THE EFFECT OF SOME ENGINE VARIABLES ON IGNITION QUALITY IN DIESEL ENGINES.

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ABSTRACT.

Ignition delay in compression ignition engines is the origin of many problems and performance limitations in diesel engines. Its length affects olmost all the post-ignition processes and the development of combustion in diesel engines . These processes control the power output , efficiency and general public acceptance of diesel power . Much experimental work has been directed towards the ignition delay , and previous researches have led to various expression for its prediction in terms of fuel and air charge variables.

Measurements of ignition delay and other combustion phenomena are carried in a direct injection , single cylinder , diesel engine . The influence of engine speed , load and injection timing are reported. The measured pressure rise , ignition delay period decreases with the increase of engine speed or engine load.

On the basis of the experimental results obtained for a fuel has cetane number(C.N.)49, the optimum injection timing of the engine used is 19 C.A.D. before T.D.C., at the engine speed of 1000 R.P.M. and load of 9 HP..

The optimum injection timing is corrosponding to the maximum efficiency , and it is not necessary occured at the shortest ignition delay period.

I- NOMENCLATURE.

B.HP.............Brake horse power (HP).
B.S.F.C..........Brake specific fuel consumption(gm/HP·hr)
C.A.D. ....Crank angle degree.
C.N. ....Cetane number.
F_d...............Mass of fuel injected during delay period (gm./cycle)
F_i...............Total amount of fuel injected per cycle (gm./cycle)
$(R.P.R.)_m$.........Maximum rate of pressure rise(at./C.A.D)
T.D.C............Top dead center
T_d...............Ignition delay period (m.sec). or (C.A.D)
T_f...............Injection period (C.A.D.)
T_i...............Injection timing (C.A.D)

II- INTRODUCTION.

The term ignition quality is used to cover the ignition temperature versus delay characteristics of a fuel when used in an engine . Good ignition quality means a short delay angle at a given

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speed,compression ratio , air inlet and jacket temperature. In compression engines, the time lapse between the beginning of injection and ignition of the fuel is normally termed ignition lag or ignition delay. The length of this period is of considerable importance , as it affects almost all the post-ignition processes and normally subdivided into physical and chemical phases . The physical phase of the delay, involving processes such as fuel jet break-up, mixing and vaporization is usually regarded as being the period between the beginning of fuel injection and the start of pre-ignition reaction at rates worthly of consideration . The chemical phase normally terminates with the onset of ignition noted by the first apperance of a pressure rise . During this part of the delay , chemical reactions , both endothermic and exothermic, with progress towards the general inflammation of the charge and the release of energy producing pressure rise. It is difficult to draw a distinct line separating the two phases, they do overlap.

Ignition delay has been defined in different ways. Researchers agree that the start of fuel injection is the beginning of the delay period. The differences in definitionarise from the criteria used to the end of delay, that is , the start of combustion. The two most commonly used definitions are the pressure rise and illumination delay [1]. The end of the pressure rise delay is defined by the point at which pressure rise cuased by combustion is detected on a cylinder time record . While,the illumination delay, marked by the emission of visible radiation . In a detailed study [2,3] , it has been found that the pressure rise delay is more reproducible. Also, it has the greater engineering significance in engine design,especially as related to stresses and noise .

In the present study all rererence will be to the pressure rise delay .

The delay period measured in engines [4,5] is dependant upon many variables, and in general , no satisfactory general expression has been developed which permits the delay period to be predicted . This is perhaps to be expected in view of the difficulty of changing one variable at a time during the engine operation . In the present work, the engine running conditions are controled in an effort to accomplish this . The variables studied and presented in this paper are ,engine speed ,load and injection timing .

III- APPARATUS AND GENERAL EXPERIMENTAL PROCEDURE.

The experimental investigation was carried out using a single cylinder direct injection , four stroke diesel engine of 145 mm. stroke and 115 mm. bore . Acompression ratio 15:1 was used . The maximum power is 15 HP.at 1500 R.P.M. .

The engine is directly coupled to water dynamometer and electronic tachometer for measuring the engine output (B.HP.)and engine speed(R.PM).

