Development of Vacuum-Operated Engine Test Rig.

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Abstract— An automobile engine on the assembly line undergoes various fitments of a large number of components until it is ready for its final dispatch. It so happens sometimes that some of the components may be missed out due to high and continuous workload. Such faulty engines are not ready for dispatch and have to be sent back for rework after the testing process has been performed. This leads to losses in terms of resources and time of the company. The engine test rig is an apparatus developed to check the engine fitments on the engine assembly line. The concept was to manufacture an engine which has zero defects. The test rig works on the principle of vacuum generation in the oil pathway of engine block. The amount of vacuum generated for a zero defect engine has a standard datum value. Deviation from the standard value of vacuum generated gives an indication of missing components. Greater the number of missing components more is the vacuum generated. Thus the fault is detected much earlier (on the assembly line itself) even before it is sent for testing and dispatch.

Key words: Engine Test Rig, Zero Defect Engine, Continuous Workload

I. INTRODUCTION

The engine test rig is an apparatus developed to check the engine fitments on the engine assembly line. The concept was to manufacture an engine which has zero defects and matches the world class quality. This would lead to customer satisfaction along with a marginal growth in sales and a reduction in the warranty claims from the customers.

The test rig works on the principle of vacuum generation in the oil pathway of engine block. The various components of the engine fitments which are generally found missing are as follows:

(1) MB shell Bearing
(2) Con-Rod Bearing
(3) Oil Gallery Plug
(4) Oil Pump
(5) Piston Cooling Nozzle

The operator happens to miss such essential fitments at times which may lead to a faulty engine to be sent out.

Fig. 1: Assembly View of the Engine Test Rig

II. PRINCIPLE OF OPERATION

A. *Vacuum Generation by Venturi.*

The Venturi effect is the reduction in fluid pressure that results when a fluid flows through a constricted section of pipe. The simplest apparatus, as shown in the photograph and diagram, is a tubular setup known as a Venturi tube or simply a venturi. Fluid flows through a length of pipe of varying diameter. To avoid undue drag, a Venturi tube typically has an entry cone of 30 degrees and an exit cone of 5 degrees. It is not used where the Reynolds number is less than 150,000. Venturi tubes are used in processes where permanent pressure loss is required and where maximum accuracy is needed in case of high viscous liquids.

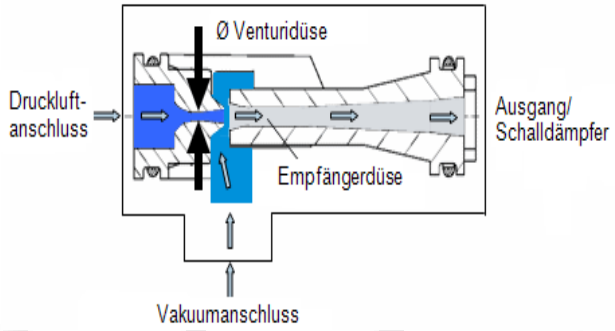

Fig. 2: The Operation Of A Venturi

B. *Components for vacuum generation.*

1) Vacuum ejectors

These function according to the venturi principle, i.e. they are driven purely pneumatically and have a much simpler design compared with other vacuum generators.

2) Displacement vacuum pumps

Air flowing into a space is mechanically shut off, compressed and ejected. This allows a very high vacuum to be achieved at a very low flow rate.

3) Kinetic vacuum pumps

Air is forced to flow in the delivery direction through the application of additional mechanical force. This method achieves only a relatively low vacuum level despite a high suction rate.

C. *Working.*

The most important components are the jet nozzle (venturi nozzle) and at least one receiver nozzle. Accelerated compressed air generates a suction effect between both nozzles (vacuum). Accelerated compressed air generates a suction effect between both nozzles (vacuum). Depending on the principle, air is either carried away in a flow by a rotating impeller on the suction side or compressed using vaned chambers.

D. *Festo Vacuum Generator(Festo VAD 1/4th 9394)*

Festo vacuum generators operate according to the venturi principle. The compressed air flows from the pressure supply port into the ejector. The constriction in the venturi nozzle increases the flow velocity of the air to supersonic speed. After exiting the venturi nozzle, the air expands and flows through the receiver nozzle into the outlet port (silencer). In the process, a vacuum is created in the

chamber between the venturi and receiver nozzles, which causes air to be drawn in from the vacuum port. The vacuumed air and exhaust air both leave through the outlet port (silencer).

