WEAR OF FUNCTIONAL PAIRS OF A GASOLINE ENGINE COMBUSTION CHAMBER

ZOLTAN ZALEZAK[1], RASTISLAV BERNAT[1], NORBERT KECSKES[2], VANESSA PRAJOVA[3], KATARINA LESTYANSZKA SKURKOVA[3]

[1]Slovak University of Agriculture in Nitra, Faculty of Engineering, Institute of Design and Engineering Technologies

[2]Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Statistics, Operational Research and Mathematics

[3]Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology in Trnava, Institute of Industrial Engineering and Management, Slovakia

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e-mail: vanessa.prajova@stuba.sk

Gasoline combustion engine is generally the most important part of a car. With this driving unit the car achieves the best ratio between its fuel utilization and weight. In order to comply with required parameters, such as performance, ecology and economy of combustion engines, their regular service inspections and associated maintenance operations must be followed. For testing the operability of these engines, especially for testing the wear of functional pairs of the combustion chamber, we use various methods. The paper deals with detection of wear of combustion engine functional pairs and with subsequent comparison of obtained values with the values declared by the manufacturer. The measurements were carried out on a Suzuki gasoline engine G13BA with a cubature of 1298 cm^3 and a total mileage of 160,000 km.

KEYWORDS

gasoline engine, wear, functional pairs, piston clearance

1 INTRODUCTION

Gasoline combustion engine is still one of the most frequently used driving unit of different vehicles. This type of engine converts chemical energy bound in fuel into heat by combustion, and subsequently heat energy is transformed to mechanical work by driving and transmission mechanisms of a vehicle. Therefore, many driving mechanisms and functional pairs become increasingly worn due to heat and friction [Uhrinova 2011, Cacko 2014]. The construction of combustion engines is given by their fixed and moving parts [Saga 2019]. Our paper deals with detection of wear of functional pairs which belong to fixed and moving parts of a combustion engine.

The crankcase together with the engine block, cylinders and cylinder heads forms a basic carrier system for balancing internal forces and moments resulting from the combustion process [Soska 2016]. Currently, a common crankcase and cylinder block casting is used, which is called the engine block. The moving parts consist of a piston assembly, i.e. piston with compression and wiper rings and a piston pin [Zarnovsky 2012]. The piston assembly must comply with certain technical requirements. These requirements include force transmission from gas pressure to the connecting rod as well as absorption of lateral forces from the crank mechanism to the side walls of cylinders [Uhrinova 2012]. This assembly must also seal the combustion chamber to prevent any flue gas leakage into the crankcase or oil penetration into the combustion chamber [Zarnovsky 2006].

Pistons of all current engines are made of aluminum alloys. The piston of a combustion engine is heavily heat-stressed by flue gases. The most stressed parts are the piston bottom, the upper bridge and the edges between the piston bottom and the upper bridge [Kotus 2011]. Heat from the piston to cylinder walls is transferred by piston rings and bridges between the rings and the piston shell. The piston clearance in the cylinder should be as small as possible in order to eliminate flue gases leakage into the crankcase and to reduce the noise caused by the movement of the piston inside the cylinder. Smaller piston clearance in a cold engine cylinder is gained by pistons with so called regulated deformation [Jablonicky 2010].

Piston rings provide sealing of the combustion chamber, transfer of heat from the piston to cylinder walls and an even layer of oil between the piston and cylinder walls. Piston rings are divided into two groups: compression and wiper rings. The piston ring lock allows its mounting in the piston groove and further it serves to allow ring dilatation when it is heated. The clearance in the piston ring lock must prevent breakage in case of overheating [Kotus 2020]. The top compression ring generally has the greatest play compared with the others. Its seating area is finely ground and the main sealing surface ensures sealing of the combustion chamber in contact with cylinder walls [Lendak 2010]. Surface treatment of piston rings consists of galvanic coating with a chromium layer or a chromium-containing ceramic material, and in order to improve run-in and anticorrosive properties it is possible to choose phosphate, ferox or tin surface treatment [Kovac 2005].

