Effects of air filter type and condition on performance and emission of four-stroke S.I. gasoline engine- Review study

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Abstract— to study of different paper related to air filter condition and filtering media and their effect on the performance of the I.C. engine. The role of the engine air induction system and air filter increased because of recent engine exhaust particulate and evaporative emission regulations. Engine lifetime, engine emission and fuel consumption depend on the air induction system design and its performance, So Study of papers on different type of air filter filtration media and their effect on engine performance is done in this paper. This study is useful to select zero maintenance, long life, reliable and durable air filters improves performance of the existing engines without any major modifications.

I. INTRODUCTION

Air is not only vital for any life form on earth but also important for today's state of the art automotive engines. An average Heavy Duty truck engine requires 13,000 to 20,000 litre of air to burn just one litre of fuel. However, this air is polluted with all kinds of contaminants, such as fumes, dust, smog and other particles. Like temperature and humidity, these particles are not always visible to the eye, but they are harmful to the engine. They diminish the purity of the air and can lead to severe damage of all engine components. Under normal highway conditions, the air consumed by a 16 litre engine contains almost 20 kilograms of dirt/contaminants per 100,000 kilometres [1].

There is no room for compromise. The air intake is an open loop system, and the air filter only has one opportunity to filter the contaminant out of the intake air. Air filters are essential for automobile engines and the air that these engines 'breathe' needs to be as clean as possible [1]. Poor air quality will significantly impact the performance of an automobile engine. To properly perform its function of reducing wear and extending engine life, the air filter must filter 100% of the pre-combustion air and remove as much contaminant of any and every particle size as it can to a very high final efficiency. Sooner or later, the choice of the right filter for the right application can make a substantial difference in wear rate, cost and performance of any automobile engine.

To solve global problems of emission and fuel crisis there should be need of contribution by automotive engineers and automotive. By providing proper 'breath' (clean air) to automobile engines the clean power with minimum emission is generated. This is to be achieved by good air induction system with air filters and proper maintenance of the system.

II. EFFECT ON ENGINE PERFOMANCE WITH RESPECT TO AIR FILTER CONDITION

Kevin Norman and Shean Huff [2], Vehicle design, including mass, rolling resistance, aerodynamic drag, and engine and transmission efficiency, is an important factor affecting a vehicle's fuel economy on the prescribed driving schedules. Fuel economy can also be greatly affected by driver/owner behaviour [2]. Hard acceleration, excessive idling, and carrying unnecessary weight can all negatively affect fuel economy. Proper vehicle maintenance, on the other hand, can help the vehicle perform as it was designed, thus positively affecting fuel economy, emissions, and the overall drivability of a vehicle.

Fuel economy of modern engines would not be affected by a clogged filter, but acceleration and power output affected by the clogged filter, a clogged filter might impact a carburetted engine due to a "choking effect" in which the engine operates at richer combustion conditions.
The vehicles used in test: 2007 Buick Lucerne 3.8L V6, 2003 Toyota Camry 2.4L I4, 2006 Dodge Charger 5.7L V8 with MDS (Multi- Displacement System), 1972 Pontiac Grandville—455ci V8 with factory four Barrel carburettor[2].

A. Initial testing: Four filter setups, an OEM filter, an aftermarket filter, a performance aftermarket filter, and no filter, were tested, using the 2007 Buick Lucerne as the test vehicle, to determine a baseline and the filter to be used for the remainder of the testing. Each setup was tested over the WOT cycle described previously. It was observed that the OEM filter resulted in a higher Outlet DP than the aftermarket filter and the performance aftermarket filter, as is shown in Fig 1.

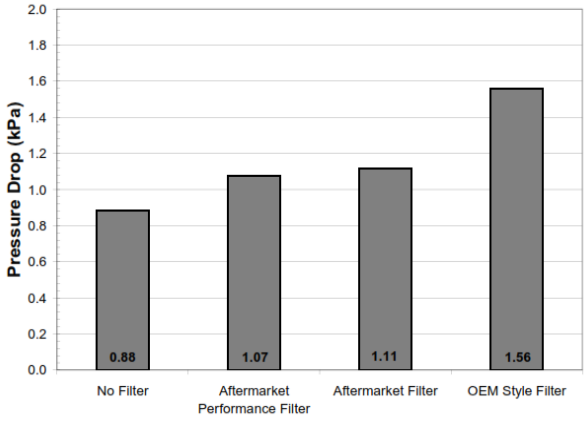

Fig.1. Maximum outlet pressure drop for 2007 Buick Lucerne clean air filter [2].

