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Experimental and Numerical Study on Performance of Air Filters for Diesel Engine

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Abstract: - The air filters in an air intake system permanently removes foreign particles such as dust, dirt and soot from the intake air, thereby maintaining the performance of the engine and protecting it from damage. **Proper maintenance can help vehicles perform as designed, thereby positively affecting fuel economy, emissions, and overall drivability. This paper addresses the issues of air filters replacement.** ***o*****lder studies of carbureted gasoline vehicles have indicated that replacing a clogged or dirty air filter can improve vehicle fuel economy and, conversely, that a dirty air filter can be significantly detrimental to fuel economy. In contrast, a recent study showed that the fuel economy of modern gasoline vehicles is virtually unaffected by filter clogging due to the closed loop control and throttled operation of these engines. Because modern engines operate without throttling, a different result could be anticipated.** ***Today there are 30 to 40 different filter applications around the automobile to be found. The technological performance requirements of the majority of these products are usually more straightforward and are often but vaguely defined. This paper describes the measured results with focus on changes in vehicle fuel economy but also includes emissions and performance. Previous studies shows that, replacing clogged air filter can improve vehicle fuel economy and conversely a clogged air filter can be significantly detrimental to fuel economy.*** **The effects of air filters performance were studied** ***and the analysis is carried out with different simulation results in the form of numerical simulation of flow particles captured by air filters.***

Key words: **Air filters, CI engines, simulation, modeling.**

I. INTRODUCTION

Air cleaners are used in a wide range of automotive applications. From passenger cars to heavy duty trucks, there is always an air cleaner to keep inlet air free of impurities and air flow passage obstruction in low levels. The air filters in an air intake system permanently remove foreign particles such as dust, dirt and soot from the intake air, thereby maintaining the performance of the engine and protecting it from damage. A clean air filter results in improved gas mileage, better acceleration, increased engine life, lower emissions and overall improved engine performance. Not only does an air filter clean the air entering the engine but it also prevents debris from entering the engine and causing damage. As an air filter becomes dirty, the capacity for it to filter the air going into the engine is reduced [1]. Because of this, the engine is not able to function properly, which may cause numerous drivability issues. Symptoms of a dirty air filter vary but often times include a noticeable decrease in gas mileage. A dirty air filter prevents the necessary volume of clean air from reaching the engine which affects the emission control systems of the car; reducing air flow and causing a too rich air-fuel mixture which can foul the spark plugs. Fouled spark plugs can create an engine miss, rough idle and even starting problems. In addition, a too rich fuel mixture increases engine deposits which may even cause the Service Engine Soon light to come on. Over the past decade, numerous emission standards and engineering achievements have come together to create advanced, clean, and flexible engines. These diesel engines and the vehicles they power are demanding for smaller air cleaner system package sizes, increased contaminant loading performance, improved contaminant separation efficiency, and higher temperature performance, all the while maintaining low initial restriction to airflow. Emissions compliant engines, extended oil drains and oils and tighter component tolerances all contribute to the need for increased air filtration system performance. Proper maintenance can help vehicles perform as designed, positively affecting fuel economy, emissions, and overall drivability. The issue of air filter replacement improves fuel economy. The automobile air cleaner element is a part that needs to be replaced periodically, and making this part last longer is essential. Generally, to achieve longer life, it has been necessary to raise the space ratio of the material making up the filter element, but it is difficult to do this and maintain cleaning efficiency at the same time. For this particular reason, it has been necessary to select filter elements to suit the properties of impurities as well as the usage environment, and to replace these elements or remove impurities on a frequent basis.

In contrast, the recent studies indicates that the fuel economy of modern gasoline vehicles is virtually unaffected by filter clogging due to the closed loop control and throttled operation of these engines. [2]Because modern

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diesel engines operate without throttling, a different result could be anticipated. The effects of clogged air filters on the fuel economy, acceleration and emissions results reveal rather low sensitivity of these modern diesel vehicles to air filter condition. The filter performance is typically a trade-off between pressure loss, load capacity and efficiency. Exhaust gas regulations and customer requirements such as filter duration always determine air filter development.

II. LITERATURE REVIEW

Today continuous research on automotive air intake systems are developing to deliver maximum filtration efficiency, maximum dust holding capacity and maximum service interval range based on engine performance and reliability requirements [3].The primary purpose of automotive air induction systems (AIS) is to reduce the airborne contaminant level ingested by engines, especially abrasive contaminants which can cause engine wear. [4]A superior air filter performance is necessary for automotive AIS to protect the engine from wear and to provide the engine with required amount of air. The buildup of dust on the filter surface increases the resistance of the filter medium to flow, which in turn increases the pressure drop across the filter. The problem is so severe in high dust environments like off highway application. In this study, numerical techniques like commercial CFD code, Fluent used to calculate flow through a filter and predict average pressure loss of the flow knowing the initial properties of the filter medium. In this work an attempt has been made to consider the deposition of dust on the filter and the resulting changes in the filter medium properties, which lead to increasing pressure loss across air filter. Dust distribution and pressure drop are predicted for a constant flow rate of air. Further investigating the performance of air filter development. The stratified concepts offer a reduction of the scavenging losses in 2-stroke engines. The results of the engine optimization process including flow simulation, concept evaluation and combustion process development are presented and further focused on the design specifications of the air head carburetor and the specific layout of the reed valve scavenging process. A proposal is presented by [5] the three-dimensional CFD analysis of flow inside an automotive air filter conducted by SMARTtech Fluidos for SOGEFI Filtration do Brasil Ltda., in order to determine the pressure drop overAIS (Air Intake System). Two geometries have been analyzed in seven operation conditions, each. The flow was considered steady-state, incompressible, turbulent and isothermal. The region occupied by the filter element was treated as a porous medium and the porosity coefficients were extracted from experimental results. The contribution given by each component to the total pressure drop was determined.When using a new filter, dust particles,first settle on the fibers of the filter. [6] As contamination increases, the thickness of this dust layer increases and causes a decrease in the pore volume. This leads to the increase in pressure difference. This increase in pressure difference is a typical phenomenon in depth filtration. The pressure difference rapidly increases when the volume gets exhausted. When it reaches a specified value by the manufacturer, the filter should be replaced. While studying this process it is found that there is a new parameter that affects the performance of engine pleated air filter, which is the efficiency of the effective filtration area. The efficiency of the effective filtration area (η_{eff}) is defined as the ratio between the effective filtration area and the total geometric filtration area. The effective filtration area is found to decrease with the increase in temperature, specific dust and flow rate. A numerical study presented [7] on air filters used for an off-highway vehicle by using commercial CFD code FLUENT v 6.1. For the primary filter, the flow is obtained by the use of Reynolds stress model and stochastic Lagrangian model is used to study the gas solid flow. The separation efficiency for dust particles of sizes 50 and 100 microns is found to be 94.4 %. For the secondary air filter, filter portion is modeled as equivalent porous medium. The pressure drops obtained by the analysis agrees very well with the experimental results. The convective scheme is found to have little effect on the prediction of pressure drop through the secondary filter. Today most new passenger vehicles on the road are equipped with a disposable OEM engine intake filter made of cellulose paper or synthetic non-woven media. Engine intake filters have an expected and recommended service life (by OEMs) of approximately 45K to 75K kilometers under normal driving conditions. Majority of air filter element manufacturers do not recommend any type of cleaning to be performed on their OEM products. Vehicle owners in some regions would like to service and clean their own air filter elements in an effort to reduce vehicle operating costs. As a result, [8] a number of OEMs selling passenger vehicles in these regions are requesting their suppliers explore solutions and the effects of whether cleaning air filter elements is appropriate for proper engine operation. In contrast a number of heavy duty and motorcycle air filter manufacturers do include a recommended cleaning schedule and procedure to maintain optimal operating performance. On the other hand, filter cleaning is more popular in the aftermarket industry. An attempt tried [9] to address the issue using a multi-disciplinary approach that employs failure analysis, laboratory experimentation, predictive correlation, and concurrent engineering with an emphasis on contaminant characterization and filtration strategies. Practical contamination analysis methodologies are discussed on

