1. ENGINE POWER MEASUREMENT

Introduction

An engine is a related group of parts assembled in a specific order. In operation it is designed to convert the energy given off by burning fuel-air mixture into a useful form. The horsepower therefore is a unit of measurement in rating engines and motors. For an engine to operate, a definite series of events must occur in sequences:

1) Fill the cylinder with a combustible mixture (fuel/air)
2) Compress the mixture (or air) into a smaller space (combustion chamber)
3) Ignite the mixture causing it to expand and produce power
4) Remove the burnt gases from the cylinder

The engine power is developed from the burning of the fuel-air mixture. The gases expand in the combustion chamber and force the piston down during the power stroke.

NOTE:

[One horsepower (Hp) = 0.7457 kilowatt (kW) = 750 Watts (W)]

There are four basic aspects affecting the engine power output:

1) **Displacement** – determined by cylinder area, stroke length and number of cylinders. Engine power output increases with engine displacement (other factors constant). A given displacement can be obtained with fewer cylinders of greater individual displacement or with greater number of cylinders of smaller displacement.

2) **Compression ratio (C.R.)** – determined by cylinder volume before and after compression. The more volume is reduced, resulting in higher C.R. – the greater the power output. Engine design considerations and fuel characteristics limit the maximum compression that can be obtained.
3) **Gas flow** – the intake manifold should be shaped and arranged in such a way that it does not retard the flow.
4) **Engine speed** – since one power stroke is produced per cycle; engine power output tends to increase with engine speed.

There are several categories of horsepower, all very necessary for the design of an efficient engine. The most common horsepower terms include:

1) **Indicated horsepower (IHP)** – a theoretical power the engine could develop measured in the engine combustion chamber of a cylinder based upon the gas pressure occurring in the cylinder at the time of combustion
2) **Friction horsepower (FHP)** – this is a loss factor and a producer of heat and is the difference between indicated horse power and usable (net) horsepower
3) **Flywheel or Brake horsepower (BHP)** – this is the maximum horsepower the engine can produce (without alteration) measured at the engine flywheel
4) **Drawbar horsepower** – the power available for moving a load along. This is a function of **force** and **speed.** Maximum drawbar power is normally the most useful performance criterion for farm tractors

NOTE; the flywheel horsepower is reduced by losses as the power is transmitted through the transmission, the differential and the final drive gear. There are further drawbar horsepower losses caused by slippage, over ballasting and operating on inclines.

1) **Power takeoff (PTO) horsepower** – measured at the PTO shaft while operating under load and is a function of **torque** (turning force) and **speed.** A PTO usually has some gear reduction between the engine and the PTO shaft. The reduction increases the torque value, but reduces the speed
2) **Rated horsepower** – a value used by engine manufacturers to indicate the HP an engine should produce under normal operating conditions. This rating takes into account the maximum pressure forces in the engine as well as speed and torsional forces. If the values are exceeded, the engine can be damaged.

NOTE: Power is defined as the rate of doing work. Brake horsepower (BPH) is given by:

$$Power = \frac{2\pi \ell Fn}{60{,}000} kW$$

Where,

ℓ = arm length (m)

F = kilogram force (N)

N = revolutions per minute

But,

Torque (T) = Fℓ(Nm)

Therefore,

$$Power = \frac{2\pi nT}{60{,}000} kW$$

Objective

To determine the internal combustion engine performance parameters to enable one to make both **technical and economic** decisions relating to the size of equipment to use and to determine the operating costs.

Apparatus

i. Dynamometer

This is an instrument for determining power, usually by the independent measure of force, time, and the distance through which the force is moved. Dynamometers may be classified as brake, drawbar, or torsion according to the manner in which the work is applied. Also, they may be classified as absorption or transmission, depending on the disposition of the energy.

A dynamometer is a test unit for measuring the actual power produced by an engine. The flywheel or brake horsepower is measured by a **Prony Brake** (the most elementary form of absorption dynamometer) or an **Electronic Dynamometer**. Both test instruments apply a load to the engine which is measured in kilograms.

If the length of the lever arm is known in metres, Newton-metres of force can be measured as engine load. Speed is measured with a tachometer in revolutions per minute (RPM)

1. Apparatus for a Prony Brake test unit - a mounted engine, scale balance, tachometer, metre rule and an operator's handbook.

