Experiment No.: 04

Experiment Name: Performance test of Diesel Engine

Objectives:

i) To perform a load test on a four stroke diesel engine to study its performance.

ii) To plot the following engine performance graph based on the experiment.

iii) To know the actual Efficiency of diesel engine.

Theory:

Diesel engine is an internal combustion engine in which heat is produced by the compression of air and fuel in the cylinder.

The four stroke diesel engine is an internal combustion engine in which the piston completes four separate strokes per crankshaft cycle:

1) Intake stroke - Air enters the cylinder.
2) Compression stroke - Air is compressed, raising temperature.
3) Power Stroke - Fuel is injected, ignites due to compression, and produces power.
4) Exhaust Stroke - Burnt gases are expelled.

The engine's performance is evaluated using key parameters:

Brake Power, $BP = \frac{2\pi NT}{60}$

Where, N = Engine speed (RPM)

T = Tourque (Nm)

Brake Thermal Efficiency, (BTE) $= \frac{BP \times 3600}{M_f \times C_v} \times 100\%$

Where, BP = Brake power

M_f = fuel Mass flowrate (kg/hr)

C_v = Calorific value of fuel (kJ/kg)

Brake Specific Fuel Consumption (BSFC)

$$BSFC = \frac{M_f}{BP}$$

Here, lower BSFC indicates better fuel efficiency.

These parameters help analyze engine performance, efficiency & fuel consumption, making engines suitable for power generation, transportation & industrial applications.

Required Apparatus:

1) Four-Stroke Peter Diesel Engine.
2) Generator for electrical load.
3) Dynamometer for load measurement
4) Stopwatch for fuel consumption time

Working Procedure:

1) The diesel engine was connected to a generator to generate electrical power.
2) There ~~was~~ electrical laad was setup ~~to~~ in increasing steps to increase load on the generator.
3) A mechanism was used to convert the electrical load, mimic it to mechanical load for the diesel engine.
4) The weight (mechanical load) was recorded.
5) Fuel consumption time was measured by recording the time taken for a fixed amount of fuel. ~~to~~
6) Shaft length was measured to determine torque.
7) Using recorded values, BP, BTE & BSFC was calculated.

Data:

No. of Test	Speed RPM (N)	Load (lb)	Fuel Consumption (sec)	Length of shaft (inch)	Brake Power (W)	BTE (%)
1	972	4	75	13	596.48	11.68
		7.2	68		1074	19.08
		8.4	64		1255	20.98
		9.4	61		1402.6	22.35%

Calculation:

Formulas used:

Torque, $T = wl$

$w = mg$

Mass of fuel, $m_f = \rho v$

Fuel Consumption rate, $M_f = \dfrac{m_f \times 3600}{time}$

$BP = \dfrac{2\pi NT}{60}$

$BTE = \dfrac{BP \times 3600}{M_f \times C_v} \times 100\%$

$BSFC = \dfrac{M_f}{BP}$

$\rho = 0.86$ gm/cc

$C_v = 44500$ kJ/kg

BP in kW

T in Nm

N in RPM = 972

M_f in kg/hr

Length of shaft in m

Load, w in N

v = 10 cc

Speed, $N = 972$ RPM

Length of shaft, $l = 13'' = 0.3302$ m

Mass of fuel, $m_f = \rho V = 0.86 \times 10 = 8.6$ gm
$= 8.6 \times 10^{-3}$ kg

(i) For load = 4 lb

$T_1 = w_1 l = m_1 g l = 4 \text{ lb} \times (9.8 \times 0.3302)$

$= 1.81 \times 9.8 \times 0.3302$

$= 5.86$ Nm

$$M_{f_1} = \frac{m_f \times 3600}{75} = \frac{8.6 \times 10^{-3} \times 3600}{75} = 0.4128 \text{ kg/hr}$$

$$BP_1 = \frac{2\pi N T_1}{60} = \frac{2\pi \times 972 \times 5.86}{60} = 596.48 \text{ W}$$
$= 0.596$ kW

