ISSN 2395-1621

Developing Oil Filter to Extend Oil Drain Interval

#1Mrinmayee B. Pokharkar, #2Dinesh H. Burande

[1]mrinmayee.pokharkar@gmail.com
[2]dhburande.scoe@sinhgad.edu

#12Department of Mechanical Engineering, Savitribai Phule Pune University,
Sinhgad College of Engineering, Vadgaon Bk., Pune-41.

ABSTRACT

Oil filters keep engine oil clean by capturing contaminants that can cause engine damage. Now a day there is trend in customer demand that engine design requires extended oil drain interval than current. Oil drain interval is extended by adding additives into it. These additives improve oil quality. Detergents, dispersants, anti-foam agents, anti-wear additives are the different additives used to improve oil quality. Adding these additives manually creates human errors. To avoid this problem oil filter with chemical doser is designed. Hence, this paper covers design of oil filter to extend oil drain interval.

Keywords— Oil filter, oil drain interval, additives, oil quality.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

Engine Oil is needed to be changed after particular interval as it gets degraded after using it for some period. There are many causes that can result in the degrading of engine oil. The most common are oxidation, thermal breakdown of the oil, micro-dieseling, additive depletion and contamination. Extended Oil Drain Intervals are pre-determined by Original Engine Manufacturers and are designed to provide maximum engine protection under a wide variety of conditions. But there is now trend in customers demand for extended oil drain interval than current intervals. The fact is, the filter alone will not extend the life of engine oil. The filter has one function, and that is to filter contaminants from the oil. Lube filter is needed to be designed in such way that it will satisfy customer demand of extended oil drain interval. Instead of making changes in filter media or steel construction, a mechanism is developed which relies on pressure gradient principle. In this type of liquid can be released slowly to mix with oil which can reduce the oil degradation rate and maintain oil quality for longer period of time. In this paper design of oil filter for mid range engine is described.

II. THEORY

A. Oil Degradation

There are various reasons behind degradation of oil. But the main are oxidation, thermal breakdown and contamination of oil.

Oxidation is breakdown of oil oxygen as reagent [5]. Oxidation process involves series of reactions forming acidic compounds which ultimately leads to formation of sludge. It may precipitate as a thin film forming lacquer or varnish deposit on metal surfaces. This results in increase in viscosity of oil and due to which catastrophic failure of filter may occur as it may plug filter media. Thermal breakdown of oil is activated by high temperature of oil. It is seen at hot spots of the system. If thermal heating is prolonged the base oil molecules may experience thermal cracking. Oil contaminants which cause oil degradation are soot, unburned fuel, metallic particles, water, engine coolant and acid by-products of fuel combustion.

B. Oil Additives

Detergents and dispersants:
They keep oil-insoluble combustion products such as soot in suspension. Prevents resinous and asphalt-like oxidation products from agglomerating into solid particles. Prevents oil thickening, sludge and varnish deposition on metal surfaces [6].
Antifoam agents: The foaming tendency of oil is influenced by the surface tension of the base oil and by the presence of surface-active substances such as detergents and corrosion inhibitors. Surface foam can be controlled by antifoam agents [7].
Anti-wear Additives: Anti-wear additives react with metal surfaces to form a tribochemical reaction layer that prevents direct contact between the sliding surfaces. The most important additives of this group are the zinc dialkyldithiophosphates ZDTP. ZDTP is also an effective antioxidant and metal passivator[6].
Friction Modifier: Friction between surfaces experiencing boundary lubrication can be reduced with friction modifiers. These compounds work at temperatures where anti-wear additives are not yet reactive [7].
Corrosion Infibitor: Corrosion inhibitors can be divided into two main groups:
Antirust additives for the protection of ferrous metals and metal passivators for nonferrous metals [6].