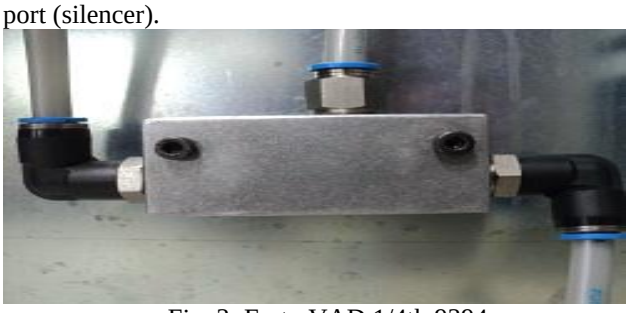

Fig. 3: Festo VAD 1/4th 9394

E. Pressure Regulator

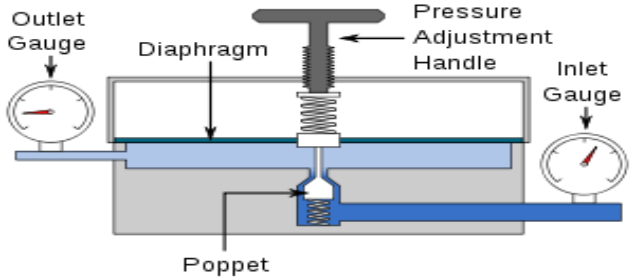

Fig. 4: Single Stage Regulator

High pressure gas from the supply enters into the regulator through the inlet valve. The gas then enters the body of regulator, which is controlled by the needle valve. The pressure rises, which pushes the diaphragm, closing the inlet valve to which it is attached, and preventing any more gas from entering the regulator.

The outlet side is fitted with a pressure gauge. As gas is drawn from outlet side, the pressure inside the regulator body falls. The diaphragm is pushed back by the spring and the valve opens, letting more gas in from the supply until equilibrium is reached between the outlet pressure and the spring. The outlet pressure therefore depends on the spring force, which can be adjusted by means of an adjustment handle or knob.

F. Festo LOE-D-MINI D643

A pressure regulator's primary function is to match the flow of gas through the regulator to the demand for gas placed upon the system. If the load flow decreases, then the regulator flow must decrease also. If the load flow increases, then the regulator flow must increase in order to keep the controlled pressure from decreasing due to a shortage of gas in the pressure system.

Fig. 5: Festo Loe-D-Mini D643

A pressure regulator includes a restricting element, a loading element, and a measuring element*:*

- The restricting element is a valve that can provide a variable restriction to the flow, such as a globe valve, butterfly valve, poppet valve, etc.
- The loading element is a part that can apply the needed force to the restricting element. This loading can be provided by a weight, a spring, a piston actuator, or the diaphragm actuator incombination with a spring

The measuring element functions to determine when the inlet flow is equal to the outlet flow. The diaphragm itself is often used as a measuring element; it can serve as a combined element.

II. MISSING COMPONENTS

A. MB Shell Bearing

The MB Shell bearings fit into the MB cap on the block of the engine. These are five in number for a four cylinder engine and seven in number for a six cylinder engine. The bearings are sliding contact bearings along with fluid oil lubrication for smoother operation. MB shell Bearing supports the rotating motion of the crankshaft.

If the MB shell Bearing, there will not be smooth relative motion between the MB Cap and the Crankshaft, which will eventually lead to wear and tear of the shaft. The crankshaft would undergo misalignment and deformation. Finally leading to the seizure of engine.

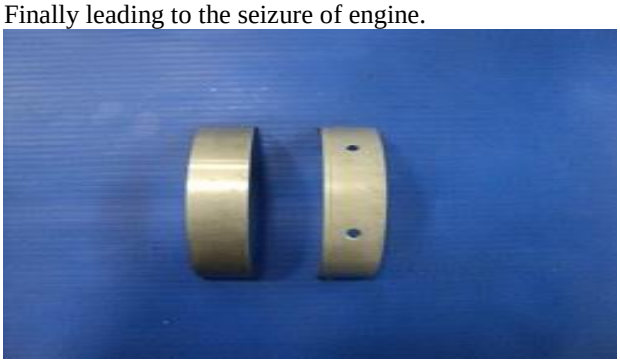

Fig. 6: Mb Shell Bearing

B. Con-Rod Bearing

The connecting rod bearing is also a sliding contact bearing along with a film of lubrication for even better operation. These bearings fit over that section of the con-rod which has its fitment and relative motion with the crankshaft. The

numbers are four for a four cylinder engine and six for a six cylinder engine.

