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TEST PERFORMANCE OF DIESEL ENGINE SUITABLE FOR MULTIPURPOSE USE AS PRIME MOVERS IN BANGLADESH

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ABSTRACT

A 9 kw SIFANG diesel engine made in China was tested by hydraulic dynamometer to find out the power performance in different loading condition. A hydraulic dynamometer was installed in Farm Power and Machinery Departmental Workshop, Bangladesh Agricultural University, Mymensingh for testing of diesel engines. Maximum brake power of the engine was found to be 7.36 kW at no load engine speed of 2000 rpm and at maximum brake power corresponding loaded speed was 1900 rpm. When the engine was started at no load speeds of 1800 rpm and 1550 rpm, then brake power were found to be 6.0 kW and 4.6 kW respectively and corresponding loaded speed were 1680 and 1410 rpm respectively. Maximum torque of engine was found to be 38 N-m, 35 N-m and 32 N-m at no load speed of 2000, 1800 and 1550 rpm respectively. Name plate rating of engine was 9 kW at 2000 rpm. Minimum specific fuel consumption of the diesel engine was found to be 0.27 to 0.31 l/kWh in brake power range of 5.28 kW to 7.36 kW and loaded speed of 1710 to 1940 rpm respectively while starting no load speed was 2000 rpm. In this study, brake power output of SIFANG engine was observed 18% lower than rated maximum output. The findings in the study show that, there exist needs for testing engines for overall performance, so that user can extract maximum benefit from an engine.

Key wards: *Break power, diesel engine and hydraulic dynamometer.*

INTRODUCTION

Diesel engine plays an important role in supplying power for mechanization of agriculture in Bangladesh. Acceptance of diesel engines in agricultural sector throughout the country is increasing due to multipurpose use as prime movers of tillers, rice mills, pumps, threshers, harvesters, boats, trolley etc. To drive a machine, power must be supplied in the mechanical form i.e. application and movement of a force or torque, in accordance with the requirement of machine, it is driving.

Demands of small to medium sized engine in agricultural activities are increasing rapidly. But, there are complaints from field level that performance of these engines are not good in quality as well as not delivering rated power. Therefore, some standardization, testing of these engines is being felt today. Fundamental purpose of testing of agricultural machinery is to inform users about relative merits of different machines, as an aid to evaluation and selection of most appropriate machine from those available. Such information should, therefore, relate as closely as possible to specific needs of individual farmer. An additional purpose may be to help farmers in formulating new or improved mechanized farming system possibly involving use of alternative power sources. Prospective buyers and users of agricultural machinery are generally less educated or/and less sophisticated as compared to buyers and users of non-agricultural machinery of similar value and they are more in need of independent and important organization for testing and evaluating farm machinery in their interest (Farouk, 1992).

Agricultural machinery started coming into Bangladesh in mid-sixties as a part of efforts towards reaping benefits of 'Green revolution'. A large number of irrigation and land preparation machines were planned to be imported and Bangladesh Agricultural Development Corporation

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(BADC) had to make choice amidst a large number of makes and models offered by many vendors. Need of testing and standardizing imported agricultural machinery in the country and assuring availability of after-sales services began to be felt by all concerned.

Test and performance evaluation procedures of diesel engines are not available to farmers as well as to traders of Bangladesh (Hussain, 1996). Test reports of Nebraska, European Community, Mercedes and RNAM are available.But thes are confined for engine having more than 20kw (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 due 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.

Machinery selection implies that a potential user makes a choice based on information relating to profitable performance of competing machines. Information relating to technical performance, machine profitability, compatibility and sustainable use should be available in form according to user's circumstances and under their control. A user requires information on comparative performance of complete range of available machines, tested in field conditions which are similar to one's own and reported in user-friendly terminology and format. To meet farmer's demands for comparative information on in-field performance of different machines, it is necessary to complement functional tests with field or workplace tests. Functional testing is the process of assessing and reporting construction and performance of a machine/equipment using specified objective procedures in repeatable conditions. On other hand, field testing complements functional testing by assessing performance of a machine/equipment in working conditions typical of those for which, it is offered for sale. The machine's performance will be compared with that of standard references (name plate information's). In this study, functional testing of power performance had been undertaken.

