Warsaw University of Technology
Faculty of Automotive and Machinery Construction Engineering
Institute of Vehicles

Laboratory of Combustion Engines

Spark ignition engine speed characteristics

Elaboration
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1. What is spark ignition engine speed characteristic

Spark ignition engine (SI) speed characteristic is a chart that shows main engine work parameters in function of engine operating speed. These parameters are:
N_e - engine power in horsepower HP (or alternatively in kW),
M_e - engine torque in Nm,
g_e - specific fuel consumption in g/kWh,
G_e - hourly fuel consumption in kg/h,
η_e - engine efficiency, which shows (in percentage) engine ability to change fuel energy into mechanical energy.

There are three main kinds of SI engine speed characteristics:

Characteristic of engine maximum power – these characteristic is taken when engine is operating with full throttle and the fuel mixture doses and ignition overtake angle are set to achieve maximum of engine power.

Exploitation (or external) characteristic – these characteristic is taken when engine is operating with full throttle and the fuel mixture doses and ignition overtake angle are set for nominal values.

Partial power characteristic – these characteristic is taken when engine is running with nominal values of fuel mixture doses and ignition overtake angles but with partial throttle opening.

During this laboratory you will achieve exploitation characteristic of typical SI engine used in standard passenger car. Below on figure 1 you can see an example of external SI engine characteristic with main engine work parameters changes over the whole engine operating speed range.

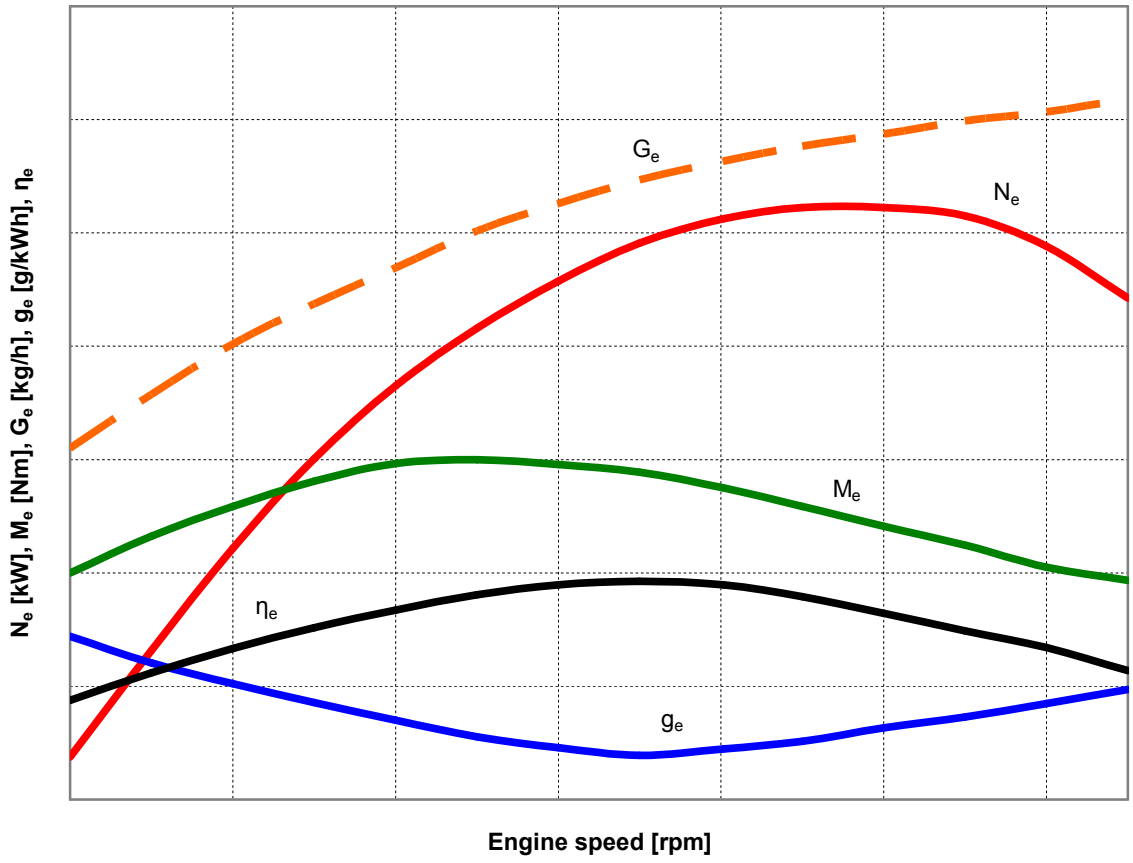

Figure 1. Example of external SI engine characteristic

2. Engine test bench and examination procedure

Engine test bench

Figure 2 presents an SI engine test bench with its main elements. The SI engine is loaded with electric brake which is connected with engine by propeller shaft. The dyno brake allows loading engine in its whole operating range (M_e). Electronic control unit that is connected with engine and dyno brake allows to control and read both engine and dyno work parameters (M_e and engine speed). Fuel consumption is measured by use of fuel volume measurement system. During the laboratory the time of given fuel volume will be measured. This will let to calculate engine hourly fuel consumption (G_e). Other engine work parameters will be calculated from values achieved from measurements made during engine examination.

