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EFFECT OF LUBRICATING OIL TEMPERATURE ON THE PHEMONENON OF EXHAUST GAS SCAVENGING

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Abstract. The paper presents the results of experimental research on the effect of lubricating oil temperature on the values of crankcase exhaust gas scavenging intensity in a test SB-3.1 engine. It was showed that lubricating oil temperature affects crankshaft rotational speed, crankcase exhaust gas scavenging volume, but above all an engine's start-up time.

Key words: blow-by, combustion engines, piston, piston rings, cylinder.

INTRODUCTION

The basic and most widespread prime mover for automotive vehicles and transport facilities is still a piston combustion engine. Forecasts referring to depletion of global petroleum resources and growing environmental contamination have an influence on main directions when constructing and using engines. Increase in life and reliability as well as larger and larger service intervals induce imposing high requirements in relation to basic engine kinematic pairs, in particular to the piston-piston rings-cylinder liner (PRC) system. Piston and ring cooperation with cylinder bearing surface has a decisive influence on the whole engine life and work parameters, which should not change during operation, and charge losses induced by the leakage of this system. Leak-tightness of the PRC kinematic pair is of decisive importance during the start-up of cold engine when ambient temperature is negative, a battery is in bad technical condition (low starting current and small capacity induced by wear and negative temperature), there is a small rotational speed of crankshaft and a thick lubricating oil (leading to difficult formation of a good oil film), which unsatisfactorily seals the PRC system [Serdecki 2002, Niewczas 1998, Merkisz, Tomaszewski, Ignatow 1995].

At the Department of Automotive Vehicle Operation, Western Pomeranian University of Technology in Szczecin, a test bed for examining exhaust gas scavenging into engine crankcase was made. A detailed description of the test bed can be found in literature [Abramek 2005].

RESEARCH OBJECT

The SB-3.1 engine is a prototype construction of a single-cylinder four-stroke compression-ignition engine with direct fuel injection to open combustion chamber in piston, the construction of which was based on parts of the SW-680 engine, including a piston with rings (piston stroke 146 mm), a cylinder liner (cylinder diameter 127 mm), a connecting-rod with bearing sleeve, valves, injectors and others. The engine head is remade from an engine head of the SW-680 engine as a sector of one cylinder.

Prior to testing, the engine was checked out with respect to its technical condition. Activities connected with that were limited to checking out the condition of cylinder bearing surface and piston rings and the compression ratio, regulating the valve clearances (valve clearance regulated to 0.5 mm) and the injection advance angle (injection advance angle adjusted to 26º of crankshaft rotation before IDC (inner dead centre) and determining the starting dose. Regulation of the injection advance angle was made easier by an angular graduation scale placed on the flywheel. Fuel injection pressure was checked out, which amounted to 170 x 10^5 N/m^2, while the quality of fuel spraying was correct. Furthermore, the engine was equipped with an apparatus enabling measurement of oil pressure in the lubrication system as well as measurement of its temperature. The characteristic of injection pump was made on a test bench. The volume of the starting dose was consistent with the factory instruction (190 mm^3/injection). Lubricating oil in the oil sump was replaced with Lotos Diesel 15W/40 engine oil. In order to eliminate the effect of different factors on the start-up time, e.g. of cold filter plugging point, clog point, diesel oil freezing point, and possibilities of obtaining a required rotational speed of crankshaft (capacity of batteries), a number of activities was executed connected with elimination of these factors. Air filter and fuel (diesel oil) filters were replaced, batteries were charged and their charged condition was checked out prior to each testing. Winter diesel oil (IZ 35) was used during the testing.

The test SB-3.1 engine was placed in an isothermal low temperature chamber. The cabin was equipped with two refrigerating units. In the chamber walls, ducts were made enabling application of a wire remote control system. The chamber allowed carrying out engine testing up to 248 K (-25ºC) at different ambient temperatures.

RESULTS OF EXPERIMENTAL RESEARCH

Problems connected with the start-up in lowered temperatures are affected, apart from general technical condition of engine, by temperature in the combustion chamber which depends mainly on ambient temperature, rotational speed of engine crankshaft (decreased during the start-up due to larger start-up resistance) and the value of charge losses induced by exhaust gas scavenging through rings into crankcase [Abramek 2005]. The start-up characteristics of the SB-3.1 engine presented in Fig. 1 illustrates how the start-up time extends and how the rotational speed of the engine's crankshaft decreases at low temperatures.

Results of the examination of exhaust gas scavenging into crankcase in the function of lubricating oil temperature carried out on the SB-3.1 engine are presented in Fig. 2. The testing was carried out for temperatures from 253 K (-20ºC) to 293 K (20ºC), every 5 degrees. In order to preserve start-up thermal equilibrium, temperature was stabilised for a period of 18 hours prior to each testing. The start-up time t is a mean from five measurements.

Attention should be paid to the fact that the value of exhaust gas scavenging depends significantly on the start-up temperature, despite a small rotational speed of crankshaft. For a higher temperature, the value of exhaust scavenging is larger. Changes in the amount of work medium losses through piston rings depend on changes in the oil viscosity, depending on the start-up temperature. The lowering of temperature by several dozen degrees may induce a multiple increase in the oil viscosity, which affects oil film life and better oil film sealing properties, which in turn has a favourable effect on leak-tightness of the working space and smaller exhaust gas scavenging [Serdecki 1990, Sygniewicz 1991, Kozaczewski 2004].

