Lectures

3rd Semester M. Tech. - Mechanical Systems Design

Mechanical Engineering Department, NIT Srinagar

Subject: Advanced Engine Design

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Topic: Engine Design And Operating Parameters Continued

1. **Engine Friction Power P_f:**

The friction power of the engine include the following:

(i) Power required to expel exhaust gas and induct fresh charge.

(ii) Power required to overcome the friction of the bearings, pistons, and other mechanical components of the engine, and to drive the engine accessories.

This friction power gets used from the gross indicated work per cycle or power.

Therefore the relation between gross indicated power P_{ig}, brake power P_b and friction power P_f can be written as:

$P_{ig} = P_b + P_f$

2. **Mechanical Efficiency η_m:**

The mechanical efficiency of the internal combustion engine is defined as the ratio of the brake power delivered by the engine to the gross indicated power.

$$\eta_m = \frac{P_b}{P_{ig}} = 1 - \frac{P_f}{P_{ig}}$$

Since brake power, indicated power and also the friction power varies with respect to engine speed, load and engine design, so mechanical efficiency of the engine also varies with respect to engine speed, load and engine design.

The operating parameters, brake power, indicated power and friction power show a non-linear behavior with respect to engine speed, load and design.

Further the proportional rise or fall in the numerical value of brake power, indicated power and friction power with respect to a change in engine speed, load and design is not same.

Typical values of mechanical efficiency for a modern automotive engine are as follows.

Full load and variable speed operation:

Mechanical efficiency of the engine **decreases** with a rise in engine speed under full load operation.

Load = 100% (wide open throttle or full throttle):

$\eta_m = 90\%$

N = (1800 rpm to 2400 rpm) or 30 rev/sec to 40 rev/sec

$\eta_m = 75\%$

N = Rated Speed (say 5500 rpm)

Part Load Operation:

Mechanical efficiency of the engine **decreases** under part load operation or (when engine is throttled).
Part load operation of an engine is possible both under **constant speed** (Electrical Generators or **DG Sets**) as well as **variable speed** operation (**Automotives**)
Mechanical efficiency is zero under idle operation (the minimum required engine speed, say 900±50 rpm for Maruti Suzuki Car engine)

3. **Mean Effective Pressure:**

Definition: As per the concept from air standard cycles for I C engines, mean effective pressure is defined as that constant pressure which could act on the piston and produce the same work during one cycle as that produced by the varying pressure during the same cycle.

Significance Of Mean Effective Pressure In The Engine Design:

An engine is basically designed to **do some work**. **Torque** is the capability of the engine to do work. **How faster** the engine can do the work is taken care of by its **designed operating speed**.
As per thermodynamic and stress analysis based concepts of engine design small engines can be designed to operate at high speeds and heavy duty engines operate at slow speeds.
For **example** a motorcycle engine produces a power of 12 BHP @ N = 9000 rpm to 12000 rpm.
A medium speed car engine produces a power of 39.5BHP at 5500 rpm.
A large heavy duty truck engine produces a power of 300 KW or 428bhp at 1800 rpm.
One more parameter to check the **ability** of an engine **to do** some useful **work** is by normalizing the work done by the engine with its size or **displacement volume**.
This one basically tells how big or small an engine has to be if it designed for a big work or a small work with corresponding high or low torque.
For **example** a motorcycle engine producing a power of 12 BHP has a displacement volume of say 110cc.
A medium speed car engine producing a power of 39.5BHP has a displacement volume of 800cc.
A large heavy duty truck engine producing a power of 428 BHP has a displacement volume of 12400cc.
The term obtained by diving the work done by the engine per cycle by the displacement volume of the engine has the units of pressure and is known as mean effective pressure.
It has been seen practically that the value of mean effective pressure remains fairly constant (within a range) for a particular class of engine.
In order to design an engine for a particular application, it is possible to assume the value of mean effective pressure for that class of engine and design the engine for all other design and operating parameters.

Work per cycle = $\frac{Pn_R}{N}$

Where n_R Is the number of crank revolutions for each power stroke per cylinder. (two for four-stroke cycles; one for two-stroke cycles), then

mep = $\frac{Pn_R}{V_d N}$

where mep = mean effective pressure
In SI Units

mep (KPa) = $\frac{P(KW) n_R * 10^3}{V_d\,(dm^3) N(\frac{rev}{sec})}$

Mean effective pressure can also be expressed in terms of torque by using the following equation:

P = 2πNT

We have

mep(KPa) = $\frac{6.28 n_R T (N.m)}{V_d\,(dm^3)}$

Table: Mean Effective Pressure Of Internal Combustion Engines

S. No.	Class of engines	Speed - maximum torque	Mean effective pressure	Speed - maximum power	Mean effective pressure
1	Naturally aspirated SI engines	2800rpm	850 to 1050 KPa	Say 5400rpm	10 to 15% lower
2	Turbocharged automotive SI engines	3800 rpm	1250 to 1700 KPa	5400 rpm	900 to 1400 KPa
3	Naturally aspirated four stroke diesel engines	2500 rpm Approx	700 to 900 KPa	5000 rpm	700 KPa
4	Turbocharged four stroke diesel engine	1600 rpm	1000 to 1200 KPa	2100 rpm	850 to 950 KPa
5	Turbocharged after cooled diesel engines	1600 rpm	1400 KPa	2100rpm	850 to 950 KPa
6	Two stroke cycle SI engine	3500 rpm	654 KPa	4500 rpm	590 KPa
7	Two stroke cycle diesel engine	1500 rpm	1065 KPa	2500 rpm	952 KPa
8	Two stroke cycle **large diesel engine**	**Slow speed** engines	1600 kPa	1.9 MW per cylinder @ 78 rpm 4-12 cylinders	

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In charge Course:

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