$$BTE_1 = \frac{BP_1 \times 3600}{M_{f_1} \times C_v} = \frac{0.596 \times 3600}{0.4128 \times 44500} \times 100\%$$
$= 11.68\%$

$$BSFC_1 = \frac{M_{f_1}}{BP_1} = \frac{0.4128}{0.596} = 0.693 \text{ kg/kWh}$$

(ii) For load = 7.2 lb

$T_2 = W_2 l = m_2 g l = 3.26 \times 9.8 \times 0.3302 = 10.55$ Nm

$$M_{f_2} = \frac{m_f \times 3600}{68} = \frac{8.6\times10^{-3}\times3600}{68} = 0.4553 \text{ kg/hr}$$

$$BP_2 = \frac{2\pi N T_2}{60} = \frac{2\pi\times972\times10.55}{60} = 1.074 \text{ kW}$$

$$BTE_2 = \frac{BP_2\times3600}{M_{f_2}\times C_v} = \frac{1.074\times3600}{0.4553\times44500}\times100\% = 19.08\%$$

$$BSFC_2 = \frac{M_{f2}}{BP_2} = \frac{0.4553}{1.074} = 0.424 \text{ kg/kWh}$$

(III) For load = 8.4 lb

$$T_3 = W_3 d = m_3 g d = 3.81\times9.8\times0.3302 = 12.33 \text{ Nm}$$

$$M f_3 = \frac{m_f\times3600}{64} = \frac{8.6\times10^{-3}\times3600}{64} = 0.4838 \text{ kg/hr}$$

$$BP_3 = \frac{2\pi N T_3}{60} = \frac{2\pi\times972\times12.33}{60} = 1.255 \text{ kW}$$

$$BTE_3 = \frac{BP_3\times3600}{M f_3\times C_v} = \frac{1.255\times3600}{0.4838\times44500}\times100\% = 20.98\%$$

$$BSFC_3 = \frac{M_{f3}}{BP_3} = \frac{0.4838}{1.255} = 0.385 \text{ kg/kWh}$$

(IV) For load = 9.4 lb

$$T_4 = W_4 d = m_4 g d = 4.26\times9.8\times0.3302 = 13.78 \text{ Nm}$$

$$M_{f_4} = \frac{m_f\times3600}{61} = \frac{8.6\times10^{-3}\times3600}{61} = 0.5075 \text{ kg/hr}$$

$$BP_4 = \frac{2\pi N T_4}{60} = \frac{2\pi\times972\times13.78}{60} = 1.4026 \text{ kW}$$

$$BTE_4 = \frac{BP_4 \times 3600}{M_{f4} \times C_V} = \frac{1.4026 \times 3600}{0.5075 \times 44500} \times 100\% = 22.35\%$$

$$BSFC_4 = \frac{M_{f4}}{BP_4} = \frac{0.5075}{1.4026} = 0.362 \text{ kg/kWh}$$

$$\text{Mean BTE} = \frac{11.68 + 19.08 + 20.98 + 22.35}{4}$$

$$= 18.52\%$$

$$\text{Mean Brake Power} = \frac{0.596 + 1.074 + 1.255 + 1.4026}{4}$$

$$= 1.0819 \text{ kW}$$

$$\text{Mean BSFC} = \frac{0.693 + 0.424 + 0.385 + 0.362}{4}$$

$$= 0.466 \text{ kg/kWh}$$

Result:

Brake Power, (Average) = 1.0819 kW

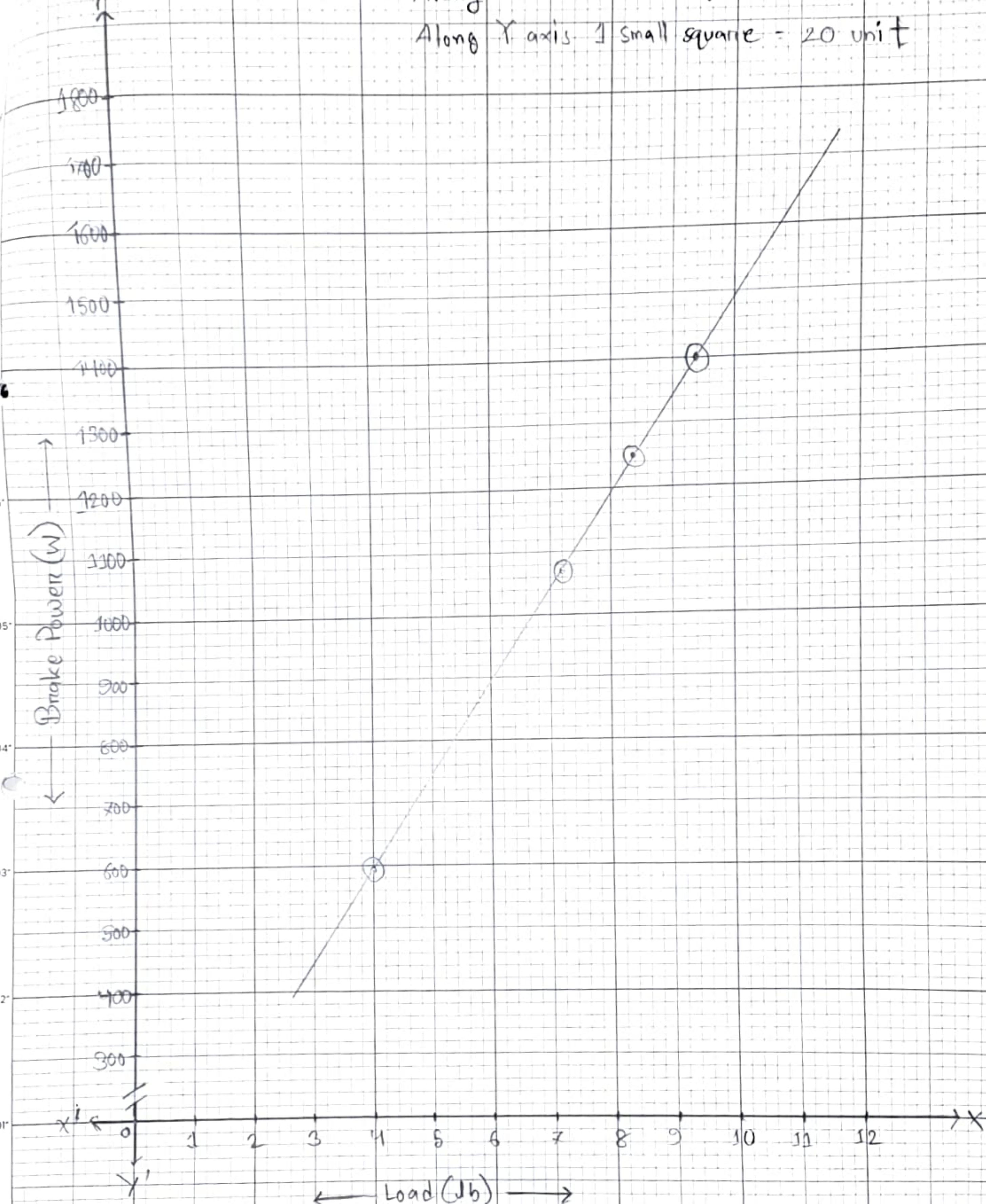
Brake Thermal Efficiency (Average) = 18.52%

Brak Specific Fuel Consumption (Average) = 0.466 kg/kWh

[Brake Load vs. Brake Power]