The aftermarket filter was chosen for the test process due to its lower initial Outlet DP compared to the OEM filter and because it is more common than the performance aftermarket filter; thus, it allowed us to explore the largest clean-to-clogged difference for a commonly used air filter. No measureable differences were observed in vehicle performance with these filters over the CRC E-60 WOT test cycle [2]. Result is after market performance filter provides minimum pressure drop means maximum air flow.

B. Wide Open Throttle (WOT) Test: Wide-open throttle tests were used to measure the changes in the filter pressure drop In a real-world application, the vacuum needed to set one of the air filter indicators would likely occur under heavy acceleration, such as merging onto an interstate, or climbing a steep grade. Therefore the level of restriction was set, using an artificial clogging technique, to achieve the desired Outlet pressure drop during a WOT acceleration from idle to approximately 85 mph or a steady-speed (SS) WOT test in which the dynamometer was held at a fixed speed, 65 mph, and the throttle was held open for 10 seconds. Using these test procedures, the 2007 Buick Lucerne was configured to achieve an Outlet DP of approximately 7.0 kPa under the WOT acceleration and approximately 5.7 kPa under the SS WOT. Once the method for achieving this restriction was developed, it was used with each vehicle [2]. The test result for maximum average pressure drop shown in Fig 2.

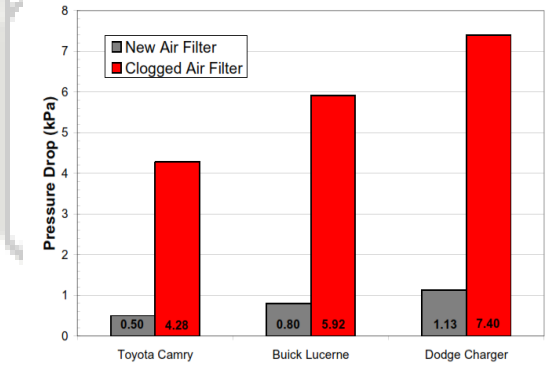

Fig.2. Average maximum outlet pressure drop for SS WOT tests [2].

In this new filter shows1.13 kPa pressure drop as compared to 7.40 kPa for the clogged air litre. For acceleration time maximum 11% and minimum 6% increment is achieved in new air filter as compared to clogged air filter which is shown in Fig 3.

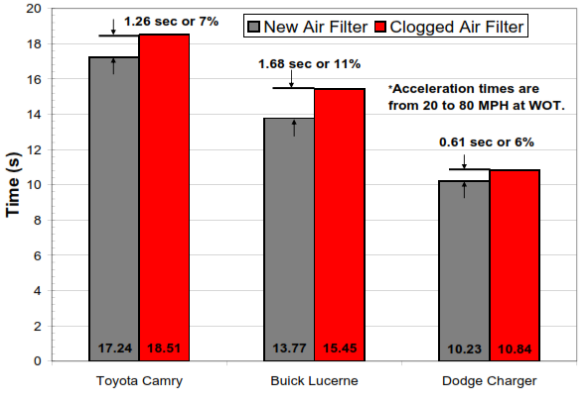

Fig.3.Acceleration time for CRC E-60 WOT tests [2]

C. Highway fuel economy test (HFET): Despite the filter restrictions. Each vehicle was run through at least three rounds of HFET with the new air filter, and the same protocol was repeated with the clogged air filter. The tests were conducted on consecutive days for each vehicle [2]. Result of each vehicle is shown in Fig 4. Fuel economy is increase by 0-2 % for electronic injection car model and 2.5 % for carburetted car.

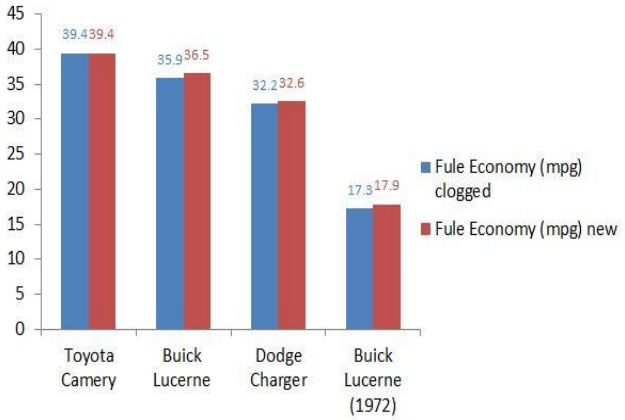

Fig. 4. Fuel economy HFET test [2]

III. EFFECT OF FILTERATION MEDIA ON FILTERATION AND ENGINE PEFORMANCE

Tadeusz Jaroszczyk and Scott W. Schwartz [3], Although dust-holding capacity is the primary feature of engine air filters operating in dusty environments, efficiency becomes a major factor when selecting an engine air filter. Inertial separators and high porosity or fibrous prefilters are commonly used to decrease the dust load to the main filter while high efficiency is achieved by utilizing submicron or nanofiber fibres in the main filter [3]. Fig 5 shows dust capacity for commercial fluted filters and newly introduced Direct Flow filter having approximately the same volume.

