An Effect of Atmosphere on Fuel Economy And Air Consumption through Clogging of an Air Filter

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***Abstract*— Auto motive is self propelled power generating device which used atmospheric air to optimize the complete combustion of a fuel. In today's world utilization of automotive is increases as well as increase of pollution with industrial development. Recently due to increase in rapid development of industries increase the number of automotive used to achieve the requirement. To increase the efficiency expects of designing it should be focus to achieve a complete combustion of fuel to improve an efficiency of an engine. Efficiency of an engine depends upon combustion of a fuel that mainly depends upon the supply of Stochiometric air. Air is supplied through air filter but due to different climate condition clogging of air filter reduce the supply of an air. This reduction of air to engine leads to loss of fuel due incomplete combustion and increase economy loss.**

***Key word*- combustion, clogging of air filter, semi automatic cleaning air filter**

I. INTRODUCTION

Achieving fuel-efficiency in Internal Combustion Engines (ICE) is very crucial and important according to availability of fuel. In order to efficiently burn fuel in an ICE, you need the correct air-fuel ratio. For obtaining a correct air fuel ratio it should be supply clean air properly within requirement. Air filter is a part of air intake system and it is designed to achieve high, unrestricted air flow while maintaining filtration levels critical to ensure long engine life. Air filter plays a key role to improve performance of engine and its function is to clean the air before it gets into the engine's intake manifold system by retaining dust and other particles contained in air.

The air filter delivers clean air for certain duration of time after which it is needed to be cleaned for the optimum performance of engine it might need to be changed. The performance of air filter and engine efficiency vary with different atmospheric condition due to dusting and moisture by clogging of air filter. The atmospheric condition varies with varying region change the quality of the clean air. As example in desert area like Dubai and Saudi region dust particle is more compare to another region similarly in a coal mining presence of coal slurry in atmospheric air. As dust particles and other slurry type impurities will reduce the efficiency compare to another region atmospheric air. When an air filter gets clogged by dust and debris, air supply to the engine is reduced. This cause poor performance, high fuel consumption, reduction in supply of air, increase rate of restricted air flow and eventually will cause damage to the engine. Due to reduction of air flow the fuel mixture will be too rich to burn properly, and the engine can be starved of needed oxygen. In this research paper clogging condition was made by tapping according to size and dimension on filter to measure loss of fuel due to un burnt and economy loss

1.1 Problem occurs due to use of improper air filter.

- Black smoke in exhaust
- Rough Engine Noise
- Engine Back Firing
- Lower Gas Mileage
- Smell of Gasoline in the Exhaust
- Clogging of air filter

II. EXPERIMENT SETUP WITH DETAILED DESCRIPTION AND MEASUREMENT OF AIR FLOW UTILIZED FOR COMBUSTION

Fig experimental setup

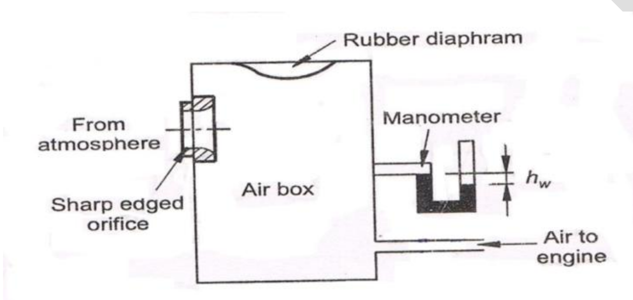
Table 1Experimental engine specification

Model	TATA 407 SP TURBO engine
Type	High speed, Water-Cooled direct injection ,naturally aspirated high pressurized diesel engine
No of cylinder	4 INLINE
Bore specification	97 mm
Stroke length	100 mm
Capacity	2956 cc
Compression ratio	17:1
Ideal speed	600 RPM
Maximum Speed	3000 RPM
Engine power	50 HP
Max Engine Output	75 HP @ 2800 rpm
Max Torque	225 at 1500 -1800 rpm

2.1Calculation of air flow requirement for engine through air filter (B1)

Air consumption of an engine can be measured by using the "orifice chamber method". In it consist of an air box fitted with a sharp edged orifice of known coefficient of discharge of 0.68.

Due to suction of the engine there is a pressure difference in the combustion chamber which causes the flow through the orifice for obtaining a steady flow. The volume of the air box or air chamber is large compared to the 400 to 500 times the swept volume with a provision of rubber diaphragm to reduce pressure pulsation.



