International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 4 Issue 2, Feb.-2015, pp: (194-205), Impact Factor: 1.252, Available online at: www.erpublications.com

The Influence of Air Filter on Car Fuel Consumption

Timur Choban Khidir[1], Abbas Mohammed Ismael[2], Ali Hasan Abdulla[3]
[1,2]Kirkuk University / College of Engineering - Mechanical Dept.
[3]Kirkuk University / College of Engineering - Petroleum Dept.

Abstract: The aim of this research is to know the effect of air filter on the fuel consumption for new and old cars. To achieve this study, we have chosen three cars two of them were new models, the first was Toyota Camry (2003) rectangular shape filter, and the second was Dodge Charger (2006) rectangular shape filter too. They were working with spark ignition system(multi-displacement system).The third car was an old model Super Saloon (1984)cylindrical shape filter, which was working with carburetor system. In addition, we used the same filters but they were clogged which are belonged to the same cars to know the effect of air filter on the fuel consumption.

Keywords: Air Filter, Clogged Filter, Air Fuel Ratio, Fuel Consumption.

1. INTRODUCTION

In recent years, fluctuations in the price of crude oil and corresponding fluctuations in the price of gasoline and diesel fuels have renewed interest in car fuel economy in the world. This research study aimed specifically at the effect of engine air filter condition on fuel consumption. Car design, including mass, rolling resistance, aerodynamic drag, and engine and transmission efficiency, is an important factor affecting a car’s fuel consumption on the prescribed driving schedules. Fuel consumption can also be greatly affected by driver/owner behavior. Hard acceleration, excessive idling, and carrying unnecessary weight can all negatively affect fuel economy. Proper car maintenance, on the other hand, can help the car perform as it was designed, thus positively affecting fuel consumption, emissions, and the overall drivability of a car.

Our research investigates the effect of one of these maintenance factors, air filter replacement, on car performance and fuel consumption. Past studies have indicated that replacing a clogged or dirty air filter can improve car fuel consumption. For example, Jaroszczyk, Wake, and Connor reported in 1993 that proper filtration systems make engines more fuel efficient; however, they gave no data or reference information to support this claim.[2]. The Organization for Economic Co-operation and Development claimed in a 1981 report based on earlier research by the Thornton Research Center that “excessive pressure across a dirty air filter” can cause a 1–15% increase in fuel consumption. [3]. In the Thornton study, six 1970–73 model year cars were tested using the Economic Commission for Europe hot-start driving cycle (ECE 15) to explore the fuel economy effects of “deliberate malfunctions,” defined as maintenance problems such as damaged spark plugs, poor idle mixture, improper idle speed, and “restricted air cleaners. Of the six cars, only five were tested with restricted air filters, accomplished by “masking the cross-sectional area of the air cleaner element. No further description of how the amount of restriction was quantified was given, but the cars showed a variable response to the testing. Two of the cars showed less than a 1% decrease in fuel economy, two others showed 11% and 15% decreases in fuel economy, and the fifth car showed a decrease in fuel economy of more than 30% due to the restricted air cleaner. The Thornton researchers believed that this large change was due to the style of carburetor used in this 1971 Vauxhall Viva, which utilized a fixed-jet atmospherically vented carburetor, believed by the researchers to be very sensitive to a throttled air intake. The wide variability in the effect of restricted air intake from a simulated clogged air filter was attributed to the different styles of carburetors, whichvaried among the tested cars.[4].

The results of the Thornton Research Center tests are of limited use to consumers today because the car engine technology has evolved significantly since those tests were conducted. The authors hypothesized that the fuel consumption of modern closed-loop feedback systems would not be sensitive to the state of the air filter, given that the engine power is controlled by throttling the intake air. Because of this, at a given engine power condition (or given manifold pressure) additional throttling from a clogged air filter would be offset by further opening the throttle (to achieve the same manifold pressure); however, maximum engine power would be expected to be affected by the intake air restriction imposed by a clogged filter. While the authors hypothesized that the fuel consumption of modern engines would not be affected by a clogged filter, we further hypothesized that a clogged filter might impact a carbureted engine due to a “choking effect” in which the engine operates at richer combustion conditions. This research describes funded investigation into the effects of clogged air filters on the fuel consumption of two modern cars, ranging from 2003 to 2006, that use closed-loop fuel control and a vintage 1984car equipped with a carburetor. The objectives of the program included:

1. Determining the effects of clogged air filters on the fuel consumption and performance of modern cars,
2. Confirming the results of previous studies indicating that clogged filters affect the fuel consumption of carbureted or open-loop control cars.
3. Determining other car performance impacts of clogged filters (e.g. the potential impacts on engine power).

2. EXPERIMENTAL SETUP

2.1 TEST FACILITIES

Testing was conducted at the maintenance center. Conventional emissions measurements were conducted with analyzers from Analytical Instruments. Nondispersive infrared sensors were used to measure carbon dioxide (CO_2) and carbon monoxide (CO), and heated chemiluminescence detectors were used to measure nitrogen oxides (NO_x). Total hydrocarbons (THC) and methane were measured with a heated flame ionization detector with a methane cutter. In this method, total carbon in the exhaust from the measured CO_2, CO, and THC emissions is used to compute fuel consumption. The fuel used in all cars for all tests with known carbon fraction and density for computing fuel economy.

2.2 TEST SETUP

The cars tested included the following.

1. 2003 Toyota Camry—2.4L I4.
2. 2006 Dodge Charger—5.7L V8 with MDS (Multi-Displacement System).
3. 1984Super Saloon (Toyota)—2.8L I6 with factory four barrel carburetor.

For each of the two modern cars, two different pressure differentials (DPs) were measured on the engine along with lambda excess air factor [non dimensional air fuel ratio (AFR)] and tunnel emissions.The DPs measured were as follows (see also Fig. 2.1).

1. Inlet DP—The pressure differential between the area just before the air filter and the atmosphere.
2. Filter DP—The pressure differential between the area just before the air filter and the area just after the air filter.
3. Outlet DP—The pressure differential between the area just after the air filter and the atmosphere.
4.

