EFFECT OF FUEL INJECTION PRESSURE ON PERFORMANCE OF DIESEL ENGINES AT HIGH ALTITUDES

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It is known that reducing injection pressures improve the performance of diesel engines at high altitude. An attempt has been made to quantify the improvement on a typical, multi-cylinder automotive pre-chamber type diesel engine widely used in such conditions. The studies were carried out under simulated conditions representing about 2,600 metres altitude. It is observed that the changed settings lead to an improvement in sfc upto 6·15% and power output upto 7·66% at 1600 rpm.

The recent energy crisis has highlighted the need of conserving fuel. Attempts are being made by all concerned to achieve maximum efficiency in the utilization of fuel. In the case of diesel engines more intensive work on some of the proven methods to improve the efficiency, such as (a) increasing the compression ratio, (b) turbocharging, (c) increasing the speed, (*d*) use of variable injection timing etc., has been reported by some investigators.

It is well known that performance of diesel engines deteriorates with increasing altitude due to reduction in air mass flow leading to power loss and consequent poor thermal efficiency, higher exhaust temperatures and smoke density [1–6]. Since some of the methods such as increasing the compression ratio etc., to offset at least partly, these deleterious effects are not practical and viable on existing engines, it was proposed to study the effect of changing the injection pressure to improve the performance of a diesel engine operated under high altitude conditions[6].

EXPERIMENTAL SETUP

A multi-cylinder pre-chamber diesel engine (Appendix) was coupled to a hydraulic dynamometer and was fully instrumented to check and maintain the operating conditions. To simulate the high altitude conditions, the inlet air manifold was connected to a large surge chamber and the desired depression was obtained by throttling the intake air. Corresponding depression was maintained in the exhaust manifold also. A schematic diagram of the setup is shown in Fig. 1.

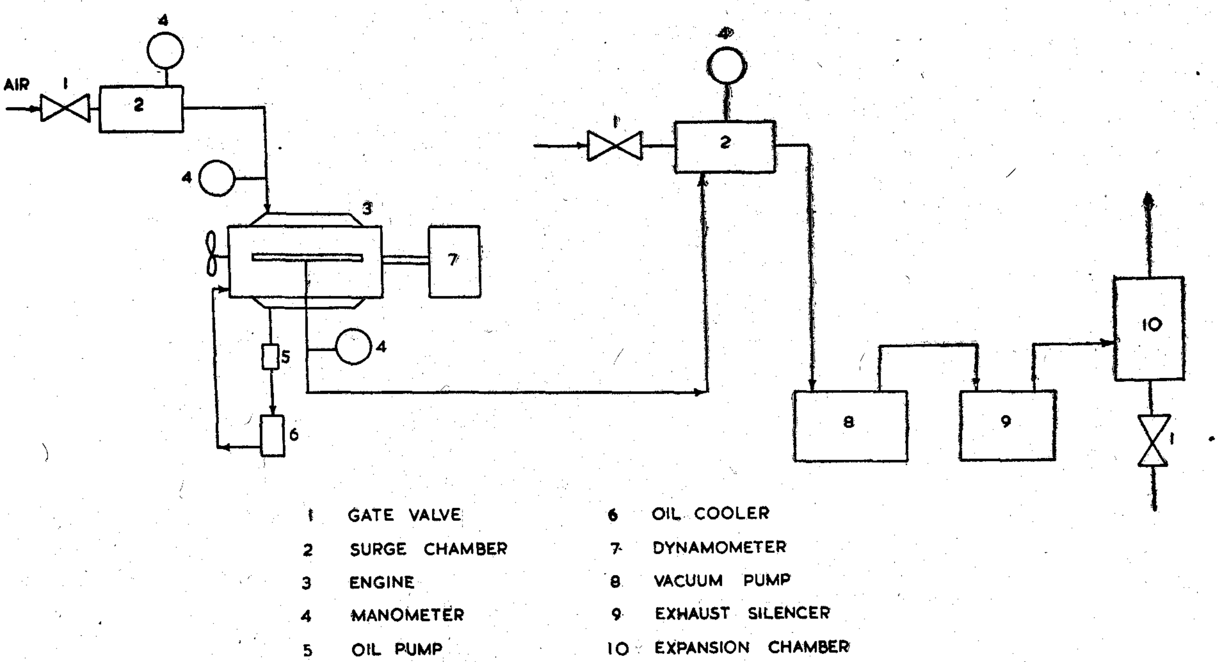

Fig. 1—Schematic diagram of the experimental setup.

