TEKA Kom. Mot. Energ. Roln. – OL PAN, 2008, 8a, 7–11

PHENOMENON OF LOAD LOSSES AT THE ENGINESTART-UP STAGE

Karol Franciszek Abramek

Department of Motor Vehicle Exploitation, Faculty of Mechanical Engineering and Mechatronics, Szczecin University of Technology

Summary. In the paper are presented the results of exhaust gas scavenging testing for the start-up speed. The speed of SB-3.1 engine was determined by means of external driving device composed of a three-phase motor, gearbox, unidirectional clutch and control desk. The obtained findings allowed for an evaluation of the character of changes in the course of exhaust gas scavenging curve from a basic zero speed to the rotational speed of engine crankcase at which the start-up takes place. Exhaust gas scavenging measurements were made in different measuring series in order to determine the effect of oil film development on cylinder bearing surface on the phenomenon of exhaust gas scavenging into crankcase casing.

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

INTRODUCTION

The cold starting of diesel engine is a specific process, which is very different from engine operation under fixed conditions. In general, a diesel engine has to achieve an appropriately high load pressure and temperature, ensuring spontaneous ignition of diesel oil, at a relatively small rotational speed of engine crankshaft (approx. 200 min^{-1} on average) in order for the start-up of engine to take place. In positive temperatures, the start-up does not cause problems, which occur only at negative temperatures. Among the factors that affect an engine's start-up, the main role is played by ambient temperature. It influences directly and indirectly many factors that have an effect on an engine's start-up. Among other things, it affects the viscosity of lubricating oil and capacity of accumulator, hence the rotational speed of engine crankshaft during start-up, exhaust gas scavenging into crankshaft casing, heat losses, pressure and temperature at the end of the compression stroke, formation of air-fuel mixture and diesel oil self-ignition, and in consequence the startability of engine [Abramek 2005]. This study aims at determining the volume of load losses in the form of exhaust gas scavenging into crankshaft casing for the initial stage of an engine's start-up. The testing was made on a SB-3.1 single-cylinder test motor with spontaneous ignition.

TEST STATION FOR EXHAUST GAS SCAVENGING MEASUREMENTS DURING START-UP

In order to examine the volume and the character of changes in exhaust gas scavenging into crankshaft casing for the initial stage of an engine's start-up, a test station for external SB-3.1 single-cylinder motor drive was constructed, presented in Fig. 1.

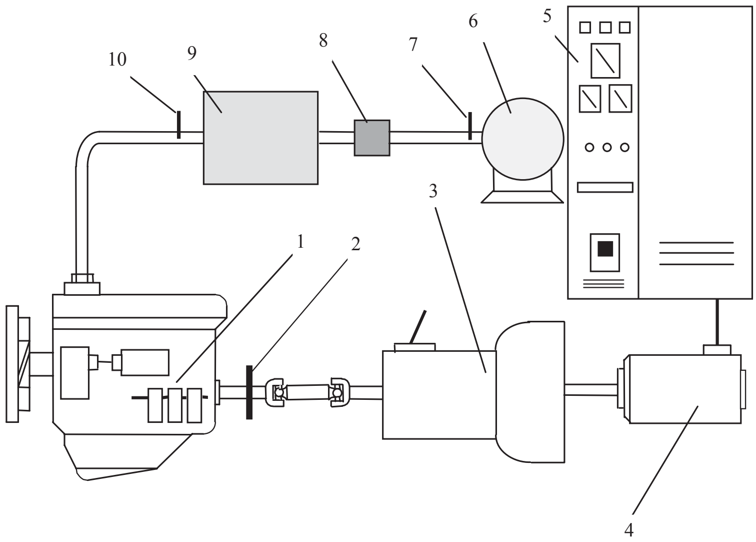

Fig. 1. Schematic drawing of a test station using external drive for determination of exhaust gas scavenging start-up characteristics [Abramek 2008]: 1-tested engine, 2-unidirectional clutch, 3-gearbox and friction clutch, 4-three-phase motor, 5-control desk, 6-laboratory gas meter, 7-gas temperature meter, 8-filter, 9-equalising tank, 10 – temperature meter

Preparation of the start-up characteristics of exhaust gas scavenging into crankshaft casing, i.e. for the speed below engine idle run, required the use of external source of drive, which was a three-phase motor. Thanks to unidirectional clutch, engine disconnection took place in the whole power transmission system when SB-3.1 engine was starting. This eliminated possible failures to engine or external source of drive. This type of drive eliminated also unfavourable phenomena which occured with starter drive. This concerns a change in the rotational speed of engine crankshaft during start-up, which results from a voltage drop on starter clamps. The main advantage of this type of external drive is that any speed can be set on a tested engine and exhaust gas scavenging measurements can be taken.