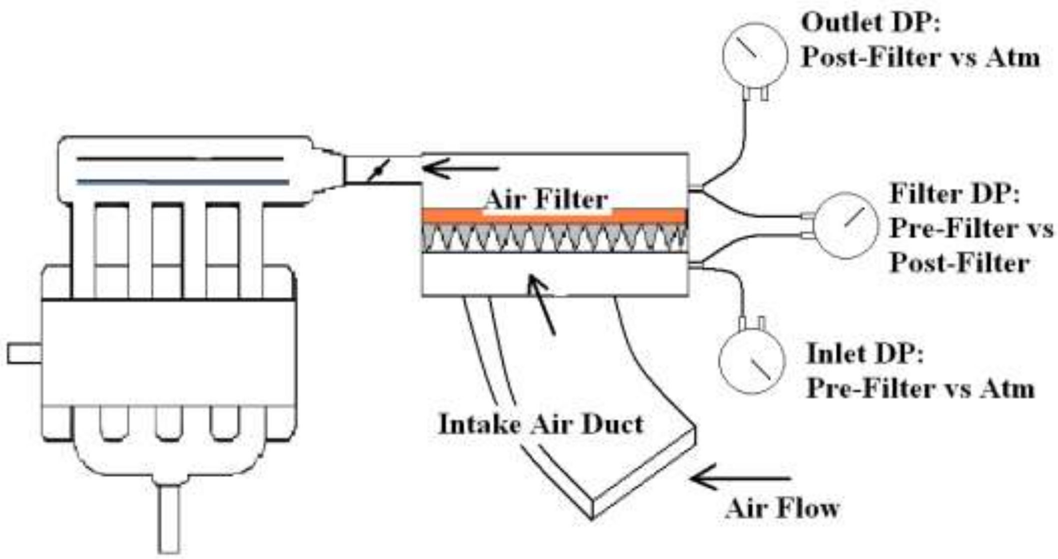


Fig. 2.1 : Pressure transducer setup for modern cars.

These pressures were measured using three separate electronic delta P pressure transducers. Each transducer was able to measure 0 to 7.5 kPa (0 to 30 inches of water column). The sensors were calibrated before testing began using a water manometer. In a few experiments, the measured pressures exceeded the range of these sensors. This issue did not present itself as a significant problem until late in testing when “severe” test cases were explored.

2.3 DEFINING A CLOGGED AIR FILTER

The results of the testing of these air filter indicators agreed with the information found in the literature as to what the definition of a clogged air filter is in engineering terms. The function and design of intake air filters must address the following.[5]

1. Engine durability
2. Filtration
3. Flow management
4. Pressure or head loss constraints
5. Overall noise, vibration, and harshness standards
6. Service requirements
7. Packaging
8. Styling/appearance
9. Emissions

All of these functions are to be met for the service life of the filter without allowing engine performance to be affected.[5]. In light- and medium-duty applications, the service life is normally defined by accumulated mileage. However, it is very common for over-servicing to occur in these applications due to a lack of understanding of how optimum air filter efficiency is achieved.[5,6] The standard recommended service life for an air filter in light- and medium-duty applications, during normal driving conditions, is about 30,000 miles.[5,7]. It is common, however, for servicing to occur when the filter appears dirty. Engine air filters are designed to actually increase their efficiency by using this initial layer of dust as an added filter layer. Initial filter efficiency is usually approximately 98% but increases to more than 99% by the end of the service life of the filter.[7,8]. Therefore, changing an air filter before the useful service life is achieved can result in premature engine wear.[6,9]. In engineering terms, the service life of an air filter is commonly defined as a level of restriction which results in a pressure drop across the filter of approximately 2.5 kPa (10 in. water) more than the pressure drop of the new or clean filter.[5,9,11]. Bugli and Green define this as the “final pressure drop” when conducting tests to investigate filter cleaning procedures:

Final pressure drop = initial clean pressure drop + 2.5 kPa. [10]

According to Patil, Halbe, and Vora, it is common for air filter service indicators to be set between about 5.0 and 7.0 kPa, which corresponds to the setting of the unit taken from the Chevrolet Silverado. The unit tested from the 2006 Dodge Ram is set at a slightly lower level, which is believed to be due to the car being equipped with a diesel engine. While the level of restriction on a closed-loop, feedback, throttled, spark-ignition (SI) engine would not be expected to affect fuel economy (as described above), the additional pumping loss might be expected to affect the fuel economy of the unthrottled diesel engine. This restriction level is noted as the point of critical pressure drop because at levels greater than the “final pressure drop,” overall engine performance begins to degrade significantly.[5,7,8,11].

2.4 CAR TESTING

Wide-open throttle (WOT) tests were used to measure the changes in the filter pressure drop (Outlet DP). 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 described below, to achieve the desired Outlet DP 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 method for achieving this restriction was developed, it was used with each car. Using this approach, the V8-equipped Dodge Charger showed a slightly higher Outlet DP than the I4 Camry that showed a slightly lower Outlet DP. The 1984I6Super Saloon was restricted in a similar manner and level. It is important to note that the two modern cars used rectangular cartridge style air filters (Figs. 2.3 and 2.4), while the 1984Super Saloon used the cylindrical filter element common in that era (Fig. 2.2).

