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Improvement of Horse Power and Specific Fuel Consumption in Diesel Engine: Technical Note

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ABSTRACT:

The output performance characteristics of the engine used in Tillers is based on the various factors such as discharge of the pump, nozzle, and dimensions of rocker arm, rocker screw, adjusting crank case, gear case, timing gears, piston, piston rings and cylinder head. The objective of the work is to get the optimum solution for getting the increased Horse Power (HP) and Specific Fuel Consumption (SFC) of the engine based on maintaining the mentioned components dimensions in close tolerance in addition to process wise monitoring during assembly & engine testing. During engine testing, the pump discharge is adjusted by the fuel adjuster and the tolerance limits are kept closer to the actual value to obtain the required HP and SFC.

KEYWORDS:

Diesel engines; Horse power; Specific fuel consumption; Engine assembly;

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1. Introduction

The engine used in tiller is typically the gasoline powered type and is typically mounted to place weight over them to promote better tilling. Hence they are usually horizontally mounted type and some of the large tillers utilize vertical shaft engines. In the tillers the output of the engine is governed by horse power (HP) and specific fuel consumption (SFC). The objective of this project is to increase the HP and reduce the SFC to improve the efficiency of the tillers. Galindo et al [1] analysed the influence of exhaust gases thermal energy saving and reduction of pressure pulses interference on engine dynamic performance during the load transient of high speed direct injection turbo charged diesel engines. They estimated maximum improvement in engine performance by finding an optimum design in exhaust manifold. Devendra Singh et al [2] identified an alternative fuel among Hydrogenation-derived Renewable Diesel (HRD) and B100 in terms of emissions and fuel consumption characteristics.

The C–H–O based lubrication was added to HRD to give adequate lubricity to fuel injection pump. Both biofuels showed substantial reduction in particulate matter (PM), carbon monoxide (CO) and hydrocarbon (HC) emissions as compared to petro-diesel. Brake specific fuel consumption (BSFC) of the engine fuelled with HRD was lower than with B100 and petro-diesel. A comparative analysis of emission results revealed that the engine fuelled with B100 performed well on many counts such as PM, CO and HC, but the HRD outperformed B100 in terms of NOx emission and BSFC, which are vital parameters for CI engines.

Mavropoulos [3] investigated the heat transfer phenomenon occurring in the cylinder head and exhaust manifold wall surfaces of a direct injection (DI), air-cooled diesel engine. A series of engine performance and heat transfer variables were acquired on a cycle-to-cycle basis, using a customized experimental installation. Ibrahim [4] indicated that the heat rejection on insulated engine through engine program considering the desired high power densities and high efficiency. A diesel engine operating near stoichiometry with the insulated engine with turbo compound device offers the most horsepower for a given engine displacement at the highest thermal efficiency. Mukesh Kumar et al [5] analyzed the effect of fuel mixture used in a set up on CI engine. LPG air mixes have been used in the air intake manifold at different concentration level while the diesel injection through injector at the end of compression stroke has remained undisturbed at the original level. The experiments were conducted at different loads to minimize the pollutant emission and have shown an all round favourable impact of LPG injection.

Gaurav et al [6] reviewed engine performance and emissions using biodiesel from different feed stocks and compared that with the diesel. From their review it was found that the use of biodiesel leads to the substantial reduction in PM, HC and CO emissions with power loss, the increase in fuel consumption and the increase in NO emission on conventional diesel engine with no or fewer modification. Amit et al [7] performed experiment on single cylinder water cooled diesel engine and found out friction power is about 1.5. Similarly brake thermal efficiency increase from 10.85% to 27.37% with respect to load and identified some variation in indicated power mechanical efficiency and mass of fuel consumption also gradually increases. Ahmad et al [8] conducted experimentation on alternative sources by developing new mixtures of fuels to reduce the fuel consumption and to reduce the environmental impact of combustion emissions. The experiments were conducted using four stroke 1400cc-8hp and 1 cylinder diesel engine test bed at different operating conditions such as torque, thermal efficiency and SFC. The experimental results obtained concluded that the diesohol mixtures improved the torque and the thermal efficiency of the engine compared to pure diesel samples.

Deva Kumar et al [9] conducted experiment on Single Cylinder Diesel engine and concluded the following:

- In cylinder, flow is greatly influenced by the intake manifold inclination.
- It is found that at 60º intake manifold inclination at 180 bar gives the maximum brake thermal efficiency.
- By increasing fuel injection pressure, pollution levels reduce due to complete combustion of fuel. Emissions are reduced at 200 bar with different manifold inclinations compared to other pressures.