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Excessive wear and malfunctions in fluid power handling systems are often caused by contaminants or small particles that may be built-in, self-generated, or ingested from the environment. Filtration subsystems in such systems are designed to prevent these problems from happening. The influence of multi cyclones application study done [10] on a harvester air cleaner system. Its compact size summed to high contaminant retention capacity improves usual air cleaner systems performance to longer service intervals with reduced pressure drop. Improvements on technology performance were demonstrated through numerical simulations and laboratory tests that simulate the actual application. Virtual Prototyping (VP) is an important method to assess the sound performance of possible designs in earlier stages of development. The common noise simulation with simple level determination can now be combined with subjective assessments that can be particularly interesting for noise content judgment. Engine Air Induction System inlet orifice noise field reviewed [11] and illustrated the main advantages and difficulties in the implementation of VP. In a research, a new filter element was investigated [12] in order to achieve longer life without reducing cleaning efficiency. Choosing a wet type, nonwoven filter made of hollow fibers and impregnated with oil enables not just the filter element's mesh, but also the fiber surface, to trap dust, unlike a nonwoven filter made of ordinary fiber which produces a filter with not only higher cleaning efficiency but also a smaller decline in pressure and no loss of efficiency, even at high flow rates.

To assess the acoustic performance of modern automotive air filters, both the air-borne engine noise propagating through the interior air of the system and the structure-borne noise radiated by the shell should be evaluated. In this contrast, these different propagation paths are modeled using the finite element solver Actran on industrial test cases set-up by SOGEFI Air and Cooling Systems. The test-case is designed [13]in such a way that the different propagation paths are assessed separately. First the engine acoustic pulsation that is transmitted through the filter's structure is considered. Second, the noise radiated by the shell excited by mechanical forces at the support location of the filter is evaluated. Finally, the acoustic transmission loss of the filter is predicted. The ingredients of the finite/infinite element models are reviewed. In particular, the recently implemented modal/physical coupling is successfully applied to benefit from an existing modal representation of the structure of the filter. Using this approach, the acoustic CAE engineer does not need to create a new mesh for the structure of the filter and can thus focus on the modeling of the acoustics. The results of the simulation are compared with measurements data. Proper maintenance can help vehicles perform as designed, positively affecting fuel economy, emissions, and the overall drivability. [14]This effort investigates the effect of one maintenance factor, intake air filter replacement, with primary focus on vehicle fuel economy, but also examining emissions and performance. Older studies, dealing with carbureted gasoline vehicles, have indicated that replacing a clogged or dirty air filter can improve vehicle fuel economy and conversely that a dirty air filter can be significantly detrimental to fuel economy. The effect of clogged air filters on the fuel economy, acceleration and emissions of five gasoline fueled vehicles is examined. Four of these were modern vehicles, featuring closed-loop control. Three vehicles were powered by naturally aspirated, port fuel injection (PFI) engines of differing size and cylinder configuration: an inline 4, a V6 and a V8. A turbocharged inline 4-cylinder gasoline direct injection (GDI) engine powered vehicle was the fourth modern gasoline vehicle tested. A vintage 1972 vehicle equipped with a carburetor (open-loop control) was also examined. Results reveal insignificant fuel economy and emissions sensitivity of modern vehicles to air filter condition, but measureable effects on the 1972 vehicle. All vehicles experienced a measured acceleration performance penalty with clogged intake air filters. Proper maintenance can help vehicles perform as designed, positively affecting fuel economy, emissions, and overall drivability. [15] This addresses the issue of whether air filter replacement improves fuel economy. Described are measured results for increasing air filter pressure drop in turbocharged diesel-engine-powered vehicles, with primary focus on changes in vehicle fuel economy but also including emissions and performance. Earlier studies of carbureted gasoline vehicles have indicated that replacing a clogged or dirty air filter can improve vehicle fuel economy and, conversely, that a dirty air filter can be significantly detrimental to fuel economy. In contrast, a recent study showed that the fuel economy of modern gasoline vehicles is virtually unaffected by filter clogging due to the closed loop control and throttled operation of these engines. As the modern diesel engines operate without throttling (or with minimal throttling) a different result could be anticipated. The effects of clogged air filters on the fuel economy, acceleration, and emissions of three late model turbocharged diesel-powered vehicles were examined. The vehicles were powered by turbocharged diesel engines with different displacements and engine designs. The results reveal rather low sensitivity of these modern diesel vehicles to air filter condition. Some applications require outstanding performance for the air cleaners. One of them is at harvester application. In this case, vehicles are exposed to thin soil particles in high quantities due to harvester movement at plantation work. At the same time, engine performance needs to be kept during long journeys. According to this limitation, re-fuelling and components replacements are done directly at field. Any vehicle stop means lower productivity and more costs. For this reason [16] Automotive has developed a new software tool for estimating air filter lifetime which simplifies and significantly shortens the pre-development of filter elements with regard to filtration and pressure drop. In addition, it is possible to compare the different filter geometries in order to limit the number of different filter elements. By correlating the total air consumption with the average dust concentration typical for the environment involved, the air filter lifetime can be precisely predicted. The program utilizes input data such as the maximum flow rate, the condition of the ambient air, filter geometry, filter media and air consumption per kilometer. All of these data allow precise predictions to be made regarding filter duration, load capacity and maximum face velocity. A further study on filter testing explains how usually carried out according to the ISO 5011 standard, and it describes the testing conditions and regulations with which the test rigs used have to comply. After some general facts on the software tool, this paper focuses on the basic principles behind it as well as its analysis of performance of various air filters.