For all of the cars, a warm-up test was run before starting the WOT cycles. The warm-up cycle consisted of 5 minutes at 50 mph followed by 3 minutes at 30 mph. This 8-minute warm-up was always conducted on a warm engine (i.e., the engine had been run earlier that day). The acceleration WOT tests were run first, followed by the SS WOT tests. Five of each WOT test were conducted. The acceleration WOT tests used a procedure known as the modified Coordinating Research Council (CRC) E-60 protocol.[12]. The SS WOT tests were run by slowly accelerating the car to approximately 65 mph, where the dynamometer control was set to hold a fixed speed. Once the car speed reached 65 mph, the operator held this cruise condition for 10 seconds then opened the throttle to the WOT position for another 10 seconds. The car was then brought back to idle for 30 seconds, and the process was repeated. In all cases, the “new” air filter was a newly purchased aftermarket filter for that specific application. The simulated clogged air filter was another identical filter that was blocked off with a series of disposable shop towels to create the desired pressure drop. For the newer cars, the shop towels were placed in the air box on the upstream side of the air filter to increase the resistance of the air flowing through, as shown in Fig. 2.5. In the case of the 1984Super Saloon, the round filter was wrapped with shop towels to create the desired resistance, as shown in Fig. 2.6. Before the procedure for simulating a clogged filter was established, several filters were tested on the 2006Dodge. The OEM (Original Equipment Manufacturer) air filter was found to have a slightly higher pressure drop at WOT (Wide-open throttle) than several aftermarket air filters. The aftermarket filters were used for this testing to generate the largest difference between “clean” and “clogged” for these experiments. Other methods of restriction were considered before we decided upon the use of shop towels. The idea of using an orifice plate was decided against due to the fear of not having a consistent restriction across a range of flow rates or engine speeds. Loading the filter with particles such as soil or flour was not considered to be repeatable or feasible due to the handling issues that would result. Taping off sections of the filter could be used to accomplish the desired pressure drop; however, this approach would not result in uniform restriction across the full area of the filter. In addition, completely blocking off sections of the filter could affect the flow dynamics of the inlet system. Paint was also considered but rejected due to drying time, the inability to reduce pressure drop if set too high, and the potential for undesirable hydrocarbon emissions. Thus, the use of shop towels was adopted to generate a repeatable air filter pressure drop.

Fig. 2.2: 1984Super Saloon air filter

Fig. 2.3: 2006 Dodge Charger air filter.

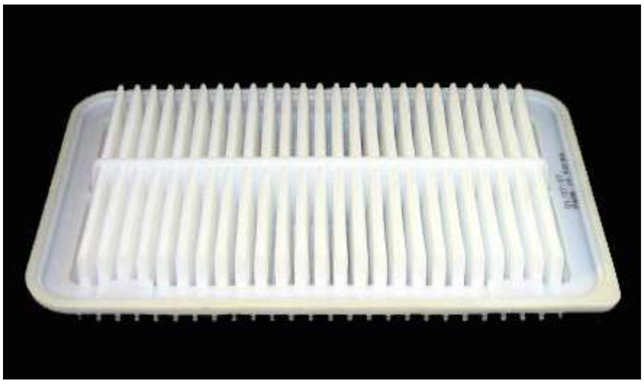


Fig. 2.4: 2003 Toyota Camry air filter.

Fig. 2.5: filter restriction. Shop towels inserted into air box upstream of the air filter.

Fig. 2.6: 1984Super Saloon air filter. Filter on the left shows damage that occurred during "severely clogged" filter testing

3. RESULTS AND DISCUSSION

3.1 MODERN CARS

3.1.1 Initial Testing

Four filter setups, an Original Equipment Manufacturer filter, an aftermarket filter, a performance aftermarket filter, and no filter, were tested, using the 2006Dodge Charger as the test car, to determine a baseline and the filter tobe 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. 3.1. 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.

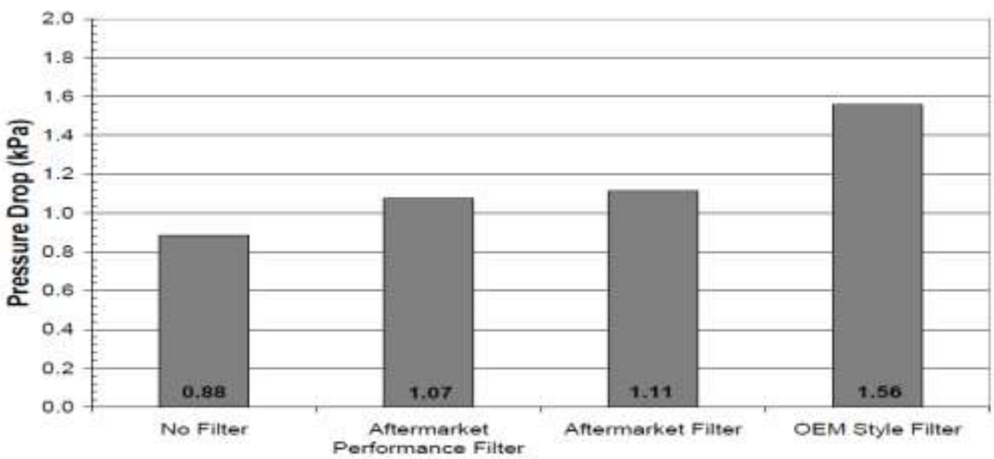


Fig. 3.1: Maximum Outlet DP for 2006Dodge Charger baselined clean air filters. Initial testing done to baseline multiple clean air filters.

3.1.2 WOT (wide – open – throttle) Testing

Each of the two newer cars was tested in the same manner to compare the effects of a clean versus a clogged filter. The cars are shown in Fig. 3.2. Each car was instrumented with the electronic delta P pressure transducers reading Inlet DP, Filter DP, and Outlet DP during testing. For the 2006 Dodge Charger, which was equipped with a 5.7L V8 with Multi-Displacement System, the clogged filter resulted in an increase of the Outlet DP. The Charger testing resulted in a maximum Outlet DP in excess of 7.5 kPa and approximately 7.2–7.5 kPa for the steady speed WOT tests. The multi-displacement system is Chrysler's cylinder deactivation system. This system disables the intake and exhaust valves and fuel delivery for four cylinders during low-load operation to reduce pumping losses and improve part-load fuel consumption. This system was monitored during testing by collecting fuel injector pulse width data from two injectors, one which is intermittently deactivated by the multi-displacement system and one which is not. For the 2003 Camry, which was equipped with a 2.4L I4, the clogged filter created an Outlet DP in excess of 6.2 kPa (Fig. 3.3), while the new filter produced less than 1.7 kPa under the same acceleration conditions. For the steady speed WOT tests (Fig. 3.4), the clogged filter created an Outlet DP in excess of 4.2 kPa, while the new filter generated approximately 0.5 kPa under the same acceleration conditions.

The data in Fig. 3.3 represent the Camry's average maximum Outlet DP recorded for the WOT.