2 METHODOLOGY

The analysis of the safety of employees in railway transport is in order to determine the wear of functional pairs of the gasoline engine combustion chamber, we had to select a suitable measuring object. Measurements were therefore carried out on a Suzuki gasoline engine G13BA with a cubature of 1298 cm^3 and a total mileage of 160,000 km. technical parameters of this engine are shown in Table 1.

Table 1. Technical parameters of the selected engine

Engine configuration	Straight
Engine position	Front transverse
Mixture preparation	Gasoline with single point injection
Wheel drive	Front
Compression ratio	9.5 : 1
Cubature	1298 cm^3
Number of cylinders	4
Number of valves	8
Max. torque	99 Nm
Engine output	50 kW

Measurement of functional pairs of the combustion chamber was preceded by dismantling of the engine according to the manufacturer's service manual. The individual steps of dismantling are listed below:

- placing of the engine on the mounting rack,
- operating fluids releasing,
- dismantling of intake and exhaust pipes,

- dismantling of timing belts and a crankshaft pulley,
- dismantling of cylinder heads,
- dismantling of the crankcase.

The following steps list the engine functional pairs dismantling:
- dismantling of connecting rods from the crankshaft,
- dismantling of pistons,
- labeling of pistons according to the order of cylinders.

After complete dismantling of the engine and its functional pairs we carried out thorough cleaning by means of a special engine cleaner and subsequent rinsing with water.

In order to perform individual measurements for detection of functional pairs wear, it was necessary to create a measurement chain which consisted of individual measuring devices - sliding gauge, micrometer, plug and thickness gauge.

The sliding gauge was used in a measuring range from 0 to 600 mm to measure the diameters of pistons and cylinders and the micrometer was used to measure outside diameters of pistons in a measuring range from 50 to 75 mm. The plug gauge, as an instrument for inspection of inside diameters of openings, was used to measure cylinders in a measuring range from 65 to 75 mm. Finally, we used thickness gauges to measure the clearance in the piston ring lock inserted into the cylinder and the piston rings clearance in the piston groove. These gauges were used in a measuring range from 0.005 to 1 mm.

Measurement was divided into several parts according to functional pairs of the engine combustion chamber. Initially, we measured the inside diameter of cylinders using a plug gauge, which had to be adjusted to basic dimension by the micrometer. Thus, the cylinder dimension was first measured by a sliding gauge, this value was set on the micrometer and subsequently it served as a basic dimension for the plug gauge. Since engine cylinders have circular cross section, each measurement had to be done in two planes, i.e., in the piston pin plane and in the plane perpendicular to the piston pin (Fig. 1). According to the service manual, the diameter of cylinders should be measured at a distance of 50 mm and 95 mm from the cylinder edge from the top dead center where the sliding gauge was used.

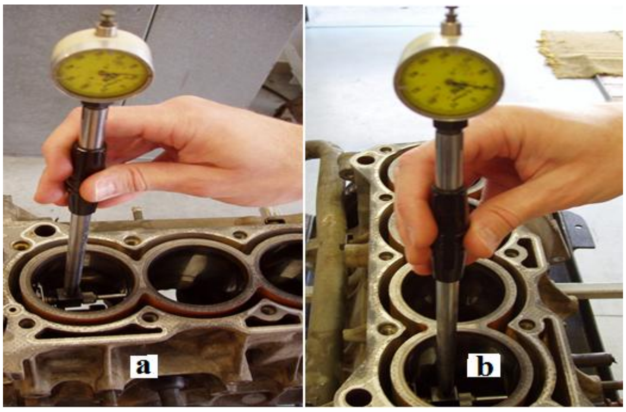

Figure 1. Measurement of an inside diameter of a cylinder a) in the piston pin plane, b) in the plane perpendicular to the piston pin

Further measurement concerned the piston diameter and it was measured by the micrometer. Here the manufacturer's instructions had to be observed again, i.e., at a distance of 15 mm from the piston shell edge (on the crankshaft side) in a direction perpendicular to the piston pin (Figure 2). Measurements were carried out on all pistons.