III. CLEAN AIR PROVIDES SUPERIOR PERFORMANCE

Air is necessary for successful combustion in the engine [17] In fact, for efficient combustion; a modern diesel engine requires several thousand times as much air as it does fuel. Clean air — air almost 100% pure — is critical to engine survival and vital to its performance. If a turbocharger engine added then, it may need to make changes to the intake ducting. Turbocharged engines require even more free-flowing clean air, 750 cubic feet per minute or more. Naturally aspirated engines demand about 20% less, but still these engines can require up to 15,000 gallons of air for every gallon of fuel. In either case the induction system (ducting, hoses and reducers) brings outside air to the engine. The system should have enough intake capacity to meet engine requirements for air flow, avoiding sharp bends or constrictive ducting. It should be installed in a clean location, away from exhaust flow, road grime and splash. It should be vented to remove airborne moisture. Air may flow into the engine through a series of components and an air-inlet hood to eliminate moisture. So an air filter will typically remove 80% to 90% of all airborne contaminants. One air cleaner can be significantly more effective than another - even if the difference in efficiency appears to be marginal. An air filter @ 99.0% efficiency permits twice as much dust to pass into the engine compared to an air filter @ 99.5% efficiency. This means 10 times more dust than at 99.9% efficiency. So, the choice of the filter for the right application can make a substantial difference in wear rate, cost and performance of the diesel engine. In the search to improve the performance of the engine, one way of air intake system of the engine continue to be examined. This can often take the form of either increasing the air filter's life along with diesel engine. Size reductions in the system can allow for alternate configuration. [18] 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 pre filters are commonly used to decrease the dust load to the main filter while high efficiency is achieved by utilizing submicron or Nano fibers in the main filter. The patented multi-stage filter was designed to achieve ultra-high particle removal efficiency and dust holding capacity, and long life in dusty and on highway environments. The main (final) filter is located downstream of the pre filter. The main filter is made of pleated filter media containing Nano fibers with a diameter in the range of 40 – 800 nanometers. The upstream in-line pre cleaner utilizing flow-through mini cyclones has separation efficiency of 95%. A high dust capacity, high efficiency pre filter can be used instead of the pre cleaner. The pre filter is made of vertically lapped nonwoven filter media made from synthetic fibers of different materials to fully utilize the tri biological effect. The volume of the pre filter is determined by the performance required and space allotted. This paper discusses the filter performance of high dust holding capacity engine air filters. Filter specifications, design and performance are discussed in detail. Performance characteristics of the media and full size filters were determined using on-line particle counters and the gravimetric test method. Initial and final efficiency, and dust loading performance characteristics, are provided.

IV. ANALYSIS AND COMPARATIVE STUDIES

Design of diesel engine air intake systems requires the integration of many technologies and the balancing of many factors. At a given technology level, each property can be improved through compromises in another property. Size can be reduced by reducing filter efficiency, reducing filter life, or increasing filter pressure loss. Advancements in technology are required to achieve simultaneous improvement in multiple parameters. These technology advancements can take several forms, from simply improving via design and materials expertise. Therefore the engine testing was performed only with the specified air filters available in the market which were

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arranged and plugged for kirloskar AV-1 engine and considered as constant speed @ 1500 rpm with different load conditions to analyze performance and emission pollutants. The results anticipated are

A. Case – 1 (a) Marathi filter NF 560(used)

S. No	Load (KW)	T.F.C (Kg/hr)	S.F.C (Kg/KW.hr)	A/F	η_{mech}	η_{Btherm}	η_{therm}	HC (ppm)	CO (%)	CO_2 (%)	O_2 (%)	NO_X (ppm)
1	0.5	0.501	0.8016	18.66	32.98	10.44	31.66	27	0.186	3.78	15.04	48
2	1.0	0.642	0.467	15.23	51.97	24.64	32.7	14	0.091	3.19	16.11	84
3	1.5	0.78	0.363	12.7	62.97	23.08	35.62	18	0.135	2.87	16.65	150
4	2.0	1.02	0.333	9.77	70.64	25.08	35.5	13	0.202	3.45	15.48	205
5	2.5	1.11	0.318	8.97	73.3	26.31	35.8	18	0.231	2.3	17.1	144

Case – 1 (a) Maruthi filter NF 560(New)

S. No	Load (KW)	T.F.C (Kg/hr)	S.F.C (Kg/KW.hr)	A/F	η_{mech}	η_{Btherm}	η_{therm}	HC (ppm)	CO (%)	CO_2 (%)	O_2 (%)	NO_X (ppm)
1	0.5	0.49	0.75	19.5	36.62	11.11	30.34	18	0.143	3.05	16.08	34
2	1.0	0.6	0.43	16.2	55.09	19.27	34.98	12	0.1	3.24	16.22	96
3	1.5	0.6	0.27	16.2	65.64	30.02	45.32	14	0.124	4.22	14.63	196
4	2.0	0.96	0.31	10.12	72.98	26.52	36.34	14	0.144	3.1	15.84	174
5	2.5	1.08	0.3	9	75.78	27.28	36	34	0.32	3.9	14.87	194