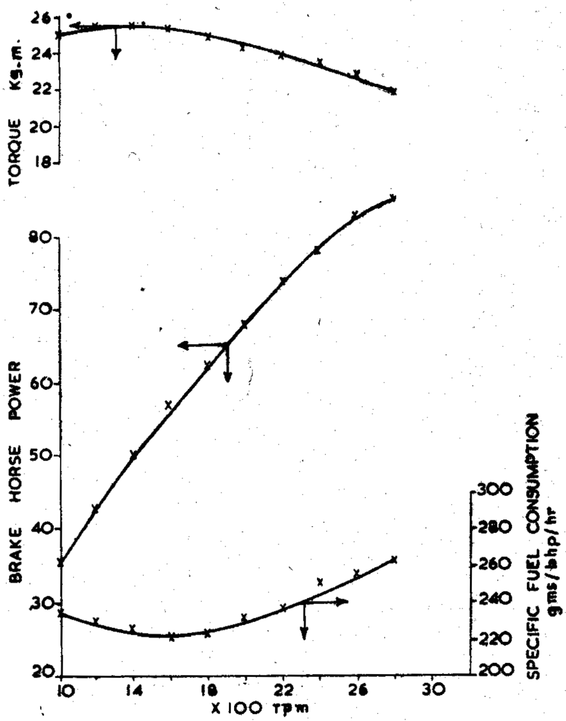

Fig. 2—Performance of an automotive diesel engine at ambient conditions.

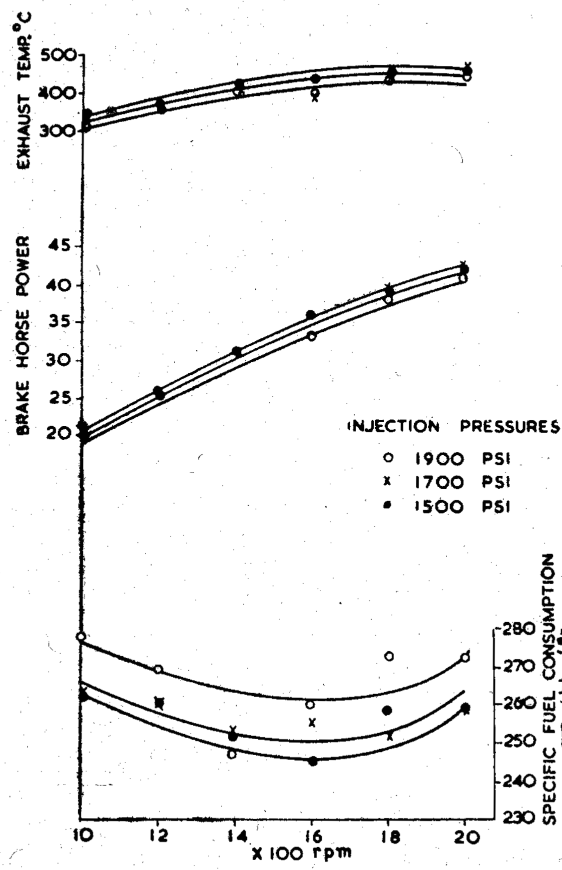

Fig. 3—Performance at simulated altitude conditions corresponding to 2600 m, varying the injection pressures.

EXPERIMENTAL PROCEDURE

The performance of the engine at ambient conditions (the altitude being 680 metres app.) with the standard settings was studied and is shown in Fig. 2. The performance of the engine was again studied with the standard injection timing i.e. 23° btdc, but injection pressures were reduced from the recommended 1900 psi to 1700 psi and 1500 psi at 15 cm Hg depression, corresponding approximately to 2600 m altitude. Studies were also carried out by varying the injection timing under simulated conditions corresponding to 2600 metres altitude.

The results are presented in Figs. 2 and 3 and summarised in Table 1.

