FORMULAE USED:

(a) Electrical Power Developed by Generator-
\[
P_E = V \times I \text{ (Watts)} \tag{1.1}
\]
Where,
- \(P_E\) = Electrical power developed by Generator
- \(V\) = Voltage
- \(I\) = Current (amperes)

(b) Engine Brake Power (B.P.)-
\[
B.P. = \frac{P_E \eta_g}{\eta_g} \text{ (Watts)} \tag{1.2}
\]
Where,
- \(B.P.\) = Engine Brake Power
- \(\eta_g\) = Generator efficiency (70 %)
- \(P_E\) = Electrical power developed by Generator (Watts)

(c) Torque (N-m)-
\[
B.P. = \frac{2\pi NT}{60} \tag{1.3}
\]
\[
T = \frac{B.P. \times 60}{2\pi N} \text{ (N-m)}
\]
Where,
- \(T\) = Torque
- \(B.P.\) = Engine Brake Power (watts)
- \(N\) = r.p.m

(d) Stroke Volume (Vs)-
\[
Vs = A \times L \times N/2 \text{ (m}^3\text{/min)} \tag{1.4}
\]
\[
Vs = \frac{A \times L \times N}{2 \times 60} \text{ (m}^3\text{/sec)}
\]
Where,
- \(L\) = Stroke length (m)
- \(A\) = Area of cylinder (m\(^2\))
- \(N\) = r.p.m.

(e) Brake Thermal Efficiency (\(\eta_{Bth}\))-
\[
\eta_{Bth} = \frac{B.P.}{\frac{m_t}{3600} \times cv} \times 100 \% \tag{1.5}
\]
Where,
- \(B.P.\) = Engine Brake Power (KW)
mf = Total fuel consumed (Kg/hr)
Cv = Calorific value of fuel (KJ/Kg)

(f) Total Fuel Consumed (mf)-
m_f = \rho_f \times v_f

\begin{align*}
    v_f &= \frac{\text{Fuel consumed in 20 sec (ml)}}{20 \text{ sec}} (\text{ml/sec}) \\
    v_f &= \frac{\text{Fuel consumed in 20 sec(l)}}{20 \text{ sec} \times 1000} (\text{l/sec}) \\
    v_f &= \frac{\text{Fuel consumed in 20 sec(m}^3\text{) x 3600}}{20 \times 1000 \times 1000} (\text{m}^3/\text{hr})
\end{align*}

m_f = \rho_f \times v_f \left(\frac{\text{Kg}}{\text{hr}}\right) \quad (1.6)

Where,
m_f = \text{Total fuel consumed} \\
\rho_f = \text{Density of fuel (Kg/m}^3\text{)} \\
v_f = \text{Volume of fuel consumed (m}^3/\text{hr)}

(g) Brake Specific Fuel Consumption (B.S.F.C.)-
B.S.F.C. = \frac{mf}{B.P.(KW)} (\text{Kg/KWh}) \quad (1.7)

(h) Volumetric Efficiency (\eta_{vol})-
\eta_{vol} = \frac{\text{Fuel supplied during suction (m}^3/\text{sec)}}{\text{Stroke volume (m}^3/\text{sec)}} \quad (1.8)

\begin{align*}
    \eta_{vol} &= \frac{v_a}{v_s} \\
    v_a &= C_d \times A \sqrt{2gh_a} (\text{m}^3/\text{sec}) \\
    h_a &= \frac{P_w}{\rho_a} \times h_w \text{ mm of air column} \\
    h_a &= \frac{1000}{1.19} \times \frac{h_w}{1000} \text{ m of air column} \\
    h_a &= \frac{h_w}{1.19} \text{ m of air column}
\end{align*}

Where,
Cd = Coefficient of discharge = 0.62 
A = Area of orifice (m²) 
g = Acceleration due to gravity (m/sec²) 
h_w = Manometer reading (mm) 
\(\rho_w\) = Density of water (1000 Kg/m³) 
\(\rho_a\) = Density of air (1.19 Kg/m³)

