MEASUREMENT OF MECHANICAL LOSSES IN THE COMBUSTION ENGINES

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Abstract

The development of a new combustion engines is connected with endeavour for escalation of the total efficiency. Escalation of the total efficiency can be: minimization of the mechanical losses in the combustion engines or minimization of the unsuitable equipment capacity of accessories. Now research and development programs of a manufacturer of the combustion engines search effectual equipment and method for this escalation of the total efficiency. The escalation of the total efficiency is important for a minimization fuel consumption and consequently for lower emissions.

Turn of the combustion engines is used method for measurement of mechanical losses very often. The paper will show choice of the measurement results on the testing bench. The Technical University of Liberec, Department of Vehicles and Engines, has developed a design of a testing bench which would enable the measuring mechanical losses of the combustion engines for different temperatures of cooling water and engine lubrication oil. Each medium (lubrication oil and cooling water) have own circle with automatic temperature regulation. The testing bench has automatic system for change revolution and automatic system for measurement: torque, revolution, temperatures and pressures. The asynchronous motor (company SIEI, type MA 133 K - 62 with power 28 kW/ 6000 1/min) is used for drive of combustion engine in the testing bench.

Keywords: *combustion engine, measurement of mechanical losses*

1. Introduction

An increase of overall efficiency of engines by means of reducing mechanical losses in the engine or by cutting down useless power inputs to groups of accessories is of very high interest nowadays. Therefore, research and development programs of engine manufacturers (and of the automotive industry generally) focus on looking for effective measures increasing the overall efficiency of piston combustion engines. An important part of these efforts also consists in methods serving to ascertain mechanical losses, with quantitative evaluation of the effect of implemented modifications or even essential alterations in the engine.

One of often employed methods of ascertaining mechanical losses in the engine is induced revolution of the engine on a testing rig with electric dynamometer. Such measuring of a complete engine can bring rather satisfactory results. A certain disadvantage of these measurings are the values of the "loss" torque, which are relatively low with respect to nominal value of the moment of the pick-up on the dynamometer; consequently, the result of measuring is laden with a relatively higher degree of uncertainty. The modern testing (brake) stands with automated measuring (data collection, stabilisation of temperatures both of coolant and lubrication oil) suppress the said "disadvantage" to a great part; nevertheless, modern brake rigs are employed for measuring mechanical losses in the engine by induced revolution only as a component of more extensive measurings on the engine. To employ a brake rig equipped with modern testing and measuring equipment for studying mechanical losses (passive resistances) of the complete engine or of its structural assemblies only is not economical; therefore, it is of advantage to realise such experimental research on separate testing stands.

2. Testing bench for measurement of mechanical losses in the combustion engines

As the basis of the testing station for measuring mechanical losses in piston combustion engine by induced revolution there serves a regulating induction motor of the firm SIEI, type MA 133 K-62, with the output 28 kW/6000 1/min. The torque during induced revolution is measured by a shaft pick-up HBM of the type T20WN (100 Nm, 0.2%, 10000 1/min), or by a pick-up HBM T5 (50 Nm, 0.1%, 4000 1/min) – both pick-ups can be overloaded statically to 200% of nominal value of Mt. Because of the required range of r. p.m., the basic configuration of the testing rig is equipped with the pick-up T20WN.