Let

A_0 =Area of orifice in m^2

C_d =coefficient of discharge of orifice

ρ_a=density of air in kg/ m^3

ρ_w=density of water in kg/ m^3

h_w=head of water in cm

D =Diameter of Orifice in cm

Head in terms of meter of air

$H \times \rho_a = h_w/100 \times \rho_w$;

$H = h_w/100 \times \rho_w/\rho_a = h_w/100 \times 1000/\rho_a$

$= 10\, h_w/\rho_a$

The velocity of air passing through velocity

$V = \sqrt{2gH} = \sqrt{2g \times 10hw/\rho a}$ m/sec

The volume of air passing through the orifice is given by

$V_a = A_0 \times v \times C_d = A_0 \times v \times \sqrt{2g \times 10h\, w/\rho a}$

$= 14.01 \times A_0 \times C_d \sqrt{h\, w/\rho a}$ m^3/sec

$= 840.428 \times A_0 \times C_d \times \sqrt{h\, w/\rho a}$ m^3/ min

Let

Diameter of orifice: 60 mm

Area of a orifice A_0=0.2826 m^2

Coefficient of discharge C_d =0.68

Density of air $\rho_a = P_a * 10^5 / (287 * T_a)$

Density of air ρ_a=1.196 kg/m^3

Now

$V_a = 840.428 A_0 \times C_d \sqrt{h\, w/\rho a}$ m^3/min

$= 840.428 \times 0.2826 \times 0.68 \times \sqrt{h\, w/1.196}$

$= 147.678 \times \sqrt{h\, w} m^3$/min

Different clogging condition of an air filter by tapping

10 % clogged by tapping

20 % clogged by tapping

40 % clogged by tapping

70 % clogged by tapping

90 % clogged by tapping

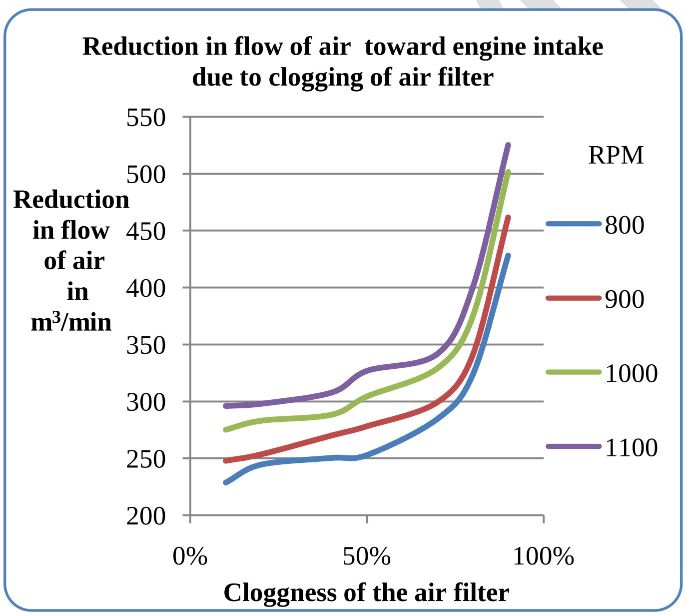
III. EXPERIMENTATION AND CALCULATION

In this section measurement of air flow is done by orifice chamber method and measurement of fuel is done by measuring time to fall of 10 ml fuel and fuel consumption is measured in mlpm. In this section air is measured for different condition of air filter and reduction in air flow is measured for different clogging condition of air filter.

3.1. Calculation of reduction in air flow due to clogging(tapping) of an air filter

Let for new filter
Before filter h_w=0.6 and after filter h_w=5.3 and according to difference air flow after filter is 225.59 m^3/ min and before filter is 114.391 m^3/ min respectively at 800 rpm. So the reduction of an air supply toward engine is the difference between them is 225.59 m^3/ min.
Similarly for other head Reduction in air flow due to clogging of an air filter for different condition of air filter by tapping is obtained in below table.

