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Lubrication Improvement in Internal Combustion Engines

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Abstract : In IC engine, the lubrication oil is circulated to the various reciprocating and rotating parts in order to reduce the friction losses and to reduce the wear and tear of engine parts. When the engine lubrication oil is flowing through the oil hole in the cylinder barrel, there could be the problem of oil leak through the fins from cylinder barrel, due to the inherent limitations in the quality of casted cylinder barrel. In order to avoid those oil leak situations, oil holes are made of copper tubes which leads to increase in the manufacturing cost. In this project, we have planned to do some value analysis and value engineering on cylinder barrel oil flow way to reduce the cost of manufacturing, without altering the functionality of oil hole.
Key words: ICE- Internal Combustion engines, VAVE- Value analysis and Value engineering, FAST- Function Analysis System Technique, SAVE- Society of American Value Engineers.

1. Introduction:

Purpose of Lubrication:

Oil must be circulated throughout the engine from crank case to lubricate the moving parts such as rocker bearings, overhead cams and rocker arms. For this purpose, in earlier days, the oil flow line from oil pump which is housed within the crank case and operated by crank shaft, is designed outside of the engine.

IC engines:

Fig 1.1 shows the construction of internal combustion Engine. The heat engine in which the combustion of fuels takes place inside the engine is called Internal Combustion engines.

1.1 Literature review:

Charles introduced a methodology called Function Analysis System Technique (FAST) by extending the Lawrence D. Miles concept to the Society of American Value Engineers (SAVE) in 1965 at the international convention. FAST includes intuitive logic which decomposes a high level objective function to lower level functions and displayed in FAST model, generally a logic diagram. [1].

Die casting is a manufacturing process in which the shape can be obtained is net shape which is near to accuracy. This process leads to good surface finish, good strength, high integrity, close dimensional control and high rate of production than any other processes. It features the production of thin wall castings, low weight. [2].

Shrinkage Cavity may affect the performance of mechanical parts. Many design engineers' uses large safety factors due to lack of understanding of cavity defects. Now a day casting has become an effective tool for mould filling, solidification and cooling to predict the location of porosity(type of internal effect), sand inclusions and cold shuts. It can be used for developing new casting without shop-floor trials. This paper frames the benefits of casting simulation and how to decrease porosity defect theoretically [3].

2.Experimental Procedure:

2.1 Methodology:

This chapter explains the methodology followed for the present work, which starts from the value analysis on present oil flow way in the cylinder barrel. Following the value analysis, various value engineering activities will be applied to the oil flow way and the impact on manufacturing cost and product quality in the leak point of view will be analyzed.

Development of Experimental Test Setup

A suitable engine (Single cylinder air cooled SI engine) is selected to perform the experiments and checked and prepared for good running condition[5].

Value Engineering Activities Planned

Presently, oil hole is machined and copper tube is inserted. It is planned to introduce "AS CAST "oil hole, Vacuum impregnation of casting and leak testing at casting stage after impregnation.

Validation Method

With all those value engineering activities, the cylinder barrel which is leaking at the moment will be taken for vacuum impregnation. After impregnation, leak testing will be done with reduced allowable leak rate, from the limit of 0.15 bar drop allowed to 0.03 bar drop in 10 second. The leak tested barrel will be fitted in the test engine to run for 4000 kms in the road test to check for the withstanding ability of impregnate.

Observation of Results and Discussion

With the testing feedback and observation for the oil leak from the cylinder barrel fins after test riding, VAVE manufacturing cost will be compared with present machined and copper tube fitted oil hole and the discussed.