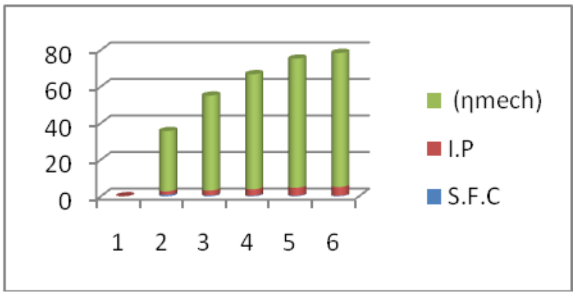

Fig 1: S.FC V/s η_{mech}(NF 560-used)

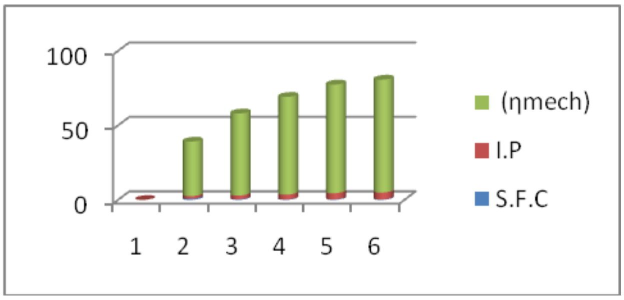

Fig 2 : S.FC V/s η_{mech}(NF 560-New)

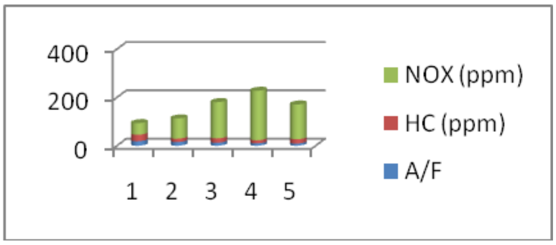

Fig 3: A/F v/s No_x (NF 560-used)

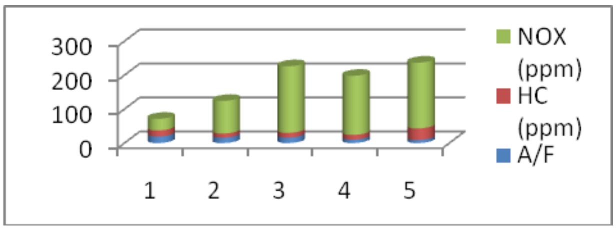

Fig 4: A/F v/s No_x (NF 560-New)

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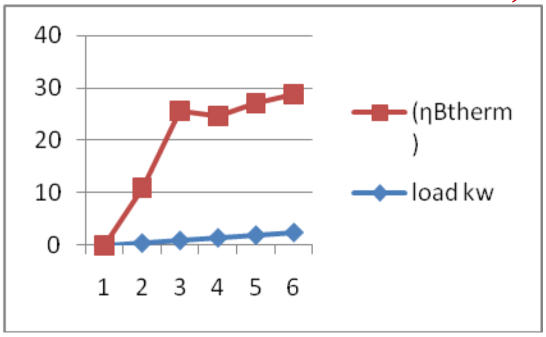


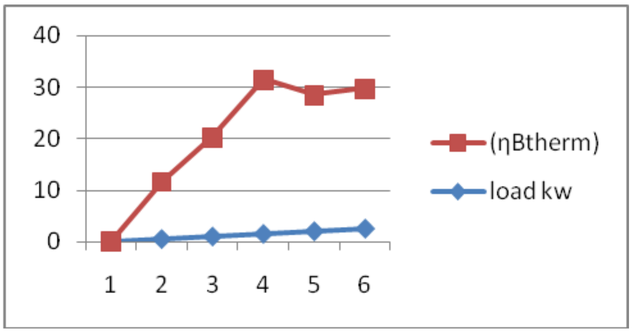


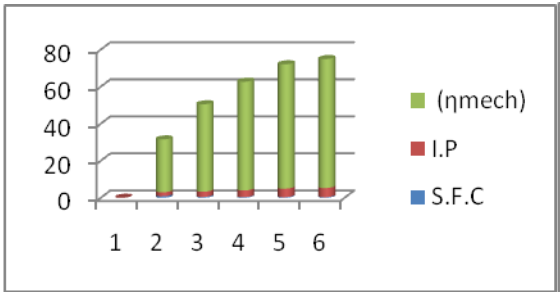
Fig 5: Load V/s η_{Bth}(NF 560-used) **Fig 6:Load V/s η_{Bth}(NF 560 -New)**

B. Case – 2 (a) Tata Indica NF 615(used)

S. No	Load (KW)	T.F.C (Kg/hr)	S.F.C (Kg/KW.hr)	A/F	η_{mech}	η_{Btherm}	η_{therm}	HC (ppm)	CO (%)	CO_2 (%)	O_2 (%)	NO_X (ppm)
1	0.5	0.5142	0.845	20.42	28.57	9.9	34.24	13	0.161	2.94	16.21	30
2	1.0	0.618	0.458	17.28	47.18	18.26	38.48	15	0.137	2.9	16.3	87
3	1.5	0.755	0.354	13.89	58.67	23.62	40.24	9	0.131	4.69	13.8	175
4	2.0	0.984	0.32	10.12	67.17	26.15	38.89	15	0.191	4.46	13.99	226
5	2.5	1.1094	0.321	8.97	69.63	26	37.28	10	0.186	2.95	16.46	110

Case – 2 (b) Tata Indicca NF 615(New)

S. No	Load (KW)	T.F.C (Kg/hr)	S.F.C (Kg/KW.hr)	A/F	η_{mech}	η_{Btherm}	η_{therm}	HC (ppm)	CO (%)	CO_2 (%)	O_2 (%)	NO_X (ppm)
1	0.5	0.51	0.822	15.8	29.24	10.18	34.81	2	0.141	3.09	16.2	26
2	1.0	0.6	0.44	13.5	47.55	18.99	39.94	10	0.147	4.11	14.58	97
3	1.5	0.6	0.27	13.5	58.9	30.02	50.97	5	0.144	4.99	13.28	208
4	2.0	0.96	0.31	8.43	67.1	26.7	39.79	9	0.122	2.59	17.1	133
5	2.5	1.08	0.3	7.5	70	27.13	38.75	32	0.48	6.97	10.48	324