A pressure pick-up, capacitance transducer, and pressure transducer were used to measure the cylinder pressure , injector needle lift and injection pressure . These together were observed and recorded by means of double beam oscilloscope and universal camera .

The fuel used is a commerical diesel fuel, it has a cetane number 49.

Shown in fig.(1), is a typical recorded diagram taken during the experimental programe on oscillescope screen. The operating conditions were , engine speed 1400 R.P.M. ,and 19 C.A.D.before T.D.C. injection timing . Refering to fig.(1) , the ignition delay period (T_d) is estimated as crank angle degree between the initiation of needle valve lift and beginning of combustion pressure rise . The maximum pressure rise rate $(R.P.R.)_m$ is calculated from cylinder pressure-crank angle diagram, and the amount of injected fuel during the delay period (F_d) is calculated by using the valve lift and injection pressure diagrams. The general layout of the experimental plant is shown fig.(2).

IV- EXPERIMENTAL RESULTS AND DISCUSSIONS.

A series of tests are made covering a range of engine speed , engine load and injection timing . In the initial tests, the the injection timing is adjusted so that the needle valve lift (as observed on the oscillescope screen) would start at a constant crank-angle of 19° before T.D.C. (constant injection timing) at each engine speed and load, while the effect of engine load is studied at different engine speeds. In the second series of tests, the effects of injection timing on engine combustion characteristics are studied. The engine load is kept constant by controling the injection pressure at a constant engine speed of 1000 R.P.M. .

IV-1. Effect of engine speed on the ignition delay;

The results of the ignition delay, in crank angle degrees and in milliseconds , are plotted as a function of engine speed on fig. 3 . The ignition delay is 7.8 degrees of crank angle at engine speed of 750 R.P.M. ,and engine load of 7 HP. and increased to 10.6 degrees at speed of 1500 R.P.M. . While , in terms of millisecond, the ignition delay has been reduced from 1.73 m.sec. at 750 R.P.M. to 1.178 m.sec. at 1500 R.P.M. . This is because an increase in engine speed may be expected to reduce the physical delay, the time required for fuel to evaporate and form a combustible mixture . Thus if the physical parameters are the main controling factors in the length of ignition delay, it would be expected that an increase in engine speed would reduce the length of the ignition delay period.

IV-2. Effect of load on the ignition delay and combustion characteristics;

The load is varied over a wide range from 4 HP. to 14 HP. . The injection timing is maintained constant at 19 C.A.D. before T.D.C. . The other engine parameters are maintained the same as in the tests of speed variation.

The variable load experimental results are in figs.(4 through 7) , from which it can be noted that the delay period (T_d) decreases with the increase of engine load . The slope of the curve fig.(4), is downward . For the other three tests figs.(5 through 7) the load has a different effect on delay period (T_d). This is believed to be due mainly to the increase in the gas temperature with the increase of engine load. Higher engine load results in higher wall and gas temperature which would result in a decrease in the length of the ignition delay. This is because of the increase in the total amount of fuel injected during the delay period (F_d) . It must be also mentioned that , the total injected fuel per cycle (F_i) is increase linear by with engine loads figs. (4 through 7).

For example the delay period (T_d) at engine speed of 1000 R.P.M. is obviously affected by the load . It decreases to a minimum and then rises again . The minimum value of (T_d) for the other three tests figs. (5 to 7) of speed occurs at 80 % of engine maximum load .

From fig.(4) through fig.(7) , it can be seen , that maximum rate of pressure rise $(R.P.M.)_m$ path follows a similar path of the fuel injected during delay period .

IV-3. Effect of injection timing (T_i) on the ignition quality:

Combustion characteristics curves showing the effect of injection timing at constant speed of 1000 R.P.M. and load of 9.1 HP. are shown in Fig.(8) . Also, the period of fuel injection (T_F) is constant during this test. The engine load is kept constant by controlling the injection pressure. As shown in fig.(8), varying the injection timing , changes the delay period . The minimum delay period (T_d) at these test conditions occurs at (T_i) equals 21 C.A.D. before T.D.C..