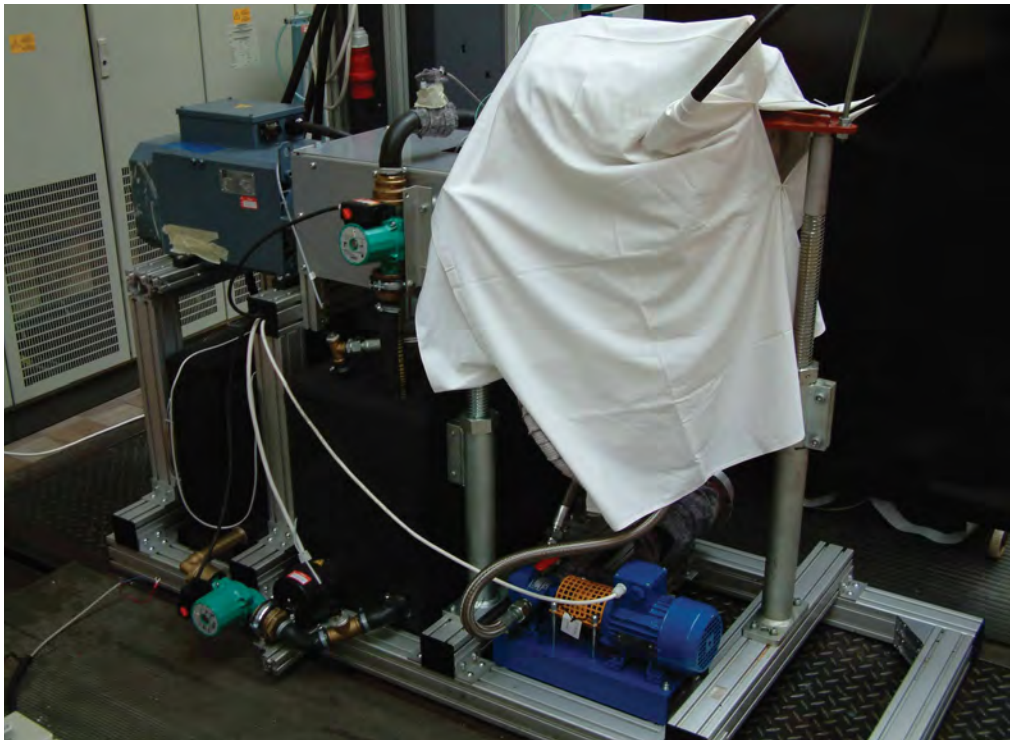


Fig. 1. Testing bench for measurement of mechanical losses in the combustion engines

In order to guarantee reproducibility of measurings of torque loss by means of induced revolution of piston combustion engine, an acceptably low variability of temperatures (overall warming-up of the engine, temperatures of coolant and lubrication oil) must be provided on the revolved engine. The testing stand is equipped with a system of exchangers (heaters, coolers), connected to cooling and lubricating systems of the revolved engine. The heating/cooling of coolant in the cooling circuit as well as the heating/cooling of lubrication oil in the circuit of engine lubrication are regulated by controlled heating by means of electric heating elements and/or by controlled operation of a fan on auxiliary cooler. The operation of the whole system for temperature control is optimised step by step by means of PID regulators.

2. Measurement system

The testing rig for induced revolution of the engine is coupled with a data logger MGCplus (Hottinger), allowing to record 2.400 samples of data per second in the 8-channel version of the amplifier. Each sample comprehends the data from the pick-up of the torque (Mt and revolutions n) and from 13 temperature pick-ups (Pt 100 and thermocouples). The number of sensed temperatures can be increased according to measuring needs. From the effective values of the measured torque and r. p.m., the power loss is calculated.