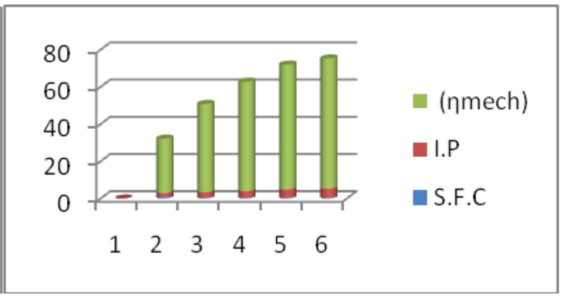


Fig 7: S.FC V/s η_{mech}(NF 615-used) **Fig 8: S.FC V/s η_{mech}(NF 615-New)**

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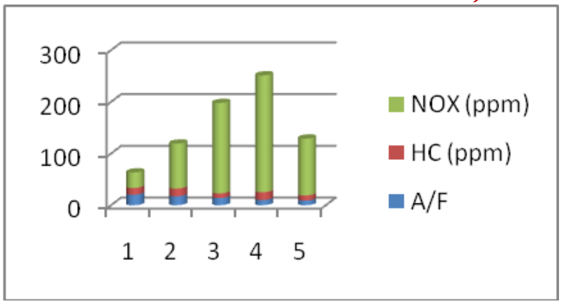


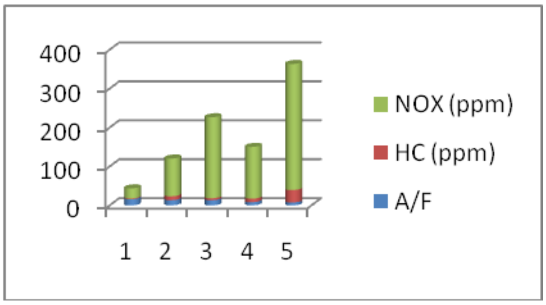
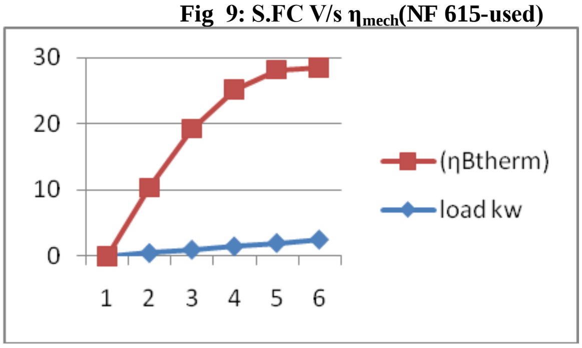


Fig 9: S.FC V/s η_{mech}(NF 615-used)   **Fig 10: S.FC V/s η_{mech}(NF 615-New)**



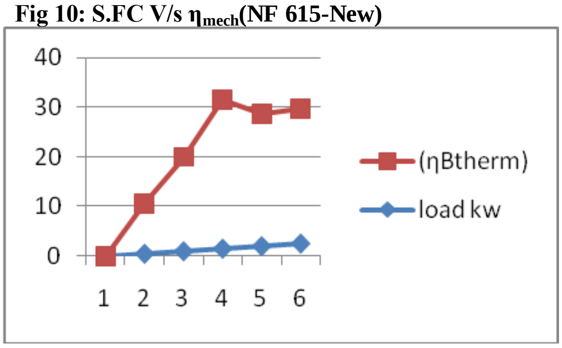


Fig 11: Load V/s η_{Bth}(NF 615-used)   **Fig 12 :Load V/s η_{Bth}(NF 615 -New)**

C. Case – 1 (a) Tata Sumo – NF 1004 (used)

S. No	Load (KW)	T.F.C (Kg/hr)	S.F.C (Kg/KW.hr)	A/F	η_{mech}	η_{Btherm}	η_{therm}	HC (ppm)	CO (%)	CO_2 (%)	O_2 (%)	NO_X (ppm)
1	0.5	0.5	0.79	23.29	35.89	10.55	29.39	39	0.086	2.37	17.07	36
2	1.0	0.6	0.36	20	59.45	23.04	38.75	31	0.08	1.87	18.22	91
3	1.5	0.72	0.33	16.6	65.85	25.23	38.31	19	0.084	3.82	15.69	182
4	2.0	0.96	0.31	12.5	73.3	26.96	36.78	15	0.127	2.7	17.57	164
5	2.5	1.08	0.3	11.11	75.78	27.28	36	20	2.22	2.22	18.7	180

Case – 2 (a) Tata Sumo – NF 1004 (New)

S. No	Load (KW)	T.F.C (Kg/hr)	S.F.C (Kg/KW.hr)	A/F	η_{mech}	η_{Btherm}	η_{therm}	HC (ppm)	CO (%)	CO_2 (%)	O_2 (%)	NO_X (ppm)
1	0.5	0.707	1.05	17.18	43.94	7.9	18	31	0.187	3.51	15.64	29
2	1.0	0.69	0.48	17.13	62.28	17.23	27.06	29	0.165	4.01	14.84	115
3	1.5	0.79	0.36	15	71.7	23.11	32.23	13	0.147	4.85	13.86	333
4	2.0	0.98	0.31	12.19	78.22	26.41	33.76	16	0.185	4.03	14.98	346
5	2.5	1.04	0.42	11.32	80.22	28.09	35	14	0.214	3.12	15.71	343

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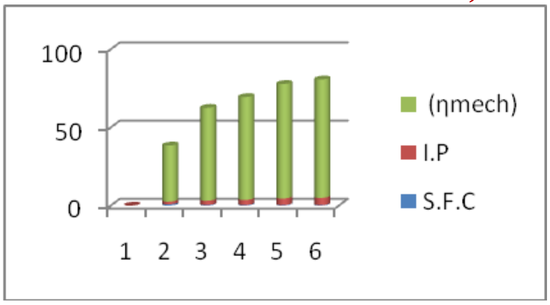