Krishna Reddy et al [10] conducted experiments on single cylinder four stroke water-cooled variable compression diesel engine. Methyl ester of cotton seed oil was blended with the commercially available xtramile diesel. Cotton seed oil methyl ester (CSOME) is blended in four different compositions varying from 10% to 40% in steps of 10% in volume. Using these four blends and xtramile diesel brake thermal efficiency and BSFC determined. Engine ran without any difficulty using CSOME blends. These blends of cotton seed oil can be recommended for present diesel engines without any modification. Meshack et al [11] modified Direct Injection Compression Ignition engine into a dual-fuel engine that used biogas as the primary fuel and diesel as pilot fuel, with the focus on reduction of harmful exhaust emissions while maintaining high thermal efficiency. They studied the effect of exhaust gas recirculation (EGR) on engine performance and emission characteristics. The results indicated EGR caused a decrease in exhaust gas temperature because of that it reduces NO_X emission. But emissions of HC and CO increased slightly with EGR.

This work is carried out in VST Tillers and Tractors Ltd., Bangalore. The company launched the MITSUBISHI 130 DI Tiller which is compact with rotary attachment with powerful and fuel efficient 13HP engine. The four wheel drive is capable of easy operations especially in marshy land as well in slippery fields would have difficulty for similar operations. This is primarily due to better traction.

2. Procedure

The improvement of the HP & SFC for the engine can be carried out by analysis of critical dimensions of components involved in engine assembly, quality control tools and engine testing. The specifications of engine test setup and a photograph of considered engine are shown in Table 1 and Fig. 1 respectively. The procedure starts with writing down all the information related to the assembly of engine components stage by stage and indicate the nature of the problem occurring in each stage and the necessary corrections made in the engine components to improve the HP and reduce the SFC. The performance of the batch of engines produced over a month was analysed. The control chart and cause and effective diagram were used as the quality control tools. Figs. 3 and 4 show the control chart on a time series scale for the HP of earlier test data and present test data.

Table 1: Engine specification

Parameter	Description or Value
Type	Horizontal 4 stroke cylinder water cooled diesel engine/OHV
Combustion chamber	Direct injection (DI)
Bore (dia.)	95 mm
Stroke	95 mm
Displacement	673 cc
Compression ratio	18:1
Max. torque	4.2 kg-m at 1600 rpm
Max. HP	13.0 HP at 2400 rpm
SFC	195gms/hp-hr
Governor system	Mechanical, centrifugal type
Cooling system	Condenser type thermo siphon
Starting system	Hand cranking
Lighting system	12 V/35 W
Std. Pulley(dia.)	100mm/optional 120 mm
Dry weight	125 kg

Fig. 2: Diesel engine photograph

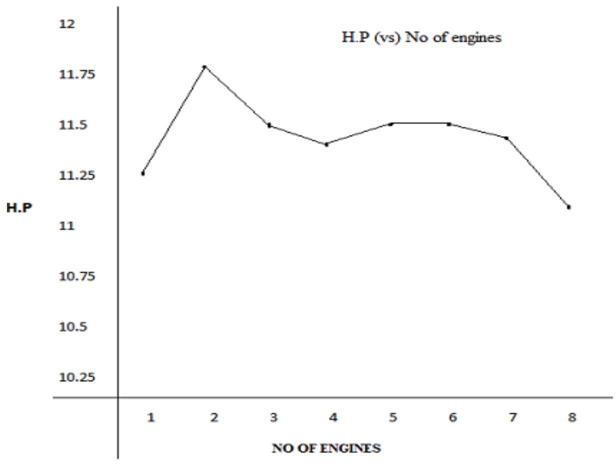

Fig. 3: Earlier results of HP

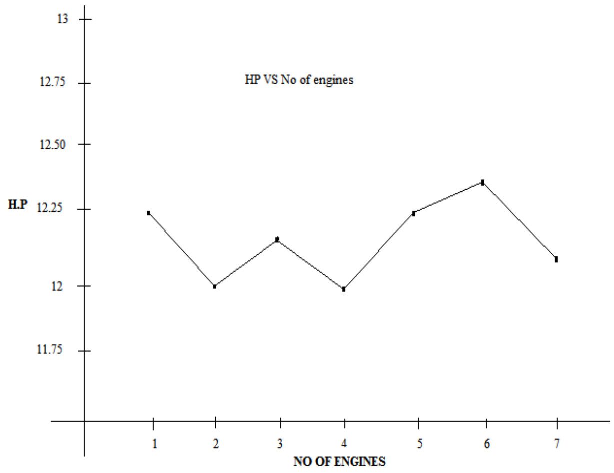

Fig. 4: Present results of HP

Cause and effective diagram shows the causes of a specific event. An example diagram is shown in Fig. 5. Each cause for imperfection is a source of variation. Causes are usually grouped into major categories to identify their sources of variation.