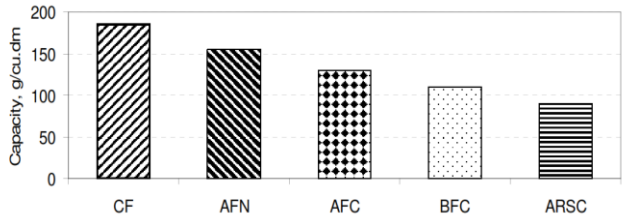

Fig 5.Dust capacity of fluted and Direct Flow Filters [3].

CF - Direct Flow filter with cellulose filter media, AFN company A, commercial fluted filter with nanofiber filter media, AFC company A, commercial fluted filter with cellulose filter media, BFC - company B, commercial fluted filter with Cellulose filter media, ARSC - company A, commercial radial seal cylindrical filter [3].

The fractional efficiency of the commercial nanofiber filter media Fig 6 is practically the same as high quality HD cellulose media. It has lower efficiency at 3 cm/s than the developed media at 20 cm/s [3].

Contaminant passages around the individual filter cylinders or panels. The angled gaps between the individual filter elements form flow passages that make it possible for contaminant particles to enter the plated material through the filter front side between the alternately sealed pleats and

through the space above or below the element. Therefore, the filter front side stays open to the flow and filter media surface is loaded with the particles.

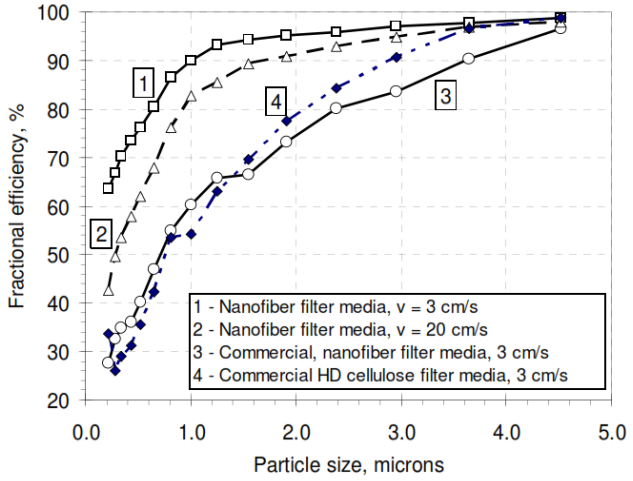

Fig 6. Fractional efficiency of pleatable filter media[3]

It was shown that nanofiber filter media provide high initial efficiency for small particles. However, a quality assessment of nanofiber filter media is even more critical.

Classical cellulose filter media since nanofiber filter media permeability is usually higher than of the standard cellulose media. The classical HD media have lower permeability and work at lower aerosol velocities; therefore, the probability of re-entraining the larger, most damaging particles is relatively low [3].

Direct Flow filters have been recently introduced to the engine filtration market to extend the options of in-line reduced volume filters. The purpose of this design is to achieve high value of media utilization factor, smaller, more compact components while maintaining a long life. Direct Flow filters provide high filtration performance while occupying less space. Moreover, the contaminant will not clog the filter inlet because there are allowable [3].

Neville J. Bugli and Gregory S. Green [4], studies shows that use of low performing serviceable aftermarket air filters significantly affect the performance and durability of engine air cleaners. High mileage studies confirm that engine durability, service issues, warranty field returns and customer satisfaction was affected by use of aftermarket filter brands. Innovative air cleaner designs are required to maximize filtration performance, improve flow management, extend air cleaner service life and improve engine durability [4].

A new Long Life Filtration System was developed for OEM (Original Equipment Manufacturer) applications (2003/2004 Ford Focus Vehicle) and requirements. This new technology uses a unique multi-layered reticulated foam media which does not need servicing or maintenance for the life of the vehicle. This technology also provides some unique advantages over the traditional serviceable air induction filters.

Long Life air cleaners were extensively tested in the lab and in real world field environments. ISO fine test dust was used for all evaluations to more closely represent actual field loading.