Customers/ users do not know which power works needs how much power. They do not know which type of engine will be suitable for them in terms of economic considerations and longevity. Considering the users' problem a study was undertaken to determine the performance of under different loading conditions. The objectives of this study are as follows:

i) To find out the output power of SIFENG engine at different loading condition
ii) To study the relationship of torque, power output and break specific fuel consumption with engine speed

MATERIALS AND METHODS

This study was undertaken to find out the output power of diesel engine at practical condition. The experiment was conducted in workshop of Department of Farm Power and Machinery (FPM), Faculty of Agricultural Engineering and Technology, Bangladesh Agricultural University, Mymensingh-2202. The experiment was conducted during 16 January to 30 April, 2002. To conduct the experiment mainly required tested engine, dynamometer and cooling pump. The specification of test engine, required dynamometer and pump are:

Engine	**Dynamometer**	**Cooling pump**
Mode: S195GXK06-1051107 Type: 4 cycle horizontal diesel engine No of Cylinder: 1 Out power : 9 KW Rated speed : 2000 rpm Combustion : Pre- combustion Cooling : Water cooling Manufacturer : Zhejang Sifang Group Corporation China	Mode: TD 315 VI The electronic load cell converted signal 4 to 20mA and with digital display, range: 0 to 175 N-m. Maximum Brake power : 80kw Maximum speed : 7000 rpm Direction of rotation : Clockwise or counter clockwise Water supply : connection 20 mm, pressure 2 bar, flow rate 0.6 l/s	Mode: Pedrollo pump CPMI 58 Discharge rate : 10-90 liter/min Head range: 20-24 meter Power : 0.75 KW Voltage : 240 V Frequency: 50 Hz

Hydraulic dynamometer

A dynamometer is an instrument for determining power, usually by independent measurement of force, time, and distance through which force is moved. There are hydraulic dynamometers, which absorb power by fluid friction. One common arrangement is similar to a centrifugal pump, except that casing instead of being rigidly fixed to a bed plate and is freely supported on propeller shaft. It is restrained from rotating by an attached arm. Restraining moment in brake arm is measured by platform or spring scales. Energy absorbed results in water heating in dynamometer. To prevent it from boiling, it must be steadily renewed. Thus energy is carried off in a stream of water entering dynamometer cool and leaving warm. Hydraulic dynamometer operates on the principle of converting work into heat. Working medium, usually water, is circulated within housing and because of friction, comes out at a raised temperature than when it entered. The outer casing, which is free to rotate about shaft, is connected to restrain by torque arm. With exception of bearing friction torque produced is equal to that supplied to dynamometer. Since torque on a hydraulic dynamometer increases with cube of speed, it is desirable for handling open throttle tests where speed is controlled by load.

Experimental setup for measuring engine performance

Chinese 9 kw engine was installed on a portable test stand to measure the speed, torque and fuel consumption. The hydraulic dynamometer was setup on the base frame. Cooling the hydraulic dynamometer a pump was installed. After setting up of hydraulic dynamometer and pump, connected the coupling the inlet of water of dynamometer to the water feed by means of a flexible pipe to the pump and suitable to bear the maximum feeding pressure as well as pressure gauge is attached to the delivery pipe of pump (i.e. inlet pipe of dynamometer) so that control the suitable feeding pressure by means of flow control value. And connected the coupling the outlet of the hydraulic dynamometer by means of 38.1 mm dia. flexible pipe suitable to stand the maximum temperature around 70^{0}C. The hydraulic dynamometer and pump were connected to the electric supply with single phase with earth plug. In Fig. 1 the experimental setup of the installed hydraulic dynamometer for testing engine performance.

The engine was set up on the test bed for testing the engine by adjusting the base frame according to the engine bed plate. Different size wooden block were used for maintaining the required height of the test bed.

