International Journal of Engineering & Technology, 7 (3.8) (2018) 42-47

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Performance Analysis and Testing of Aftermarket Filters

Srinivaas A[1]*, Vishnu R[1]

[1]*Department of Mechanical Engineering, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, India.*
**Corresponding author E-mail: a_srinivaas@cb.amrita.edu*

Abstract

Aftermarket segment is one of the promising and growing section in automobile industry. The popularity of this section is due to the low cost and high replacement rate. Best filters among many will survive in the market. Different Filter manufacturers develop filters for same purpose but varies in their construction. There are a wide variety of aftermarket performance filters for the same type of OEMs. They vary in their brand name, filter area, filter medium, price, service life and method of install. The presence of increased number of aftermarket performance filters has prompted automotive enthusiasts to replace the OEM filter for the same purpose available in lower cost. The paper discusses about the testing procedures to be done to compare the performances both the brands (OEM and Aftermarket filters). All the experiments were conducted at PSG institute of science & Technology Coimbatore. This study shows how much an aftermarket filter varies from that of OEM. The performance of both OEMs (BOSCH and FLEETGUARD) and Aftermarket filter(UCAP) are evaluated by pressure drop, filter efficiency, media strength, porosity tests.

Keywords: *Aftermarket filter, filter efficiency, media strength, porosity, pressure drop, OEM.*

1. Introduction

Automobile Industries in India, is getting developed very fast. This industry has a very high potential to generate employment trade and infrastructural inputs hence Govt. of India has included this industry in extreme focus groups. Day to day changes in the choice and approaches of the user Automobile industry is also bound to introduce new models, designs and technology in their vehicles. The impact of the market compulsions made this industry very competitive and innovative. Hence, the growth of this industry is very high as compared to other industries. Automobiles are run either by diesel or by petrol. Lubricating oil is also used in these vehicles for smooth uninterrupted fuel supply, oil supply and to safe guard the parts and components of the engine and filters are required. These automobile filters are called as per their use i e. diesel filter, petrol filter, oil filter and air filter. [1]
Automotive filters have great demand in the automobile industry as the number of vehicles are increasing day by day. This lead to the price incrementation of filters by their demand. OEM and Aftermarket are the two important classifications of global automotive filter market. Almost all the aftermarket performance filters promise an increase in performance, fuel economy and increased service life compared to OEM style filters. The three major categories in Automotive filters are,

- Oil Filter or Lube Filter
- Fuel Filter
- Air Filter

1.1. Oil Filters

Oil filter or lube filters are used to remove the particles from the oil (engine oil, transmission oil, lubricating oil, or hydraulic oil) entering the engine. Unfiltered oil will produce wear and tear to the engine parts during their operation. This create negative affect to the engine performance. The Auto filters are manufactured in different steps. It contains following parts i. e. core of iron or brass net, hosiery cloth or paper filter, outer iron or brass net body and top and bottom rubber rings. The core and outer body is made on pleating and jointly machine and then spot welded to get desire circular shape. After this filter are wrapped on it with the help of primary raping machine and suitably punched on punching machine. Finally, the rubber rings are assembled to the body and core with filter paper and cloth and packed for sales. [2]

1.2. Fuel Filters

Fuel filters are vital parts of the engine fuel system in which it filters out the contaminants or foreign particles from the fuel. Unfiltered fuel contains several kinds of contamination that can cause harmful effects to the engine operation. If the contaminants are not filtered from the fuel then it results in wear and tear of the engine parts. Fuel filters are classified according to the fuel(petrol/diesel) used in the engine. This paper deals with testing the filters of commercial vehicles. Diesel is the main fuel used in these types of vehicle. But type of fuel is not considered as testing is done to check the capability of the filters alone. [3]

1.3. Air Filters

An engine air filter is used to protect the engine and its components from the dust or abrasive particles which will enter in to it during the operation. These particles can produce wear and tear to the mechanical parts. Pleated paper filter in the form of a flat panel is used in most of the vehicles. Usually air filters are situated in a plastic box connected to the throttle body with ductwork. Air filters have the diameter in the ranges between 6 inches (150 mm) and 16 inches (410 mm). They are usually seen above the carburetor or throttle body which is secured with a metal or plastic lid and also have a duct to provide cool or warm inlet air.