METHODS OF TAKING EXHAUST GAS SCAVENGING MEASUREMENTS

Measurements of the intensity of exhaust gas scavenging into crankshaft casing for the speed below idle run were made in three measuring series. The first series consisted in measuring exhaust gas scavenging for SB-3.1 engine that had not worked for one week and was driven by a three-phase motor from a crankshaft rotational speed of 5 to 195 min^{-1}. This was to show how the absence of lubricating oil affected the volume of exhaust gas scavenging in the first minute of start-up. In the second series, measurements were made on the engine that worked for 19 minutes and stabilised its temperature for two hours. On the other hand, in the third series, before proceeding to tests, the engine was "cranked" by means of a thyristor box for five minutes in order that the lubricating oil could enter into all lubricated elements and a "good" oil film could develop on cylinder bearing surface, while maintaining the same temperature of engine. Carrying out the measurements this way allowed evaluation the effect of oil film on the intensity of exhaust gas scavenging during engine start-up. In all cases, a change in the rotational speed of SB-3.1 engine crankshaft was obtained by controlling with external driving device. It should also be kept in mind that results of exhaust gas scavenging measurements are of random character [Abramek 2007].

RESULTS OF EXHAUST GAS SCAVENGING MEASUREMENTS

Fig. 2 presents the characteristics of exhaust gas scavenging into SB-3.1 engine crankshaft casing for the speed below idle run, i.e. from 5 min^{-1} to 188 min^{-1}, after initial engine "cranking" to eliminate the effect of absence and preliminary development of oil film on the volume of exhaust gas scavenging [Serdecki 2002]. For the rotational speed of approx. 42 min^{-1}, there is an increase in exhaust gas scavenging, followed by a decrease in the amount of lost load in the form of exhaust gas scavenging into crankshaft casing up to approx. 168 min^{-1}. From 168 min^{-1} on, the intensity of exhaust gas scavenging increases again. This is caused most likely by development of first spontaneous ignitions that induce an increase in compression pressure in combustion chamber and simultaneously an increase in exhaust gas scavenging.

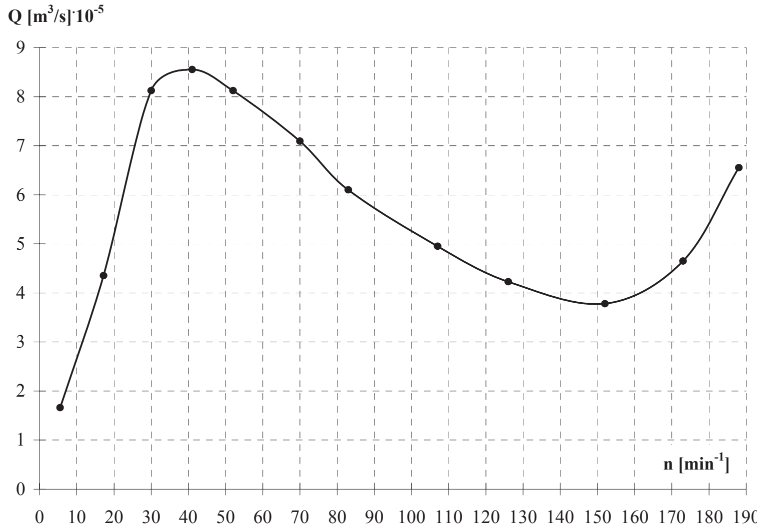

Fig. 2. Characteristics of exhaust gas scavenging to SB-3.2 engine crankshaft casing for the speed below idle run

In Fig. 3 are presented the results of exhaust gas scavenging tests for the speed below idle run made in three measuring series. For the cold engine (lubricating oil temperature 288 K) that did not work for one week, exhaust gas scavenging in the first stage of engine start-up is the highest and amounts to $7{,}9 \cdot 10^{-5}$ m^3/s. This is caused by the absence of lubricating oil and a very weak packing of piston-ring-cylinder (PRC) assembly due to existing necessary clearances. For comparison, a characteristics was made for the cold engine that was initially "cranked" by a three-phase motor drive. This caused an entry of lubricating oil into rings and a better caulking of the whole piston-ring-cylinder assembly. The observed situation is illustrated by a lower value of exhaust gas scavenging intensity in the first stage of engine start-up. On the other hand, the engine after "preliminary" operation shows larger exhaust gas scavenging than the cold one. Most likely, this is caused by a change in the viscosity of lubricating oil [Abramek 2005].