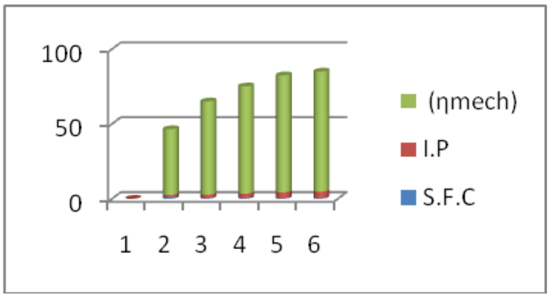
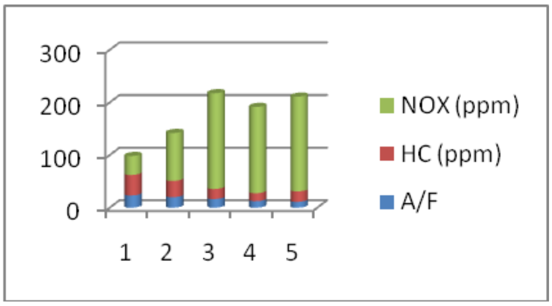


Fig 13: S.FC V/s η_{mech}(NF 1004-used) **Fig 14: S.FC V/s η_{mech}(NF 1004New)**



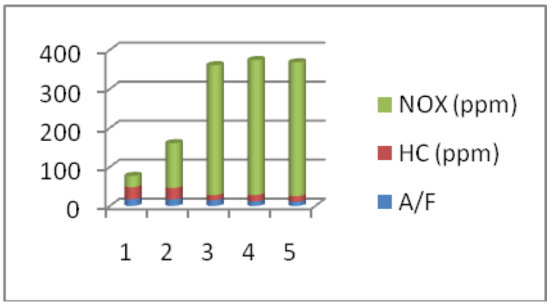
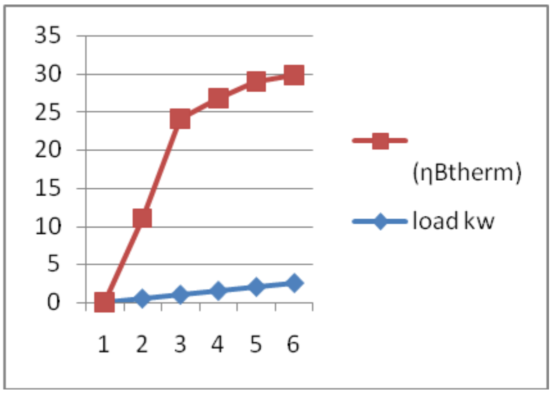


Fig 15 : S.FC V/s η_{mech}(NF 1004-used) **Fig 16: S.FC V/s η_{mech}(NF 1004-New)**



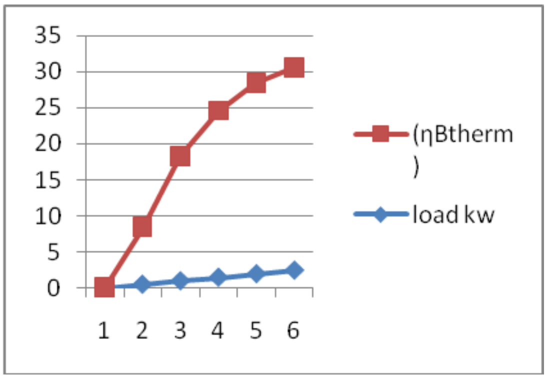


Fig17 : Load V/s η_{Bth}(NF 1004-used) **Fig 18:Load V/s η_{Bth}(NF 1004-New)**

A study of clogged air filter results shows no significant effect on the fuel economy of the engine. The engine control systems were able to maintain the intake restrictions, and therefore fuel consumption was not increased. By considering the Case 1 study filter the initial change in Specific fuel consumption decreased in clogged type air filter as resulted in higher in efficiency of the engine, as with introduction of new air filter of same model with same specific fuel consumption. The efficiency of the engine validated and difference observed as 2.4 % increase of efficiency. By observing the data obtained of emission and pollutants with comparison of air fuel ratio with different parameters like HC and NOx, as decreases in air fuel ratio then rise in HC and NOx as 144ppm. At constant speed of 1500 rpm with different same load conditions in both filters the efficiency of break thermal is increased with .97 %, but as load increases after 1.5 kw the efficiency slightly decrease, this is due to observation of in sufficient air supply / proper fuel burning .With the same air fuel ratio in new filter also rise in HC and Nox as 194 ppm. Fuel economy decreased more than 5% from the initial clogged air filter test results and about 7.5% from the results for the new air filter. Further study of case 2 filter the initial change in Specific fuel consumption decreased in clogged type air filter as resulted in higher in efficiency of the engine, as with introduction of new air filter of same model with same specific fuel consumption the efficiency of the engine validated, where there 0.7 % increase of efficiency . By observing the data obtained of emission and pollutants with comparison of air fuel ratio with different parameters like HC and NOx, as decreases in air fuel

