INSTRUCTION MANUAL

FOR

THERMAL SCIENCE LABORATORY EXPERIMENTS

(INTERNAL COMBUSTION ENGINE)

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ENGINE TEST SET UP (Computerised)
SINGLE CYLINDER FOUR STROKE DIESEL ENGINE

Setup Description

The set up consist of single cylinder, water cooled, 4-stroke compression ignition engine using diesel fuel. The engine is attached with eddy current dynamometer for application of load. It is provided with necessary equipments and instruments for measurement of load applied, fuel consumption for the load applied, air consumption, the cooling water circulated through engine, exhaust gas temperature before and after calorimeter. Water jacket temperature through calorimeter.The set up enables study of brake power, brake thermal efficiency, brake specific fuel consumption, air –fuel ratio, heat balance, energy carried away.

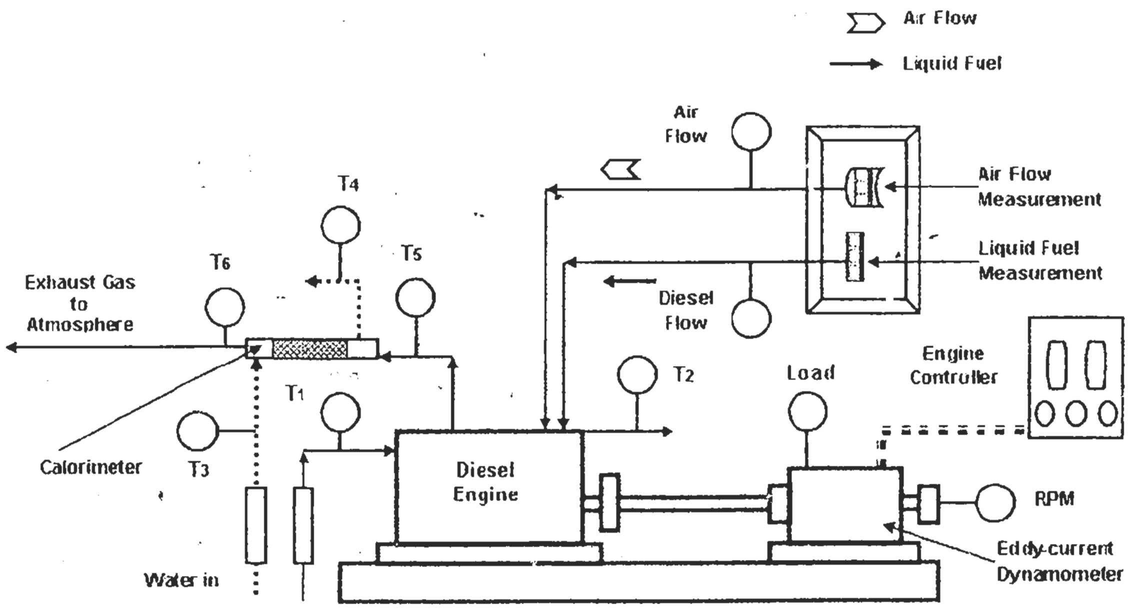

Fig.1 Schematic diagram of base diesel engine with equipments.

Specifications:

System Specification

Parameter specification	
Make and Model	Kirloskar,Model-TV1
Engine Type	Single Cylinder,4-stroke,DI diesel engine
Rated Power	5.2 kW(7 BHP)@1500 rpm(Diesel mode)
Type of cooling	Water cooling
Borex stroke	87.5×110 mm
Swept volume	0.661 liter
Compression Ratio	17.5:1
Speed	1500 rpm ,constant
Injection pressure	210 bar
Combustion chamber	Hemi-spherical bowl-in-piston type
Dynamometer	Eddy-current(Make:Saj,Model:AG10)
Governor	Mechanical governing(centrifugal)
Air flow	Orifice meter and manometer(100-0-100 mm)
Fuel flow	Fuel measuring unit, range 0-450 ml
Speed indicator and sensor	Digital, non-contact type speed sensor
Load indicator	Model AX-271,0-50 kg,230 V AC
Load sensor	Load cell, type strain gauge, range 0-50 kg
Temperature indicator	Type digital, multipoint
Temperature sensor	K-Type thermocouple
Rotameters	Engine cooling 40 -400 lph, calorimeter 10-100 lph
Engine software	'Engine soft' Engine performance analysis software
Pressure Transducer	
Make, type of sensor and maximum power	PCB make, Piezo electric(15000 psi)
Resolution and response time	0.1 psi,2 microseconds
Crank angle sensor	360 degree encoder with a resolution of 2 degree

Theory

Following are the formulae used for calculation of various results.

