Lectures

8th Semester B. Tech. Mechanical Engineering

Subject: Internal Combustion Engines

I/C Prof M Marouf Wani

Chapter: Engine Design

Topic: Numericals Continued – 29-04-2020

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

Q2. An automobile has a 3.2 Litre, five cylinder four stroke cycle diesel engine operating at 2400 rpm. Fuel injection occurs 20 degrees before TC to 35 degrees after TC. The engine has a volumetric efficiency of 0.95 and operate with fuel equivalence ratio of 0.80. Calculate:

(i) Time for one injection.
(ii) Fuel flow rate through an injector.

Solution:
Given data:
Engine Displacement Volume = Vd = 3.2 litre = 3200 cc
Number of cylinders = 5
4 stroke cycle engine
N = 2400 rpm
Volumetric Efficiency = 0.95
Equivalence Ratio = 0.80
Start of Fuel Injection = SOI = 20 degrees before TC ---------- towards end of compression process
End of Fuel Injection = EOI = 35 degrees after TC --------------during expansion or power process
Therefore duration of fuel injection = DOI = 20+35 = 55 degrees of crank angle

Note: **This numerical demonstrates the basics behind the design of micro-controller based electronic fuel injection system for a diesel engine. The logic behind this design will suit the spark ignition engine as well. The numerical also leads to the design of air supply system or design of intake manifold of the engine.**
(i)
Time For One Injection:
Since N = 2400 rpm
Therefore
Time taken to complete 2400 revolution = 1 minute or
Time taken to complete 2400*360 degrees of crank angle = 60 seconds

Therefore time taken for 55 degrees of duration of fuel injection = [60*55]/[2400*360] seconds
Time for 55 crank angle degree based duration of one fuel injection = 0.00381 seconds
Time for 55 crank angle based duration of **one fuel injection** = **3.81 milliseconds = 3.81 msec**
Conclusion: This means that the electronic solenoid injector should open for 3.81 msec or 55 degrees of crank angle at the engine speed of 2400 rpm.
This will be controlled by using a programmed microcontroller in the embedded electronic engine management system

(ii)
Fuel Flow Through an Injector:
We have
Fuel - air equivalence ratio = Ø = 0.80
Fuel – air equivalence ratio is defined as follows:

$$Ø = \frac{(\frac{F}{A})actual}{(\frac{F}{A})stoichiometric}$$

Or

$$Ø = \frac{\left(\frac{F}{A}\right)a}{(\frac{F}{A})s}$$

(A/F)s for diesel fuel = 14.6
Therefore
(F/A)s for diesel fuel = 1/14.6
Using the above definition based equation for fuel air equivalence ratio, we have
(F/A)a = 0.80/14.6 = 0.0547
(F/A)a = 0.0547
Or
(A/F) a = 1/[(F/A)a]
(A/F)a = 18.25
Therefore
Operating value of A/F ratio = 18.25
Or

$$\frac{\dot{m}_a}{\dot{m}_f} = 18.25$$

Using concept of volumetric efficiency to find the mass flow rate of air for the above equation so that the mass flow rate of fuel could be calculated

$$\eta_v = \frac{\dot{m}_a * 2}{\rho_{a,i} * V_d * N}$$

Assuming
Density of ambient air = $\rho_{a,I}$ = 1.2 Kg/m^3
Using the data given in the numerical in the above equation we have:

$$0.95 = \frac{\dot{m}_a * 2}{1.2 * 3200 * 10^{-6} * 2400}$$

Therefore

$\acute{m}_a$ = 4.3776 kg/min = 0.07296 Kg/sec
Using the value of mass flow rate of air in the above definition of air-fuel ratio
We have
[4.3776/$\acute{m}_f$] = 18.25
Therefore
Mass flow of fuel:
$\acute{m}_f$ = 4.3776/18.25 = 0.2398 Kg/min = 0.00399 Kg/sec
This fuel flow rate or fuel supply rate corresponds to five injectors in five cylinders
Fuel flow rate through one injector = 0.00399/5 = 0.000798 Kg/sec
Fuel flow rate through one injector = 0.000798 Kg/sec

Dated: 29-04-2020

In charge Course:

Prof M Marouf Wani
Mechanical Engineering Department
National Institute of Technology
Srinagar, J&K
India – 190006

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