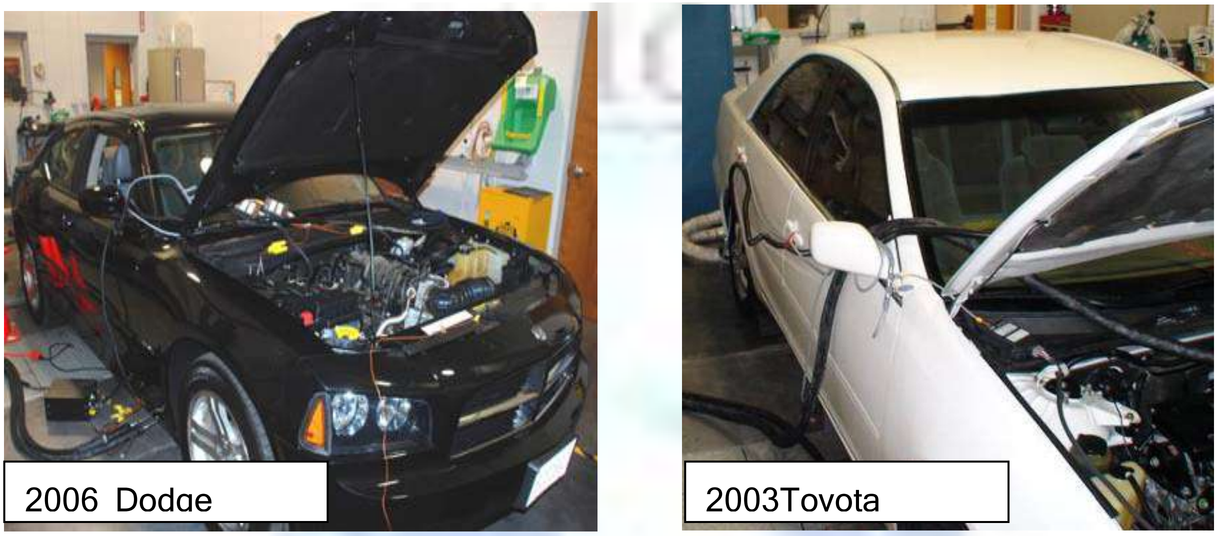


Fig. 3.2: Newer cars tested.

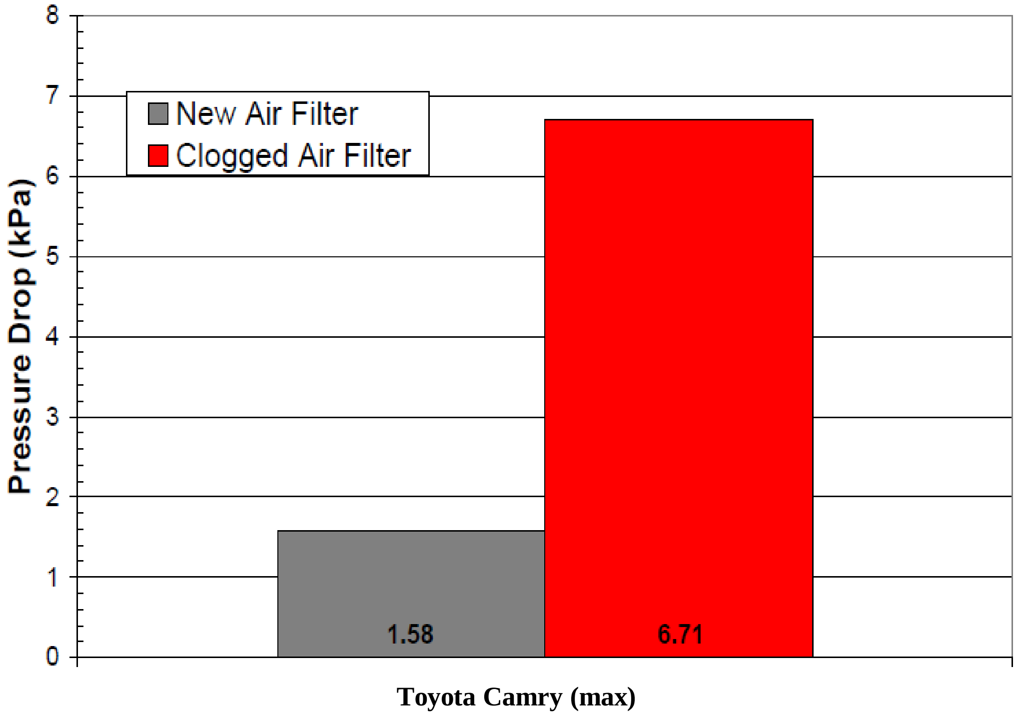
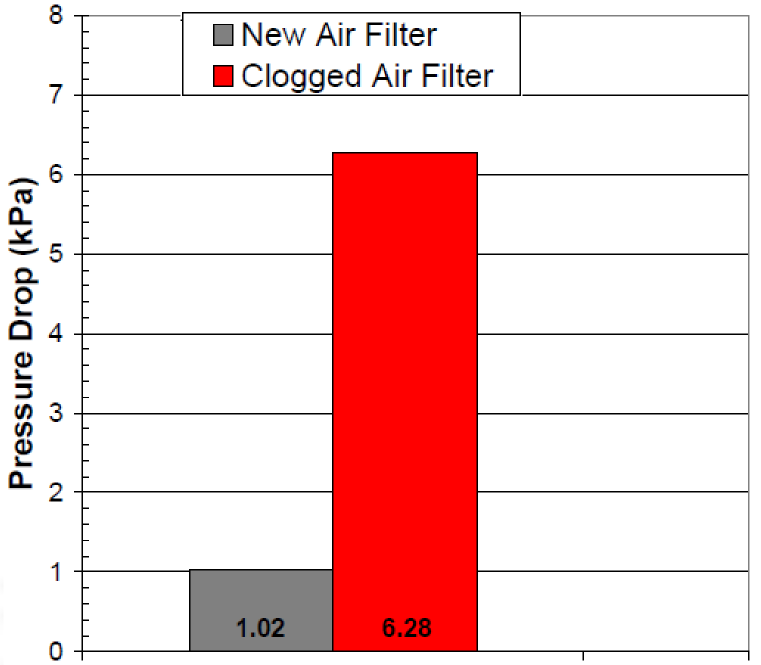


Fig. 3.3: Average maximum Outlet DP for the 2003 Toyota Camry.