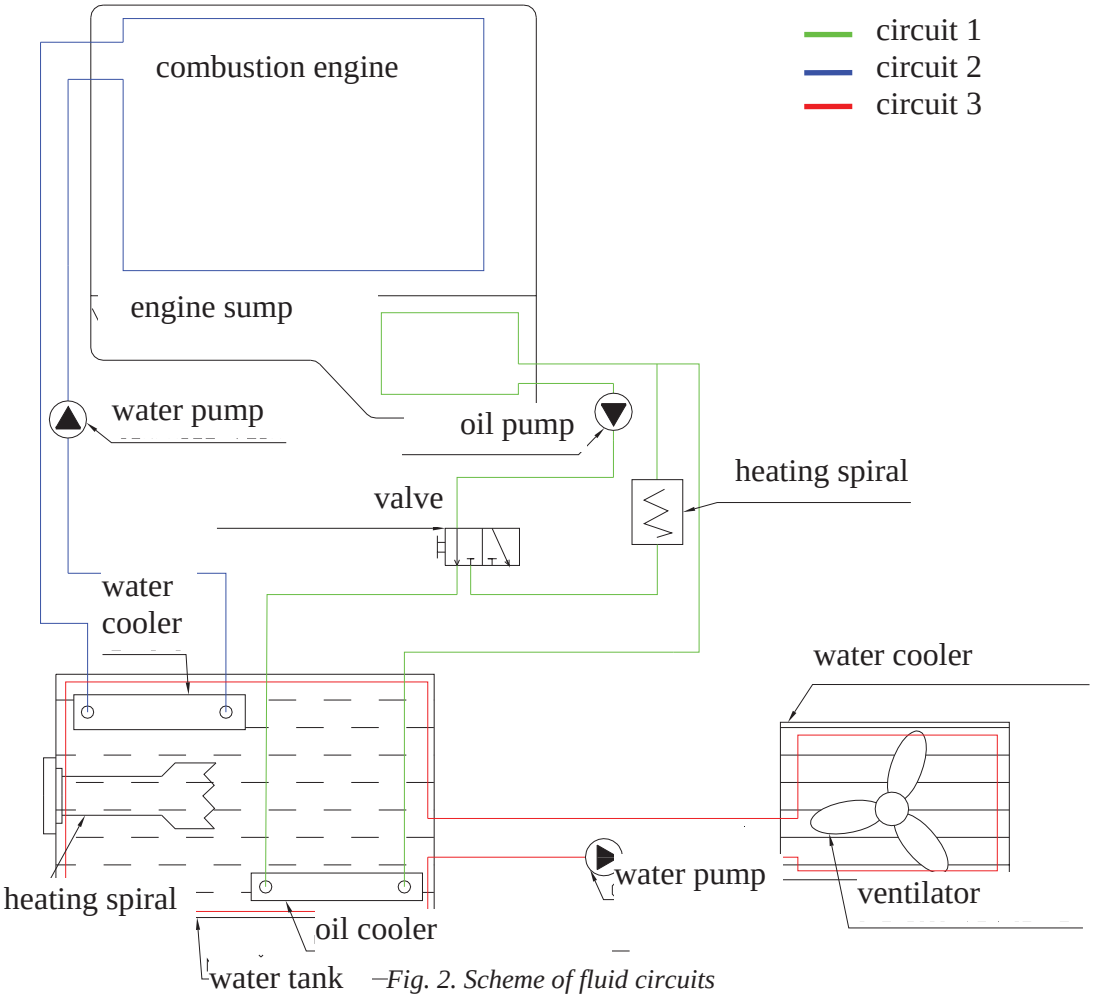


Fig. 2. Scheme of fluid circuits

The operational environment for measuring passive resistances is generated by means of the SW CaMtan Easy. During measuring, on the PC monitor there are displayed graphical values of measured temperatures and the time courses of Mt and n. The values of all measured quantities (Mt, n and temperatures) for each measured regime are established by statistic data processing (as mean values of the data file in chosen time interval). The Fig. 3 shows a photo of the monitor with displayed data of monitored quantities. Circular indicators present the information of measured temperatures; in the centre of the monitor, there is displayed the time course of the measured torque Mt, and in the bottom of the monitor, the time course of momentary r. p.m. (on the basis of data of this course, it is possible to determine the variability of angular velocity in the location of the torque pick-up).

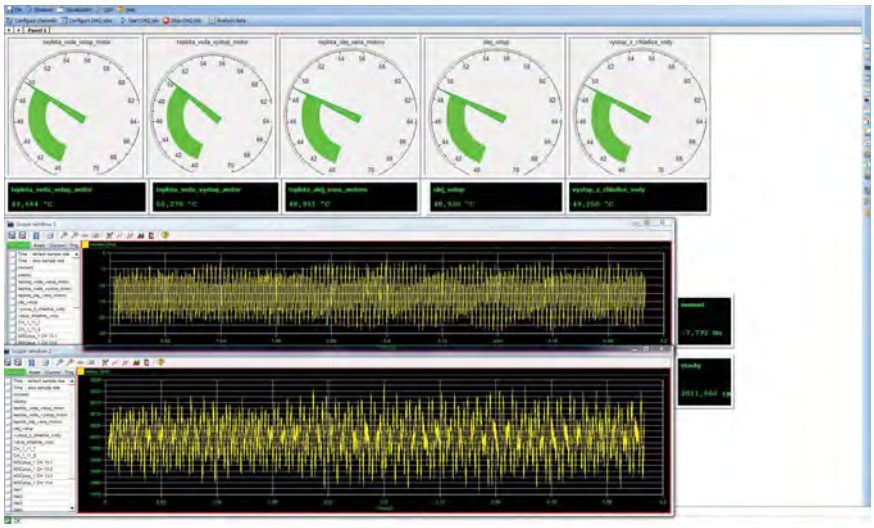
3. Control system

To provide for automatic control of r. p.m. of the regulated induction motor (or frequency converter), an application for the required change of r. p.m. regime has been generated in the computer. At the same time, this application governs the collection of samples in the respective time segment, which contributes to repeatability of measuring.

4. Results of measurement

For the comparison of courses of the torque loss, two temperature regimes have been chosen. As the first temperature regime, 35°C have been chosen for both media (lubrication oil and

coolant/water) – for cold engine, and as the second one, 90°C for both media (lubrication oil and coolant/water) – for warm engine. The regime of r. p.m. change is shown in the Fig. 4 . The combustion engine has been revolved in the range of 1.500-5.500 r. p.m. The step of a change of r. p.m. has been chosen to amount to 250 r. p.m.