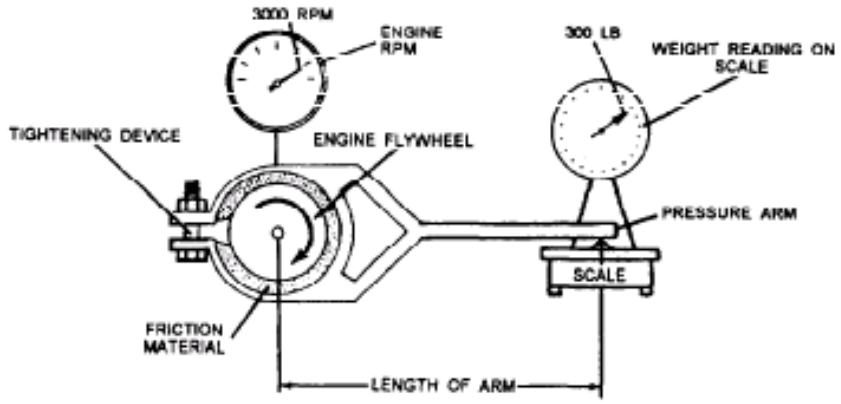

Figure 1. layout of a prony brake

Table for the prony brake test runs

Test Run	Engine RPM	Load (Kgf)	Horsepower (Kw)	Torque (NM)
1				
2				
3				
4				
5				
6				

2. Apparatus for the Froment Electronic Dynamometer test unit – a tractor, fuel flow monitor (for engine efficiency test), Froment Dynamometer Computer System - DCS40, a 3 phase 72kVA electricity generating set and an operator's handbook.

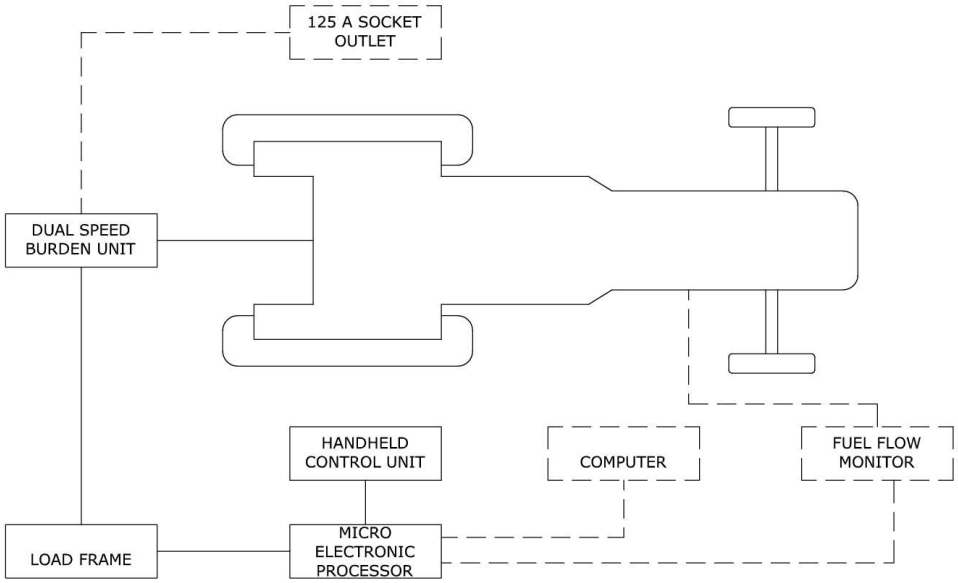

Figure2. Schematic Layout of Froment Electronic Dynamometer

The Froment Electronic Dynamometer consists of the following main components:

- Dual speed burden unit – consists of an alternator and two input shafts (540 and 1000 RPM). The output from the alternator terminates at a circuit breaker.
- Load frame – the output from the circuit breaker is connected to the load frame and applied to the resistive load bank by fine and coarse controls on the hand held unit.
- Micro-electronic processor – constantly monitors the speed and energy absorbed by the burden unit and provides all data required for the hand held unit display, the computer and the fuel flow monitor data capture units.

- The fuel flow monitor – designed for determining the fuel consumption of diesel engines. This monitor indicates specific fuel flow when it is connected to the micro-processor in the load frame and is a measure of engine efficiency
- The computer – captures, stores, and synthesizes data (power, speed and torque) from the micro-processor giving power curve graph. It also has The Tractor Test Centre Test Data Library for various tractor-makes readily available for easy reference.

Methodology

The test methodology and safety procedures are outlined in the test manuals available in the Farm Power and Machinery Laboratory. These should be read through and understood well before the test is begun.