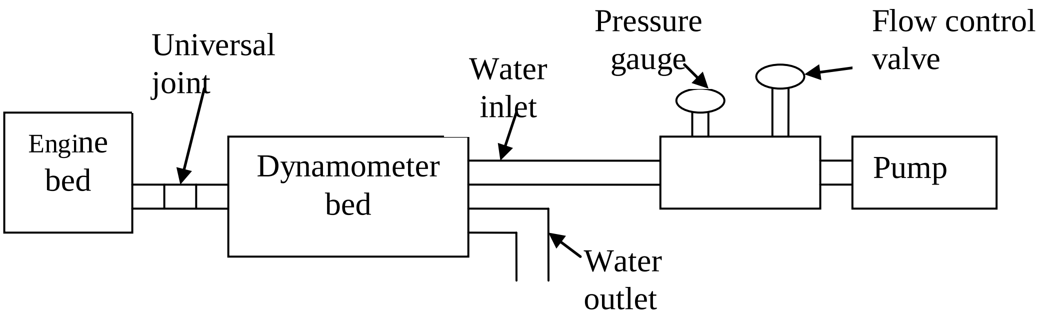

Figure 1. Schematic diagram of the installed hydraulic dynamometer

Set up of universal joint

To measure power of tractor, power tiller, different engines and motors, PTO shaft of tractor, fly wheel shaft of engines are required to join with shaft of dynamometer and this joint have to be perfectly lined-up. Perfect alignment of engine shaft with dynamometer shaft is very difficult and to overcome this problem, a universal joint was connected with dynamometer and engine shaft so that there was no problem of running away engine

Power measurement

Before starting test run, alignment of engine, fuel, lubrication oil, coupling of universal joint, electric connection of pump and dynamometer and all other instrumentation were checked. Then hand wheel of brake's rolling gate was fully turned in counter clock wise direction so that rolling gate was down and flow control valve was completely closed. Thereafter, feed water was opened and engine was started at full throttle setting. After starting engine, flow control valve was partly opened and braking was adjusted at same time by acting on hand wheel of brakes rolling gate. In this hydraulic dynamometer, water flow was for cooling purpose as well as acts as a brake.

Flow control valve of inlet of hydraulic dynamometer was opened (water flow rate at brakes inlet increased) for increasing braking and/or turned hand wheel of rolling gate in clock wise direction. Periodically temperature of drain water was checked so that it was not exceeds 60^0C. To decrease drain water temperature, flow control valve of hydraulic dynamometer inlet was opened and turned hand wheel of brake counter clock wise, to increase flow rate. To decrease braking, hand wheel of brakes was turned in counter clock wise and closed flow control valve of dynamometer inlet.

In certain special working conditions, periodical oscillations can be raised in order to eliminate them and therefore, to stabilize speed at desired value, it is necessary to increase water flow rate and contemporaneously its discharge opening respectively inlet valve and discharge gate. In that way, capability of braking did not change but brake working conditions changed, and get rid of instability point. Data were recorded from display boards (revolution per minute and Torque). When tests were over, water flow control valve to control water flow rate to brake was closed. Waited a few instants to secure that brake was discharged all water from its internal part. Then engine was stopped.

For calculation of delivered power, about this model with electronic cell, following formula was applied:

$$P(kW) = \frac{c[N\text{-}m]\,n\,[rpm]}{9550} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where,

P = Brake power of engine
c = Torque of engine
n = Speed of engine

Measurement of fuel consumption

In this experiment, engine performance was determined on the basis of BHP. For measurement of fuel consumption, fuel was supplied to engine directly from a plastic measuring cylinder instead of fuel tank. The measuring jar was connected to the fuel filter by a 9.5 mm diameter plastic pipe. A 500-ml volumetric cylinder was used for recording fuel consumption. At the operating time, measuring jar were filled with fuel and after a certain period fuel consumption was determined by pouring known volume of fuel to the measuring jar. A gate valve was used to control fuel through pipe. Fuel consumption was recorded at no-load and at different loaded speed of engine.

Calculation of specific fuel consumption

The specific fuel consumption (SFC) is defined as the total fuel consumption per hour per horse power developed. The specific fuel consumption expresses as the quantity of fuel used with respect to break horse power (Narang, 1989). Specific fuel consumption was calculated by following formula:

$$SFC = FC/P \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where, SFC =Specific fuel consumption, l/kW-hr, FC = fuel consumption by engine, l/h, P = brake horse power of engine, kW.