Dodge Charger (3000 rpm)

Fig. 3.4: Average Outlet DP at 3000 RPM

The Outlet DP values for the steady speed WOT tests were all within the range of the sensor and are shown in Fig. 3.5.

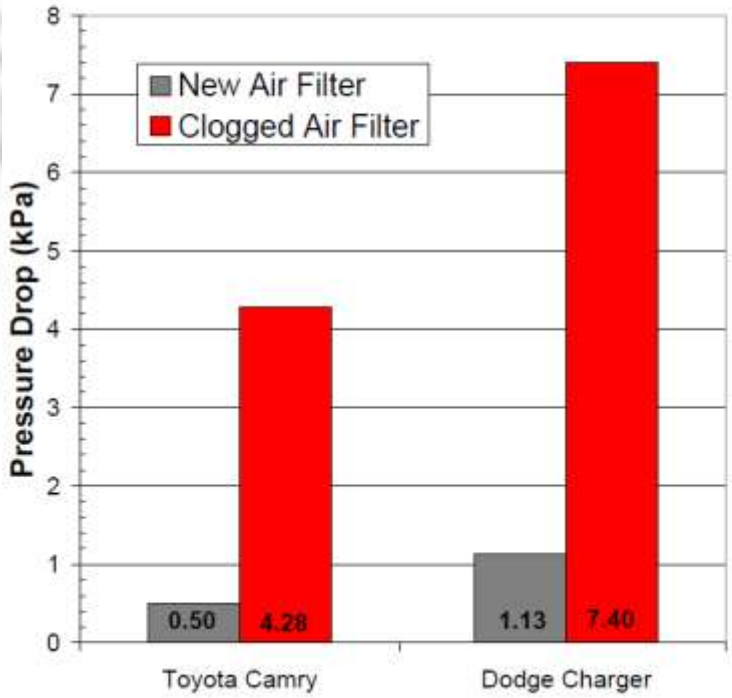


Fig. 3.5: Average maximum Outlet DP for steady speed WOT tests.

For the Charger, the Outlet DP at 3000 RPM during the initial acceleration WOT tests was in excess of 6.2 kPa for the clogged filter, while that for the new filter was less than 1.1 kPa under the same acceleration conditions (Fig. 3.4). During the steady speed WOT tests the clogged filter created an Outlet DP in excess of 7.2 kPa, while the new filter Outlet DP was less than 1.2 kPa under the same acceleration conditions (Fig. 3.5). Also, for the Charger, under these acceleration conditions with the filter clogged, the pressure drop was so severe that the air filter was actually dislodged from its position in the air cleaner box and pulled into the intake hose. Fig. 3.6 shows the damage that was done to the air filter as a result of these clogged air filter WOT tests. Figure 3.7 shows the acceleration times for the cars with both a clogged and new air filter. The data were analyzed from 20 to 80 mph to ensure that the car was at WOT, removing any driver induced variability. The WOT protocol requires the car to be accelerated at WOT from idle to 85 mph. The driver reported being able to "feel" the restriction created by the clogged filter and sense the decreased acceleration for the Camry. The Charger was 0.6 seconds slower in the clogged state, but the driver reported no noticeable decrease in acceleration.

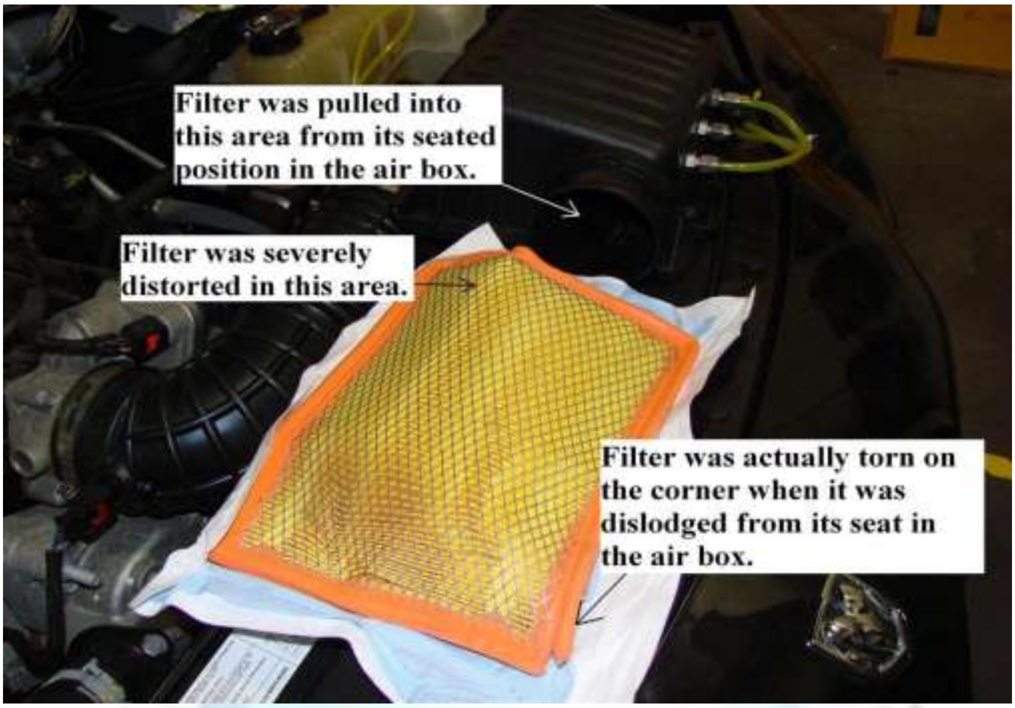


Fig. 3.6: Air filter damage from WOT testing 2006 Dodge Charger. Filter was damaged due to the pressure drop across the filter, resulting in the filter being torn out of its seat in the air box.