Also the fuel injected during the delay period (F_d) increases with retardation of (T_i) , while the $(R.P.R.)_m$ decreases with the advance of (T_i) . Earlier injection results in longer delays.

The longest delay occurs with the earlier injection when average pressure and therefore average temperature during the delay period is lowest .

$(R.P.R.)_m$ is affected in this case both by the delay angle and by piston motion . Early injection gives a very high $(R.P.R.)_m$.

Here , a long delay occurs, together with inward piston motion during the subsequent rapid combustion .

V- CONCLUSION.

From the experimental results it can be concluded that;

1- For a certain fuel , the delay period depends on the engine load , engine speed and injection timing .

2- The apparent effect of the increase in engine speed, is to increase the pressure rise ignition delay in crank angle degrees, while the ignition delay period has been reduced.

3- The increase in engine load for constant engine speed, resultants in an apparent decrease in the ignition delay.

4-Earlier injection results in longer delay period because of the lowest average pressure and temperature during the delay period .

5- On the basis of the experimental results obtained for a fuel with a C.N. 49 , the auther suggests that the optimum injection timing for this type of engine to be 19 C.A.D. before T.D.C. ,when the engine is running at speed of 1000 R.P.M. and loaded with 9.1 HP. fig.(8).

VI- REFERENCES.

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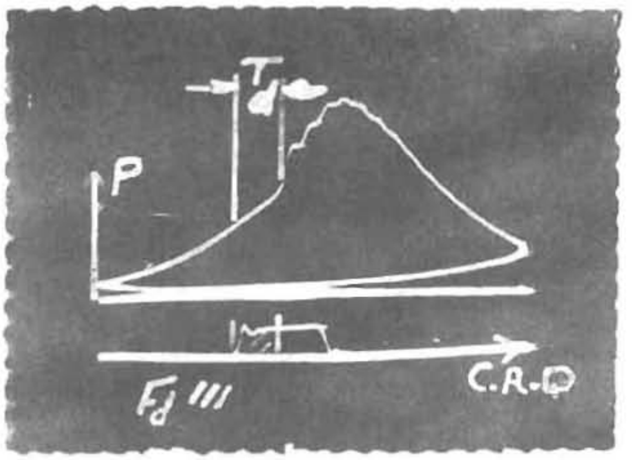

Fig.(1).A typical recorded diagram as seen on the oscilloscope screen.

1- Fuel pump
2- Injector
3- Fuel metering
4- Tachometer
5- Dynomemter
6- Synchronise sensor
7- Pressure sensor
8- Degree marker sensor
9- Top dead center sensor
10 Oscilloscope
11- Amplifire
12- Capacitance transceducer
13- Control rack
14- ENGINE

