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DETERMINING THE INFLUENCE OF OIL TEMPERATURE ON VALVE ROTATION FOR A DIRECT ACTING VALVE TRAIN

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Abstract: This paper presents an experimental research regarding the engine exhaust valve rotation for a direct acting valve train. In the first part of the paper the direct acting valve train is described. After that the advantages and disadvantages of the engine valve rotational movement are presented. In the main section of the paper, the test rig and the equipment used for measuring the influence of the oil temperature upon valve rotation is described. The result obtained on this test rig revealed the fact that the oil temperature represents an important parameter influencing the valve rotation.

1. INTRODUCTION

Analyzing the evolution of the internal combustion engines, a major concern of the manufactures can be noticed. This refers to increasing the service life of an engine up to 250000km whit a minimal mechanical intervention during this period [5]. Increasing the engine life caused an improvement of the valve train by using new materials and new manufacturing technologies [4].

Also, because of this necessity new types of valve train were designed. Today, five types of valve train exists, as shown in Figure 1, each of them having their own advantages and disadvantages [3]. The most used types are the direct acting, Type 1, and the finger follower, Type 2 [6].

Figure 1. Types of valve train: I direct acting; II end pivot rocker arm; III center pivot rocker arm; IV center pivot rocker arm with follower; V pushrod.

This research was conducted on a direct acting valve train. For this type, the motion of the camshaft is transmitted to the valve, trough a hydraulic tappet. The main advantage of this type consists in its high stiffness during functioning, which permits to be used at high engine speeds. Also, this type is characterized by a small number of components, simple design, a relatively high degree of friction due to the sliding contact between cam and tappet and a high level of inertia forces [1].

2. THE VALVE ROTATION

The main role of the valve train is to ensure the gas exchange process during engine functioning. This process is ensured by opening and closing the valve at well known moments of times. Concluding this, it can be noticed that the main movement of the valve is the translation in its guide, but because the cylindrical configuration of the guide, an additional movement appears: the rotation of the valve around its own longitudinal symmetry axis. This rotational movement can be generated by the configuration of the valve train or by using auxiliary devices like Rotocap, Turnomat and Rotocoil [3].

The valve rotation has a lot of advantages that are reflected on its life time period. First of all, the valve rotation reduces significantly the wear of the head and tip of the valve and also of the guide and seat. Also, the carbon deposits that might appear on the conical facet of the valve and seat are removed. Because of the manifold configuration, the valve temperature isn't uniformly distributed, so by rotation the valve temperature becomes uniformly distributed. By rotation, the contact point between valve and seat is modified, so it prevents the apparition of cracks on valve head and also prevents the valve burning and gas escaping from cylinder, which will affect the exhaust emission level [2, 3, 6].

The single disadvantage of valve rotation appears only if the amplitude of valve rotation is too large. In this case, on valve tip, valve head conical facet and on the seat, pronounced radial scratches might be observed [2].

3. MEASURING THE VALVE ROTATION

The test rig, shown in Figure 2, used for measuring the valve rotation was created starting from a cylinder head whit direct acting valve train from a SAAB 900 spark ignition engine.

Figure 2. Test rig used for measuring the valve rotation

The camshaft was driven using a chain from an electric motor which has a maximum power of 3.5kW and a maximum speed of 3000rpm. On the electric motor shaft, a flywheel was mounted to level the torque. The camshaft speed was modified and measured using a frequency converter and an AVL 364-C01 encoder.

The lubrication circuit necessary for filling the hydraulic tappets and grease the moving parts, consists from an oil tank which contains 10W40 oil, an electric oil pump, a pressure relief valve, an oil filter and pipelines.

With the pressure relief valve, the oil pressure was modified, the value of the pressure being measured using two manometers and a piezoelectric transducer from Keller PR-11/80059.2-20. The oil temperature was modified by an electric heater and was measured using a Pt100 sensor and a digital thermometer.

The method chosen for measuring the valve rotation was by filming the valve head during valve train functioning. For this, on the valve head were positioned markers as shown in Figure 3. Those markers were filmed using a FASTCAM SA3 high speed video camera at 1000 frame per second, each video length was of 4 seconds. The videos obtained were then analyzed using Target Tracking v1.1 software from DSD as in Figure 4. This software measures the marker movement giving its coordinate and angle of rotation for each frame in a text table from which the desired values can be extracted and displayed on graphics.