Figure 2. Measurement of the piston diameter

Functional pairs: cylinder - piston ring and piston ring – piston groove was examined by measuring their clearance in the locks. First, we examined clearance in the locks of piston rings in cylinders. Prior to measurement it was necessary to remove and clean carbon deposits from piston rings in order to obtain most objective values. Subsequently, the piston rings were inserted into the cylinder according to manufacturer's instructions, i.e., 10 mm from the cylinder edge (from the cylinder head side). The measurement was carried out by means of thickness gauges inserted into piston ring locks (Fig. 3). By the last measurement we determined the piston ring clearance in the piston groove (Fig. 4).

Figure 3. Measurement of piston ring locks clearance in a cylinder

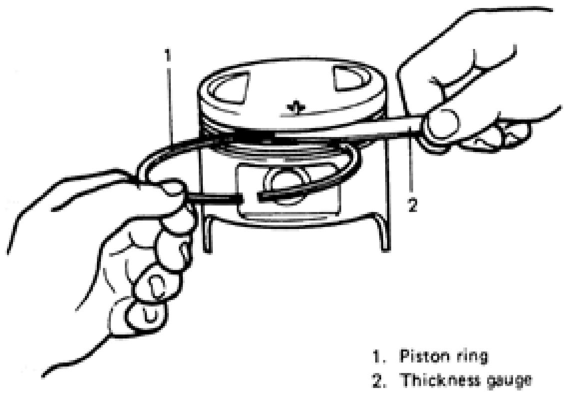

Figure 4. Measurement of piston ring clearance in a piston groove

3 RESULTS

Values obtained from each measurement were divided into the following series.

The first series of inside diameter measurements of cylinders is given in Table 2. At both planes A and B, dimensions of permitted distances to measuring points are given. Table 2 displays an average value which was calculated from each measured value of individual cylinders, and further they are listed with the permissible interval in Figure 5. The permissible value prescribed by the engine manufacturer represents the interval 74.01 - 74.02 mm.

Table 2. Measured values of inside diameters of cylinders

Cylinder	plane A 50 mm [mm]	plane B 50 mm [mm]	plane A 95 mm [mm]	plane B 95 mm [mm]	Σ [mm]
cylinder 1	74.02	74.03	74.01	74.01	74.02
cylinder 2	74.03	74.02	74.02	74.01	74.02
cylinder 3	74.02	74.03	74.01	74.02	74.02
cylinder 4	74.02	74.03	74.02	74.01	74.02

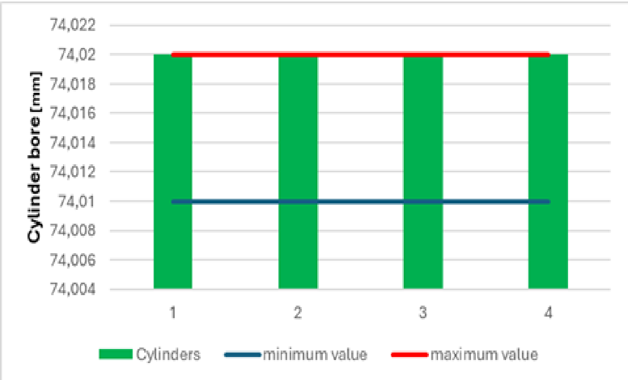

Figure 5. Comparison of inside diameters of cylinders with permissible interval

From graphical comparison of measured values with the permissible interval given by the manufacturer we can see that all four cylinders are within the maximum prescribed tolerance.
The second series of measurements represents the values measured from average of individual pistons and is shown in Figure 6. The permissible value prescribed by the manufacturer is given by the interval 73.98 - 73.99 mm.