Nomenclature:

T_1	Jacket water inlet temperature	K
T_2	Jacket water outlet temperature	K
T_3	Calorimeter water inlet temperature	K
T_4	Calorimeter water outlet temperature	K
T_5	Exhaust gas to calorimeter inlet temperature	K
T_6	Exhaust gas from calorimeter outlet temperature	K
T_{amb}	Ambient temperature	K
F_1	Fuel flow	kg/hr
F_2	Air flow	kg/hr
F_3	Jacket water flow	kg/hr
F_4	Calorimeter water flow	kg/hr
W	Dynamometer load	N
N	Speed of engine	rpm

System constant

D	Engine cylinder diameter	m
L	Engine stroke length	m
No.cyl	Number of cylinders	
N	No. of revolutions per cycle	1 for 2 stroke 2 for 4-stroke
R	Dynamometer level arm for loading	m
Cal.val.	Calorific value of fuel.	kJ/kg
d	Orifice diameter	m
C_d	Coefficient of discharge	
ρ_a	Air density	kg/m^3
ρ_w	Water density	kg/m^3
h	Manometer reading across orifice	m (of water)
Cp_w	Specific heat of water at constant pressure	KJ/kg. K
Cp_{ex}	Specific heat of exhaust at constant pressure	KJ/kg. K

Formulae

1. **Brake Power**

$$\text{BP} = \frac{2\times\pi\times N\times W\times R}{(60\times1000)} \quad kW$$

2. **Brake specific fuel consumption**

$$\text{BSFC} = \frac{F_1}{BP} \quad kg/kW-hr$$

3. **Brake thermal efficiency**

$$bte = \frac{BP\times3600}{F_1\times Cal.val.}\times100 \quad \%$$

4. **Air-fuel Ratio**

$$\text{A/F} = \frac{F_2}{F_1}$$

5. **Heat Balance**

a. **Heat supplied by fuel** $= F_1\times Cal.val. \quad KJ/hr$

b. **Heat equivalent to useful work** $= BP\times3600 \quad KJ/hr$

In percentage

$$= \frac{Heat\ equivalent\ to\ useful\ work}{Heat\ supplied\ by\ fuel}\times100 \quad \%$$

c. **Heat in jacket cooling water** $= F_3\times C_{pw}\times(T_2-T_1) \quad KJ/hr$

In percentage

$$= \frac{Heat\ in\ jacket\ cooling\ water}{Heat\ supplied\ by\ fuel}\times100 \quad \%$$

d. **Heat in exhaust gas**

$$Cp_{ex} = \frac{F_4\times Cp_w\times(T_4-T_3)}{(F_1+F_2)\times(T_5-T_6)} \quad KJ/Kg^0K$$

So,

Heat in exhaust $=(F_1+F_2)\times Cp_{ex}\times(T_5-T_{amb}) \quad KJ/hr$

In percentage

$$= \frac{Heat\ in\ exhaust}{Heat\ supplied\ by\ fuel}\times100 \quad \%$$

6. Heat to radiation loss etc.

$$= Heat\ \sup plied\ by\ fuel(100\%) - \begin{Bmatrix} (Heat\ equivalent\ to\ useful\ work(\%)) + \\ (Heat\ in\ jacket\ cooling\ water(\%)) + \\ (Heat\ to\ exhaust(\%)) \end{Bmatrix}$$

Operating Procedure

1. Baseline performance tests were carried out with the engine operating on diesel fuel only. The engine load ranges from a minimum of 0.1 kg to a maximum of 16 kg load. The engine tests were conducted for the entire load range i.e., 0 to 100% in steps of 20% at constant speed of 1500 rpm.
2. First, engine was warmed up and run for few minutes at 1500 rpm under no-load condition to reach stable operating conditions.
3. The water flow was adjusted to 250 and 70 liters per hour for the engine cooling and calorimeter respectively according to the engine supplier instructions.
4. Then, as per experimental design a load level was set for engine operation. Once the engine reaches the steady-state condition, the engine was ready to present the baseline results.
5. For this, the following data were recorded manually: 1) Engine jacket water (in/out), calorimeter water (in/out) and exhaust gas temperature,2) The difference in liquid level in the manometer for air flow, and 3) Volume of diesel fuel consumption by the engine in one minute.4) temperatures at all points
6. This experimental measurement procedure was repeated for 0%, 20%, 40%, 60%, 80% and 100% engine loading. The load variations on the engine were conducted at 1500 ±50 rpm. The load was varied in steps by means of the eddy-current dynamometer with the help of a manually controlled knob with a digital load indicator provided in the engine controller.
7. The engine efficiency, BP, bsfc, air and fuel flow rate, A/F ratio, heat balance, etc will be calculated and accordingly plot the performance characteristics of the test.

Air Flow F_2: $C_d \pi/4d^2(\sqrt{2gh} \times W_{den}/A_{den}) \times 3600 \times A_{den}$ Kg/hr

System Constants

Orifice diameter:	20 mm
Dynamometer arm length:	185 mm
C_d for orifice:	0.6
Specific heat of exhaust (C_p):	1.1 KJ/Kg K
Air density:	1.17 kg/m^3
Calorific value of fuel:	42000 KJ/kg
Ambient temperature:	27$^{0\,C}$
Fuel Density:	850 kg/m3

Observation Table

Load Kg	Speed RPM	Air mm	Fuel CC/min	Water flow for engine LPH	Water flow calorimeter LPH	Temp. Engine		Temp. Calorimeter		Temp. Exhaust	
						T_1 K	T_2 K	T_3 K	T_4 K	T_5 K	T_6 K

Results

BP Kw	FC kg/hr	BSFC kg/kW-hr	Air flow kg/hr	Bte %	A/F ratio	Heat equi. of work,%	Heat cooling water, %	Heat by exhaust %

Performance Characteristics curves

1. Brake Power variation with brake load.
2. Brake specific fuel consumption variation with brake load.
3. Brake thermal efficiency variation with brake load.
4. Exhaust gas temperature variations with brake load.
5. Energy carried by coolant variations with brake load.
6. Air fuel ratio variations with brake load.

Conclusions