Figure 3. The markers positioned on exhaust valve heads

Figure 4. The Target Tracking v1.1 software

4. RESULTS

For determining the oil temperature influence on valve rotation, an experimental procedure was established. Three values for oil temperature were chosen: 40°C, 60°C, 70°C which were analyzed as a function of five camshaft speeds: 2250rpm, 2375rpm, 2625rpm, 2750rpm, 2875rpm.

The testing conditions for the first tests were as follows: 0.4MPa oil pressure, 40°C oil temperature and 4 seconds of functioning. As it can be seen in Figure 5, the valve rotational movement doesn't respect a trend because at 2250rpm the valve rotates 400deg after 4 second of functioning, at 2375rpm the valve rotation decreases significant until 330deg. At 2625rpm the valve rotation increase until 440deg, at 2750rpm the rotation increases with another 20deg and, at the biggest value of camshaft speed, 2875rpm, the valve rotation reached only a value of 280deg.

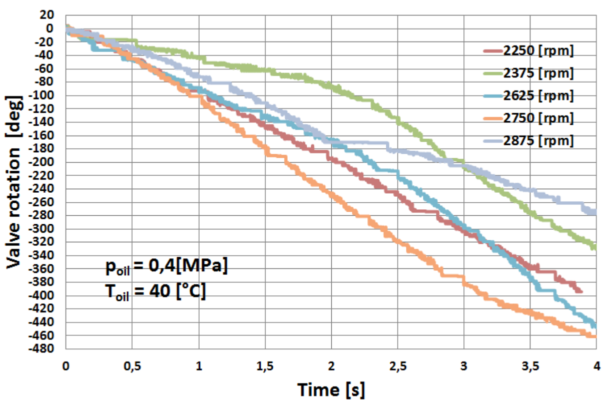

Figure 5. Valve rotation at 40°C oil temperature

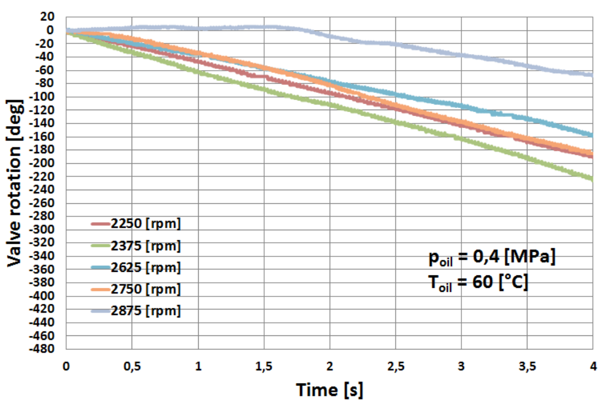

Figure 6. Valve rotation at 60°C oil temperature

Keeping the same oil pressure and the same values for camshaft speeds, the oil temperature was increase at 60°C. The results presented in Figure 6, reveal an important modification of the valve rotation. For all the values of the camshaft speeds, the valve rotational movement decreases significantly. The biggest drop was reached at 2625rpm were the valve rotation was with 280deg smaller than at 40°C.

In the next approach, the oil temperature was set at 70°C and the oil pressure was maintained at 0.4MPa. The results reveal the same tendency of decreasing in valve rotation with an exception. When the camshaft rotates with 2625rpm, the valve rotation angle increases until 220deg, compared with the previous case.

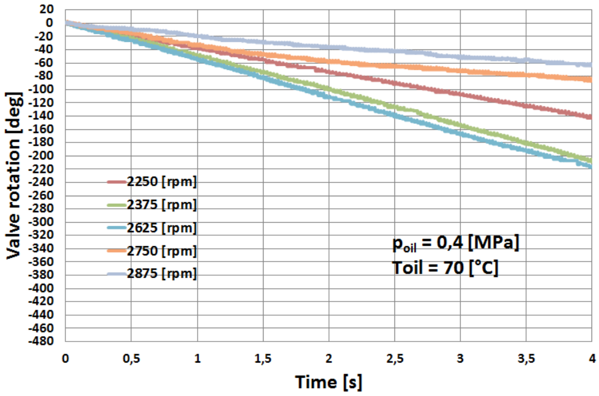

Figure 7. Valve rotation at 70°C oil temperature

5. CONCLUSIONS

The engine valve rotation is necessary for reducing the wear and the carbon deposits, improving the temperature distribution on its head, reducing the risk of cracking and providing a better cylinder sealing.

A test rig was developed to analyze the valve rotation for a direct acting valve train.

The valve head was filmed using a high speed video camera at different camshaft speeds and different oil temperatures. The experimental results obtained on the test rig, revealed a major reduction on valve rotation when the oil temperature was increased.

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