Bulletin of the *Transilvania* University of Braşov • Vol. 2 (51) - 2009
Series I: Engineering Sciences

FAN CHARACTERISTICS DETERMINATION FOR 392 L4 DIESEL ENGINES

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Abstract: *This paper is based on an experimental method regarding the determination of fan absorbed powers and air flows produced by two different types of fans fitted on a diesel engine manufactured by Roman Truck company. There were performed specific tests on the engine and fan dynamometric test-bench, in order to find out which type is more convenient regarding consumed power and air f low demand.*

Key words: *axial fans, air flow, consumed power.*

1. Introduction

Internal combustion engines convert in mechanical power only one third of fuel energy while the rest is lost as heat in the ambient air. Around another third must be extracted from engine cylinders by the cooling systems. For heavy–duty applications the driving of engine cooling system requires a significant power, most consumed by fan. A source of fuel economy could be the appropriate match of the fan-radiator-engine which must be optimized in terms of minimum fan absorbed power at maximum allowable air flow. So, for a given diesel engine, 392-L4-DTI, the fan-engine match is studied using engine and fan dynamometers. Regarding engine codification, 392-L4-DTI, the first group of figures represents the engine displacement 3.92 l, cylinder configuration and number, namely – in line cylinders and 4 cylinders; group of letters DTI represents type of injection (Direct injection), type of supercharging (Turbocharged) and intake air cooling (Inter-cooled). There were performed comparative tests with two fans, one made of steel sheet having reference number 89.06601.5028 and dimensions (diameter, no of blades, blade width) ø460 x 6 x 80 and the other made of plastic having reference number 59.06601.4000 and dimensions ø470 x 9.

2. Test Procedure

The tests were performed at S.C. INAR Brasov as engine speed test at full load and fan air flow test on a continuous current test bench type DS 1146 – 4k / V of 300 kW power as well as fan power absorbed test on a continuous current test bench type DS 742 – 4 / N of 65.5 kW. The testing equipment included dynamometric brakes MEZ - VSETIN, for engine torque and fan power, fuel consumption meter ACG; electronic tachometer and anemometer.

The engine was fitted with a package of two radiators - water-air radiator with reference 89.06101.6106 and intake air cooler, having the reference 59.09501.6001. The test conditions were as mentioned in table 1.

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Ambient parameters Table 1

Test	Fan absorbed power	Fan air flow
Ambient temperature [°C]	15	5
Atmospheric pressure [mm Hg]	698	709

The air flow was determined measuring average air speed passing through the radiator using an anemometer on the frontal radiator surface which for this purpose was divided into 9 sectors. As air intercooler is placed behind water radiator the points 1, 2, 3, 7, 8, 9 are situated on frontal radiator areas without the overlapping of the air-intercooler while points 4, 5 and 6 represent the overlapping areas of radiators. The following test procedure was performed [5]:

a. Engine speed curve at total load;
b. Air flows driven by both fans through the package of radiators;
c. Fan absorbed powers versus speed.

a. The main engine performance fitted with steel sheet fan is presented in table 2.

Engine parameters Table 2

Parameter	Value
Rated power	121.6 HP (93 kW) -5 %
Rated speed	2600 ±50 revs/min
Maximum torque	439 kgfm ± 5 %
Maximum torque speed	160 ±50revs/min
Minimum specific fuel consumption	167 g/HPh

b. Air flows were determined measuring air speed in each of 9 rectangular sections of frontal water radiator surface. It is worthy to mention that fans were mounted on the water pump with transmission ratio crankshaft-water pump of 1:1.4, the fan being belt-driven. The values are presented in table 3 for plastic fan (59.06601.4000) and in table 4 for steel sheet fan (89.06601.5028).The average air flow is represented in fig.1 for both fans.

c. Fan absorbed powers are presented in fig.2.