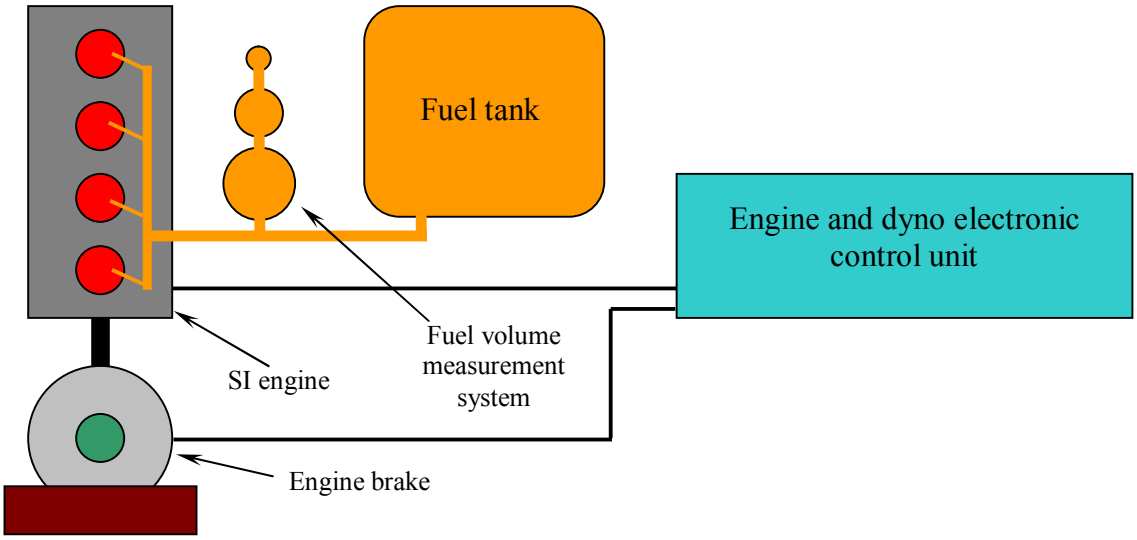

Figure 2. SI engine test bench

Engine examination procedure

Only the laboratory leading person can operate test bench. No one from students can operate test bench without permission from leading person!!!
Anyone that will not obey this rule will not be allowed to continue the laboratory!!!

The leading person will start the engine test bench and guide you how to make specific measurements. This procedure is shown as below:

- Before starting the measurement the engine temperature should be at the range of its normal work temperature (above 75°C),
- Leading person will tell what is the engine speed operating range in which measurements will be make,
- The scheme of engine operating values regulation by the use of electronic unit and fuel volume measurement system will be presented by the leading person,
- Group starts the measurements in the engine operating range given by the leading person,
- ***After measurements only leading person can turn off the engine test bench***
- Leading person will explain what laboratory report should contain and also answer your question if their will be.

3. Elaboration of received measurements values

The laboratory report should contain following information:

1. Short explanation what is SI engine external characteristic,
2. Engine test bench scheme and its technical specification,
3. Formulations of main engine work parameters that are calculated during the laboratory – made as an example for whole calculated values in chosen engine operating speed,
4. Table of all measured and calculated values of engine work parameters,
5. Chart (on one graph) of engine: power, torque, specific fuel consumption, hourly fuel consumption and engine efficiency in function of engine operating speed,
6. Final conclusions.

4. Formulations needed for leading engine work parameters calculations

On the base of achieved measurements values the main engine work parameters will be calculated. For this formulations that are presented below will be needed.

First the engine power should be calculated on the base of equation 1:

$$N_e = M_e \cdot \omega \ [kW] \tag{1}$$

$$\omega = \frac{\pi \cdot n}{30}$$

where:

M_e - engine torque [kNm]
ω - engine crankshaft angular speed [rad/s]
n - engine crankshaft speed [rpm]

Then the hourly fuel consumption can be calculated from equation 2:

$$G_e = \frac{3{,}6 \cdot V_p \cdot \rho_p}{t} \ [kg/h] \tag{2}$$

where:

V_p - volume of fuel consumed during measurement [cm^3]
ρ_p - fuel density [g/cm^3]
t - time of measurement [s]

When hourly fuel consumption is calculated the specific fuel consumption can be counted up from equation 3:

$$g_e = \frac{G_e \cdot 10^3}{N_e} \ [g/kWh] \tag{3}$$

The last engine parameter should be calculated is its efficiency. It can be calculated from equation 4:

$$\eta_e = \frac{3600}{g_e \cdot W_u} \tag{4}$$

Where:

W_u - fuel calorific value [MJ/kg]

When engine work parameters are calculated the final report from the laboratory should be made as presented in point 3 of this instruction.