RESULTS AND DISCUSSION

After installation hydraulic dynamometer, one stationary engine i.e. SIFANG engine was tested for performance evaluation by using hydraulic dynamometer and results are discussed below:

Effect of engine speed on engine power

Figure 2 show relationship between engine power and engine speed at no load varying speed. Maximum engine power was observed at higher no-load speed. Maximum engine power was found to be 7.36 kW with no load engine speed of 2000 rpm and observed maximum engine power were 6.0 kW and 4.6 kW for the engine no load speed of 1800 and 1550 rpm respectively. Maximum engine power was not develop at maximum speed. When load was applied and increased gradually on brake by water supply as well as turning hand wheel of rolling gate in clockwise direction then engine speed decreased slowly but torque as well as engine power increased. But after attaining certain point further load increased on brake, both engine speed and power decreased. That indicated to no more capability of engine to bear load. Maximum engine power, 7.36 kW was developed at loaded speed of 1900 rpm with starting no load speed of 2000 rpm and 6.0 kW, 4.6 kW were developed at loaded speed of 1680 and 1410 rpm respectively with starting no load speed 1800 and 1550 rpm.

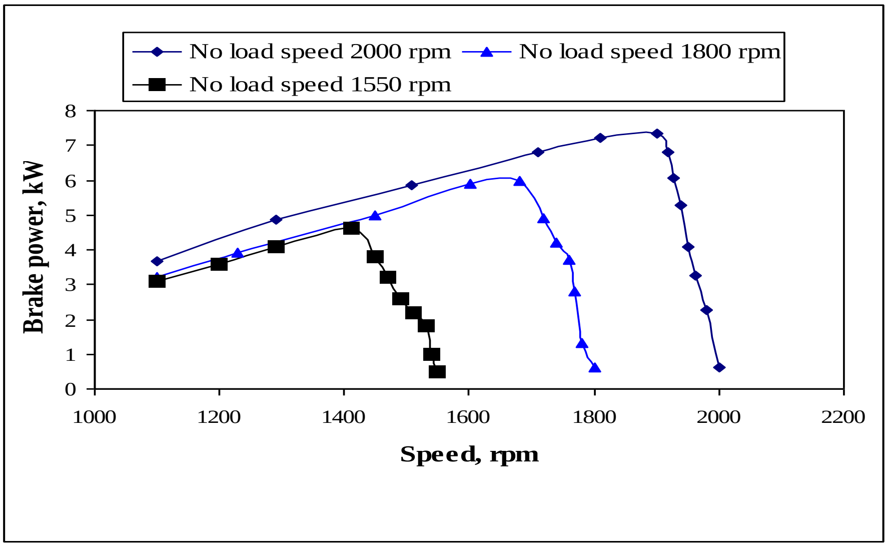

Figure 2. Relationship between engine speed and brake power at varying no load speed