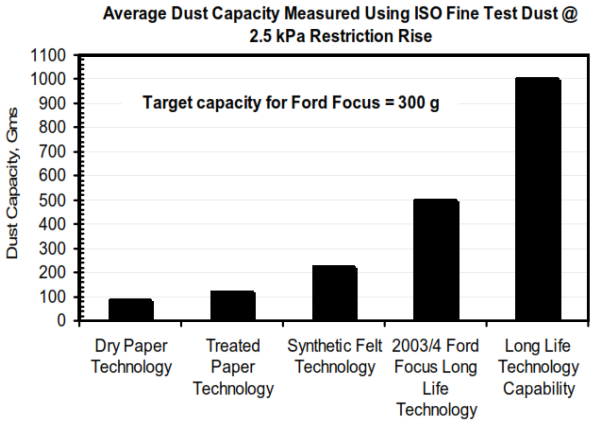

Fig 7. Dust Holding Capacity Performance of Long Life Technology compared to Traditional designs [4].

Fig 7 compares the average dust capacity measured on traditional technologies and a clean Long Life filter using ISO fine test dust [4]. The target dust capacity was set at 300g using ISO fine test dust. The target capacity was calculated based on field evaluations and specific engine size for this application [4].

	Filter name	material	type	flow cfm	flow rank	filteration rank	image
1	AEM Dryflow	synthetic	dry	519.2	9	3	
2	A'PEXi Power Intake	cotton	dry	533.3	7	6	
3	HKS Direct Drive	foam	dry	539.6	6	9	
4	K&N RR-3301	cotton	wet oil	579.6	4	1	
5	Redline Airforce 1	cotton	wet oil	596.9	2	10	
6	Simota Power Stack	cotton	dry	594.2	3	5	
7	Tenzo WS002-CH	cotton	dry	522.8	8	4	
8	3A Racing	cotton	dry	601.2	1	2	
9	Trust Airinx	foam	dry	554.7	5	7	
10	TRUST imitation	foam	dry	473.3	10	8	

Fig.8.Airfilter type and flow and filtration capacity tested on smith's engine Research's flow bench [5].

The Long Life Filtration technology developed by Visteon Corporation provides a method for minimizing the requirements to replace or clean engine air filters. Zero maintenance filtration for engine air cleaners have been

modelled, tested and validated in vehicle fleets for durability and robustness. The multilayer foam filtration technology is a cost effective method to eliminate engine air filter maintenance while improving engine durability, reducing evaporative emissions, and reducing overall material usage.

Mark Pakula [5], Air filters are one of the most common part of engine, they are cheap, provide induction noise and, as many wrongly believe, offer an immediate power gain. Is there a difference between a $20 air filter and a $200 air filter? Do they flow the same and, more importantly, do they provide the same level of protection? For that ten of the most popular pod filters selected for filtration and flow test.

A two-prong testing procedure to test how the filters flow as well as how protective they are for an engine. The flow test was done on smith's engine Research's flow bench, which was one of the few benches in Sydney capable of maxing out an air filter. Each filter was tested straight out of their boxes at ten inches of water, so the conditions were identical for each. After this, the filters were attached to a high-powered suction device, with particles spread over a set surface area. The filters would be exposed to the same amount of particles (measured on a scale) for the same amount of time (30 seconds).

Different types of filters were tested on smith's engine Research's flow bench and result of it is shown in table 1. According to this test 3 A racing filter is one of the best filter with maximum flow of 601.2 cfm with maximum filtration. The filtration and flow is depends upon the filter media wet cotton with oil has maximum filtration where as dry cotton has maximum flow.

IV. CONCLUSION

The summary of the present literature review is as follows:

1. Air filter condition is affecting engine performance clogged air filter increase pressure drop which reduces the fuel economy and acceleration. Fuel economy is not significantly affected in Electronic injection or MPFI system but in case of carburetted engine clogged air filter affects more. So it is desirable to clean or replace air filter after periodic interval.

2. The purpose of this design is to achieve high value of media utilization factor, smaller, more compact components while maintaining a long life. Direct Flow filters provide high filtration performance while occupying less space. Moreover provides free flow with minimum pressure drop which leads to increase engine performance.

3. The multilayer foam filtration technology to eliminate engine air filter maintenance while improving engine durability, reducing evaporative emissions, and reducing overall material usage. The multi-layer foam filter technology The greatest areas of improvement are in filter efficiency and the elimination of filter oil migration.

4. There are many performance filters are available in present market but the best performance is achieved by Nano fiber filter dry type and wet type cotton fitter which provides minimum pressure drop and clean breath (clean air) to engine.

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