Table: 1 comparison of value and cost addition

S.No.	Operation / Part assembly		
		Value addition	Cost addition
1	Oil hole rough drilling	To provide minimum machining stock for reaming	Rs. 4.58 (11 sec – Drilling)
2	Oil hole reaming	To produce hole with accurate hole size and roundness to fit the copper tube	Rs. 3.33 (8 sec – Reaming)
3	Ø5 hole drilling	To provide the channel for oil flow at the end of oil hole	Rs. 2.50 (6 sec – Drilling)
4	Application of thread sealant – 1.0 ml	To fill the gap between the copper tube and cylinder barrel reamed hole	Rs. 6.26
5	Copper tube assembly	To transport the lubrication oil without leak	Rs. 14 (Copper tubecost)

6	Curing about 10 minutes	To allow the applied thread sealant to make the bond between copper tube and Cylinder barrel	——

Total Cost addition: Rs. 30.67

In the point of value addition, even with copper tube as oil hole, the main function of the oil hole is not fulfilled. Still there is oil leak complaint about from the cylinder barrel through fins.

"As Cast "Oil Hole and Copper Tube Elimination

The cylinder barrel oil flow way is modified into "AS CAST "oil hole with the dimensions as shown below. Total machining operation was removed and copper tube assembly also eliminated.

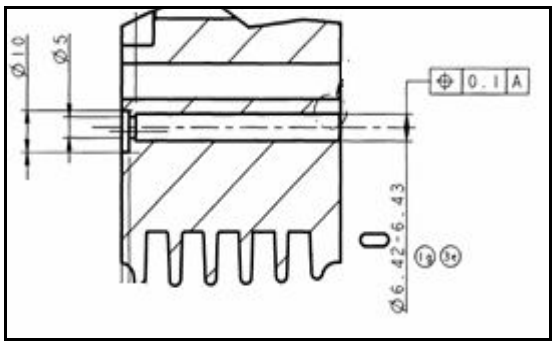


Fig: 2.1: Machined oil hole

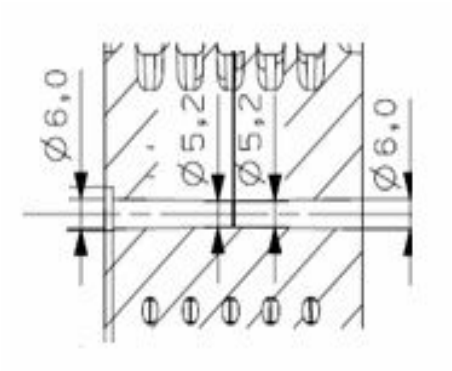


Fig: 2.2:oil hole with vacuum impregenation

Oil hole cut section
(Existing - Machined)

Oil hole cut section
(VAVE - " AS CAST ")

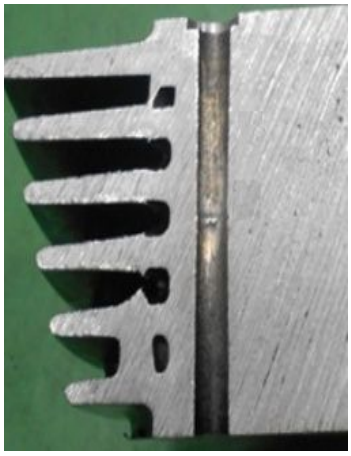


Fig. 2.3 and 2.4 : Oil hole cut section (Before / after VAVE)

Vacuum Impregnation of Castings

Fig: 2.5 : Cylinder barrel casting vacuum impregnation plant

Vacuum impregnation was done with the following process parameters.

1. Dry cycle (Vacuum: 680 mm of mercury): 10 minutes.
2. Wet cycle: 30 minutes.
3. Draining: 5 minutes.
4. Cold water wash: 5 minutes.
5. Curing with hot water (92 °C): 20 minutes.
6. Impregnate : Thermo curing Methacrylate(Commercial name : IM 3000, is a cross linking mixture of mono and polyfunctional acrylates and methacrylate's mainly methacrylate esters)

Leak Testing At Casting Stage

Before valve, leak testing was done after machining only. That too with the allowable leak rate of 0.15 bar drop in 10 second at 3 bar testing pressure. With valve, leak testing is done in the casting stage itself with stringent leak allowable rate of 0.03 bar drop in 10 second at 4 bar testing pressure.