Along X axis 1 small square = 0.2 unit

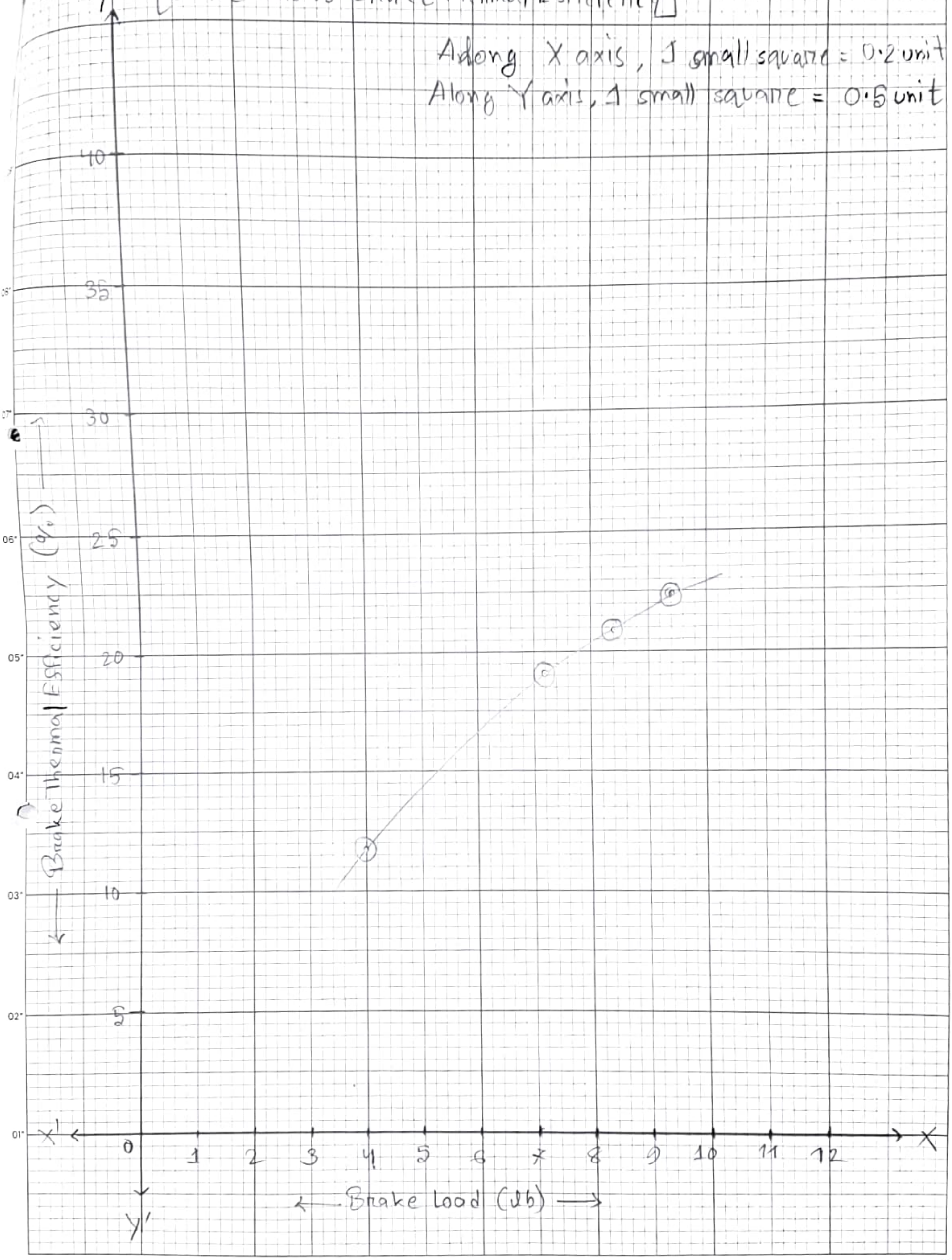
Along Y axis 1 small square = 20 unit



NAME :   ROLL

[Brake Load vs Brake Thermal Efficiency]

