Lectures

8th Semester B. Tech. Mechanical Engineering

Subject: Internal Combustion Engines

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Chapter: Engine Design

Topic: Numericals

Pre-Requisite:
Chapter - Engine Design and Operating Parameters
Topic: Geometrical Properties of Reciprocating Engines

Q1. The Maruti Suzuki Car has a three cylinder 800 cc SI engine that operates on four stroke cycle at 5500 rpm. The Compression ratio is 8.7:1, the length of connecting rods is 14.4 cm and the bore to stroke ratio is 0.95. At this speed, combustion ends at 30 degrees after TC. Calculate:

(i) Cylinder bore and stroke length
(ii) Average piston speed
(iii) Clearance volume of one cylinder
(iv) Piston speed at the end of combustion
(v) Distance the piston has travelled from TC at the end of combustion
(vi) Volume in the combustion chamber at the end of combustion

Solution:
Given data:
Vd = 800 cc
Number of cylinders = 3
r_c = 8.7:1
N = 5500 rpm
End of combustion = 30 crank angle degrees after TC
l = 14.4 cm
B/L = 0.95
(i)
Note: The following geometrical properties based calculations are to be done for each cylinder or on per cylinder basis
Displacement volume of each cylinder = 800/3 = 266 cc

Therefore $\frac{\pi}{4}B^2L$ = 266

Substituting
B/L = 0.95 or
B = 0.95*L

$\frac{\pi}{4}(0.95 * L)^2 L$ = 266 cc

L^3 = [266*4]/[0.95*0.95 * π]
L = 7.21 cm
Again B/L = 0.95
Therefore
B = 0.95*7.21 = 6.85 cm
B = 6.85 cm

(i) Average Piston Speed = $\bar{S}_p$ = 2*L*N

$\bar{S}_p$ = [2*7.21*5500]/[100*60] = 13.2 m/sec

Mean piston speed or
Average piston speed = 13.2 m/sec

(ii) Compression ratio, $r_c = \frac{V_d + V_c}{V_c}$

Or [8.7/1] = [266+V_C]/V_C
Therefore
V_C = 34.56 cm^3
Or clearance volume of each cylinder = 34.56 cm^3

(iii) Piston speed at the end of combustion, or
Piston speed at 20 degrees of crank angle after TC
So
Θ = 20 degrees of crank angle
We have or we can derive the following relationship between the mean piston speed in denominator, instantaneous piston speed in the numerator and R from the geometrical properties of reciprocating engines

$$\frac{S_p}{\bar{S}_p} = \frac{\pi}{2}\left[1 + \frac{\cos\Theta}{\{R^2 - (\sin\Theta)^2\}^{\frac{1}{2}}}\right]$$

Substituting the values:

$\bar{S}_p$ = 13.2 m/sec

Θ = 30 degrees of crank angle
R = l/a
a = L/2 = 7.21/2 = 3.60
R = 14.4/3.6
R = 4
We get
Instantaneous piston speed at 30 degrees of crank angle after TC or
Piston speed at the end of combustion = Sp
Sp = 25.27 m/sec

(iv) Distance the piston has travelled from TC at the end of combustion
[refer figure - line-diagram of engine from previous website based lecture notes]
s = Instantaneous distance of piston at any value of crank angle from centre of crank shaft

Total distance from TC to centre of crank shaft = l + a

l + a = 14.4 + (7.21/2) = 14.4 + 3.60 = 18.0 cm

Therefore the distance the piston has travelled from TC at $\Theta = 30\ degrees$

= l + a –s

Distance travelled from TC = l +a –s

From the line diagram of the engine we have or we can derive the following relationship:

s = a $\cos\Theta + (\,l^2 - \,a^2 \sin\Theta^2\,)^{1/2}$

Substituting the values of l, a, and Θ we have

s = 17.4 cm

Therefore

Distance piston has travelled from TC = l +a – s

l + a – s = 18.0 – 17.4 = 0.6 cm

Distance piston travelled from TC = 0.6 cm

(v) Volume in the combustion chamber at the end of combustion

We know or we can derive from the engine geometry,

V = Vc [1 + ½(r_c – 1) { R + 1 - $\cos\Theta - (\,R^2 - \,(\sin\Theta)^2\,)^{1/2}$]

Substituting the values of Vc, r_c ,R and Θ we get

V = 58.51 cm^3

Volume in combustion chamber at the end of combustion, Θ = 30 degrees, = 58.51 cm^3

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Text Book:

Internal Combustion Engine Fundamentals
By John B Heywood
Published By: McGraw-Hill Book Company