Fig: 2.6 : Leak testing machine

- Testing pressure : 4.00 ± 0.01 Bar
- Medium : Dry air
- Air filling time : 5 second
- Allowable leak rate in terms of pressure drop : 0.03 Bar maximum in 10 second
- Leak ok identification : Punch mark on casting surface

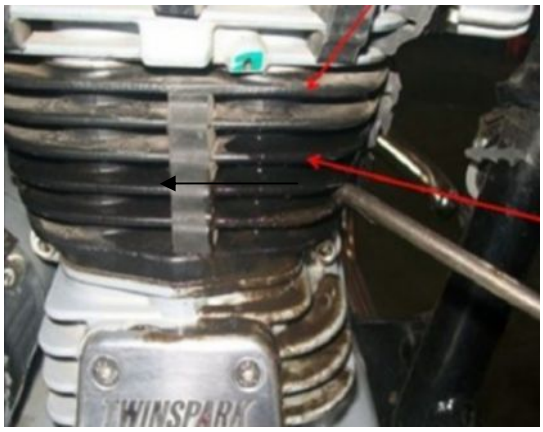
Engine Specification

Cubic capacity	:	346 cc
Bore nominal	:	70 mm
Stroke	:	90 mm
Compression Ratio	:	8.5:1
Max. Power@5250rpm	:	19.8 bhp.
Max. Torque@4000rpm	:	28 N-m.
Maximum Engine Speed	:	5500rpm.
Minimum Engine Speed	:	1000 rpm.
Maximum Vehicle Speed	:	120 kmph.
Mileage (Standard Conditions)	:	45 kmpl.
Pay Load	:	172 kg.
Transmission	:	Five speed
Ignition	:	Digital TCI
Carburettor	:	Constant Volume

3. Results and Discussion:

Leak Characteristics:

Fig 3.1 shows the with all those value engineering activities, a leak failed cylinder barrel was vacuum impregnated. After impregnation, leak testing was done with reduced allowable leak rate, from the limit of 0.15 bar drop allowed to 0.03 bar drop in 10 second at 4 bar testing pressure. The leak tested barrel was fitted in the test engine and ran for 4000 kms in the road test. No oil leak was found from cylinder barrel fins.



A case of clear fin leak from cylinder barrel.

No fin leak from tested cylinder barrel (After 4000 kms test ride

Fig. 3.1 : Oil Leak Comaparison In Engine

Manufacturing Cost Comparison

The manufacturing cost of cylinder barrel oil flow way, before and after VAVE, has been compared below.

Table: 2 Before/After VAVE – Manufacturing cost comparision

S.No	Operation / Part assembly	Before VAVE		Total cost	After VAVE	
		Value addition	Cost addition		Cost addition	Total Cost
1	Oil hole rough drilling	To provide minimum machining stock for reaming	Rs. 4.58 (11 sec – Drilling)	Rs. 30.67	Vacuum impregnation process to fill the micro porosity	Rs. 20.72
2	Oil hole reaming	To produce hole with accurate hole size and roundness to fit the copper tube	Rs. 3.33 (8 sec – Reaming)			
3	Ø5 hole drilling	To provide the channel for oil flow at the end of oil hole	Rs. 2.50 (6 sec – Drilling)			
4	Application of thread sealant – 1.0 ml	To fill the gap between the copper tube and cylinder barrel reamed hole	Rs. 6.26			
5	Copper tube assembly	To transport the lubrication oil without leak	Rs. 14 (Copper tube cost)			
6	Curing about 10 minutes	To allow the applied thread sealant to make the bond between copper tube and Cylinder barrel	___			

After the application of VAVE, there is net cost saving of Rs. 9.95 in the cylinder barrel oil flow way manufacturing cost.

4. Conclusion:

With this VAVE study, it is clear that, through VAVE, not only reduction in the manufacturing cost, but also the quality of product can be increased.

1. After application of VAVE, there is nil oil leak complaint from cylinder barrel fins.
2. There is net cost saving of Rs. 9.95 - in the oil flow way manufacturing cost of cylinder barrel.
3. Cylinder barrel machining cycle time is reduced by 25 second, which in turn effected on productivity increase in cylinder barrel.
4. Assembly of copper tube and Loctite curing time – All are eliminated from cylinder barrel manufacturing process which in turn effected on increase in cylinder barrel productivity.

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