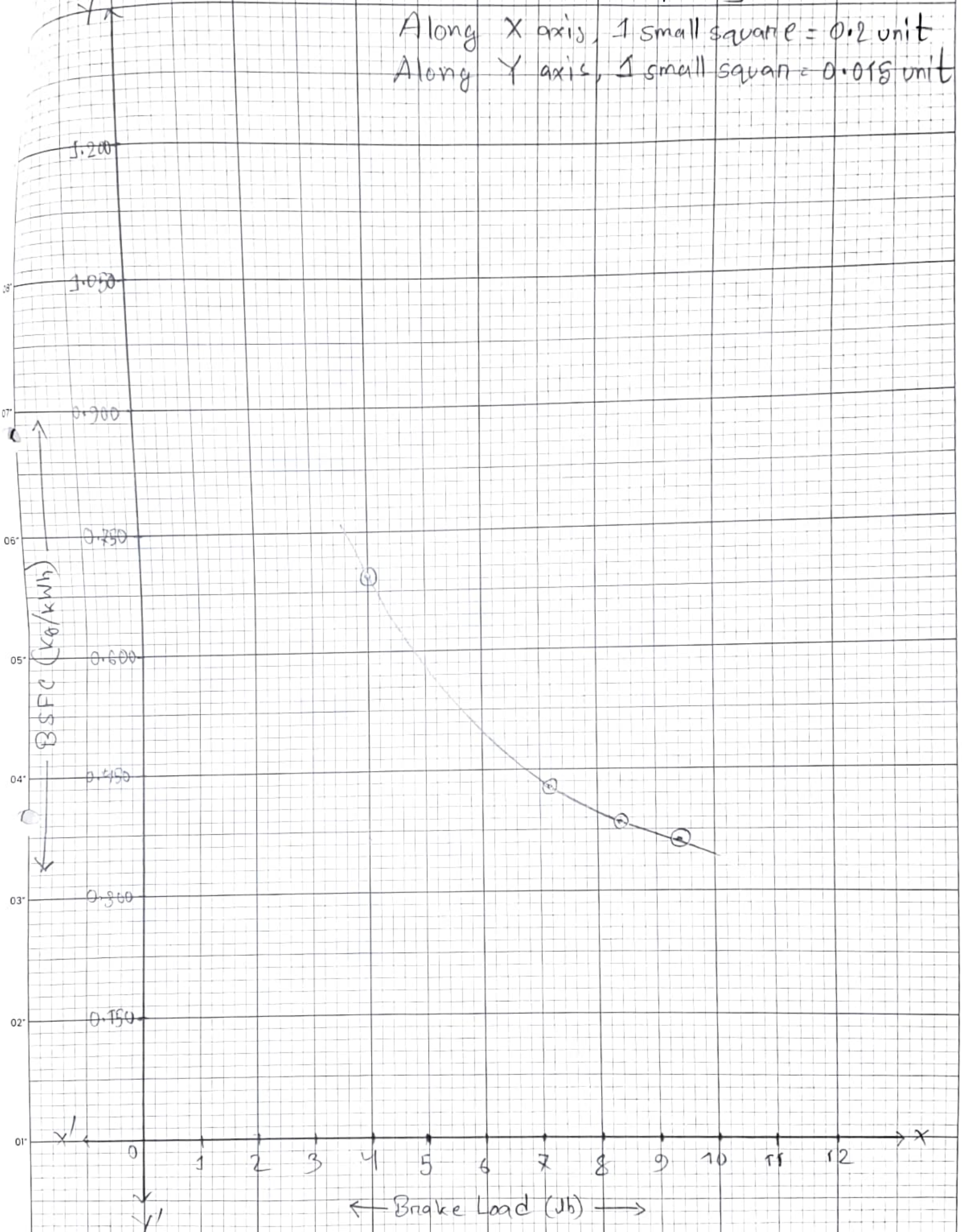
Along X axis, 1 small square = 0·2 unit
Along Y axis, 1 small square = 0·5 unit



0.1" Square - 8.0" x 10.5"

[Brake Load vs Brake Specific Fuel Consumption]

Along X axis, 1 small square = 0.2 unit
Along Y axis, 1 small square = 0.015 unit



Discussion:

The experiment successfully determined the performance parameters of the diesel engine. Minor errors occured due to fuel measurement inaccuracies, heat loss, round up errors in calculations as well as the age (old) of the engine. Variations in load affected the efficiency & fuel consumption as expected.