C. Oil Filter Operating Principal

The operating principal of the filter concept to release additive inside the filter to mix with oil is illustrated in Fig 1. The liquid flowing though the filter element creates a pressure gradient that is proportional to its velocity and liquid viscosity according to Darcy’s law for laminar flow through a porous medium[2][3][4]. The pressure gradient ΔP, also exists across the capillary tube that extends from inside of additive release vessel to outside of vessel. The resulting flow through capillary tube is accurately predicted by Poiseuille’s laminar capillary flow equation:

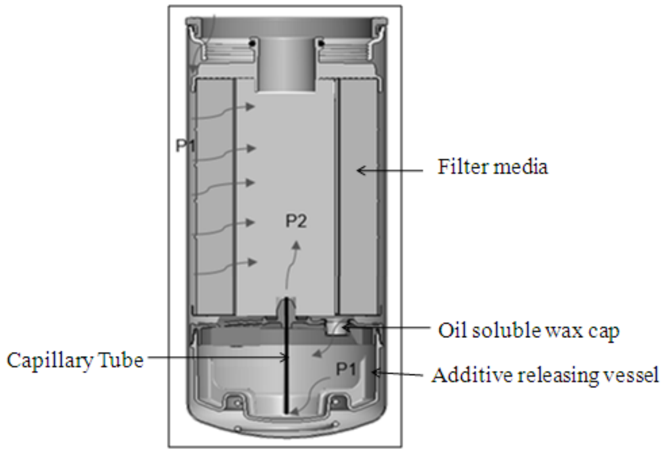

Fig. 1 Mechanism Description

$$Q = \frac{\pi . \Delta P . D^4}{128 . \mu . L}$$

Where,
Q = Volumetric flow rate (m^3/s)
ΔP = Pressure drop across tube (Pa)
D = Capillary ID (m)
μ = Viscosity of additive (kg/m*s)
L = Capillary length (m)

III. FILTER DESIGN

Filter design is shown in Fig 2. Capillary tube outlet is located at clean side of the filter element, inside centre tube through which filtered oil flows towards outlet of filter. The inlet of capillary tube is located at dirty side of the filter element. Additive vessel is covered with oil soluble wax cap. It provides leaking of additive during assembly, transportation and storage. During operation this oil soluble wax melts as oil reaches its melting point temperature and then oil starts to flow into additive vessel.

Due to addition of oil quality improving additives into oil filter, oil degradation rate slows down, as additives neutralize formed acids due to oxidation. It results in slower rate of formation of sludge and for more time oil viscosity does not increase maintaining lubrication at metal contact parts. It can be seen that oil drain interval can be extended by around 2000 km.

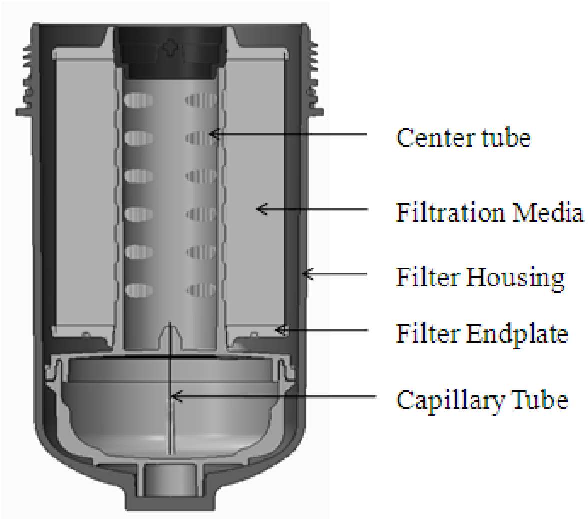

Fig. 2 Filter Design Based on Pressure Gradient

IV. Soft Validation

A. Modal and Harmonic Analysis

Modal analysis of the filter assembly is done to determine natural frequencies and mode shapes. The components like additive releasing vessel assembly, end plates, media, are not directly considered in analysis, but their mass is adjusted in the total mass of the housing and hence its density is adjusted. Also oil mass and additive mass also adjusted in the total mass of the housing. Material properties are at 22°C. All contacts are bonded contacts.