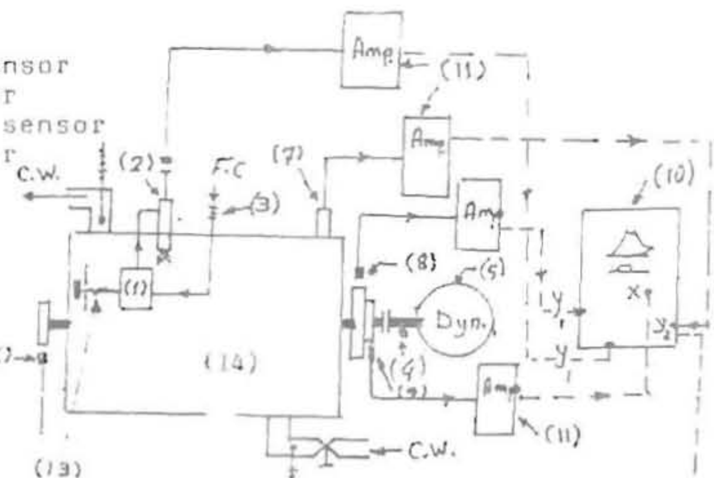

Fig.(2) Schema of experimental set-up

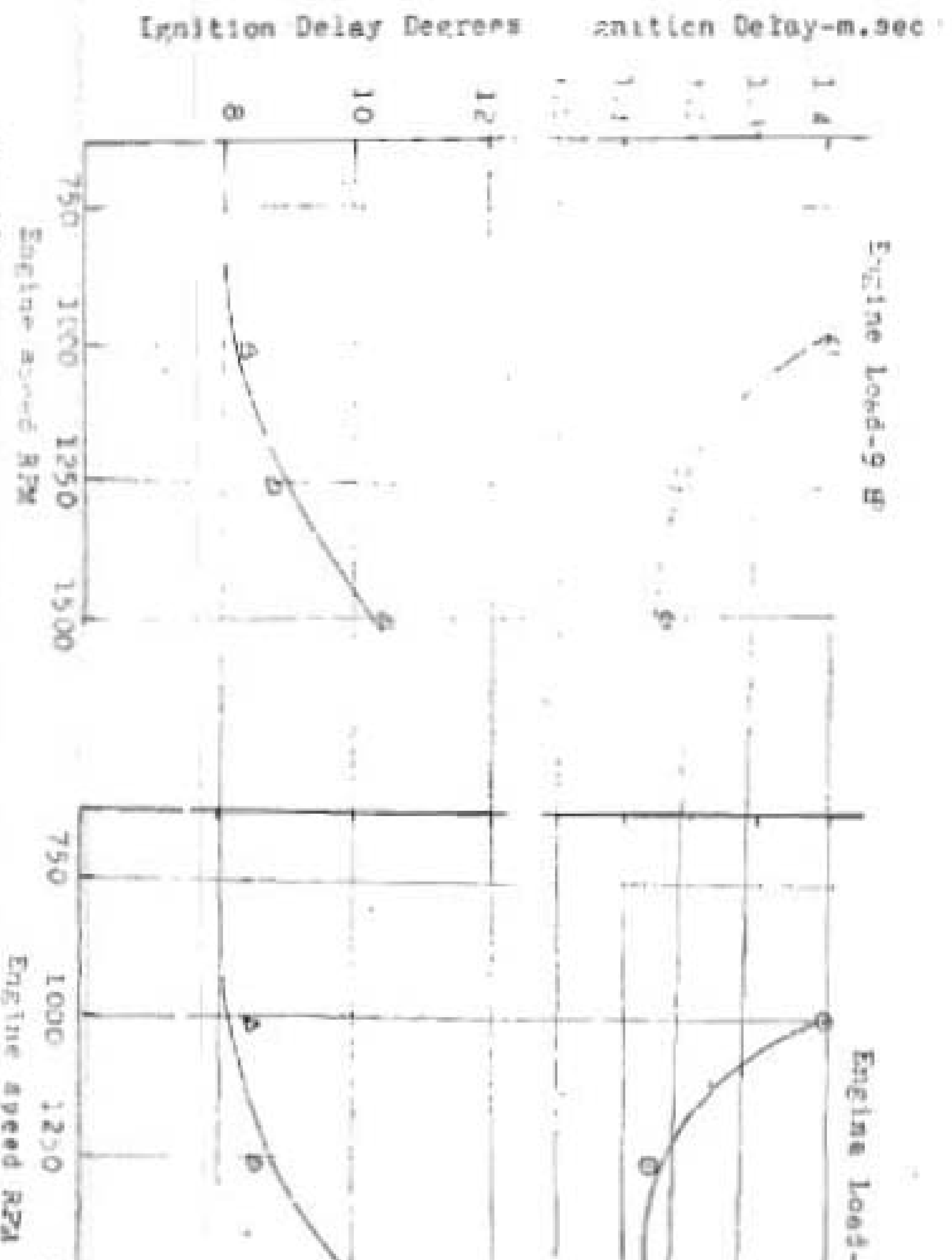

Fig.(3): The Effect of Engine Speed on Ignition Delay.

