TOTAL EFFICIENCY OF ADJUSTABLE COMPRESSION RATIO SI ENGINE

Bronisław Sendyka, Sławomir Kudzia, Marcin Kula, Jacek Soczówka

Section of Special Engines
Faculty of Mechanical Engineering
Cracow University of Technology
Al. Jana Pawła II 37, 31-864 Kraków, Poland

Abstract

The following paper includes adjustable ratio spark ignition engine's total efficiency analysis. Main modification of the engine is mounting of crankshaft on eccentric mechanism. Paper presents schemes of eccentric mechanism implemented in developed engine as well as adjustable compression ratio control system's block diagram.

Propulsion from stepper motor is transmitted through self-locking worm gear. Value of compression ratio varies from 9.5 to 14. The main input signal for electronic control system is coming from knock-sensor mounted on the engine. If control system doesn't receive that signal it levels up compression ratio. As soon as signal appears ratio mentioned above is reduced by a value 0.05.

During the investigation rotational speed of the engine was limited to nterval 1800-4000 [rpm] and throttle was partially closed. Relative increase of Suzuki engine's total efficiency presented in this paper surpasses 30 per cent. The outcome of investigation presents engine with variable compression ratio as a good prospect for the future. Constant adjustment of compression ratio with use of electronical control system allows significant improvement of total efficiency and consequently reducing fuel consumption.

Keywords: *SI engine, compression ratio, combustion engines, total efficiency*

1. Introduction

Higher compression ratio causes considerable reduction in fuel consumption and consequently increases engine's total efficiency, which is very important especially in that scope of engine's rotational speed in which it works very often. Fig. 1 presents regulated compression ratio system's scheme.

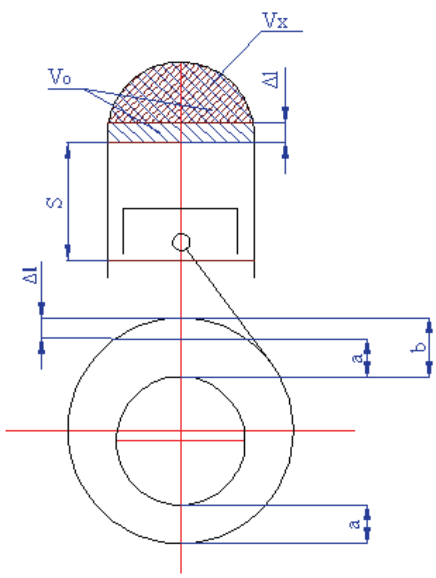

Fig. 1. Scheme of regulated compression ratio system using eccentric mechanism

In this solution piston stroke is constant whereas combustion chamber changes its volume. In traditional engine with fixed compression ratio its value is described by following formula(1):

$$\varepsilon = \frac{V_c}{V_k} = \frac{V_k + V_s}{V_k} = 1 + \frac{V_s}{V_k}, \tag{1}$$

where:

V_c – sum of V_k and V_s,

V_k – combustion chamber displacement,

V_s – piston displacement .

In modified engine with eccentric mechanism compression ratio is presented by formula 2 (markers in the fig. 1):

$$\varepsilon = 1 + \frac{V_s}{V_x}, \tag{2}$$

where:

V_x – variable combustion chamber volume.

2. Engine's modification

Constant change of compression ratio is possible thanks to eccentric mechanism. Eccentric sheave is turned by pair of spur gears. The shaft, on which one of the spur gears is fixed, is linked by a worm and gear set with stepper motor. Work of stepper motor is determined by control system which takes into consideration signal from knock-sensor.

3. Compression ratio regulation scheme

Potentiometer implemented in control system indicates position of eccentric sheaves. Peripheral positions of sheaves are determined by two optoelectronics sensors. Additional protection is formed by two marginal safety cut-outs, which turn off the engine in case of exceeding sheave's peripheral position. Fig. 2 presents control system's block diagram.

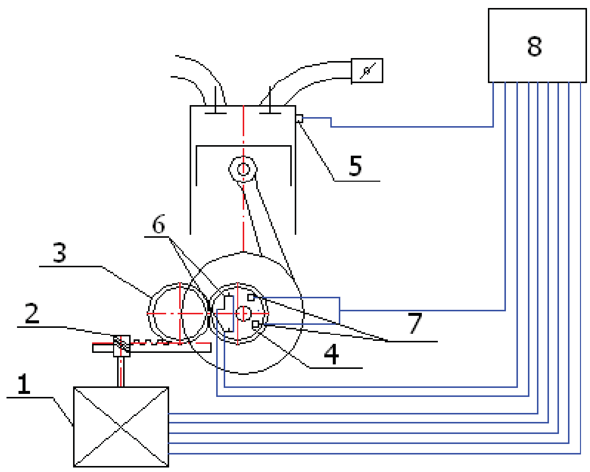

Fig. 2. Block diagram of adjustable compression ratio engine's control system 1-stepper motor, 2-worm gear, 3-spur gears, 4-eccentric crankshaft bearing, 5-knock-sensor, 6-marginal safety cut-outs, 7-optoelectronic sensors, 8-control system's adapter

4. Test bed

Investigations were carried out on a test bed in Cracow University of Technology Internal Combustion Engine laboratory. Fig. 3 presents test bed block diagram with location of most important components.