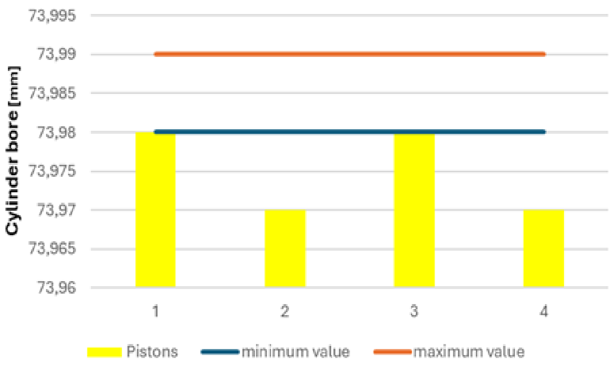

Figure 6. Comparison of diameters of cylinders with permissible interval

From graphical comparison of measured values with the permissible interval we can see that the pistons No. 1 and 3 are within the allowed interval. The pistons No. 2 and 4 showed lower values than those prescribed by the manufacturer.
In the third series of measurements, we checked the functional pair cylinder - piston ring No. 1. The measured values of piston ring locks clearance of all cylinders are shown in Figure 7. The permissible prescribed interval is between 0.20-0.33 mm with a limiting value of 0.7 mm. From a graphical representation we can see that the clearance in all piston ring locks is outside the permissible interval, even they have not yet reached the limiting value.

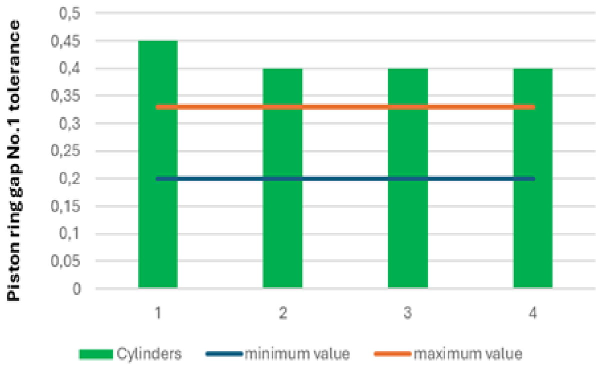

Figure 7. Comparison of piston ring locks No. 1 with permissible interval

The last series of measurements was performed on functional pairs of the piston ring No. 1 in the piston groove on each cylinder where their clearance was examined. All measurement results are shown in Figure 8. The permissible prescribed interval is 0.03 - 0.07 mm. All four measurements of clearance on the ring No. 1 fell into the prescribed interval.

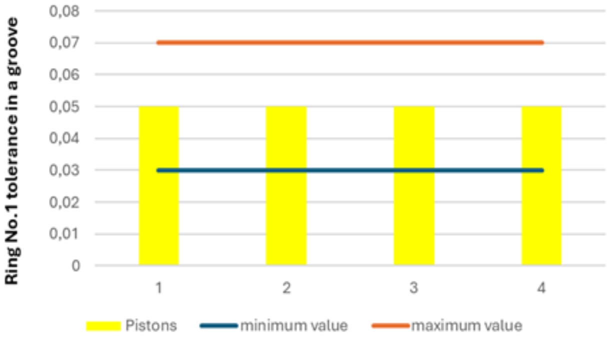

Figure 8. Comparison of piston ring No. 1 clearance in a groove with permissible interval

CONCLUSION

All functional pairs of gasoline combustion engines are gradually worn during their operation. Wear arises as a result of excessive friction caused, for example, by inappropriate lubrication or overheating due to some breakdown in the cooling system. Corrosive influences and impurities taken in with fuel as well as dust particles sucked through a damaged air cleaner have also bad impacts on the engine.
The paper describes and documents the detection of functional pairs wear of the Suzuki G13BA gasoline engine combustion chamber with a cubature of 1298 cm^3 and a total mileage of 160,000 km. After dismantling of the engine, we found that the piston diameter of the second and fourth cylinder was outside the manufacturer's prescribed tolerance [Kuric 2011]. Inside diameters of cylinders did not show values outside the prescribed tolerance. The second and the fourth cylinder showed values of clearance of the cylinder - piston pair outside the tolerance. The cylinder - piston ring wear was close to limiting values, but no limiting values were found on functional pairs: piston - piston ring. As a result of these facts, compression pressure may gradually decrease, causing worse starting, lower output and higher oil consumption [Bozek 2021]. Based on these results, the selected gasoline engine needs reparation in the near future in order to avoid its emergency state.

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CONTACTS:

Vanessa Prajova, Ing. PhD.
Katarina Lestyanszka Skurkova, Ing. PhD.
Slovak University of Technology in Bratislava
Faculty of Science and Technology in Trnava
Jana Bottu 2781/25, Trnava, 917 24, Slovakia
+421 949 157 893, vanessa.prajova@stuba.sk
+421 906 068 454, katarina.skurkova@stuba.sk