

Test Performance of Small Diesel Engine Suitable for Small Scale Farming in Bangladesh

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Abstract

A small diesel engine made in Germany was tested to find out the relationship of torque, power output, brake specific fuel consumption, and noise level with engine speed under different loading conditions. A contour map of the brake specific fuel consumption versus engine speed under different loading conditions was constructed using a radar chart system based on test data. Output power increased from 1.32 kW to 4.05 kW and then decreased with the increase of rpm of the engine. This contour map gives quicker information to the farmers about brake specific fuel consumption at different speed of the engine. For this particular engine, the minimum BSFC was 260 g/kW-hr at 1400 rpm.

Keywords: Contour map, Torque output, Brake specific fuel consumption, Noise level.

1. Introduction

Test and performance evaluation procedures of small powered diesel engines are not available to farmers as well as to traders of Bangladesh (Hussain, 1996a). Here small powered diesel engines mean those having brake power (b_p) ranges from less than 1 kW to 7 kW. Test reports of Nebraska, European Community, Mercedes and RNAM are available. But these are confined for engines having more than 20 kW (Sarker et al., 1995; Islam, 1992 and Hussain, 1995). RNAM procedures are not complete and lack of procedures to evaluate the parameters in details. Some farmers in Bangladesh are using engine power for their agricultural activities owing to shortage of draft power (Mostafa, 1997). They use engine power mainly for tilling operations, threshing, irrigation, hulling, transporting agricultural goods and power generation at night.

Farmers do not know which work needs how much power. They also do not know which type of engine will be suitable for them in-terms of economic considerations and longevity.

Considering the farmer's problem in using engine power a study was undertaken to determine the different parameters relating to engine performance. Engine performance in terms of relationship between power, speed, smoothness or noiselessness in operation was considered for this study.

The following objectives were considered for the study:

- i) To find out the relationship of torque, power output and brake specific fuel consumption (bsfc) with engine speed
- ii) To study the noise level under varying operating conditions

2. Methodology

A 5 kW diesel engine made of Germany was installed firmly on a portable test stand to measure the speed, torque, brake power, fuel consumption and noise level. Detachable fuel tank (can) was placed on an electronic balance to measure the rate of fuel consumption by the engine under the operating conditions. Sensors were directly connected to the recording computers (dynamometers and strain gauges) to record the engine speed, torque, and brake power, fuel consumption, and time and sound of exhaust gas. All data were replicated five times to get unbiased results.

Weinlich GMBL & CO., Industriestr. 6, D-68799 Reilingen, Germany has developed engine test beds with different sizes of dynamometer having personal computer with cardan shaft for measuring upto max 3000 Nm and calibration set 1000 Nm, supporting beams, exchangeable protecting housing for the cardan shaft (Hussain, 1996b). The setup was consisted of cardan shaft of length was 0.48 m, damping couplings, programmable torque limitation arrangement, and fuel consumption metering having precision balance with tank of 10 litre capacity for determination of the fuel consumption with 5 m data cable. The system prints or plots the performance data such as, time, revolution, moment or torque, brake power, fuel

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consumption. Physical properties of diesel fuel were determined in the application laboratory of the department of Agricultural Engineering, University of Hohenheim, Germany. The exhaust gas sound was measured with the help of a sound level meter. The experimental setup for measuring engine performances is shown in Fig.1.

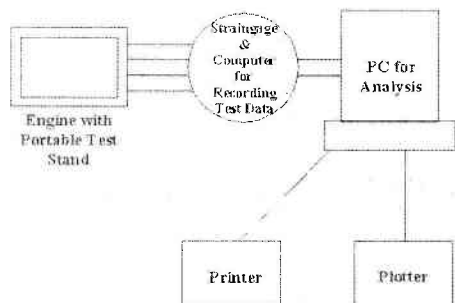


Fig. 1. Experimental setup for measuring engine performances

The physical characteristics of the diesel fuel used in the experiment were determined under normal procedure. Calorific value of diesel fuel was measured using a bomb calorimeter. Flash point is the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of the liquid. Flash points are determined experimentally by heating the liquid in a container and then introducing a small flame just above the liquid surface. The temperature at which there is a flash/ignition is recorded as the flash point. Viscosimeter was used to measure the viscosity of diesel fuel. The results are shown in Table 1.

Table 1 Physical characteristics of diesel fuel

Parameters	Value
Density	0.85 g/ml
Viscosity	4.7 mm ² /sec
Calorific value (CV)	43.6 MJ/kg (37.1 MJ/l)
Cetane Number	51.3
Flash point	60°C

3. Results and Discussion

3.1 The Revolution per Minute and Torque

The revolution per minute (RPM) was varied from 870 to a maximum upto 3000. Normally the farmers of Bangladesh use these speeds to perform different agricultural activities. The change of torque during the change of engine speed towards higher direction was more or less uniform and may be fitted to a linear condition. The torque varied from 6.75 Nm to 8.10 Nm for the engine rpm form 870 to 3000 respectively. The experimental results

are shown in Fig. 2. The performance curve of torque and revolution gives the following equation $Y = 5.3462 + 0.0025 X - 5 \times E (-07 X^2)$ $R^2 = 0.8435$