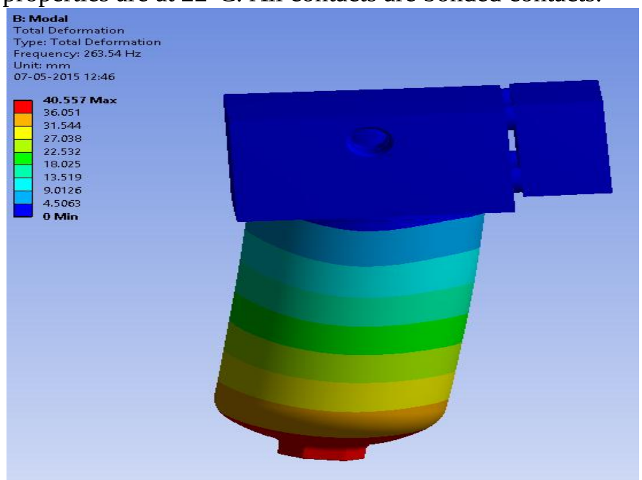

Fig. 3 First Mode of Frequency at 263.54 Hz

First mode of frequency is found at 263.54 Hz as shown in Fig 3. This is less than acceptance criteria. So to check ability of structure to survive excitation of this frequency Harmonic analysis is done with 5G loading on frequency dominant direction. Stress distribution in housing is seen below Fig 4.

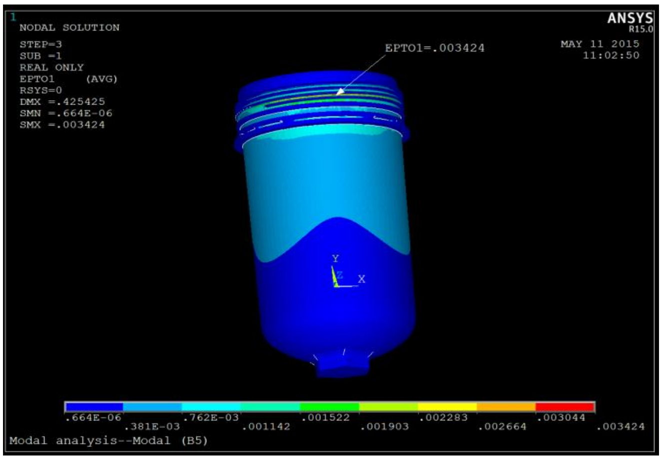

Fig. 4 Strain Distribution in Contact Region of Housing

Maximum strain occurs in thread region 0.34%, which is less than strain limit of polypropylene material of filter housing 4%. So design is acceptable.

B. CFD Pressure drop Analysis

CFD Pressure drop analysis of filter assembly is done to check whether total pressure drop is less than critical pressure drop. Mass flow rate is 0.6 Kg/s. Operating temperature is 120°C. The target pressure drop is 32 kPa. Planes used to calculate pressure drop as shown in Fig 5.