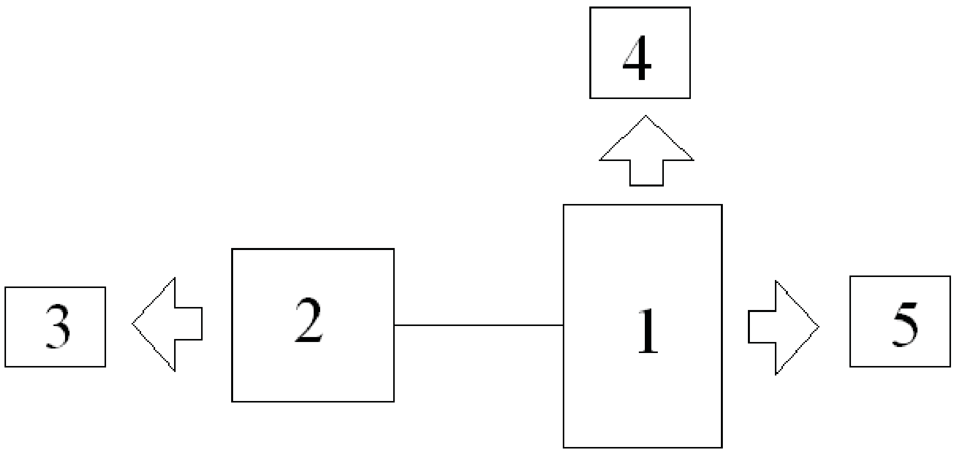

Fig.3. Adjustable compression ratio engine's test bed block diagram:
1-Tested engine, 2-torque dynamometer, 3-torque dynamometer's control unit,
4-fuel consumption measurement system (Flowtronic), 5-exhaust-gas analyser

5. The outcome of research

Conducted test showed significant engine's total efficiency increase during compression ratio adjustment from 9.7 to 12.5. Fig. 4 presents engine's total efficiency curves corresponding to different compression ratios. Research showed improvement in most often used range of engine's rotational speed, that is from 1900 to 4000 [rpm].

