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Increasing the performance characteristics of the experimental engine by using the adjustment of its planting system and burning crew

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Abstract : The task of all today's automotive designers and engineers is to design and manufacture a vehicle power unit that will be able to meet even the strictest criteria, particularly in the field of environmental and economy. At present, power plant manufacturers apply the philosophy of so- downsizing. It is a reduction in engine cylinder volume and number, with the aim of maintaining and even increasing the original power and torque of the engine. Such a goal can be achieved by optimizing the individual components of the combustion engine or by modifying its control system. Modification of the current vehicle control system consists of prepaid data of fuel and pre-ignition maps.
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1 Introduction

At present, we meet a transport vehicle everyday without which we can not imagine our life anymore. When choosing a particular means of transport, manufacturers offer us a wide selection of assortments, driving comfort, weight, dimensions, speed and, in particular, consumption. These characteristics have a great effect on the engine power.

Increasingly, the popular means of transport become a motorcycle. The motorcycle is especially popular in cities where daily journeys are crowded, with heaps of constipation and long waiting times. Single-track motorized vehicles are used not only in transport, but also in hobby, sports and tourism. In tourism they are able to overcome long distances at minimum consumption.

A major problem in increasing the output power of two-wheeled motor vehicles is to maintain their reliability and service life. Known motorcycle manufacturers are looking for the best ways to increase performance at the lowest cost to implement.

The first part of the research was aimed at increasing the performance characteristics of the ROTAX 122 experimental engine, by adjusting its rinsing system - the cylinder. On the basis of experimental measurements, we have concluded that the performance and torque in a certain engine speed range is not continuous. This fact was negative in testing the engine under real conditions on the test circuit. This negative could be eliminated by modifying the shape of the engine's ignition curve.

2 Design of the intake and exhaust ducts of the experimental engine cylinder

Optimizing the rinsing system of a two stroke combustion engine has a major impact on output output, torque, fuel consumption and also on the production of pollutants found in the flue gas. In the two-stroke combustion engine, gas is exchanged, i. combustion, fresh fuel and air mixture during one stroke, with consequent problems of ideal flushing. Flushing time is a relatively short process of about 100-130 of total crankshaft speed [1].

For two-stroke combustion engines, one factor is that the smallest volume in the crankcase is, which means that the smaller the volume in the crankcase, the more the compressible mixture is compressed, and the better the cylinder release. Because of this, the crankshaft flywheels have a cylindrical shape so that their crankcase can copy as much as possible. In some cases, the crankshaft flywheels are filled with bulkier material to reduce the damage to the crankcase. [2]

In order to define the amount of compressed piston mixture, the term "primary compression ratio" is used, which gives us the ratio of the sum of the displacement volume and the free volume of the crankcase to the size of the crankcase. The fuel and air mixture is then compressed by the piston in the crankcase. The pressure value at this compression of the fresh mixture is approximately 0.03 MPa. When the release channel is opened, this pressure is then increased to about 0.08 MPa. At the moment when the piston expands the permeation channel by its upper edge, the compressed mixture flows into the cylinder and, through its flow, pushes the flue gas out of the combustion chamber. Due to the opening of the exhaust duct, the overpressure is dropped because the exhaust channel opens rather than the leakage channel [3].

For two-stroke combustion engines, the decisive method is used to extrude exhaust gases from the cylinder into the exhaust and subsequently to avoid mixing the fresh mixture with unusable flue gases. These unnecessary, unusable combustion products cause a reduction in engine efficiency. This problem is addressed by an increase in the number of leakage channels that are designed to form a fresh mixture that exhausts the flue gas into the exhaust. The imperfect engine flushing system, in which the exhaust system is a straight tube, causes the mixture to escape into the exhaust. This results in an increase in fuel because the mixture that is formed by carburettors is not fully utilized.

In order for the cylinder to flush with the mixture, it is necessary to backpressure the exhaust pipe. This back pressure is intended to ensure that the mixture does not escape into the exhaust duct. Such back pressure in the exhaust pipe can be made by constructing an exhaust system which will comprise an expansion chamber. A throttling at the end of this chamber will result in the discoloration of the pressure waves. These reflected pressure waves move toward the cylinder and then push the fresh mixture back into the cylinder [4].