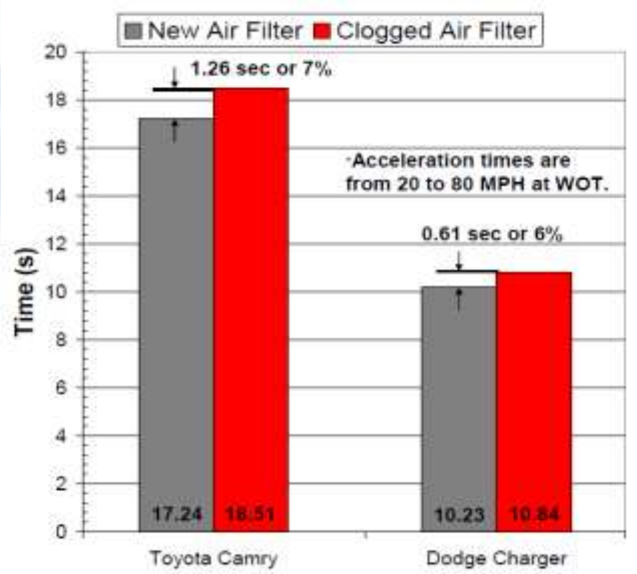


Fig. 3.7: Acceleration time for WOT tests.

3.1.3 Performance and Fuel Consumption

The simulated clogged filter significantly affected car performance, increasing the time to accelerate from 20 to 80 mph by 0.6 to 1.7 seconds on the twocars. The Outlet DP measured for each car was sufficient for setting a common air filter indicator to the "change" or "clogged" position. For each car, the Outlet DP at some point exceeded 5 kPa and showed an increase over the clean filter in excess of 2.5 kPa, a common standard for defining a dirty air filter. Despite the filter restrictions, however, no significant changes in fuel consumption were observed. Each car was run through at least three rounds of highway fuel economy test 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 car. This format was used to allow for the required soak time to perform a cold procedure each morning. The changes observed by clogging the air filter produced no significant effect on the fuel consumption of the cars tested, when tested over these two standard cycles that represent a wide range of driving conditions. It is possible that there may be some isolated operating conditions under which the fuel consumptions may be more susceptible to a clogged air filter. However, such operating conditions are not likely to be consistent from car to car. The two driving cycles used here are representative of a wide range of driving conditions.

3.2 CARBURETED CAR—1984 Super Saloon

To investigate the effect of a clogged air filter on a carbureted engine, a 1984 Super Saloon with a 2.8L I6 engine was also tested (Fig. 3.8). The Super Saloon was only instrumented with the electronic delta P pressure transducer reading the Outlet DP during testing, configured so that it measured the pressure after the air filter and referenced that to the ambient air pressure. This setup is shown in Fig. 3.9.

Fig 3.8: 1984 Super Saloon

Fig. 3.9: Pressure port location for1984 Super Saloon

The restriction level was set in the same manner as for the other cars. The shop towels were cut and taped to the outside of the round air filter used by the Super Saloon. This setup was used to correlate with the restriction that was applied to the other cars. The WOT cycles were both decreased from five accelerations to three accelerations each to minimize wear and tear on this vintage car. During the steady speed WOT tests, the maximum Outlet DP exceeded the range of the sensor. Both conditions would allow for a common air filter indicator to be set, indicating to the user that the car's air filter should be changed. Also, under these acceleration conditions with the filter clogged, the pressure drop was so severe that the air filter was crushed slightly in one area.

The Outlet DPs for the new filter and simulated clogged filter from the same fuel and steady speed WOT tests are shown in Figs. 3.10 and 3.11. The peak Outlet DP for the clogged filter is in excess of 7.5 kPa (the sensor is at its maximum range for each of the accelerations) while that for the new filter is less than 0.75 kPa under the same acceleration conditions. For the steady speed WOT tests, the clogged filter again showed an Outlet DP in excess of 7.5 kPa, while the new filter again showed less than 0.75 kPa under the same acceleration conditions. These results can be considered analogous to the Filter DP because the sensor was reading the post-filter pressure versus the ambient pressure. This means that, in both WOT cases, the clogged filter was exhibiting a pressure drop greater than 7.5 kPa across the air filter. Because of time constraints, we proceeded with testing rather than waiting to procure a sensor with a larger range