This paper investigates the performance of filters (both OEM and aftermarket) by conducting laboratory tests in order to check whether the aftermarket filters are best competitors for the OEM filter. This is done to promote the aftermarket filters of high quality at low cost and make it easily available. In this study only, oil filters and fuel filters are taken in to consideration. This paper aims to investigate variation in the parameters and performance of the OEMs and Aftermarket filters.

2. Experimental Study

The methodology and experimental procedure used in the present study are explained in this section.

2.1. Filter Media Burst Strength Test

Fig. 1: Digital Bursting strength tester

The Burst Strength Test is used to measure of the strength of the media. It is measured in pounds per square inch. Fig.1 shows the digital burst strength tester in which the experiment is conducted. The sample is tightly fixed over the rubber diaphragm of the tester. The fluid flow around the diaphragm pressurizes and force to expand it to a point in which it breaks. The corresponding pressure of the fluid at that point is taken as the bursting strength. The test is conducted for BOSCH, FLEETGUARD (OEM) and UCAP (Aftermarket) Oil filters. [4]
The maximum capacity of the machine is 500PSI.The output of the result is shown in digital form by the machine. The reading should be taken at the start of the crack noise that occurs when it reaches its maximum breaking point. These readings indicate the strength to withstand the impact force.

2.2. Filter Media Tensile Strength Test

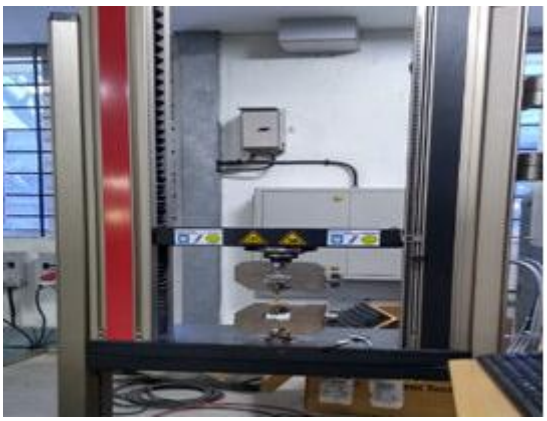

Fig. 2: Tensile Strength Testing Machine

The Tensile Strength Test is used to calculate the directional strength of the media, measured in Newton force. The sample is clamped in the testing machine as shown in figure 2, between two jaws. Bottom jaw is stationary and top one is movable. These two jaws are pulled apart each other and movement is ceased at the point of failure. Reading noted at that point is recorded as the tensile strength of corresponding filter media.
Test Machine Details

- Max capacity: - 2.5kN
- Travel speed: - 1mm/min
- Specimen thickness: - 1mm
- Specimen Width: - 60mm
- Length maintained: - 90-100mm

2.3. Porosity Test

Fig. 3: Simple Porometer

Porosity test on filter media is the measure of minimum and maximum pore size by applying Galwick fluid (Surface tension: - 15N/m) on top and pressurized air at bottom. The sample is securely clamped. The principle of simple porometer is that a wetting liquid of specific surface tension occupy the pores of the specimen and the liquid is displaced from the pores by non-reacting gas. System will automatically measure the gas pressure and flow rate through wet and dry samples. The pore diameter is evaluated with set pressure and gas flow rate. [5]
Test Requirements

- Flow Rates: - 200LPM (liters per minute)
- Operation: - 0.1-inch diameter (up to 1.5" thick)

- Sample Geometry: - circular shape
- Operating temperature: - 25°C
- Test Pressure: - 700kPa

2.4. Pressure Drop Test

Pressure Drop Test is the crucial test carried out to determine the performance of any filter. If the rated pressure drop is excess, chances of early choking is high. This testing is done Oil/Fuel Multi pass test rig where the ISO standard oil (Mil H Aircraft Hydraulic Oil) is used to pass through the filter at rated LPM, pressure and specified duration. Pressure drop test is used to determine difference in inlet and outlet pressure while oil passes through the filter at a certain flowrate.
Test Details

- Test is done as per ISO 4548-12 in oil test rig
- Oil used: - Mil-H Aircraft Hydraulic Oil
- Maximum flowrate: - 90LPM
- Test duration: - 2hrs
- Initial set pressure: - 3bar

Fig. 4: Oil filter test rig

Fig. 4 shows the Oil filter test rig where the pressure drop test is conducted. Filter is fixed in the filter housing by an adapter. Oil/ Fuel from sump is pumped to the pipe lines connected to the filter. Pressure sensors are attached between the filter. They are used to calculate the inlet and outlet pressure during the operation. Flowrate can be adjusted by flowmeter. A bypass valve is also fixed at the point where the oil enters in to the filter. This is done for bypassing the oil/fuel if pressure increases excessively. Oil temperature is also noted to check whether it remains constant.

