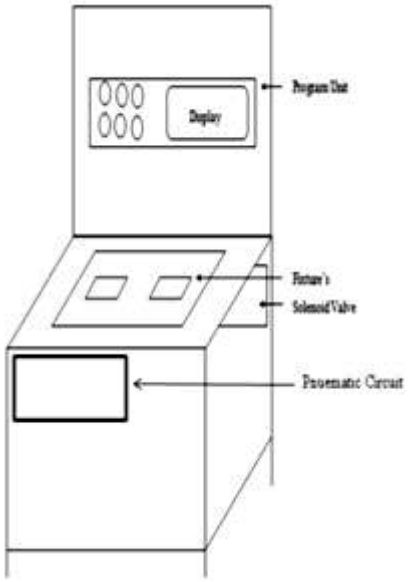

Fig.4 Schematic of Proposed Dry Leak Testing Machine:

Work Table Layout:

- Space utilization
- Size of table: The table size should be sufficient to mount 3 fixture on suitable distance. The distance between two fixture also impact on operator to perform testing.
- Hydraulic Connection: The hydraulic connections are provided to machine from bottom side of table. Because of bottom side the space is more utilized. It increases aesthetic of machine.
- Height of Table: The height of operation table also important in operators view.

Fixture

Fixture design

Need of Fixture

- To hold the workpiece / component.
- To locate the workpiece/ component at exact position without any disturbance and assurance of the tightness.

Factors considered to design a fixture

- **Type of the component-:**

In our Present work the component which is to be tested is used in **automotive**. In automotive it is used to connect the cooling hoses of radiator.

Example: Hatchback cars and Volkswagen Ameo.

- **Geometry of the component-:**

The design of fixture depends on the **geometry** of component. It is more likely to be a Replica of the component which is to be tested.

- **Material of the component-:**

The material used for the testing component is **Nylon (30%)** glass fiber reinforced, heat stabilized, hydrolysis resistant polyamide 66 resins.

- **Type of manufacturing of component-:**

The manufacturing process is **Injection Molding**.

Design procedure of Fixture-:

- **Material Selection-:**

The material of the fixture should be stronger, harder than the material of the component. There are two choices of material which harder and stronger than Nylon 30% (ie. Aluminium and Mild Steel). So we are selecting MS40 material for manufacturing the fixture, considering wear and tear of the fixture by the time as well as cost.

- **Defining Parameters-:**

While defining length of the fixture as we cannot select full length because it may cause disturbance while loading and unloading also the half length can't be selected as it will not hold the component rigidly.

Hence the length of the fixture is taken as $3/4^{th}$ of the total length of the component. The depth of the fixture is taken as half of the height of component.

- **Modeling-:**

By considering above parameters and dimensions of component the 3D model of the fixture is done in CREO parametric 2.0 Also we considered the collar on the component so we designed the groove on fixture. It will locate and hold component in fixture rigidly.

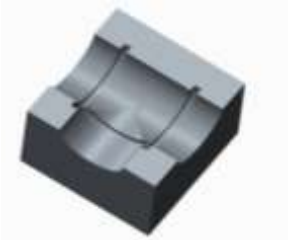

Fig.5 Design of the sample fixture

Manufacturing-:

The fixture is manufactured on VMC machine at DE group Bhosari.

The cutter radius used is 0.5-1 mm for cutting.

Other operations performed for manufacturing of the fixture

Tapping: tapping is process of drilling a hole into workpiece for with the internal threads.

After the formation of the fixture block on the VMC, tapping is performed on the fixture for the fitting arrangement to the work table.

Surface finishing:

Surface finishing is the process of removing of the excess material from the surface of the workpiece.

The surface finishing is done after the tapping to remove the burr and to meet to the required dimensional accuracy.

Analysis of Fixture:

Analysis is done for checking the durability, strength, wear and tear of fixture by using **Trial and Run Method.**

The first step is to manufacture fixture is to Material Selection. We select the material **MS40** as discussed above. Programme execution is done for fixture manufacturing to process in VMC machin. It takes appox. 45 to 60 minutes for one fixture. After manufacturing the workpiece taken to post processing. Post processing like Surface finishing, tapping,etc.