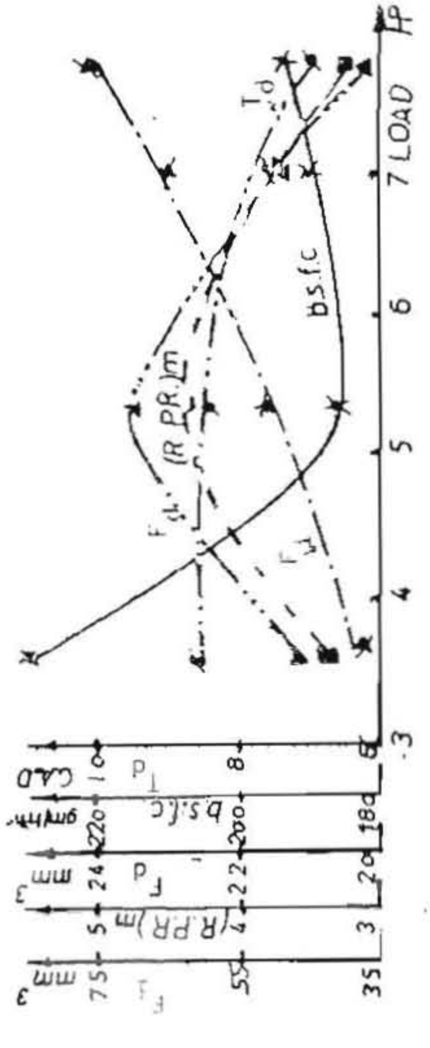

Fig. (4) Characteristics of engine at 750 R.P.M. for T_i=19 C.A.D. before T.D.C.

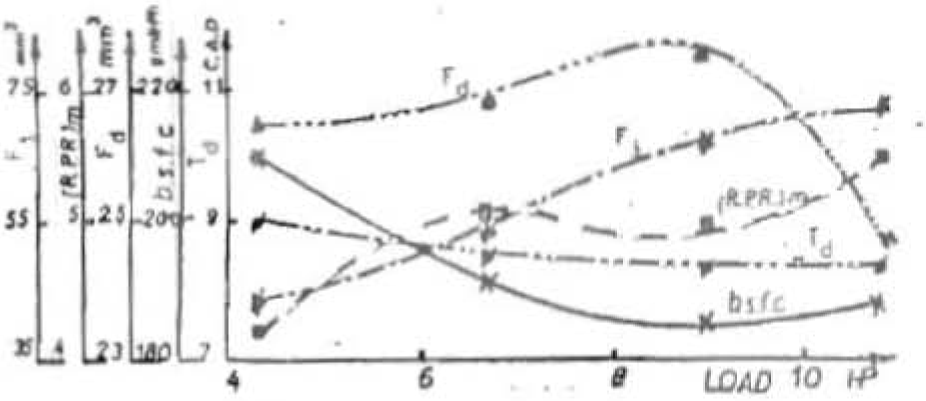

Fig. (5) Charectristics of engine at 1000 R.P.M. for T_i=19 C.A.D. before T.D.C.

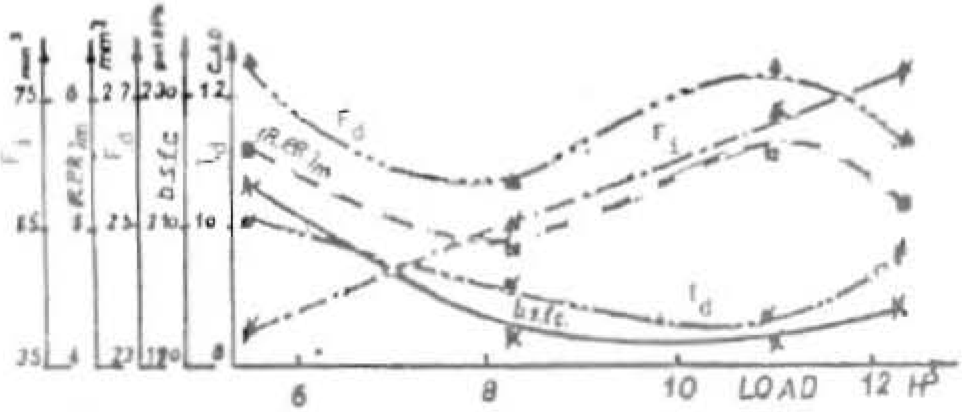

Fig. (6) Characteristics of engine at 1250 R.P.M. for T_i=19 C.A.D. before T.D.C.