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ratio then rise in HC and NOx as 110ppm. With the same air fuel ratio in new filter also rise in HC and Nox as 324 ppm. Fuel economy decreased more than 10% from the initial clogged air filter test results and about 18% from the results for the new air filter. At constant speed of 1500 rpm with different same load conditions in both filters the efficiency of break thermal is increased with 1.13 % but as load increases after 1.5 kw the efficiency slightly decrease,this is due to observation of in sufficient air supply / proper fuel burning .Comparing the case 1 and case 2 of new filters resulted good in efficiency and controlling of air pollutants with their own advantage. As comparing with case 3 with case 1 and case 2 it is observed as break thermal efficiency is increased 0.81 % with same load conditions and with constant speed. But whereas load increase after 1.5kw the break efficiency not decreasing after 1.5 kw load, so it is observed that case 3 filter has more advantage. Even study continuing for model NF 1004 with clogged and new air filters resulting good as compared with previous models. However, only by changing the air filter can keep engine running at its best. Studies have consistently shown that vehicles with clean air filters perform better than dirty old air filters. A dirty and clogged air filter reduces the amount of air flow available to engine. A limited amount of air causes a drop in performance as well as other problems. Additionally, damaged air filters can allow small particles to enter in engine, causing additional problems. As comparing with results with other studies the improvement with a new filter ranged from 2 to 6%. Optimum filtration performance of Air Filters is important to provide the minimum level of air cleanliness required to the engine. Continued demand for further reductions in air intake system size and restriction has resulted in innovative solutions. For dusty conditions these efficiency levels may have to be orders of magnitude higher. The overall/final efficiencies should be higher than the initial efficiencies. Lower overall/final efficiencies would indicate re-entrainment problems. Efficiency measurements using standard test dusts may not represent field conditions. Contaminant/dust holding capacity of Air Filters depends on the particle size distribution and concentration. The air passages are far more efficient with (mostly) radiuses corner between the air filter housing and the intake manifold. As compared the above experimented results , the analysis can be carried out a with form of numerical simulation of flow particles capture by air filter media observed as gases to be continuous fluids, influenced by the macro-properties viscosity, density, and pressure. [19] The appropriate form for analysis of flow through a given filter medium at a given operating condition depends on the gas condition and the Knudsen number (Kn) of the finest fibers in the filter medium simulated. Continuum, macro-scale methods may be usable for media with individual fiber. First of all, simulations of air filter media performance and fibers are in the continuum flow regime and the Navier–Stokes equation with a finite-volume solution is applicable and next filter media performance simulation carried out by computational approaches other than numerical solutions of the Navier–Stokes equation. These include use of the Burnett, super-Burnett, and Grad moment equations.Further lattice Boltzmann and direct simulation Monte Carlo methods could be applicable on the molecular dynamics, boundary singularity, and boundary element methods. [20] One of the applications of the air filter is in the heavy- duty diesel engine with open loop system; the air filter only has one opportunity to filter the contaminant out of the intake air. Air filters for this type of engines needs breathe to be as clean as possible. Poor air quality will significantly impact the performance of diesel engine. These filters are usually of an annular or cylindrical shape. [18-John Thomas, Brian West and Shean Huff] A method was developed for gasoline engines to obtain a level of air filter clogging that would set a filter indicator and that was beyond the level of air filter pressure drop (5.0-7.0 kPa at the maximum air flow point) considered acceptable [21]. The same method adopting across the face of the intake air filter was used for the three different diesel vehicles and limitation of equipment's FTP and HFET tests were performed with the 2500 rpm. It was obvious that the clogged filter tests had more than sufficient air filter pressure drop to simulate a filter that should be replaced.

A research was carried out to determine the fuel consumption at different levels of pollution in the air filter conditions on engine with power 45kW. Fuel consumption was measured using volumetric method by flow meter for liquid fuels type FLF-2 [22] The obtained results of the research were processed by the software product "STATISTICA" to determine the type of functional relationship, (linear or higher), between the input factors and output parameters and their confidence interval. At fig.2 is shown the regression line and confidence interval for linear model and at fig.3 for polynomial model of relationship, where "x" is engine's power in kW, and "y" is the fuel consumption in l/h.

The figures show that in both models in confidence interval (confidence probability γ=0.95) are all experimental data, but for polynomial model the confidence interval is narrower and the regression line passes closer to the experimental points. Therefore the fuel consumption is described accurately by the polynomial model. Conclusion is that Pollution of the air filter has a significant effect on fuel consumption and engine's power. 2. It

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is not economically profitable to use 75% or above polluted of its resources, air filter as significantly affect to engine performance. A variety of numerical tools are being used in this effort, including a finite element flow solver and Brownian dynamics simulation. Aspects of these techniques in relation to the problem at hand will be described, and simulation results including comparisons to round-fiber filters will be presented. The primary result presented here is the significant difference in predicted pressure drop between a prototype C-CP filter and a round-fiber filter with equal total cross-sectional area.

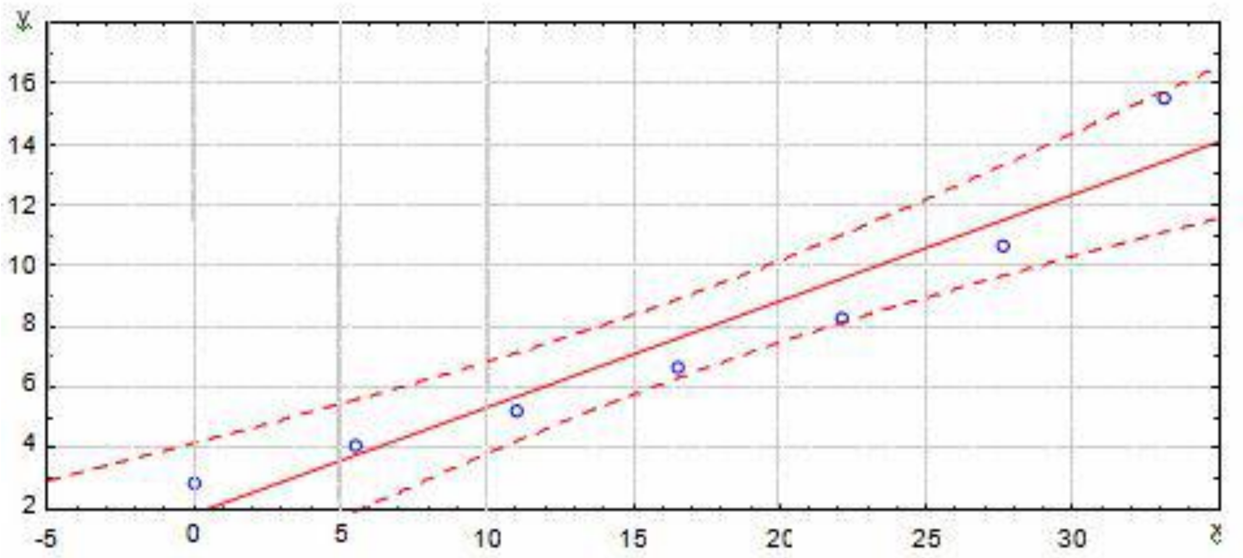

Fig.20. Regression line and confidence interval for linear model.