2.5 Dust Particle Counting/Efficiency Test

Dust Particle Counting (also called efficiency test) is carried out as per ISO 16889. The whole test was conducted in the same oil filter test rig as shown in Fig. 4. In this test, ISO dust is mixed in oil sump at rated flow rate and pressure. Then the oil is circulated in oil filter test rig, where upstream and downstream particles are counted by Automatic Particle Counter(APC) as shown below.

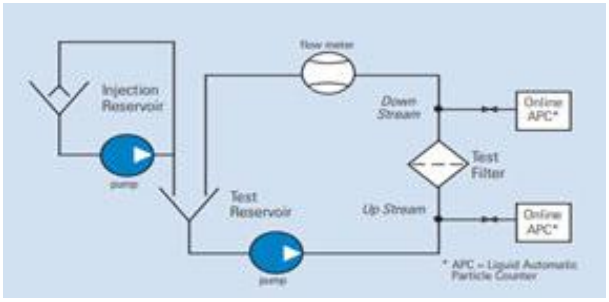

Fig. 5: Automatic particle counter (line diagram)

Fig. 5 shows the line diagram of the setup. The test is done on the same machine as shown in the fig. 4. Oil from the injection reservoir is pumped towards the test reservoir. Test filter is mounted in the filter housing in the circuit containing the test reservoir. Online APC is connected between the test filter to count the upstream and downstream particles. Beta ratio (symbolized by ß) is a formula used to calculate the filtration efficiency of a particular fluid filter using base data obtained from multipass testing. The formula used to calculate the beta ratio is:

$$\text{Beta ratio(x), ß} = \frac{\text{particle count in upstream oil}}{\text{particle count in downstream oil}} \quad (1)$$

$$\text{Efficiency} = \left(\frac{1}{ß} - 1\right) * 100 \quad (2)$$

x=particle size.

Test Details:

- Minimum particle size = 4 microns
- Maximum particle size = 70 microns
- Oil Used: Servo Spindle Oil.
- Viscosity: 11-14 at 40 °C
- Oil Used: 30L
- Amount of Dust added: 5 mg/L

Here UCAP, an aftermarket filter from the house of TVS, is compared with BOSCH and FLEETGUARD(OEM). Above mentioned tests are conducted to check the comparison between the brands.

3. Test results

3.1 Filter media burst strength test

Table 1: Filter details and burst strength result for UCAP(Aftermarket) and FLEETGUARD(OEM) Filters

Part No	Brand	Description	Average Filter Media Burst Strength in PSI
EF9009L	UCAP	Oil Filter - Tata ACE	46.41
LF16080	FLEETGUARD	Oil Filter - Tata ACE	59.51

The test duration was 2 minutes. The result shown above in Table 1 indicates that the average burst strength of FLEETGUARD filter media was more than that of UCAP (oil filter for same purpose). This shows that FLEETGUARD filter media withstand high burst pressure than UCAP.

Table 2: Filter details and burst strength result for UCAP(Aftermarket) and BOSCH(OEM) Filters

Part No	Brand	Description	Average Filter Media Burst Strength in PSI
EF9014F	UCAP	Fuel filter - coil type - 0.5 liters	109.64
9451037 4078F8	BOSCH	Fuel filter - coil type - 0.5 liters	84.14

The result shown above in Table 2 indicates the average burst strength of Bosch filter media is more than that of UCAP

(fuel filter for same purpose). This shows that Bosch filter media withstand more burst pressure than UCAP.