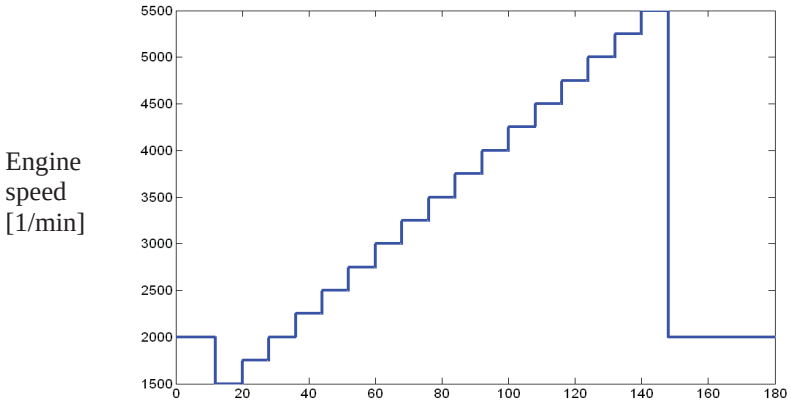


Fig. 4. Run of the test

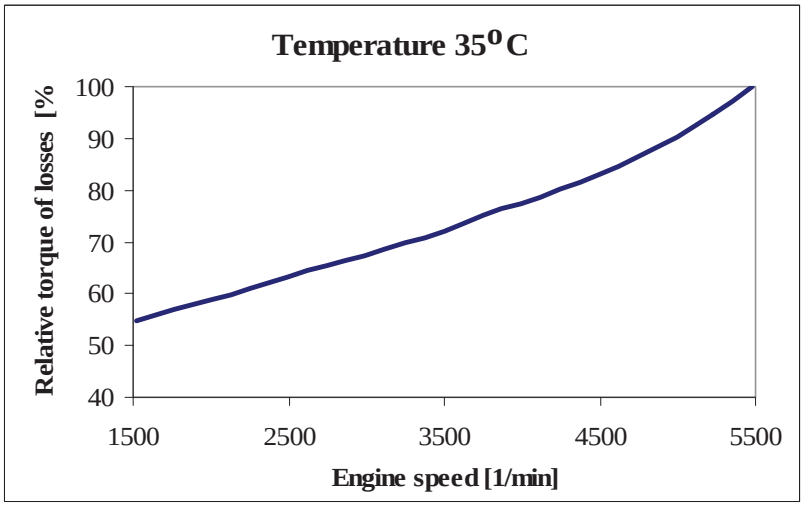


Fig. 5. Relative torque of losses for cold combustion engine

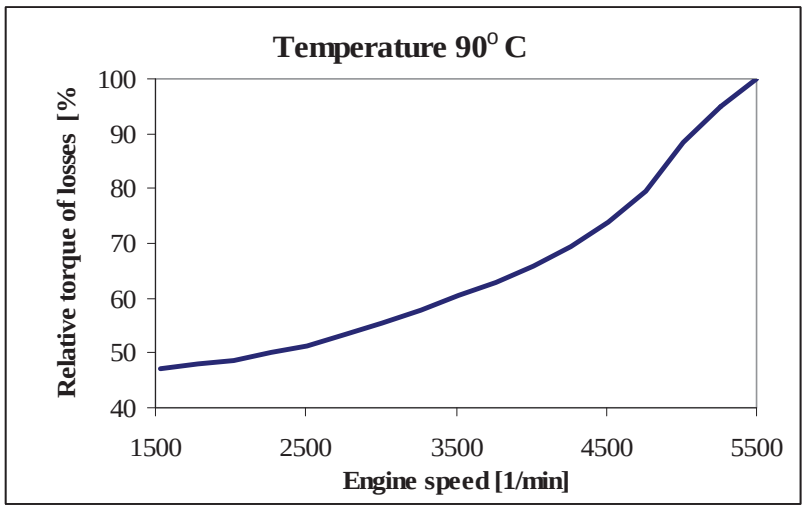


Fig. 6. Relative torque of losses for hot combustion engine

The diagrams show relative values of the torque loss. The value at the highest measured velocity 5.500 r. p.m. is considered in the diagrams as 100 %, and other values of measured torque loss have been related to this value. The diagrams allow noticing the tendency of the measured torque loss to increase with increasing r. p.m. of the revolved combustion engine. With a cold combustion engine, the measured torque loss for the highest measured r. p.m. (5.500 r. p.m.) is 1.82 time higher than at the lowest measured velocity (1.500 r. p.m.). With a warmed-up combustion engine (warm engine – 90° C), the difference of the measured torque loss between 1.500 r. p.m. and 5.500 r. p.m. increases to as much as 2.13 multiple.

5.Conclusion

The verifying measurings of mechanical losses of a piston combustion engine by means of induced revolution on the testing rig have proved full functionality of the testing rig, both concerning the requirement to measure the torque loss with high precision and repeatability, and maintaining stable temperature conditions during measuring by means of regulation of temperatures of coolant and lubrication oil. The results of measurings carried out until now show that by means of the testing station for measuring mechanical losses in piston combustion engines by induced revolution it is also possible to study such characteristics of the engine that other (calculation or experimental) procedures do not show.

Acknowledgments

This paper was developed thanks to the contribution of the Ministry of Education, Youth and Physical Education as Project 1M0568 Josef Božek Research Centre II.

Tento příspěvek vznikl za přispění Ministerstva školství mládeže a tělovýchovy jako projekt 1M0568 – Výzkumné centrum spalovacích motorů a automobilů Josefa Božka II.

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