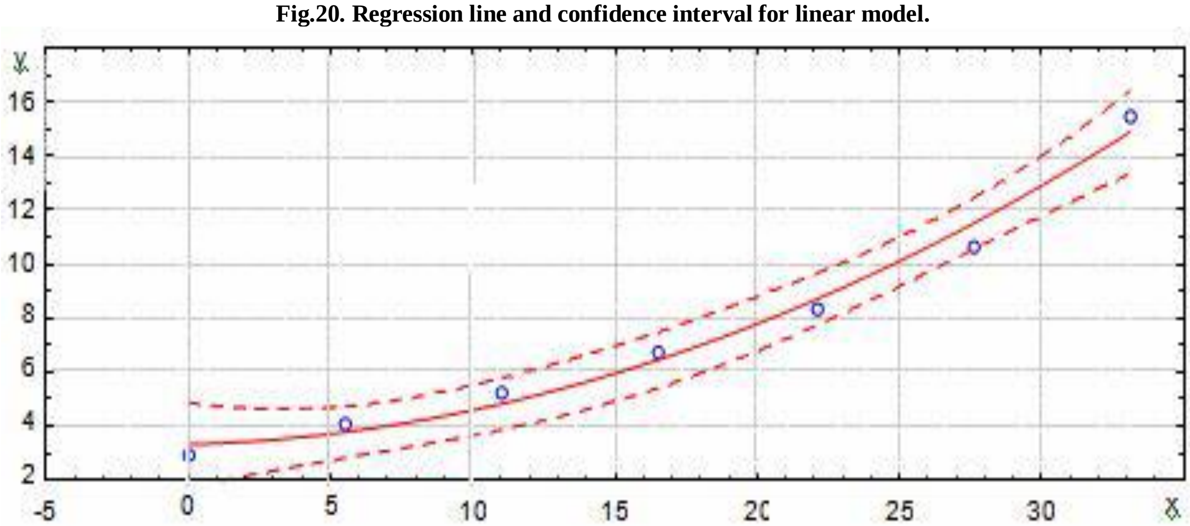

Fig.21Regression line and confidence interval for polynomial model

The simulation code is written in the GCC C programming language [23]. Matlab is used for visualization [23]. The flow simulation takes approximately 20 minutes on a standard laptop or desktop computer. The particle simulations take roughly 1 second per particle. These CPU times depend on the complexity of the domain, density of the finite element mesh, and time step for the particle simulation. For comparison, a round-fiber filter domain was constructed with the same number of fibers and identical fiber cross-sectional area as the C-CP filter. The round fiber domain and corresponding finite element mesh are displayed. Input parameters for the simulation are listed. The Figures 22 and 23 display the calculated pressure drop for the C-CP fiber filter and round fiber filter, respectively. Since the pressure is set at zero at a point on the inflow (left) boundary, the value of pressure on the outflow boundary is negative. The results demonstrate that depth filtration (rather than surface or cake filtration) is taking place since particle capture is occurring throughout the domain. Strong conclusions

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about filtration efficiency are premature at this point, though it can be observed that fewer particles passed through the C-CP fiber filter.

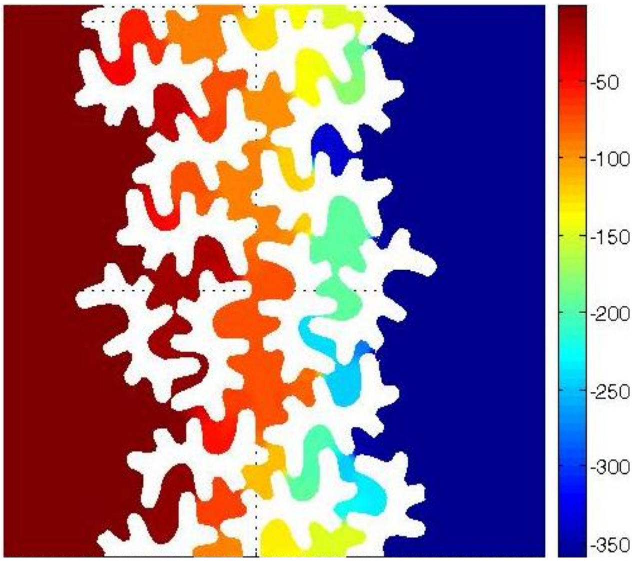

Fig 22. Pressure drop (Pa) for C-CP fiber filter

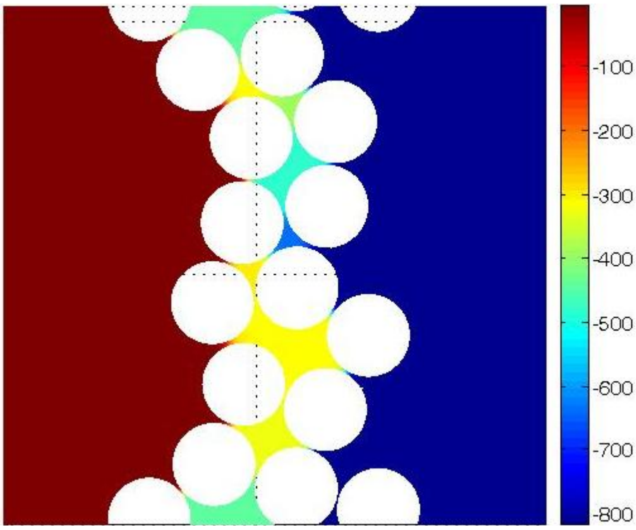

Fig 23 . Pressure drop (Pa) for round fiber filter

V. CONCLUSION

However, that's not to say that this design can't be improved upon. These new filter designs are made of a filter media that is inherently high in mass air flow handling capacity and in many cases come with an optional ducting and housing assembly that completes the package. Other cool thing about these filters is that most of them are cleanable. The ability to remove the filter and clean it with spirits and re-install in the housing saves the cost of purchasing a new filter while keeping the old filter out of the landfill. In view of the automotive air filters market studies, it is poised to witness an annualized growth of over 7.47% from 2013 to 2018. Considering the filter type, the intake air filter is the leading market for automotive air filters when compared to cabin air filters. Cabin air filters have been growing for the past few years and is growing at a promising CAGR. Power in the modern SI and CI engines is controlled by manipulating the manifold pressure through throttling of the intake air. The increased restriction of a clogged filter affects ultimate power but not fuel economy of modern engines. Any additional pumping loss due to the state of the air filter is offset by the throttle. Conventional diesel engines operate without throttles—although throttles are in use in some diesels today for active control of exhaust temperature and species, to enhance warm-up, or control exhaust gas recirculation, these throttles are full open most of the time. Because the diesel engine is not throttled, and airflow is high even at light load, the added restriction from a clogged filter may have a measureable effect on fuel economy. Future work will investigate the effect of intake air filter state on a number of diesel vehicles

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