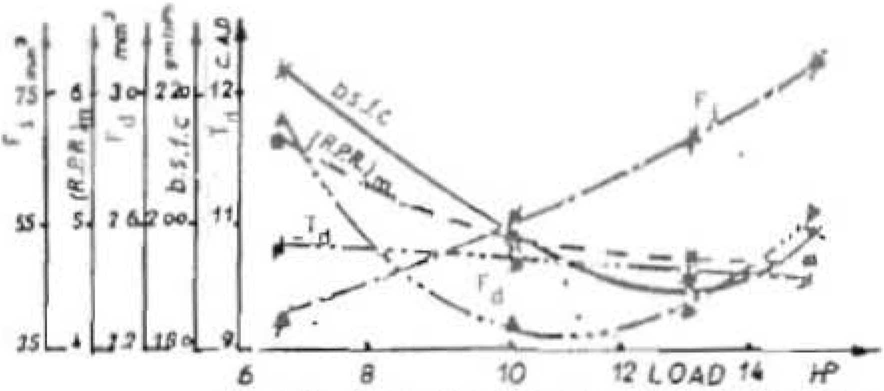

Fig. (7) Characteristics of engine at 1500 R.P.M. for T_i=19 C.A.D. before T/D/C/

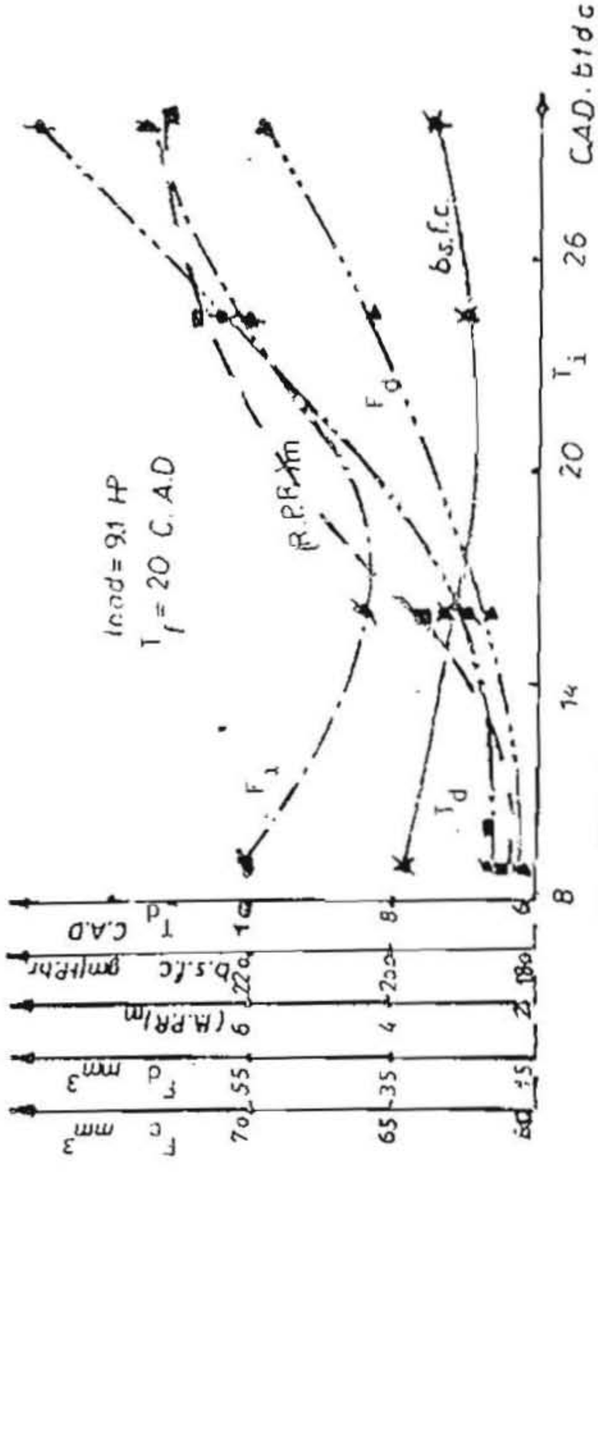

Fig. (8) Characteristics of engine at 1000 R.P.M. for constant load against injection timing.