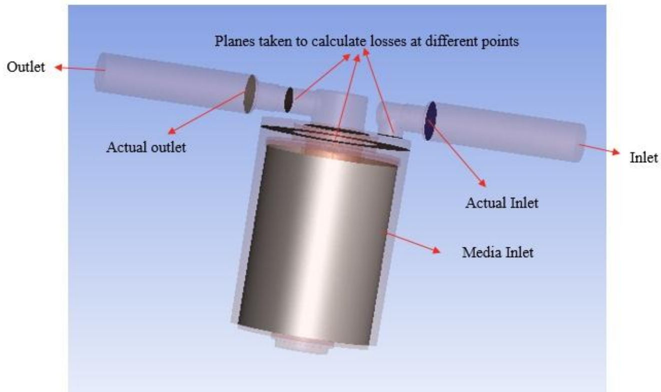

Fig. 5 Plane Location

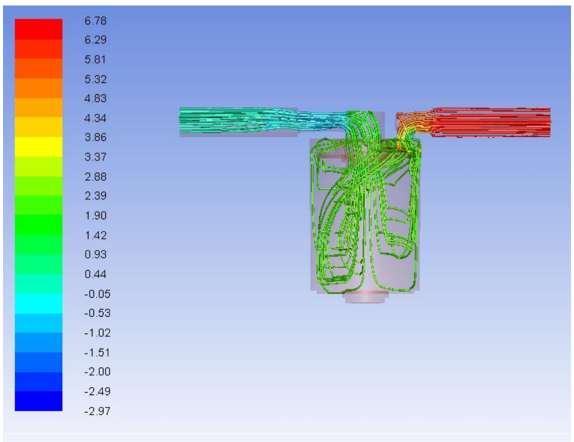

Fig. 6 Pathlines Colored by Total Pressure

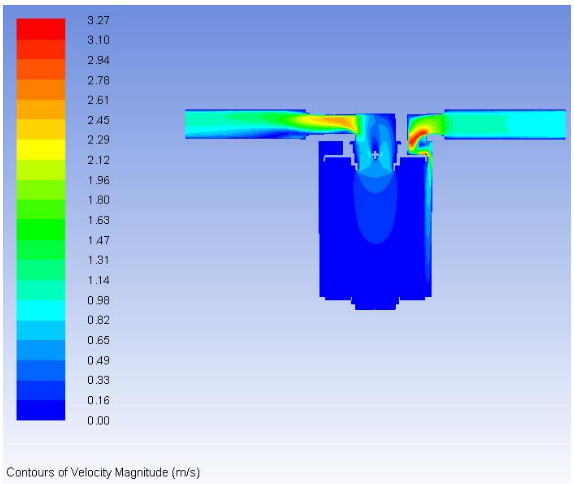

Fig. 7 Contours of Velocity Magnitude

Fig. 6 shows pathlines coloured by total pressure drop and Fig 7 shows contours of Velocity magnitude. It can be seen that significant pressure drop is observed at the inlet, bending and sudden expansion at inlet. Outlet pressure drop is observed due to bending and contraction. Total pressure drop observed is 6.11 kPa, which is well below target pressure drop of 32 kPa. So design is acceptable.

V. CONCLUSION.

a Oil filter is designed with additive releasing mechanism to extend oil drain interval. Oil drain interval can be extended by 2000 km.

The filter should perform its function without restricting its flow; hence pressure drop analysis is performed to determine the restriction across the module by using CFD.

The developed filter module is then checked for its structural integrity in Ansys 15. Modal analysis is done to determine the vibrating modes.

The structurally significant modes were then scaled for 5G loading and the further analysis is done. Thus, the induced stresses on the housing were found to be less than the endurance limit of the material, complying with vibration fatigue.

ACKNOWLEDGEMENT

Thanks to Prof. (Dr.) Y.P. Reddy (Head P. G. Studies, Department of Mechanical Engineering), Prof. (Dr.) S. D. Lokhande (Principal, Sinhgad College of Engineering) for their constant support and co-operation during work

REFERENCES

[1] Ian M. Cox and Andrew L. Samways, “Diesel Lube Oil Conditioning -the Systems Approach”, SAE psper no. 1999-01-1218

[2] Weston Gerwin and Charles Passut, 2009, “Development of a Lube Filter with Controlled Additive Release for Modern Heavy Duty Diesel Engines Utilizing EGR”, SAE Paper No. 2008-01-2644.

[3] Harold R. Martin and Joseph C. Drozd, 2009, “The Development of a Lubricity Enhancing Controlled Release Diesel Fuel Filter”, SAE Paper No. 2003-01-3141.

[4] Harold R. Martin and Peter Herman, 2006, “The Development of an Optimized Slow Release Lubricity Enhancing Fuel Filter”, SAE Paper No. 2006-01-3362.

[5] “The lowdown on oil breakdown”, [online] Available: http://www.machinerylubrication.com/Read/475/oil-breakdown.

[6] Cummins Filtration website. [Online] Available: http://www.cumminsfiltration.com

[7] HannuJaskelainen, W. Addy Majenski, “Diesel Engine Lubricants”, [online] Available: http:// www.dieselnet.com,