IITians GATE CLASSES
Exclusive GATE Coaching by IIT/IISc Graduates
A division of PhIE Learning Center

QUICK REVISION

FORMULA SHEET

for

GATE -ME IC ENGINE

Table Of Content

OUR COURSES

GATE Online Coaching

Course Features

- Live Interactive Classes
- E-Study Material
- Recordings of Live Classes
- Online Mock Tests

TARGET GATE COURSE

Course Features

- Recorded Videos Lectures
- Online Doubt Support
- E-Study Materials
- Online Test Series

Distance Learning Program

Course Features

- E-Study Material
- Topic Wise Assignments (e-form)
- Online Test Series
- Online Doubt Support
- Previous Year Solved Question Papers

OUR COURSES

Online Test Series

Course Features

- Topic Wise Tests
- Subject Wise Tests
- Module Wise Tests
- Complete Syllabus Tests

More About IGC

SAMPLE STUDY MATERIALS
https://bit.ly/3Wu7lsp

SAMPLE MOCK TESTS
https://bit.ly/3FDyF0f

SAMPLE VIDEO LECTURES
https://bit.ly/3V4xU6j

TEAM IGC GATE
https://bit.ly/3G21khi

OUR TESTIMONIALS
https://bit.ly/3Yp2Hh7

IGC TELEGRAM GROUP
https://bit.ly/3j4koCd

Follow us on:

For more Information Call Us
+91-97405 01604

Visit us
www.iitiansgateclasses.com

IC ENGINE

Chapter 1: AIR STANDARD CYCLES

Clearance ratio(C) $= \frac{v_c}{v_s}$

v_c = Clearance volume

v_s = Swept volume

Compression ratio (r) $= \frac{v_c + v_s}{v_c}$

$= \frac{\pi}{4} d^2 L$

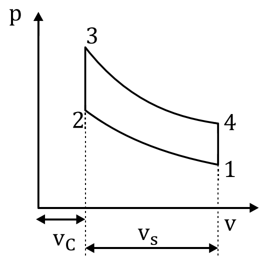
d = Bore diameter

L = Stroke Length

Compression ratio (r) $= \frac{v_c + v_s}{v_c}$

$C = \frac{1}{r-1}$

1. **Otto Cycle (S.I Engine)**



$\eta_{otto} = 1 - \left(\frac{1}{r}\right)^{\gamma - 1}$

$r = \frac{v_1}{v_2} = \frac{v_4}{v_3}$

$\frac{T_2}{T_1} = \frac{T_3}{T_4} = \left(\frac{v_4}{v_3}\right)^{\gamma-1}$

Note: η_{otto} for max work done

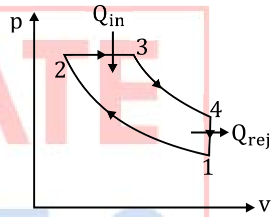
$(\eta_o)_{max} = 1 - \sqrt{\frac{T_1}{T_3}}$

Mean Effective pressure (MEP):

$P_{MEP} = \frac{(WD)_{net}}{v_{swept}}$

r_{otto} varies between 6 to 12

2. **Diesel Cycle (CI Engine)**



$r = \frac{v_1}{v_2}$

r_e = Expansion ratio $= \frac{v_4}{v_3}$

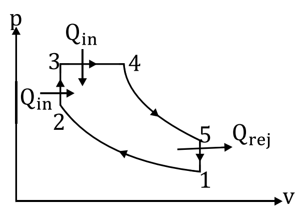
ρ(cutoff ratio) $= \frac{v_3}{v_2}$

$\boxed{r_e = \frac{r}{\rho}}$

$\eta_{diesel} = 1 - \left(\frac{1}{r}\right)^{\gamma-1}\left(\frac{\rho^\gamma - 1}{\gamma(\rho - 1)}\right)$

r_{diesel} varies between 16 to 22

3. **Dual Cycle:**



$$\eta_{dual} = 1 - \left(\frac{1}{r}\right)^{\gamma-1}\left(\frac{\alpha\,\rho^{\gamma} - 1}{\gamma(\rho-1)\alpha + (\alpha - 1)}\right)$$

pressure ratio $= \alpha = \frac{p_3}{p_2}$

Observation:

If $\alpha = 1, (p_3 = p_2) \rightarrow$ Diesel cycle

If $\alpha = 1, \rho = 1 \rightarrow$ Otto cycle

r_{dual} varies between 12 to 16

Comparison of Otto, Diesel and Dual Cycle:

1. For same r and heat addition.
   $\eta_{otto} > \eta_{dual} > \eta_{diesel}$
2. For same r and $Q_{rejection}$
   $\eta_{otto} > \eta_{dual} > \eta_{diesel}$
3. For same peak pressure, peak temperature and $Q_{rejection}$
   $\eta_{diesel} > \eta_{dual} > \eta_{otto}$
4. For same peak pressure and heat input.
   $\eta_{diesel} > \eta_{dual} > \eta_{otto}$
5. For same peak pressure and work output.
   $\eta_{diesel} > \eta_{dual} > \eta_{otto}$

Engine Performance Parameters:

1. Heat added per second.
   $\frac{HA}{sec} = \dot{m}_{fuel} \times (\text{Calorific value})_{fuel}$
2. Indicated Power (IP):
   Power available at piston due to the expansion of A/F mixture.
   $IP = \int pdv =$ Area of indicator diagram
3. **Brake Power (BP):**
   Power available at the end of engine shaft.
   $BP = T_b\omega$
   $T_b =$ Brake torque (N-m)
   $\omega = \frac{2\pi N}{60}\ (sec^{-1})$
4. **Friction power (FP):**
   IP − BP
5. $\eta_{Thermal} = \frac{IP}{\dot{m}_f(CV)}$
   Indicated thermal efficiency
6. $\eta_{Thermal} = \frac{BP}{\dot{m}_f(CV)}$
   Brake Thermal efficiency
7. $\eta_{mechanical} = \frac{BP}{IP} = \frac{\eta_{Bth}}{\eta_{Ith}}$
8. **Relative efficiency:**
   $\eta_{rel} = \frac{\text{Actual thermal effiжeicency}}{\text{Air standard efficicency}}$
   $\eta_{rel} = \frac{\eta_{Ith} \text{ or } \eta_{Bth}}{\eta_{\text{air standard}}}$
9. **Suction Flow Rate:** $(\dot{v}_s)$
   $\dot{v}_s = \frac{\pi}{4}D^2\,L \times N \times K\ \ (m^3/sec)$

$N = \frac{n}{2}$ for 4 stoke engine

$N = n$ for 2 stoke engine

$K =$ No. of cylinder

$n =$ Speed of engine (in rps)

10. **Mean Effective pressure:**

Brake mean effective pressure

$$b_{mep} = \frac{BP}{\dot{v}_s}$$

Indicated mean effective pressure

$$i_{mep} = \frac{IP}{\dot{v}_s}$$

11. **Specific Fuel consumption**

Indicated specific fuel consumption.

$$i_{sfc} = \frac{\dot{m}_{fuel}}{IP}$$

Brake specific fuel consumption.

$$b_{sfc} = \frac{\dot{m}_{fuel}}{BP}$$

12. **Average Piston Speed:**

$$V_{piston} = 2 \times \text{Stroke length} \times \frac{N_{rpm}}{60}$$

13.

$$\eta_{vol} = \frac{\dot{m}\ v_{entry}}{\frac{\pi}{4} D^2 L \times N \times K}$$

*****

Chapter 2: MORSE KEY TEST

$4B =$ Brake Power when all the engines are firing.

$$3B = \frac{3B_1 + 3B_2 + 3B_3 + 3B_4}{4}$$

= Arithematic mean of engines firing when one of the engine is stopped one by one.

$I = 4B - 3B$

$4I = 4(4B - 3B)$ Indicated power of engine

$$\eta_{mech} = \frac{4B}{4I}$$

Motoring Test:

- Used to find friction power of engine.
- rpm of running engine are noted.
- Motor is attached to engine shaft and made to run at same rpm. The power input to motor is friction power.

*****

Chapter 3: COMBUSTION

Perfect Combustion

$$C_xH_y + z\left(O_2 + \frac{79}{21} N_2\right) \rightarrow xCO_2 + \frac{y}{2} H_2O + z\left(\frac{79}{21}\right) N_2$$

$$Z = x + \frac{y}{4}$$

Stoichiometric AFR

$\Rightarrow$ No fuel in excess, No air in excess } (This ratio of AFM is stiochiometric AFR)

Equivalency Ratio (ϕ):

$$\phi = \frac{(FAR)_{actual}}{(FAR)_{stoichiometric}} = \frac{(\dot{m}_f)_{actual}}{(\dot{m}_f)_{ideal}}$$

If $\phi < 1 \Rightarrow$ Less temperature, less Power, less knocking (in petrol).

If $1 \leq \phi < 1.4 \Rightarrow$ High temperature, high Power, high knocking (in petrol).

If $\phi > 1.4 \Rightarrow$ Same effect as $\phi < 1$.

Generally:

If $\phi = 1 \Rightarrow$ Chemically correct mixture

If $\phi < 1 \Rightarrow$ Lean mixture (Excess air)

IF $\phi > 1 \Rightarrow$ Rich mixture (less air)

*****