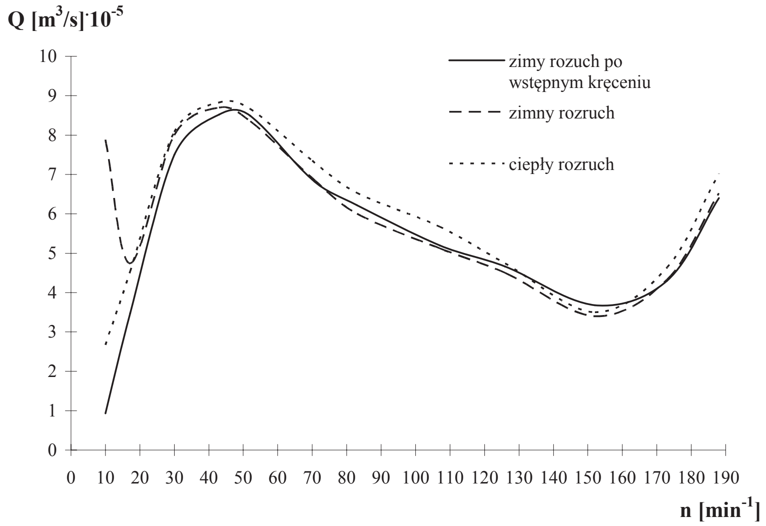

Fig. 3. Effect of earlier "operation" of SB-3.1 engine on the exhaust gas scavenging characteristics for the speed below idle run

SUMMARY

When analysing the measuring results and the exhaust gas scavenging characteristics made for the range of engine crankshaft speed at which the starter commences the first start-up stage, it is possible to state that preliminary supply of lubricating oil onto cylinder bearing surface by initial movement of engine crankshaft induced a substantial caulking of working space and the same a smaller intensity of exhaust gas scavenging into SB-3.1 engine crankshaft casing. In general, the characteristics of exhaust gas scavenging in the first stage has a considerable increase to the rotational speed of engine crankshaft of 42 min^{-1}, followed by a decrease in exhaust gas scavenging intensity to approx. 150 min^{-1}. Above this speed, the phenomenon of exhaust gas scavenging again shows an increasing nature. This is caused by the occurrence of first ignitions that greatly raise the pressure over the piston and induce a rapid increase of exhaust gas scavenging. For SB-3.1 engine, the rotational speed of crankshaft below 150 min^{-1} is a critical value below which the engine can not be started up. It is possible to state that assurance of appropriately high rotation speed during engine start-up, in particular in low ambient temperatures, is a necessary condition for a normal start-up process [Kozaczewski 2004]. The start-up process can be supported for example by an earlier activation of engine lubrication system or initial, even slow, engine cranking.

REFERENCES

Abramek K. F., 2005: Wpływ prędkości obrotowej na właściwości rozruchowe silników z zapłonem samoczynnym. Materiały V Międzynarodowej Konferencji Naukowo-Technicznej nt. Motoryzacja i Energetyka Rolnictwa. Komisja Motoryzacji i Energetyki Rolnictwa Polskiej Akademii Nauk Oddział w Lublinie. Lublin – Odessa

Abramek K. F., 2008: Change of a compression ratio and its influence on the gas scavenge effect. Archiwum Motoryzacji 2/2008

Abramek K. F., 2005: Effect of scavenging of gases to crankcase on actual compression ratio during start-up. Problems of Applied Mechanics International Scientific Journal. Georgian Committee of The International Federation For The Promotion of Mechanism And Machine Science. Tbilisi. Nr 2(19)/2005

Abramek K. F., 2007: An attempt at an analytical description of blow-by intensity to a crankcase. Teka Komisji Motoryzacji i Energetyki Rolnictwa Polskiej Akademii Nauk Oddział w Lublinie. Lublin. Vol. VII. 2007

Abramek K. F., 2007: Randomness analysis of gas scavenge measurements. Teka Komisji Motoryzacji i Energetyki Rolnictwa Polskiej Akademii Nauk Oddział w Lublinie. Lublin. Vol. VIIA. 2007

Kozaczewski W., 2004: Konstrukcja grupy tłokowo – cylindrowej silników spalinowych. Wydawnictwa Komunikacji i Łączności. Warszawa

Serdecki W., 2002: Badania współpracy elementów układu tłokowo – cylindrowego silnika spalinowego. Wydawnictwo Politechniki Poznańskiej. Poznań

ZJAWISKO STRAT OBCIĄŻENIA W FAZIE STARTU SILNIKA

Streszczenie. Praca przedstawia wyniki analizy recyrkulacji spalin wydechowych w celu ustalenia prędkości startowej. Określono prędkość silnika SB-3.1 przy pomocy zewnętrznego urządzenia kierującego składającego się z trójfazowego silnika, skrzyni biegów, jednokierunkowego sprzęgła oraz pulpitu kontrolnego. Wyniki testów pozwoliły ocenić charakter zmian w przebiegu krzywej recyrkulacji spalin wydechowych od wyjściowej prędkości zerowej do prędkości obrotowej skrzyni korbowej silnika przy starcie. Dokonano serii pomiarów recyrkulacji spalin wydechowych w celu ustalenia wpływu osadzania się oleju na powierzchni nośnej cylindra na zjawisko recyrkulacji spalin wydechowych do obudowy skrzyni korbowej.

Słowa kluczowe: przedmuch, silniki spalinowe, tłok, pierścienie tłokowe, cylinder.