The entire process takes 12-15 days.

Fig.6 Manufactured Fixture

Bush:

The bush is used for tightening of inlet ports at high pressure. Manufactured Rubber bushes with the help of Lathe machine.

Selection of Pneumatic Components:

Pneumatic component perform most important role while operation of dry leak testing. Pneumatic systems used in industry are commonly powered by compressed air or compressed inert gases. A centrally located and electrically powered compressor powers cylinders, air motors, and other pneumatic devices. A pneumatic system controlled through manual or automatic solenoid valves is selected when it provides a lower cost, more flexible, or safer alternative to electric motors and actuators.

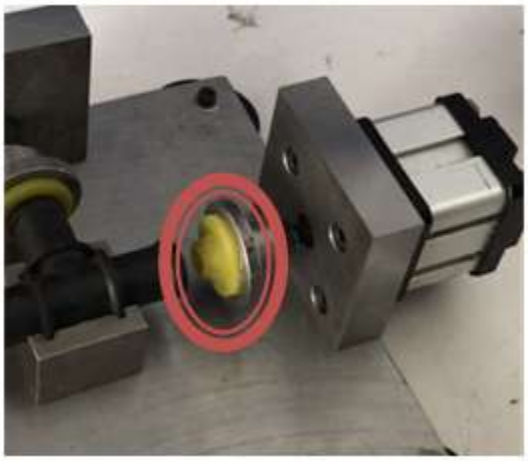

Fig.7 Manufactured Rubber Bush

Advantages of Pneumatic system-:

- Simplicity of design and control- Machines are easily designed using standard cylinders and other components, and operate via simple on-off control.
- Reliability- Pneumatic systems generally have long operating lives and require little maintenance. Because gas is compressible, equipment is less subject to shock damage.
- Safety- There is a very low chance of fire compared to hydraulic oil. New machines are usually overload safe to a certain limit.

Various components used in system are as follow;

a) Compressor
b) Pressure sensor
c) FRL unit
d) Pneumatic cylinder
e) Solenoid valve

IV. Experimental Methodology

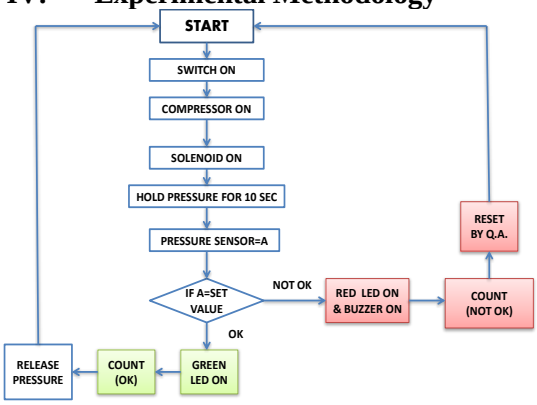

Fig. 8 Flow Chart of methodology

4.1 Principle of Operation

Preset pressure:

According to the standards of customers of the component, the pressure inside the component during the test is kept at 2.5 bars. The pressure regulator regulates the pressure at required level.

Timer:

The timer has given of 10 seconds. During this interval of the 10 seconds the drop in pressure will be observed. The Arduino contains timer in itself. It will count the time and will show on the display.

Pressure drop:

The allowable pressure drop is 0.5 bars. Pressure drop more than 0.5 bars is not allowable. The pressure sensor detects the pressure of air inside the component. The readings from the pressure sensor will be displayed on the LCD display which is the value of instantaneous pressure.

Output:

The output of the system is to detect the leak in the component and this will be done by observing the pressure drop. The allowable pressure drop is 0.5 bars hence if the pressure falls below the 2 bars, the component is said to be faulty/defected. This is detected by the pressure sensor which provides its readings continuously to the Arduino controller. The Arduino controller detects pressure drop and shows the results on the LCD display. The LED's are connected to the Arduino circuit which blinks after the results.