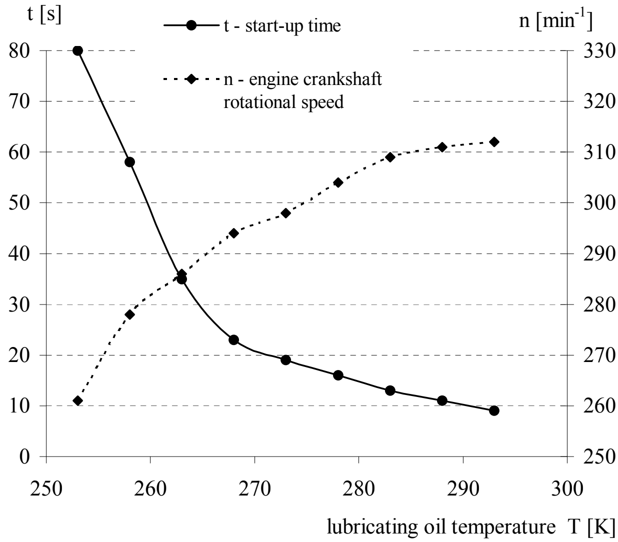

Fig. 1. Start-up characteristics of SB-3.1 engine [Abramek 2000] t-start-up time, n-engine crankshaft rotational speed, T-lubricating oil temperature

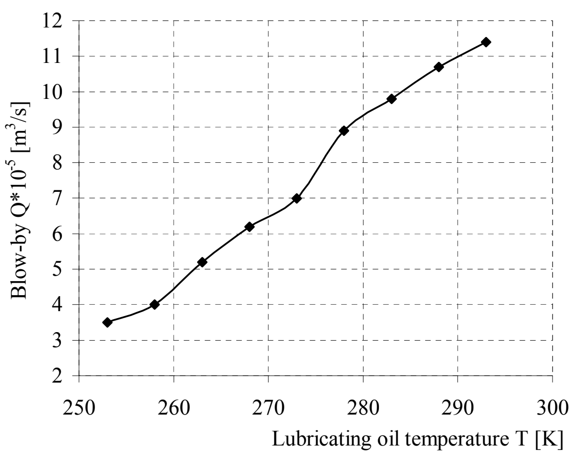

Fig. 2. Intensity of crankshaft casing exhaust gas scavenging for SB-3.1 engine in the function of lubricating oil temperature [Abramek 2000]

Leak-tightness of the PRC unit has a direct effect on the value of charge losses. It can be observed that the amount of scavenged exhaust gas decreases together with the reduction of rotational speed. This is a favourable relationship for the cold start-up of an engine (start-up made easier). Such a course of the characteristic curve for exhaust gas scavenging is affected by lubricating oil temperature. Measurements were made for real start-up conditions. Change in the rotational speed of an engine crankshaft was induced by a decrease in the start-up temperature, which affected an increase of lubricating oil viscosity and a decrease in the capacity of batteries as well as worsening of air-fuel mixture formation (reduction of pressures and temperatures in the end of compression stroke, worse spraying of fuel caused by a decrease in the rotational speed of injection pump) [Mysłowski 1996].

SUMMARY

When analysing the obtained results of experimental research concerning the effect of lubricating oil temperature on the phenomenon of exhaust gas scavenging into crankcase, it can be observed that exhaust gas intensity reaches lower values at low temperatures than for warm oil. Thus, exhaust gas scavenging for the SB-3.1 engine for lubricating oil temperature T_1=253 K amounted to $Q_1=3.5\cdot10^{-5}$ m^3/s, while for temperature T_2=293 K to $Q_2=11.4\cdot10^{-5}$ m^3/s. Therefore, it can generally be stated that exhaust gas scavenging into crankcase also increases together with an increase in the temperature of lubricating oil. Oil affects the caulking of the PRC system.

It should also be kept in mind that the value of exhaust gas scavenging into crankcase is affected by many factors and the results are of a random character [Abramek 2007].

The start-up temperature affects mainly the start-up time. Thus, the start-up time for lubricating oil temperature T_1=253 K was as long as 80 seconds, whereas at temperature T_2=293 K only 9 seconds. This is a nine-fold increase in the start-up time.

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WPŁYW TEMPERATURY OLEJU SMARUJĄCEGO NA ZJAWISKO PRZEDMUCHÓW GAZÓW

Streszczenie. W artykule przedstawiono wyniki eksperymentalnych badań wpływu temperatury oleju smarującego na wartość natężenia przedmuchów gazów do skrzyni korbowej jednocylindrowego, badawczego silnika SB-3.1. Wykazano, że temperatura oleju smarującego wpływa na prędkość obrotową wału korbowego, wielkość przedmuchów gazów do skrzyni korbowej, a przede wszystkim na czas rozruchu silnika.

Słowa kluczowe: blow-by, combustion engines, piston, piston rings, cylinder.