3.2 Filter Media Tensile Strength Test

Table 3: Filter details and tensile strength result for UCAP(Aftermarket) and FLEETGUARD(OEM) Filters

Part No	Brand	Description	Average Filter Media Tensile Strength in N
EF9009L	UCAP	Oil Filter - Tata ACE	158.2
LF16080	FLEETGUARD	Oil Filter - Tata ACE	254.3

As shown in the Table 3, the test was conducted between UCAP and FLEETGUARD filters of same category. The result indicates that the average tensile strength of FLEETGUARD filter is more than that of UCAP. Thus, FLEETGUARD filter media has more tensile strength than UCAP.

Table 4: Filter details and tensile strength result for UCAP(Aftermarket) and BOSCH(OEM) Filters

Part No	Brand	Description	Average Filter Media Tensile Strength in N
EF9014F	UCAP	Fuel filter - coil type - 0.5 liters	109.64
94510374078F8	BOSCH	Fuel filter - coil type - 0.5 liters	84.14

As shown in the Table 4, the test was conducted between UCAP and Bosch filters of same category. The result indicates that the average tensile strength of Bosch filter is similar than that of UCAP. Both UCAP and Bosch filter media has tensile strength variation of 6.3N.

3.3 Porosity test

Filter details and test are given in Table 5 and 6. The test is conducted in room temperature. The time taken to complete the testing procedure for one specimen is in the range of 5 to 10 minutes.

Table 5: Filter details and mean pore size of UCAP(Aftermarket) and FLEETGUARD (OEM) Filters

		Mean Pore Size (Microns)	
Sample no	Description	EF9009L (UCAP)	LF16080 (FLEETGUARD)
1		40.68	20.52
2	Oil Filter - Tata ACE	41.81	20.4
3		41.03	21.19

Mean pore size readings of both UCAP and FLEETGUARD are shown in Table 5. The average mean pore size of UCAP and FLEETGUARD are 41.17 and 20.7 microns respectively. Thus, it shows that FLEETGUARD's pore size is 50% smaller than UCAP Pore Size.

Table 6: Filter details and mean pore size of UCAP(Aftermarket) and BOSCH (OEM) Filters

		Mean Pore Size (Microns)	
Sample no	Description	EF9009L (UCAP)	94510374078F8 (BOSCH)
1		4.92	5.172
2	FUEL FILTER - COIL TYPE - 0.5 LTRS	4.68	4.67
3		4.75	4.528

Mean pore size readings of both UCAP and BOSCH are shown in Table 6. The average mean pore size of UCAP and FLEETGUARD is 4.79 microns. Thus, it shows that Both UCAP and BOSCH's Pore size is of same size.

3.4 Pressure Drop Test

Table 7: Filter details of UCAP(Aftermarket) and FLEETGUARD (OEM) for pressure drop test

Part No	Brand	Manufacture date	Product Weight (g)
LF16080	FLEETGUARD	Jan'18	384
EF9009L	UCAP	Jan'18	282

Table 8: Filter details of UCAP(Aftermarket) and BOSCH (OEM) for pressure drop test

Part No	Brand	Manufacture date	Product Weight (g)
F002H23572-8F8	BOSCH	Jan'18	1087
EF9009L	UCAP	Nov'17	1021

Filter details for the experiment is given in the Table 7 and 8. Here test was conducted for 170 minutes at a flow rate of 60LPM.Oil temperature was maintained at 30°C. Operating temperature and pressure of the test were 20°C and 3bar.

The pipe lines were covered with asbestos to reduce temperature loss occurred during the oil flow. The flowrate of the oil was maintained using flowmeter which was attached in the test rig. The test filter was rotated three-fourth of its full rotation while mounting it in the housing. Ensured that it was fully leak-proof. Time taken for each pressure change is noted by using a stop watch. Oil to be used in the experiment should be low viscosity. The viscosity value of the Mil-H aircraft hydraulic oil was 30mm^2/s at room temperature. About 30 Liters of oil was circulated in the test rig up to the fixed time period during the experiment.