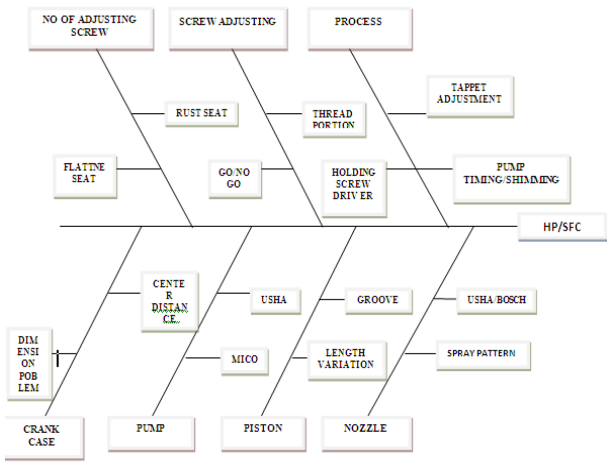

Fig. 5: Cause and effect diagram

3. Results and discussion

The tiller engine is tested by a 30 HP dynamometer test stand. In this testing, the tiller engine is evaluated by focusing on the performance. The software used in engine testing is "V-Cats Engine Testing System". The software is used to calculate and display speed, torque, HP, SFC, SFC in time and SFC in range. At present 11.5 HP maximum and 240 SFC maximum was the target fixed (standard) during engine testing. HP and SFC are the most important criteria of an automobile in which the parameters such as discharge of the pump, nozzle, dimensions of rocker arm, rocker screw, adjusting nut, crank case, gear case timing gears, piston, piston rings and cylinder head are analyzed using various quality control tools. To get solution for the problem above components dimensions are kept to minimum tolerance and process wise monitoring is also carried out during assembly & engine testing. Due to field requirement to reduce the SFC and increase in HP the project is executed stage by stage as follows:

- Stage 1: 12 HP minimum and 220 SFC maximum new standards have been set during engine testing.
- Stage 2: 13 HP maximum and 220 SFC maximum next stage standards will be reviewed.

Table 2: 11.5 H.P fuel settings

Engine No.	HP	SFC	Time	Torque
221856	11.3	225.4	58.31	31.1
221857	11.7	192.5	65.95	31.92
221864	11.5	206.8	62.44	31.61
221866	11.4	224.4	58.06	31.34
221870	11.5	210.7	61.29	31.67
221871	11.5	223.8	57.69	31.76
221878	11.4	222.8	58.46	31.31
221879	11.2	221.1	59.98	30.8
221895	11.3	234.7	56.49	30.96
221676	11.4	221.1	59.44	31.39
221677	11.3	206.6	60.98	31.35
221678	11.4	206.4	60.98	31.35
221705	11.5	220.4	56.61	31.61
220381	11.3	225.2	57.84	31.17

The HP & SFC of the engine are calculated using,

$$HP = \frac{(Torque \times RPM) \times 1.36 \times 1.069}{9549.305} \quad (1)$$

$$SFC = \frac{3600 \times CC \times Specific\ Gravity}{HP \times Time} \quad (2)$$

Where 1.069 and 9549.305 are the corrected factor and dynamometer constant. 1.36 is the conversion constant HP to kW. The minimum and maximum RPM are 1600 rpm and 2400 rpm respectively. The specific gravity of Diesel is 0.825. Engine capacity is 50 cc. Substituting these values, the calculated HP and SFC for Engine number: 221856 with 11.5 HP fuel settings are as follows:

$$HP = \frac{(31.1 \times 2400) \times 1.36 \times 1.069}{9549.305} = 11.36\ kW \quad (3)$$

$$SFC = \frac{3600 \times 50 \times 0.825}{11.36 \times 58.31} = 224.18\ g/bhphr \quad (4)$$

4. Conclusion

The analysis of HP and SFC of the tiller diesel engine is carried out using VCATS Engine testing system. During engine testing, the pump discharge is adjusted by the fuel adjuster and the tolerance limits are kept closer to the actual value. By correcting these parameters, the HP and SFC are increased.

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