C. Oil Gallery Plug

The oil gallery plugs avoid the out flow of the oil from the engine block. They act as a seal and prevent the leakage of the oil. These are three in number. The fitment of the gallery plugs requires a perfect torque to be given as even a little loose fitment may cause oil leakage. Also, excess torque will lead to oil leakage since the washer is made up of Copper. Thus Copper being a ductile material, it deforms and will gradually lead to leakage. The torque given is of 6.5mkg for two of them and the third plug is applied with a torque of 8 m-kg.

Fig. 7: Oil Gallery Plug

D. Oil Pump

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.

Fig. 8: Oil Pump

E. Piston Cooling Nozzles

A spray nozzle is a precision device that facilitates dispersion of liquid into a spray. Nozzles are used for three purposes: to distribute a liquid over an area, to increase liquid surface area, and create impact force on a solid surface. A wide variety of spray nozzle applications use a number of spray characteristics to describe the spray.

Piston cooling nozzles spray a shower of oil on the piston thus carrying away the heat from the pistons. They thus avoid the temperature effects to damage the engine and also provide lubrication for easy slide of the piston in the bore.

Fig. 9: Piston Cooling Nozzle

IV. Testing Procedure

The procedure to carry out the test for missing parts is as follows:

(1) Connect the engine test rig to the mains power supply and the compressed air line. Turn on the electric supply switch to supply the power to the engine test rig.
(2) The HMI or the GOT will be turned on and the screen will display the digital pressure dial.
(3) Insert the probe in the opening of the oil pathway of the engine to be tested.
(4) Start the test by pushing the Cycle Start button(Green push button).
(5) The testing starts.
(6) Vacuum will be built in the engine path ways. This amount of pressure built is displayed on the HMI.
(7) The test records the vacuum build for 15 sec.
(8) If the indication lamp turns green after the test is over, no fault is detected. Thus the engine is sent forward.
(9) Else if the red lamp is blown along with the hooter it would indicate a failure and the line inspector has to
(10) The line inspector has to take the engine off the assembly line and it is then sent for rectification.

The next engine is tested thereafter by the same procedure.

V. Reading And Observation Table

Sr. No.	Description	VDA -1/4 Vacuum Generator Value	Vacuum Generator Value (Part Missing)
1	Open Vacuum	-362	
2	Euro III ok Engine	-342	
3	M.B Shell(ONE BY ONE)	-342	-348
4	Piston Cooling Nozzle	-342	-362
5	Oil Gallery Plug	-342	-362
6	Oil Pump	-342	-362
7	Con Rod	-342	-348

The test results give us the vacuum pressure generation in millibar. The results give us the conclusion that a full OK engine would give us -342 mbar of vacuum generation.

If the MB Shell Bearing or the Con Rod Bearing is found missing then it develops -348 mbar of vacuum. On the other hand if either one of the Piston Cooling Nozzle or the Oil Pump or the Oil Gallery Plug is found missing then -362 mbar of vacuum will be generated.

V. CONCLUSION

After conducting various trials on different engines the test results have brought us to a conclusion that the engine test rig has found a direct solution to the stated problem.

Prior to the building of the test rig ten engines annually were found without the critical components like MB Shell Bearing, Con-Rod Bearing, Oil Gallery Plug, Piston Cooling Nozzle and Oil Pump. This led to faulty engines being dispatched leading to customer dissatisfaction and complaints, warranty claims. Higher additional costs were incurred by the company.

The engine test rig has ensured that no engine leaves the assembly line with any of the critical components missing. This has helped the company to achieve world class manufacturing with zero defects. Thereby reducing the customer dissatisfaction and complaints, warranty claims. It has also helped creating awareness in operators about preventing any mistakes on the assembly line, thus boosting the overall quality of the products.

This kind of manufacturing has led to a change in which the defects are detected at a much prior stage that is even before the engine undergoes the standard testing procedures. It is a boost for the company in its global as well as national markets meeting the international standards.

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