Conclusion:

The calculated parameters help evaluate engine performance for fuel efficiency & power output. The diesel engine operates efficiency within a certain load range, making it suitable for power generation, transportation & industrial machinery.

Grp No. 04

Exp Date: 19-1-25

Roll: 2010025

Exp No.: 04

Exp. Name: Performance test of Diesel Engine

Data:

No. of Test	RPM (N)	Load (lb)	Fuel Consumption		Length of Arm (inch)	Brake Power (W)	BTE
		~~No load~~	~~1:12~~	~~72~~		597.49	
	~~972 N~~	4	1:13	75	13'' inch		11.69%
	972	7.2	1.08	68		1075.69	19.11%
		8.4	1:02	64		1255.04	20.98%
		9.4	1:01	61			

$C_v = 19500$

$\rho = 0.86$ gm/cc

Calculation:

Eqns:

Brake Power $= \frac{2\pi NT}{60}$ W — (i)

Brake Thermal Efficiency $= \frac{BP \times 3600}{M_f \times C_v} \times 100\%$ — (ii)

$BSFC = \frac{M_f}{BP}$

Torque, $T = wd$

w = Load (N)

d = Length of Arm (m)

M_f = Mass of Fuel (kg/hr)

$C_v = 44500$ kj/kg

BP → kW

N = rpm = 972

$\rho = 0.86$ gm/cc

For Load = 4 lb

$w = 4\ lb = 1.814\ kg$
$= 17.78\ N$

$l = 13'\ inch = 0.3302\ m$

$N = 972\ rpm$

$T = wl$
$= 17.78 \times 0.3302$
$= 5.87\ Nm$

Mass of Fuel, ~~mf~~ $= \rho \times V$
$= 0.86 \times 10 = 8.6\ gm$

75 s Fuel consumption → 8.6 gm
3600 s " " → $\frac{8.6 \times 3600}{75} = 412.8\ gm/hr$

$M_f = 0.4128\ kg/hr$

~~BTE~~

$$BP = \frac{2\pi NT}{60}$$
$$= \frac{2\pi \times 972 \times 5.87}{60} = 597.49\ W$$
$$= 0.597\ kW$$

$$BTE = \frac{BP \times 3600}{M_f \times C_v} \times 100\% = \frac{0.597 \times 3600}{0.4128 \times 44500} \times 100\%$$
$$= 11.69\%$$

75 s ⟶ 8.6 gm

3600 s ⟶ $\frac{8.6}{75} \times 3600$

$= 412.8$ gm

0.4128 kg/h

75 ⟶ $\frac{10\,cc \times 3600}{75}$

.86 × 480 cc

4 ⟶

$w = 7.2$ lb $= 32.005$ N

$d = 0.3302$ m

$T = 10.568$ Nm

$m =$ ~~8.6~~ 8.6 gm
~~= 0.86 × 10~~

68 s ⟶ $\frac{8.6 \times 3600}{68}$

$= 455.29$

$= 0.4553$ kg/h

$BP = \frac{2\pi \times 972 \times 10.568}{60}$

$= 1075.69 = 1.076$

$BTE = \frac{1.076 \times 3600}{0.4553 \times 44500} = 19.11\%$

8.4 lb = 37.34 N

T = 12.33 Nm

$$\frac{8.6 \times 3600}{64} = 483.75$$

$M_f = 0.48375$ kg/hr

BP = $2\pi \cdot 972 \cdot 12.33$

$= 1255.04 = 1.255$

$$\frac{1.255 \times 3600}{0.48375 \times 44500} = 20.98\%$$