V. Experimental Results

Sr. No.	Input pressure (Bar)	Hold time (Sec)	Pressure after 5 sec (Bar)	Final pressure (Bar)	Pressure drop (Bar)	OK / NOT OK	Marking on part
1.	2.5	10	2.5	2.5	0	OK	Yellow
2.	2.5	10	2.5	2.5	0	OK	Yellow
3.	2.5	10	2.49	2.47	0.03	OK	Yellow
4.	2.5	10	2.5	2.5	0	OK	Yellow
5.	2.5	10	2.45	2.41	0.09	OK	Yellow
6.	2.5	10	2.17	1.86	0.64	NOT OK	Red
7.	2.5	10	2.5	2.49	0.01	OK	Yellow
8.	2.5	10	2.5	2.5	0	OK	Yellow
9.	2.5	10	2.5	2.5	0	OK	Yellow
10.	2.5	10	2.49	2.48	0.02	OK	Yellow

VI. Conclusion

The main objective of the Present work was to design and manufacture special purpose leak testing machine. In the first part component is studied in details for the geometry and its material. The CAD model of the fixture is drawn for simplification and understanding of the rough picture of fixture. The analysis is done for the fixture by trial and run method. The cylinders of the fixtures are selected according to the forces on the component. The specification is selected. The mounting of the cylinders is also important in the machine. The mounting is selected as front mounting for all cylinders. Manufacturing is done of fixture first and then it is attached to the main part of the machine which is a stable part. After that testing is done at various pressures and the results are as required by the customer. Electronic circuitry is fitted for the automatic operation. Arduino is used for the automation of the process. It is loaded with the program for dry test. The machine is shipped to the required destination and received by the customer.

References

[1]. T. Dragicevic, X. Lu, J. C. Vasquez, J. M. Guerrero (2016) *DC Microgrids- Part I, Control Strategy & Stabilization, IEEE Trans. Power Electronics,Vol. 31,Issue: 7*, pp. 4876-4891, October 2016.

[2]. J. Evertz, F. Krismer, J. V. Den keybus, J. Driesen, J. W. Kolar, Charge *Based Switching Analysis dual active bridge AC-DC converter, IEEE Transaction on ECCE, pp. 4820-4829, June 2013.*

[3]. S. Kulasekaran, R. Ayyanar, *Analysis, design, and experimental results of the semidual-active-bridge converter, IEEE Trans. Power Electronics, Vol. 29, No.10, pp. 5136-5147, Oct 2014*

[4]. Z. Pavlovic, J. A. Oliver, P. Alou, O. Garcia, J. Cobos, *"Bidirectional dual active bridge series resonant converter with pulse modulation", IEEE Transaction on APEC, pp. 503-508, July 2012.*

[5]. F. M. Ibanez, J. M. Echeverria, J. Vadillo , L. Fontan, *A step-up bidirectional series resonant DC/DC converter using a continuous current mode ,IEEE Trans. Power Electronics, Vol. 30, No.3,pp. 1393-1402, Mar. 2015.*

[6]. L. Corradini, D. Selzer, D. Bloomquist, R. Zane, D. Maksimovic, *Minimum current operation of bidirectional dual-bridge series resonant DC/DC converters, IEEE Trans. Power Electronics, Vol. 27, No.7,pp. 3266-3276, July 2012.*

[7]. T. Jiang, J. Zhang, X. Wu, K. Sheng, Y. Wang, *A bidirectional LLC resonant converter with automatic forward and backward mode transition IEEE Trans. Power Electronics, Vol. 30, No.2,pp. 757-770, Feb. 2015*.

[8]. Z. U. Zahid, Z. M. Dalala, R. Chen, B. Chen, J.-S. Lai, *,Design of bidirectional DC-DC resonant converter for vehicle-to-grid (V2G) applications, IEEE Trans. Transportation Electrification, Vol. 1, No.3, pp. 232-244, Oct. 2015.*

[9]. C. H. Chang, C.-A. Cheng, H.-L. Cheng , *Modeling and design of the LLC resonant converter used as a solar-array simulator IEEE Journal of Emerging and Selected Topics in Power Electronics, Vol. 2, No.4,pp. 833-841, Dec. 2014.*