Air speeds for plastic fan Table 3

Engine speed (revs/min)	Fan speed (revs/min)	Air speed in measurement points (m/s)								
		1	2	3	4	5	6	7	8	9
1200	1680	4.59	4.85	5.02	3.11	3.04	3.17	4.66	5.51	5.58
1600	2240	6.24	6.24	6.77	3.77	4.26	4.29	6.08	7.30	7.30
2000	2800	7.59	8.06	8.32	5.02	5.15	5.32	7.59	8.88	9.28
2400	3360	9.41	9.38	9.74	5.75	6.08	5.84	9.44	10.86	10.93
2800	3920	10.50	11.03	11.03	6.87	7.33	7.43	10.23	12.28	13.17
3000	4200	10.60	11.45	11.72	6.97	7.79	7.56	10.86	12.97	12.87

Air speeds for steel sheet fan Table 4

Engine speed (revs/min)	Fan speed (revs/min)	Air speed in measurement points (m/s)								
		1	2	3	4	5	6	7	8	9
1200	1680	4.26	4.39	4.26	2.74	2.78	2.68	4.13	4.59	4.82
1600	2240	5.71	5.88	5.91	3.70	3.70	3.70	5.51	6.44	6.37
2000	2800	6.54	6.80	7.03	4.26	4.62	4.36	7.00	8.35	8.06
2400	3360	8.29	8.32	8.52	5.05	5.61	5.45	8.52	9.80	9.51
2800	3920	9.67	9.74	9.47	6.24	6.74	6.37	9.71	11.75	10.70
3000	4200	10.20	10.30	10.37	6.80	6.93	6.74	10.30	12.28	11.72