Different condition	Reduction in air flow to the engine intake due to clogging of air filter in m^3/min			
	RPM			
	800	900	1000	1100
New filter	225.59	241.265	269.641	292.977
10 % block	228.78	247.773	275.033	295.925
20 % block	244.318	253.324	282.212	297.984
40 % block	250.347	269.944	288.212	307.83
50 % block	252.951	278.172	304.456	326.801
70 % block	284.613	299.329	329.216	341.865
80 % block	323.693	341.102	375.062	400.649
90 % block	428.213	461.592	501.623	525.22



3.2. Calculation of loss of fuel due to increment in fuel consumption

Now taking new air filter as reference theoretical fuel consumption is derived
As supply of air flow is increase the fuel consumption is also increases to maintain the required air fuel ratio. So reduction in supply of air is inversely proportional to the fuel consumption
Rate of Reduction in flow supply =1/ (fuel consumption)
So
Rate of reduction × fuel consumption = constant

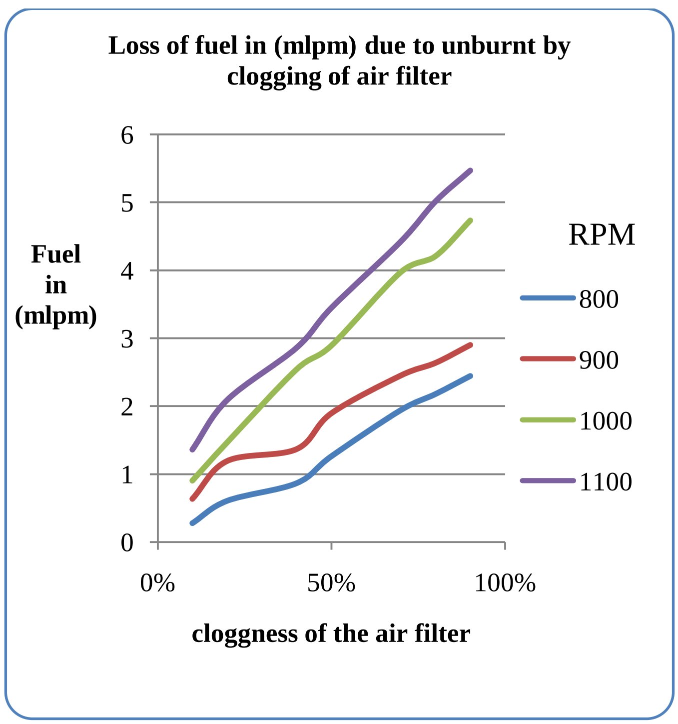
For a new filter at 225.59 m^3/min fuel consumption=18.74 mlpm

For 10% clogged at 244.318 m^3/min fuel consumption =? mlpm

Now
Rate of reduction × fuel consumption = constant
225.59×18.74=244.318×theoretically fuel consumption
Theoretically fuel consumption=18.47 mlpm, but actual fuel consumption is 18.75 mlpm. So it consume more fuel in mlpm equal to difference of actual SFC to Theoretically SFC

Thus for different condition at different rpm loss of fuel is measured as shown in below table

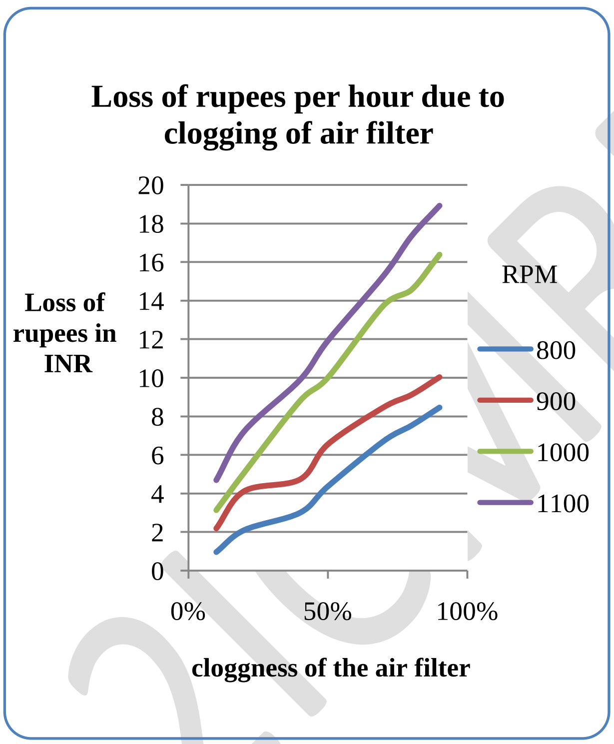
Sr no	Different condition	Loss of fuel due to un burnt fuel particle by clogging of an air filter			
		RPM			
		800	900	1000	1100
1	10 % block	0.2768	0.6366	0.9051	1.3588
2	20 % block	0.6059	1.1935	1.4666	2.0882
3	40 % block	0.8652	1.3683	2.543	2.8584
4	50 % block	1.2609	1.8944	2.8917	3.445
5	70 % block	1.941	2.4506	3.9733	4.4226
6	80 % block	2.1774	2.6364	4.2089	5.0134
7	90 % block	2.4428	2.9	4.7339	5.4677