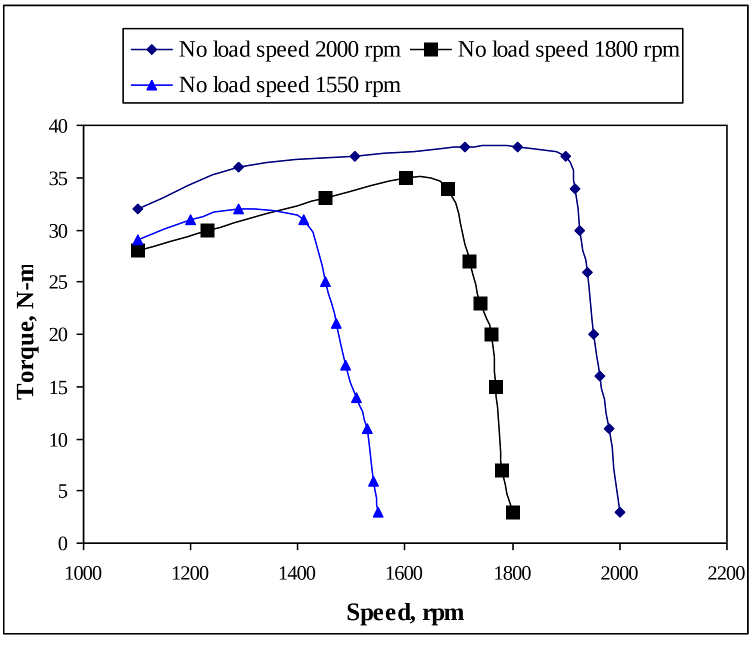

Figure 3. Relationship between engine speed and torque at varying no load speed

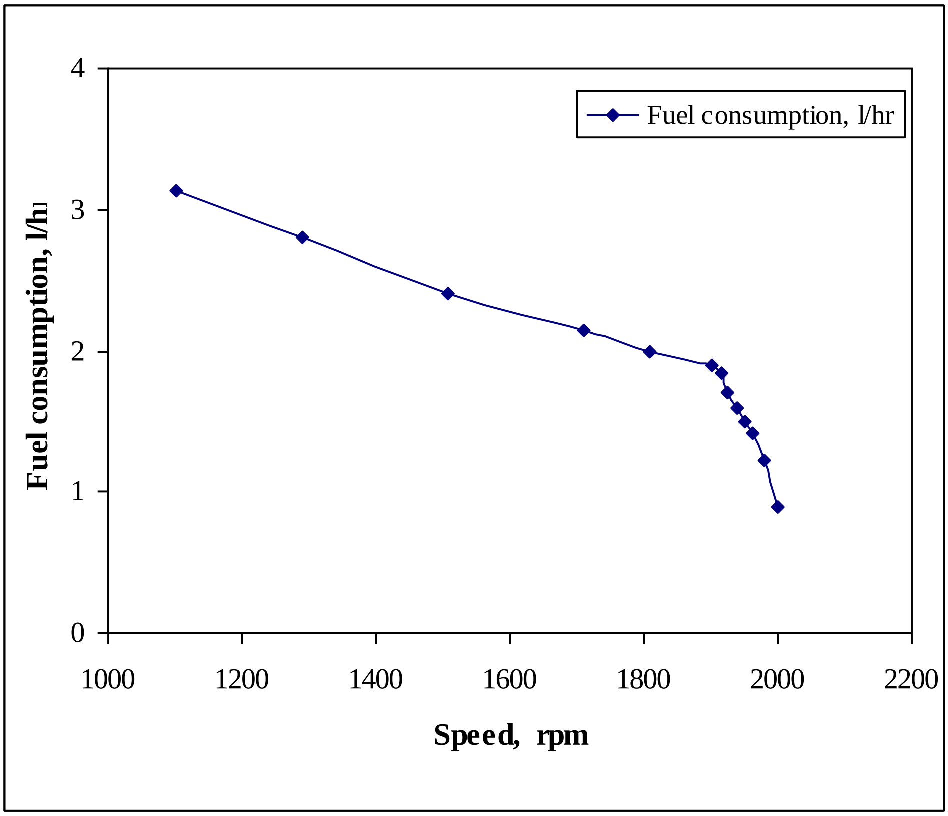

Figure 4. Relationship between engine speed and fuel consumption

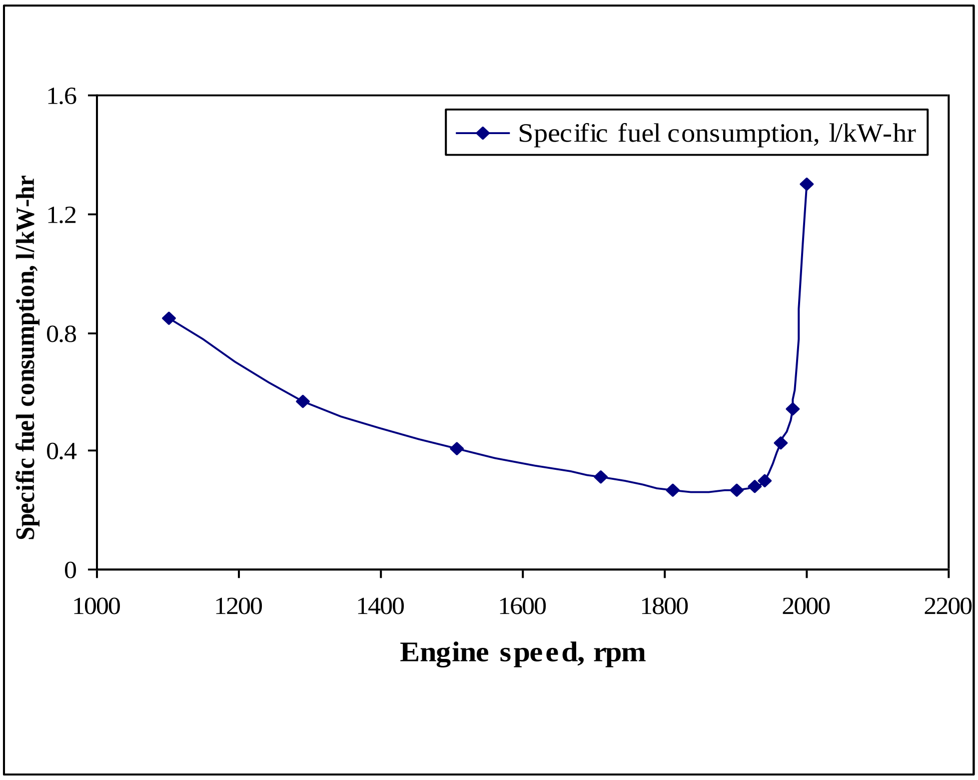

Figure 5. Relationship between engine speed and specific fuel consumption

Effect of engine speed on engine torque

Fig. 3 showed relationship between engine speed and engine torque at different no load engine speed. When load was applied and increased gradually on brake arm by flowing water as well as turning hand wheel in clockwise direction then torque was increased and at same time engine speed was decreased. Due to application of load on brake arm, torque was increased up to a certain limit, after attaining that limit torque was decreased slowly and decreasing engine speed.

Maximum torque was 38 N-m at loaded speed 1710 rpm for no load speed of 2000 rpm, 35 N-m at loaded speed 1600 rpm for no load speed of 1800 rpm and 32 N-m at loaded speed 1290 rpm for no load speed 1550 rpm of SIFANG engine.

Effect of engine speed on fuel consumption

Fig. 4 showed relationship between engine speed and fuel consumption of SIFANG engine at no load speed of 2000 rpm. It showed that fuel consumption was increased gradually with decreased engine speed. Engine speed was decreased due to application of load on brake arm and gradually increased load on brake arm by flowing water and turning hand wheel in clockwise direction. Due to increase of load on brake arm gradually then fuel consumption also increased gradually.

Fig. 5 showed relationship between engine speed and specific fuel consumption. Specific fuel consumption was found to be decreased with increased engine speed up to certain limit and then specific fuel consumption increased. Minimum specific fuel consumption was found to be 0.27 l/kW-hr at loaded speed of 1900 rpm. Very small variation of specific fuel consumption was occurred between loaded engine speed 1940 to 1710 rpm and their power range 7.36 to 5.28 kW. Beyond that range, higher specific fuel consumption was required.