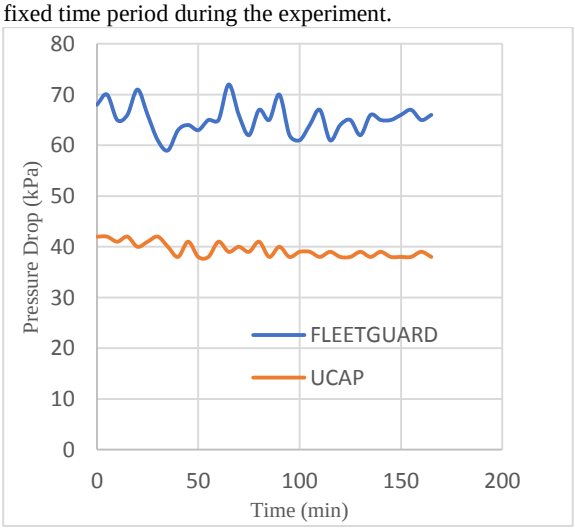

Fig.6: Graph of Pressure Drop Vs Time for UCAP AND FLEETGUARD

. From the graph shown in fig.6 it is observed that the FLEETGUARD oil filter has more pressure drop as compared to that of UCAP. The maximum pressure drop obtained from is 72kPa from FLEETGUARD filter and minimum of 36kPa from UCAP. This indicates that the flow restriction of oil is high in Fleet guard filters.

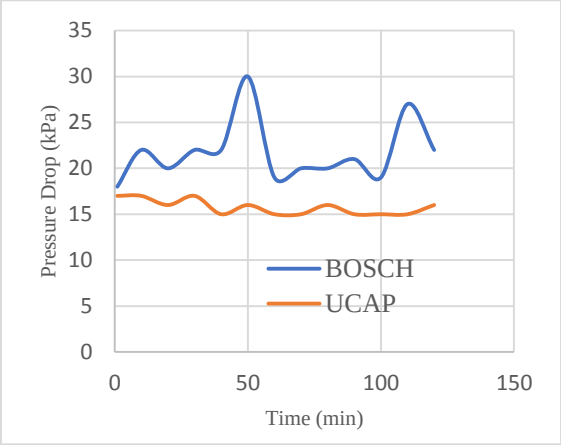

Fig. 7: Graph of Pressure Drop Vs Time for UCAP and BOSCH

From the graph shown in Fig.7 it is observed that the Bosch fuel filter has more pressure drop as compared to that of UCAP. The maximum pressure drop obtained from is 30kPa from BOSCH fuel filter and minimum of 15kPa from UCAP. So, the flow restriction of fuel is high in BOSCH filters.

3.5 Dust Particle Counting/Efficiency Test

Filter details for the efficiency test is given in table 8.

Table 6: Filter details of UCAP (Aftermarket), FLEETGUARD (OEM) and BOSCH (OEM) for efficiency test

Part No	Brand	Manufacture date	Product Weight (g)
F002H23572-8F8	BOSCH	Dec'17	384
EF9009L	UCAP	Jan'18	282
LF1068	FLEETGUARD	Dec'17	384

Figure 8 shows the efficiency curves of UCAP, BOSCH and FLEETGUARD filters as mentioned in the table. Here also operating temperature and pressure were 20°C and 3bar respectively. From the graph it is observed that efficiency curves of three filter are slightly similar to each other. Efficiency of UCAP filter is higher for the particle size ranging from 4 to 60 microns.

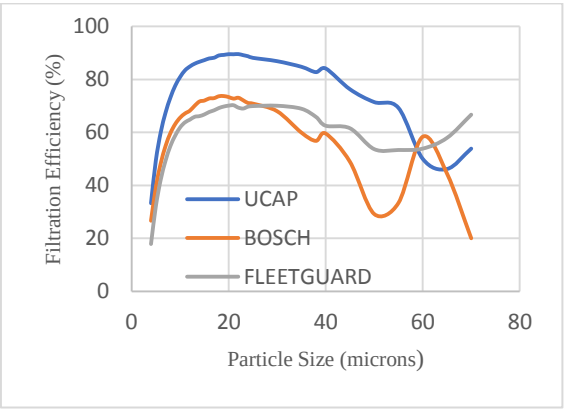

Figure 8: Graph of Efficiency Vs particle size for UCAP, FLEETGUARD and BOSCH filters

Highest efficiency value obtained from the experiment is 85% for filtering particles of size 20 micron for UCAP filters and minimum of 35% from Bosch filter of same kind.