3.3. Calculation of economy loss due to clogging of an air filter

Now according INR price of diesel is 57.70 of 1 litre. So, price of 1ml fuel is 0.0577 rupees
So for 1ml fuel loss per min loss of 0.0577 rupees.
So for 0.2768 ml fuel per min loss of 0.0577×0.2768=0.0173 rupees per min
Then loss per hour =60*0.0173=1.038
Similarly for different condition at different rpm economy loss is derived in below table

Sr no	Different condition	Loss of rupees per hour due to clogging of air filter			
		RPM			
		800	900	1000	1100
1	10 % block	0.96	2.20	3.13	4.70
2	20 % block	2.10	4.13	5.08	7.23
3	40 % block	3.00	4.74	8.80	9.90
4	50 % block	4.37	6.56	10.01	11.93
5	70 % block	6.72	8.48	13.76	15.31
6	80 % block	7.53	9.13	14.57	17.36
7	90 % block	8.46	10.04	16.39	18.93



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IV. CONCLUSION AND SUMMARY

As per studying about the different clogging condition about the air filter (i.e. different tapping condition) it seems that as jamming of the air filter due to dust and moisture remaining in the atmosphere it chock the way for air to flow and it provide restricted air flow to the engine. With a restricted air flow it is not able to provide dust and moisture free air to engine. That makes the engine starved for sufficient air and lead to incomplete combustion and be a cause of loss of fuel in the emission due to un burnt fuel. This un burnt fuel or loss of fuel due to incomplete combustion makes a economic loss and reduce efficiency of an engine. From the above three graph it seems that with increasing rate of cloggness at a different constant reduction of air flow toward engine increase and loss of fuel and economic loss also increases.

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  Page no 19.26 –19.27, Internal combustion engine V.M.DOMUNDWAR &A.V. DOMUNDWAR (B1)

Appendix A
List of experimental data

Sr. no	rpm	800			900			1000			1100		
	Clogging condition of filter	**h_w1 in cm**	**h_w2 in cm**	**T_{10}in sec**	**h_w1 in cm**	**h_w2 in cm**	**T_{10}in sec**	**h_w1 in cm**	**h_w2 in cm**	**T_{10}in sec**	**h_w1 in cm**	**h_w2 in cm**	**T_{10}in sec**
1	New filter	0.6	5.3	32.02	0.6	5.8	30.51	0.8	7.4	25.34	0.9	8.6	23.75
2	10 % tapped	0.6	5.4	32.15	0.7	6.3	30.24	0.8	7.6	25.82	0.8	8.4	23.66
3	20 % tapped	0.6	5.9	33.50	0.6	6.2	30.12	0.8	7.9	25.90	0.9	8.8	22.27
4	40 % tapped	0.6	6.1	33.80	0.7	7.1	31.66	0.8	8.1	25.16	0.8	9.2	22.30
5	50 % tapped	0.7	6.5	33.39	0.7	7.4	31.75	0.7	8.4	26.00	0.8	9.3	22.99
6	70 % tapped	0.6	7.3	35.74	0.7	8.2	32.79	0.7	9.4	26.51	0.8	10.3	23.01
7	80 % tapped	0.6	8.8	39.37	0.7	9.9	36.25	0.7	11.4	29.14	0.7	12.6	25.55
8	90 % tapped	0.6	13.5	48.74	0.7	15.7	45.52	0.6	17.4	36.10	0.7	19.3	30.67

Appendix B
Nomenclature

AFR	Air fuel ratio
D	Diameter of orifice
A_0	Area of orifice in m^2
C_d	Coefficient of discharge of orifice
ρ_a	Density of air in kg/ m^3
ρ_w	Density of water in kg/ m^3
h_w	Head of water in cm
H	Head in terms of meter of air
V	Velocity of air passing through orifice
V_a	Volume of air passing through orifice
H_{w1}	Head of water in cm in u tube manometer before filter
H_{w2}	Head of water in cm in u tube manometer after filter
T_{10}	Time required for 10ml fuel consumption