3.2 Power Output and RPM

During the experiment, power output and the corresponding RPM were recorded. The results obtained are shown in Fig. 3. The power output increased from 1.32 kW to 4.05 kW and then decreased with the increase of rpm of the engine and it could not continue to produce power due to high load. The performance curve of the power output and rpm follows the equation

$$Y = -1.922 + 0.0042X - 7 \times E (-07X^2)$$

$$R^2 = 0.9881$$

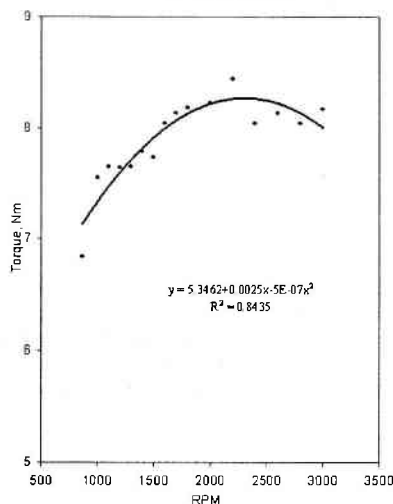


Fig. 2. Relation between RPM and Torque

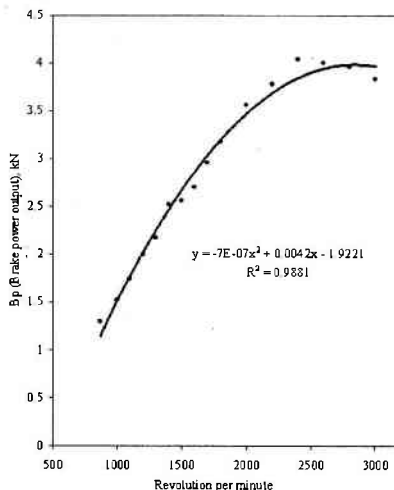


Fig. 3. Effect of engine speed on power output

3.3 Brake Specific Fuel Consumption and RPM

The brake specific fuel consumption (BSFC) at low engine speed was high and it decreased with the increase of engine revolution per minute. At RPM between 2000 to 2500 the engine produced high power at low specific fuel consumption. The experimental results are shown in Fig. 4.

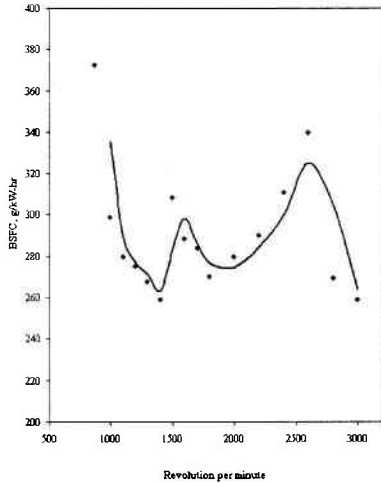


Fig. 4. Effect of engine speed on brake specific fuel consumption (BSFC)

3.4 Contour Map of BSFC and RPM

Fig. 5. describes the ideal contour map of the BSFC and RPM of the engine. The owner of the engine to run his engine very economically can use this map. As the fuel price is increasing very rapidly, this map can be used to choose the appropriate engine rpm and the corresponding specific fuel consumption. This will give the low fuel consumption for specific activities in the field. The end users are farmers will understand this map better than the figure 4

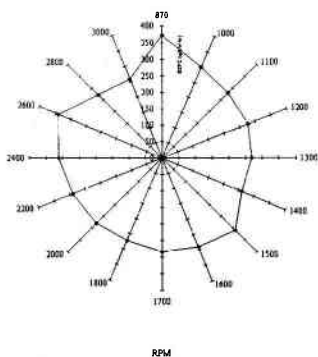


Fig. 5. Contour map of BSFC (g/kWhr) and RPM of a 5 kW diesel engine

The noise level of the exhaust gas at the exit of silencer pipe was recorded during the performance test and the results are shown in Table 2.

Table 2. Engine revolution and noise level

Engine RPM	Sound level dBA	Allowable time to use (hr)
870	65	12
1000	88	8
1500	97	6
2000	100	4
2500	102	3
3000	107	2

Table 2 shows that sound level was directly influenced by the engine speed. At low engine speed, the operator could use the engine for a long time in comparison to high engine speed without any hearing problem or any hearing aid.

4. Conclusion

The following conclusions are drawn on the basis of the results obtained in the study:

- i) The small engine can be run at the speed ranges from 1800 to 2200 rpm to get lower brake specific fuel consumption (bsfc) and at this range of rpm, higher torque and brake power could be obtainable.
- ii) The contour map will give the excellent information to the farmers for selecting engine speed for obtaining lower specific fuel consumption at different farm works.
- iii) Small engines are used in operation of irrigation pump, thresher, sprayer, country boat etc. The RPM should be adjusted in the range between 1800 to 2200 for smooth and less noisy operation. The operator can use the engine for long hours without having any problem in the hearing organ.

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