4. Conclusion

From the above results following observation are obtained

- Tensile strength and burst strength of aftermarket filter media is less than that of OEMs.This is due to the compound variation in both the brands.
- Aftermarket filters are in same range with the OEMs in case of porosity test (except slight variation in FLEETGUARD filters)
- Flow restriction is an important parameter which affect the performance of the filter. High pressure drop causes high flow restriction. OEMs filters (BOSCH and FLEETGUARD) shows high pressure drop compared to aftermarket filter(UCAP). So, oil will flow smoothly in aftermarket filter at the same condition as that of OEMs.
- A filter is usually rated by its efficiency. Efficiency of a filter is the ability to hold duct particles at a certain period. The result indicates that the efficiency of aftermarket filter (UCAP) is higher than that of OEMs (BOSCH and FLEETGUARD).

Also, the price of UCAP (aftermarket) is 10-20% lesser than that of BOSCH and FLEETGUARD(OEM). So, these types of aftermarket filters are easily assessable with similar qualities of OEMs.

Acknowledgements

The authors would like to acknowledge PSG institute of Technology – Coimbatore Deemed to be University for the great support and assistance rendered to carry out this experimental study. We express our sincere gratitude to the Head of Department, Dr. S Thirumalini, Chairperson Mechanical Engineering Department, Amrita School of Engineering, Coimbatore for her invaluable guidance, help and constant encouragement throughout this work. We would also like to express our gratitude to Mr. R. Sundarajan, General Manager, TVS Automobiles Solutions Limited, Chennai for giving the opportunity to set up the experimental work in PSG college.

References

[1] Mathews V John, Sandhya M, Balakrishnan K, "Effect of OEM Style And Aftermarket Performance Air Filters on Vehicle Parameters," Procedia Technology, vol.24, pp. 461 – 468,2016.

[2] Patel R., Shah D., Prajapti B. G. and Patel M., "Overview of industrial filtration technology and its applications," Indian Journal of Science & Technology, vol.3, pp.10, October 2010.

[3] Jian Yong Feng, Jianchun, "Zhang The Property of Automobile Engine Oil Filtration Material and the Development of New Filter," Journal of Engineered Fibers and Fabrics, vol.9, issue 3, 2014.

[4] Rashed, Md, Mahamudul Islam, "Effect of Tuck Loop In Bursting Strength OF Single Jersey Knitted Fabrics", International Journal of Research in Engineering and Technology, vol.3, pp. 2321-7308, May 2014.

[5] Yan Fang, H. Dennis Tolley, Milton L. Lee, "Simple capillary flow porometer for characterization of capillary columns containing packed and monolithic beds," Journal of Chromatography A, pp..6405-6412, 2010.

[6] IS0 4548-12:2000, Methods of test for full-flow lubricating oil filters for internal combustion engines - Part 12: Filtration efficiency using particle counting, and contaminant retention capacity.

[7] IS0 4548-4:1997, Methods of test for full-flow lubricating oil filters for internal combustion engines - Part 4: Initial particle retention efficiency, life and cumulative efficiency (gravimetric method).

[8] IS0 4548-6:1985, Methods of test for full-flow lubricating oil filters for internal combustion engines - Part 6: Static burst pressure test.

[9] IS0 4548-l:1982, Methods of test for full-flow lubricating oil filters for internal combustion engines - Part 1: Differential pressure/flow characteristics.
[10] ISO 16889:2008, Hydraulic fluid power-Filters-Multi-pass method for evaluating filtration performance of a filter element.
[11] Sathyananrayanan K. and Narayanankutty Karuppath, "UV Emission from TAURUS Molecular Cloud", 23rd Swadeshi Science Congress. MG University, Kottayam, 2013.
[12] V. Sundaram G. and Dr. Thirumalini S., "Experimental Study of Emission and Performance of Single Cylinder Diesel Engine Running on Groundnut Oil Based Biodiesel", International Journal of Scientific & Engineering Research, vol.5, no. 7, 2014.
[13] D.Vignesh and Srihari S., "Investigation on performance and emission behaviour of a single cylinder diesel engine fuelled with mixture of cottonseed and sunflower biodiesel blends along with diesel", International Journal of Applied Engineering Research, vol. 10, pp. 40265-40269, 2015.
[14] G. Kumar and Dr. Thirumalini S., "Effect of lubricating oil temperatures on fuel consumption and emissions under cold start conditions for a diesel engine", SAE International, 2016.