CONCLUSION

In the study only brake power output of engine tested has been quantified. Measured maximum power found to be 7.36 kW for SIFANG engine, while name plate rating is 9 kW. That is the discrepancy between measured power and name plate rating and it is approximately 18 percent. Main factor of concern is that general farmers are not aware of fact that an engine produces a given power at a certain rpm of the engine and at an acceptable efficiency. Performance tests show that, in many cases name plate rating may not be achievable at all, which might be one of the reasons that farmers selects an engine having built-in power reserved and then runs at an speed lower than optimum. In this way, specific fuel consumption goes up, mechanical efficiency goes down and engines become unnecessarily over loaded due to part-load operation. Prolonged part-load operation of an engine is never desirable and may shorten engine’s effective service life greatly.

User-responsive testing should ensure that farmers and other machinery users are consulted and provided with all necessary information and advice on selection and efficient operation of power according to opportunities and constraints of their individual mechanized farming systems. Therefore, it will be necessary for testing unit to work with or as part of, a comprehensive user-responsive information and advice service for farmers and other machinery users. Performance test of individual engines should be conducted as pick out in discussion with potential users and encouragement is required manufacturers to submit their engines for user oriented testing. It should be ensured that results of all tests are presented promptly in user-friendly format allowing meaningful comparisons to be made of quality and performance.

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