Table 1

Improvement in performance at 2600 m altitude by varying injection pressures

Speed (rpm)	bhp gain (%)		Saving in sfc (%)	
	1700 psi	1500 psi	1700 psi	1500 psi
1000	3·43	4·44	5·22	5·26
1200	2·42	1·53	3·34	3·34
1400	0	0·65	—2·4	—1·4
1600	0·46	7·66	1·95	6·25
1800	4·84	2·68	7·7	5·32
2000	3·21	2·22	5·14	4·78

RESULTS AND DISCUSSION

The rate of deterioration of diesel engine performance with increase in altitude is accelerated due to drop in combustion efficiency caused by increase in ignition delay[6]. The decrease in power output is therefore greater than that can be caused by the reduction in air mass flow at higher altitudes. The injection pressure and timing set for optimum performance at mean sea level conditions will not be ideal under changed operating conditions. At high altitudes, lower charge density, permits greater penetration of the fuel jet and a greater part of the fuel that impinges on the cylinder wall may not effectively take part in the combustion process, i.e., portion of the fuel, may burn at the later part of the cycle contributing to poor thermal efficiency, higher exhaust temperatures and smoke density. From the table and also from Fig. 2, it can be seen that there is improvement in performance in respect of specific fuel consumption and power output with reduction in injection pressures. However, smoke density could not be recorded under simulated conditions as the exhaust line was connected to the vacuum pump. For instance under simulated conditions corresponding to 2600 m altitude at 1700 psi injection pressure, the gain in power is upto 4·84 percent while at 1500 psi injection pressure the gain increases to 7·66 percent, in the speed range of 1000—2000 rpm. Similarly saving in specific fuel consumption at 1700 psi injection pressure varies from —2·4 to 7·7 percent and at 1500 psi injection pressure it varies from —1·4 to 6·15 percent. Further experiments with lower injection pressures and higher depressions could not be carried out due to the difficulties in operating the engine under simulated conditions. However, it can be reasonably expected from this limited study that at still higher altitudes, the improvement in performance will be more substantial. However, in this particular case, varying injection timing under similar conditions, did not show significant improvement in the engine performance.

CONCLUSIONS

At high altitudes, the performance of diesel engines can be optimised by suitably modifying the injection pressure depending upon the altitude. Besides gain in power, substantial reduction in sfc can be achieved by this simple modification. For most of the automotive diesel engines which operate in a particular location, not involving great changes in altitude, and for all stationary diesel engines at a particular altitude, suitable modification in injection pressure can be made, depending upon the engine design, operating conditions and the altitude, to ensure better performance with substantial fuel economy.

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REFERENCES

1. MAHESHWARI, B.L., PARANJPE, P.D. & VITTAL, B.V.R., *J. Inst. Engrs.* 50, 5, Pt. ME-3 (1970), 141.

2. DICKSEE, C.B., Influence of Atmospheric Pressure and Temperature upon the Performance of the Normally Aspirated Four Stroke Compression Ignition Engine', *Proc. I. Mech. E.* (A.D.), 1959-60, 83.

3. FOSBERRY, R.A.C. & HOLUBECKI, Z., 'Some Considerations of the Effect of Atmospheric Conditions on the Performance of Automotive Diesel Engines', SAE paper No. 660744.

4. RICARDO, H.R., 'The High Speed Internal Combustion Engine', (Blackie & Son Ltd; Glasgow), 1962.

5. RAO, R.A. & CHITNAVIS, B.A., 'Phenomenon of Power Loss at Altitudes—Some Possible Remedial Measures for Counteracting the Problem', Proc. of Seminar on Problems of I.C. Engines, at High Altitudes New Delhi, March 1964.

6. SCHMIDT FRIZ, A.F., 'The Internal Combustion Engine', (Chapman and Hall, London), 1965, p. 317.

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Appendix

TECHNICAL DATA OF ENGINE

No. of cylinders	6
Bore	90 mm
Stroke	120 mm
Cylinder capacity, total	4·58 litres/279·5 in^3
Engine output	110 hp at 3900 rpm
Max. torque	26 mkg. at 1600 rpm
Compression ratio	19·5 : 1
Fuel injection timing	23° btdc
Inj. pr. new nozzles	1850-1990 psi
Combustion chamber, type	Pre-chamber