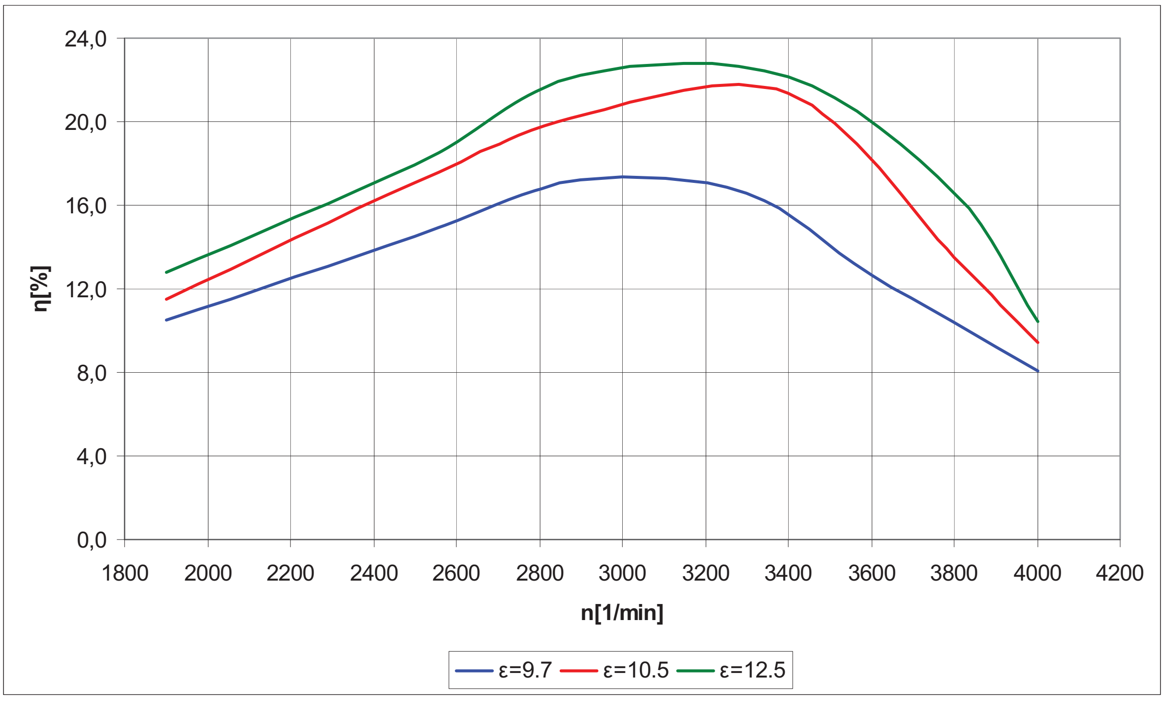

Fig.4. Suzuki engine's total efficiency for different compression ratio

Curves presented on fig. 4 correspond to specific engine's run condition that is 25 º throttle opening angle. Fig. 5 presents relative increase of engine's total efficiency which surpasses 30 per cent.

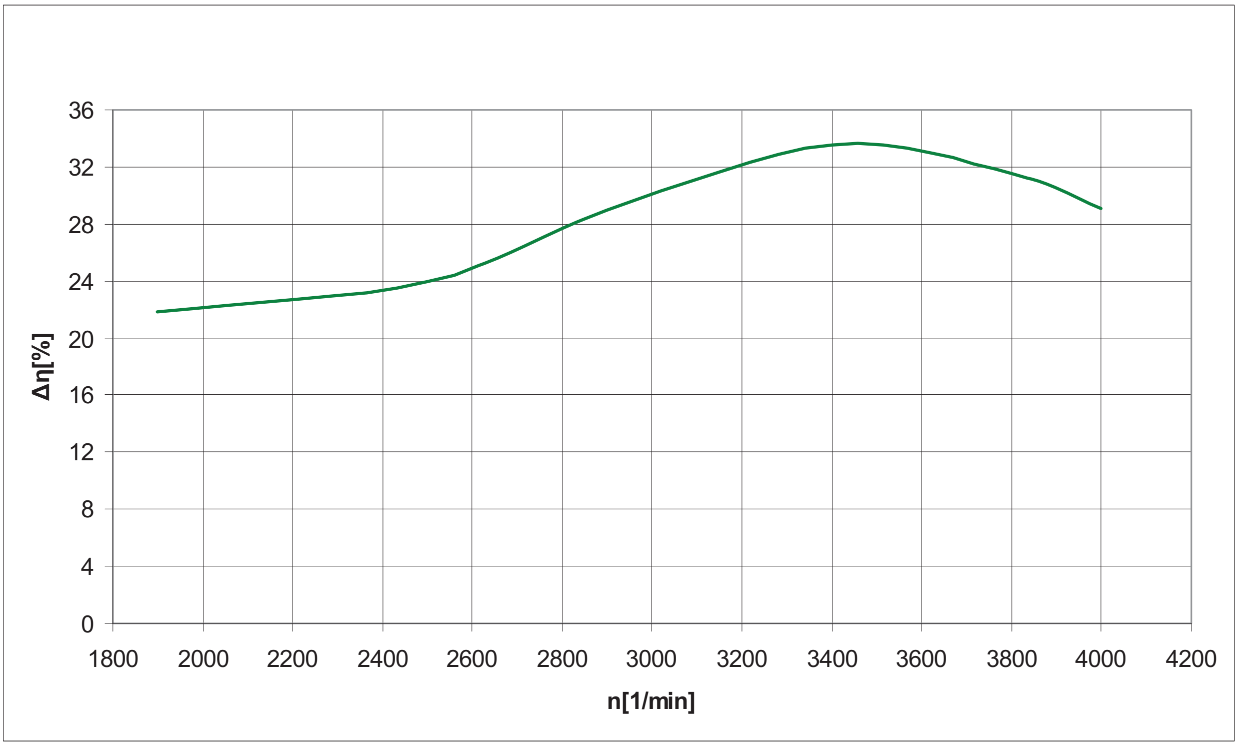

Fig.5. Relative increase of engine's total efficiency during compression ratio change from 9.7 to 12.5

7. Final conclusions

Constant adjustment of compression ratio with use of electronical control system allows significant improvement of total efficiency and consequently reducing fuel consumption. These favourable results are nowadays possible to obtain only in lab conditions. Complexity and difficulty of this technical solution causes that it is considered as a hot prospect for the future. When taking into consideration decreasing worldwide oil reserves it is worth to take a close look at this innovative construction.

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