SAMPLE CALCULATION:
  Sample Calculation for E10 (Gasoline)-

Load = 500 W, Voltage (V) = 122 volts, Current (I) = 2.8 Amp, N = 2500 r.p.m.
Manometer Reading (h_w) = 5 mm, Fuel Consumed in 20 sec = 3 ml

1. **Electrical Power Developed by Generator** -
   
   \[ P_E = V \times I \text{ (watts)} \]
   \[ P_E = 122 \times 2.8 = 341.6 \text{ Watts} \]

2. **Engine Brake Power (B.P.)** -
   
   \[ B.P. = \frac{P_E}{\eta_g} \text{ (Watts)} \quad [\eta_g = \text{Generator efficiency (70 %)}] \]
   \[ B.P. = \frac{341.6}{0.7} = 488 \text{ Watts} \]

3. **Torque (N-m)** -
   
   \[ B.P. = \frac{2\pi NT}{60} \text{ (N-m)} \]
   \[ T = \frac{B.P. \times 60}{2\pi N} \text{ (N-m)} \]
   \[ T = \frac{488 \times 60}{2 \times 3.14 \times 2500} \]
   \[ T = 1.864 \text{ N-m} \]

4. **Total Fuel Consumed (mf)** -
   
   \[ m_f = \rho_f \times v_f \]
   \[ v_f = \frac{\text{Fuel consumed in 20 sec (m}^3\text{)} \times 3600}{20 \times 1000 \times 1000} \]
   \[ v_f = \frac{3 \times 3600}{20 \times 10^6} \]
   \[ v_f = 0.00054 \text{ (m}^3\text{/hr)} \]
   \[ m_f = \rho_f \times v_f \left(\frac{\text{Kg}}{\text{hr}}\right) \]
   \[ m_f = 746 \times 0.00054 \quad [\rho_f = 746 \text{ (Kg/m}^3\text{)}] \]
   \[ m_f = 0.4028 \text{ (Kg/ hr)} \]
5. **Brake Specific Fuel Consumption (B.S.F.C.)**-

Brake Specific Fuel Consumption (B.S.F.C.) = \[ \frac{mf}{B.P. (KW)} \] (Kg/KWh)

- B.S.F.C. = 0.4028/0.488
- B.S.F.C. = 0.825 (Kg/KWh)

6. **Brake Thermal Efficiency (\(\eta_{Bth}\))**-

Brake Thermal Efficiency (\(\eta_{Bth}\)) = \[ \frac{B.P.}{mf \times 3600 \times cv} \times 100 \] (%)

- \(\eta_{Bth}\) = \(\frac{0.488}{0.4028 \times 44000} \) x 100 [ Cv = 44000 (KJ/Kg) ]
- \(\eta_{Bth}\) = 0.488/4.9231 x 100
- \(\eta_{Bth}\) = 9.91%

7. **Volumetric Efficiency (\(\eta_{vol}\))**-

Volumetric Efficiency (\(\eta_{vol}\)) = \[ \frac{Fuel\ supplied\ during\ suction\ \left(\frac{m^3}{sec}\right)}{Stroke\ volume\ \left(\frac{m^3}{sec}\right)} \]

\(\eta_{vol}\) = \(\frac{v_a}{v_s}\)

\(V_S = A \times L \times N/2\) (m³/min)

- \(V_S = A \times L \times N/2\) (m³/sec) \[d = 0.067m, L = 0.056m\]
- \(V_S = 0.0041125\) (m³/sec) \[A = 0.003525\ m²\]

\(v_a = C_d \times A \sqrt{2gh_a\ \left(\frac{m^3}{sec}\right)}\)

- \(v_a = 0.62 \times 0.000227 \sqrt{2 \times 9.81 \times 4.2016}\)
- \(v_a = 0.0012778\) (m³/sec)

\(\eta_{vol} = 0.0041125\)

\(\eta_{vol} = 31.07\%\)