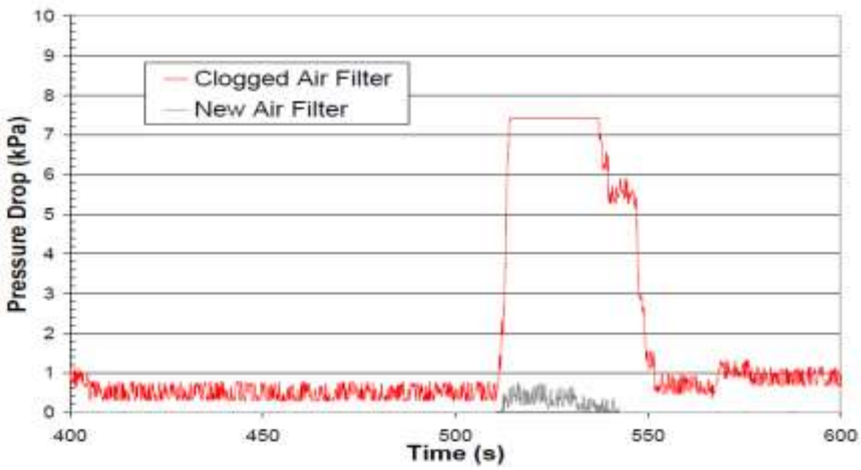


Fig. 3.10: Outlet DP for 1984Super Saloon

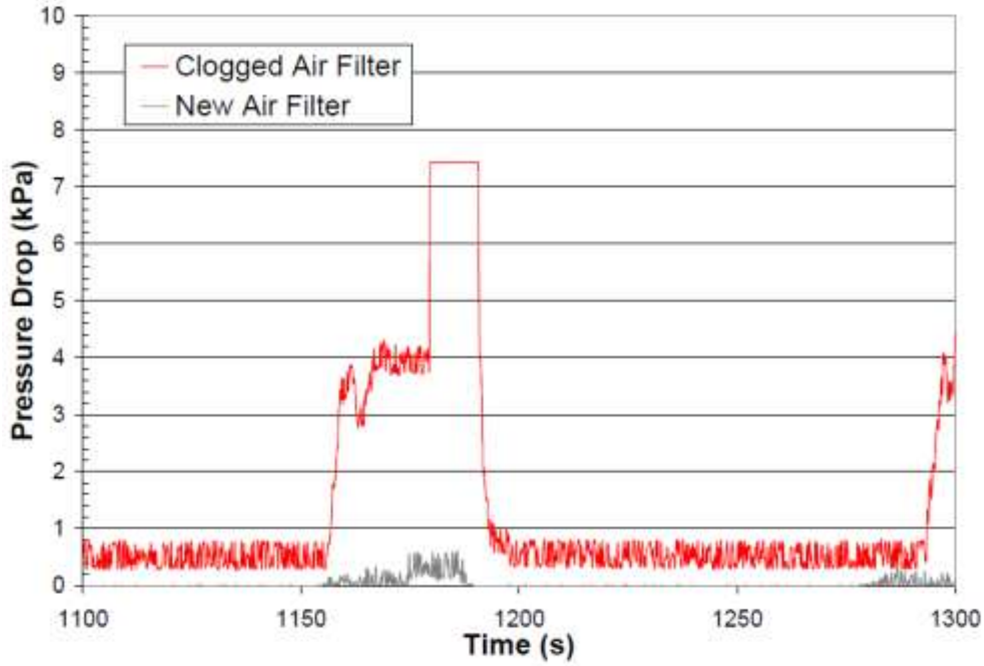


Fig. 3.11: Outlet DP for 1984Super Saloon during steady speed WOT

Figure 3.12 shows that in the clogged filter scenario, the average time it took to accelerate from 20 to 80 mph during the WOT tests increased by about 3.73 seconds or 23%. The driver reported a noticeable loss of performance during the WOT testing with the simulated clogged filter.

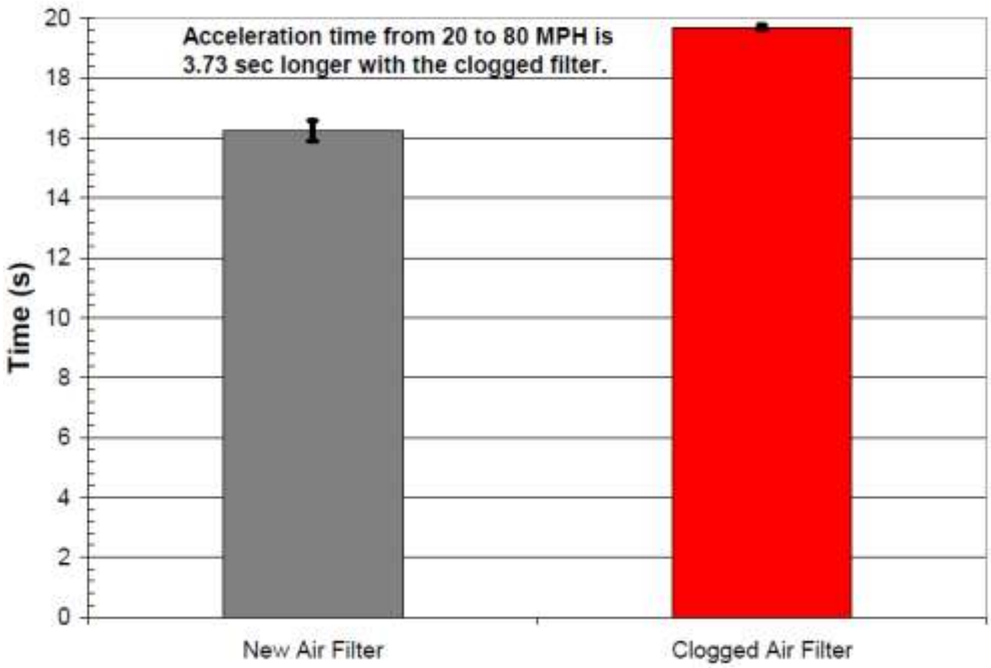


Fig. 3.12: Acceleration time for 1984Super Saloonduring WOT tests.

The Super Saloon was run through three rounds of fuel tests with the new air filter, and the same protocol was repeated with the clogged air filter. The Emission Test Cycle (US06) tests were not conducted after two failed attempts to complete that cycle with this car. The (US06) requires aggressive accelerations and has extended periods of high speed operation (up to 80 mph). The 1984Super Saloon overheated during these high speed sections. Therefore, to avoid damaging the car, the US06 tests were not conducted. This format was used to allow for the required soak time to perform a cold test each morning. The resulting fuel economy data for the Super Saloon are shown in Fig. 3.13. Test-to-test repeatability is within about 1.8% for the Super Saloon, and the new versus clogged cases show a drop of about 2%–2.5%.