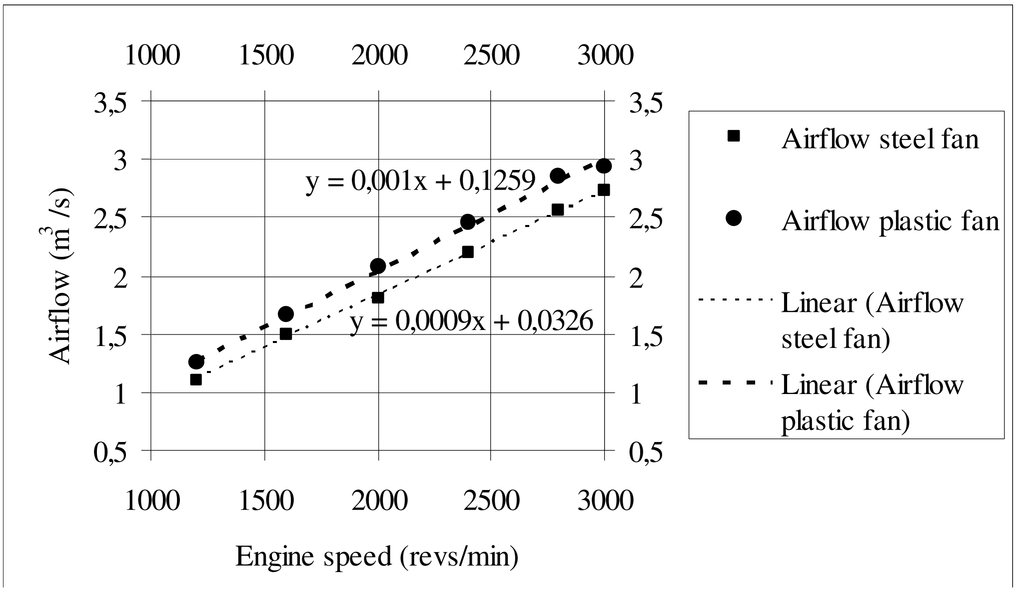

Fig.1. *Fan airflows versus engine speed*

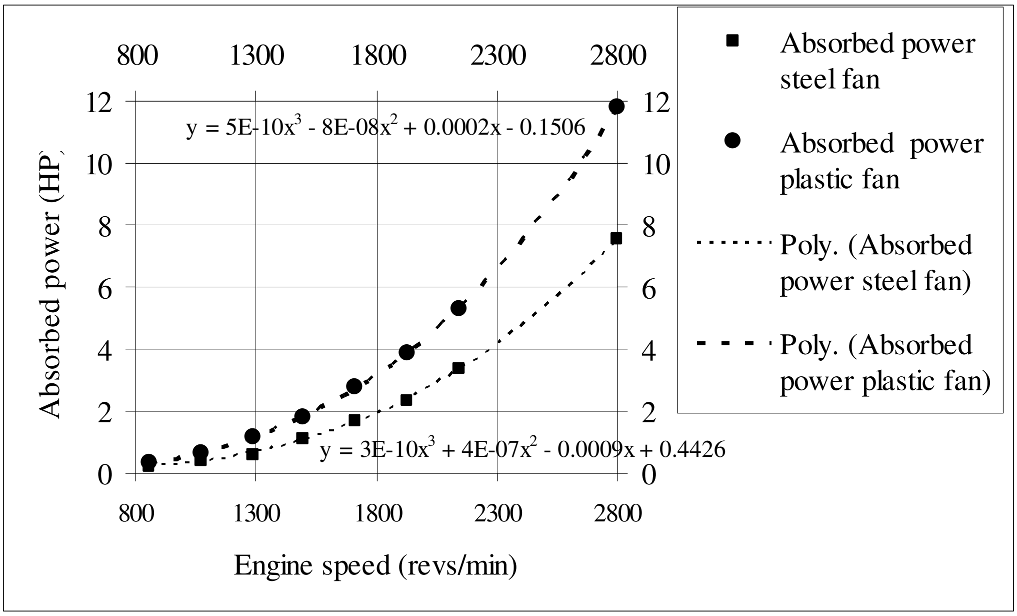

Fig.2. *Fan absorbed powers versus engine speed*

3. Data Interpretation

The interpretation of results from table 3 and 4 shows average air speeds increasing with speed. The air flows are obtained by multiplication with frontal area of radiator $S=0.286m^2$ .The air speeds in points 4, 5 and 6 are considerably smaller than in rest of measurement points (for example for plastic fan at speed of 1200 revs/min the average of speeds in points 4, 5 and 6 is 3.1 m/s and the average of the rest of points is 5.03 m/s showing high air dynamic resistance when passing through air cooler.

The effect of dynamic resistance is the same for both fans (for example for steel sheet fan at speed of 1200 revs/min the average of speeds in points 4, 5 and 6 is 2.73 m/s and the average of the rest of points is 4.41 m/s) and the ratios of average air speeds are approximately equal. From fig.1 it can be observed that plastic fan generates a higher air flow than steel fan, in average with 12.5%; also the air flow varies linearly with engine speed.

From fig.2 it can be noticed that plastic fan consumes (absorbs) a higher power than steel sheet fan, in average with 66%; also the absorbed power correlates well with the third order polynomial in function of engine speed as literature mentioned [1, 2].

The fan driving power is indicated in literature [4] as being limited to 8.5% from engine brake power. From investigated measurements and previous research on mechanical power loss it resulted that mechanical power loss for steel fan drive varies between 1,2% at 1200 revs/min up to 6.8% at rated speed, below the value of 8.5%.For plastic fan the value is exceeded reaching 10%.Knowing mechanical power loss measured by motoring [3] it was possible to determine the percentage of fan consumed power from power loss, which varied for steel sheet fan between 7% at 1200 revs/min up to 16% at rated speed. For plastic fan the values ranged from 10% up to 24%.Further research will aim to create a data base of fan characteristics for a rapid match engine- fan and to consider also the fan noise level of each application.

4. Conclusions

An optimum trade-off must be reached according to engine and vehicle use. The selection of appropriate fan can be done considering the experimental tests. The plastic fan has a higher power consumption producing a higher air flow meanwhile the steel sheet fan consumes lower power, but with lower air flow. Usually for vehicle use the power consumption is limited and in stationary applications the demand of air flow is higher

The dependency of power and air flow to engine speed are confirmed, being formulated curves by polynomial regression useful to determine for every operation mode the fan power and air flow through the radiator .

Acknowledgements

The author wishes to thank to group of research engineers from SC INAR Brasov who participated to experimental measurements: Andrei Gal, Cezar Adam, Dorel Turcu, Petru Paler and Adrian Neamțu.

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