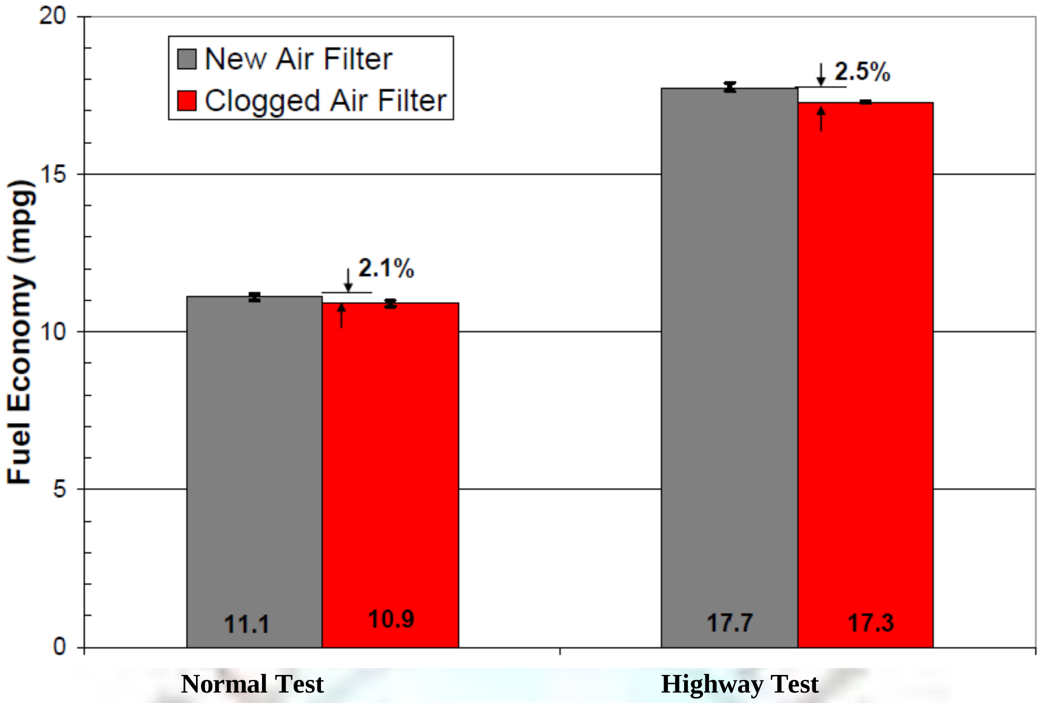


Fig. 3.13: Fuel consumption for 1984 Super Saloon. Data are averaged over the three tests conducted for each cycle and configuration. Range bars show the minimum and maximum for each data set

4. CONCLUSIONS

The goal of this study was to explore the effects of a clogged air filter on the fuel consumption of cars operating over prescribed test cycles. Two newer cars (2006 Dodge Charger, and 2003 Toyota Camry) and an older carbureted car (1984 Super Saloon) were tested. Results show that clogging the air filter has no significant effect on the fuel consumption of the newer cars (all fuel injected with closed-loop control and one equipped with Multi-Displacement System). The engine control systems were able to maintain the desired air fuel ratio regardless of intake restrictions, and therefore fuel consumption was not increased. The carbureted engine did show a decrease in fuel consumption with increasing restriction. However, the level of restriction required to cause a substantial (10–15%) decrease in fuel consumption, was so severe that the car was almost undrivable. Acceleration performance on all cars was improved with a clean air filter. Once it was determined how severe the restriction had to be to affect the carbureted car fuel consumption, the 2006Dodge charger was retested in a similar manner. We were not able to achieve the level of restriction that was achieved with the 1984 Super Saloon with the Dodge. The Dodge's air filter box would not hold the filter in place under such severe conditions.

(It is believed that this testing exceeded the design limits of the air box.) Tests were conducted at a lower restriction level (although still considerably more severe than the initial clogged filter testing), allowing the air filter to stay seated in the air box, and no significant change was observed in the Dodge's fuel consumption or the Air Fuel Ratio over the high way test cycle. Closed-loop control in modern fuel injected car applications is sophisticated enough to keep a clogged air filter from affecting the car fuel consumption. However for older, open-loop, carbureted cars, a clogged air filter can affect the fuel consumption. For the car tested, the fuel economy with a new air filter improved as much as 14% over that with a severely clogged filter (in which the filter was so clogged that drivability was impacted). Under a more typical state of clog, the improvement with a new filter ranged from 2 to 6%.

REFERENCES

[1]. Aithal, S. M. (2012). A Comparative Study of NOx Computation Methods Coupled to Quasi-Dimensional Models in SI Engines. ASME 2012 Internal Combustion Engine Division Fall Technical Conference, Vancouver, BC, Canada, American Society of Mechanical Engineers, ASME.
[2]. Cengel, Y. A. and M. A. Boles (2007). Thermodynamics: An Engineering Approach (SI Units). Singapore, Mc Graw - Hill Higher Education.
[3]. Mohanraj, T. and K. M. M. Kumar (2013). "Operating Characteristics of a Variable Compression Ration Engine using Esterified Tamanu Oil." International Journal of Green Energy: 285 - 301.
[4]. MRU (2005). Instruction and Service Manual: Flue Gas Analyser MRU 95/3 CD. Fuchshalde 8, 74172 Neckarsulm-Obereisesheim, Postfach 2736 74017 Heilbronn, MESSGERÄTE FÜR RAUCHGASE UND UMWELTSCHUTZ GMBH.

[5]. Radcliff, R. B. (2009). Small Engines. United States of America, American Technical Publishers, Inc.
[6]. Schilling, A.,1972," Automotive Engine Lubrication ", Scientific Publication (G.B.) LTD.
[7]. Stokov, I.,Sillame, Estonia, Private Communication 2002.
[8]. Peltz, A., Durst, M., Moser, N., and P. Trautmann, " Nanofiber coated filter media for engine air filtration, " Proceedings of the 4th International Conference, FILTRATION IN TRANSPORTATION, Stuttgart, Germany, October 5-6, 2004.
[9]. Myedvydyev, V. N., Nyevolin, V. F., and M. R. Kagan, "A Method of Pressure Drop Calculation in Cellulose – Type Filters for Dust Free Air and Under Dust Loading, " Engine Construction, No. 5, pp. 25-27,1984.
[10]. DIESEL PROGRESS North American Edition, November, 2008.
[11]. Baldwin Channel Flow Filters [Baldwin brochure- from 346], 2008.

AUTHORS

B.Sc. University of Technology–Baghdad / Mech. Eng. – 2005
MsD. Gazi University (Ankara) / Turkey – 2010
Specialist: Applied mechanic
Lecturer in College of Engineering / Kirkuk University

TIMURCHOBANKHIDIR

B.Sc. Mosul University / Mech. Eng. – Iraq – 1992
MsD. Gazi University (Ankara) / Turkey – 1998
Specialist: Heat Transfer
Lecturer in College of Engineering / Kirkuk University

ABBAS MOHAMMED ISMAEL

B.Sc. University of Technology–Baghdad / Chem. Eng. – 2006
MsD. Azerbaijan State Oil Academy (Baku) / Azerbaijan – 2010
Specialist: Refinery of Petroleum and Gas
Lecturer in College of Engineering / Kirkuk University

ALI HASAN ABDULLA