Rinsing	Qualitative Efficiency	Quantitative Efficiency
Transverse	50-60 %	69-74 %
Returning	60-70 %	74-80 %
Co-current	70-80 %	80-83 %

Table 1 Efficacy values during flushing [4]

2.1 Two stroke engine flushing systems

For two-stroke combustion engines, the time it takes to remove the smoke from the cylinder and fill it with a fresh charge (air, a mixture of fuel with air or fuel and air) is very short. This rollover change occurs at a time when the piston is in the lower dead center. After a free exhaust, the combustion products are exhausted by a fresh charge which, due to the gaseous state, tends to mix with the remainder of the gases in the cylinder. The fresh fill pressure must be higher than the cylinder pressure. Therefore, the fresh filling must be compressed and work is required to do so, which is taken from the positive circulation [2].

Analysis of the entire filling cycle is suitably divided into partial sections. The engine filling cycle with timing bodies (piston controlled and symmetrical timing channels, Fig. 1) begins with the opening of the exhaust duct. The flaps of the combustion are of high pressure so that the cylinder quickly escapes the exhaust duct into the air. The pressure drops in the cylinder. The free exhaust takes up to the moment when the fresh mixture flows into the cylinder through the rinsing channel P (Fig. 1) [2].

At the beginning of the rinsing, the pressure in the cylinder decreases because the influence of the discharge is predominant. After a certain amount of time, the influence of the charge flowing into the cylinder will prevail, the cylinder is full and the pressure rises. Once the rinsing channel has been closed, the piston flashes the fresh charge with an open exhaust duct into the air. This fill phase causes a fresh fill to be lost and is called an additional emptying of the cylinder. Pushing starts in the cylinder when the piston closes the exhaust duct. This loss in the useful stroke is partly compensated by filling the compression space with a fresh mixture or air. After closing the exhaust duct, a certain volume of fresh filling remained in the cylinder. The indicated engine power is the greater the larger the volume of the fresh mixture in the cylinder. In order to avoid fresh filling by closing the rinsing duct in front of the exhaust duct, in many constructions the exhaust channel and then the flush channel are first closed [4].

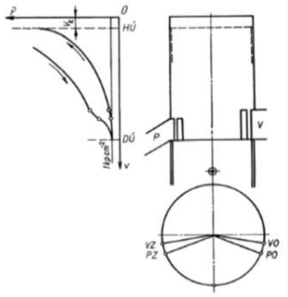

Figure 1 Timing of the distribution and the progress of the induction of the combustion engine [3]

2.1.1 Transparent flushing

This type of flushing can be considered as one of the oldest flushing systems. Its name implies that the passage channel is located opposite the exhaust duct. The mixture flows across the cylinder towards the exhaust. On the plows there is an outflow - the so-called deflector, whose task is to direct the flow of the mixture in the cylinder. This deflector must generally be higher than the height of the exhaust duct.

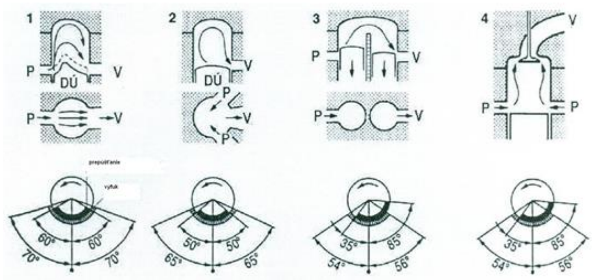

Figure 2 Transverse flushing system of the two-stroke engine [5]

Transverse rinsing has one major drawback and low rinsing efficiency is ensured. Other problems of this system include the large weight of the piston. Such a deflector piston does not center precisely in the axle of the piston, resulting in uneven wear while increasing the inertia of the piston. The combustion chamber had to copy the shape of the piston and therefore the development of the combustion chamber was limited.

2.1.2 Spray rinsing

The flow of the compressed mixture from the discharge channel and the exhaust gases that are extruded have the same direction. For this reason, this type of flushing is called coincidence. This type of flushing was mainly used for two-piston engines. [6]
A great advantage of this system was the possibility of using a piston that did not contain a deflector as it was in the transverse flushing system. The fresh mixture flowed from the leakage channel and subsequently burnt the combustion chamber. In this flushing system, a partition is important to prevent the mixture from flowing directly into the cylinder.

2.1.3 Rinse rinsing

We may consider this flushing system to be the most advanced that is currently used.
The flue gases are extruded by a stream of fresh mixture which flows out of the passageways. The type of such a flushing system is not demanding to manufacture, only to allow the passageways to align with each other. Also important is the angle to the combustion chamber to create a solid wave of fresh mixture that will flow perpendicularly upward and will not swirl. Such swirling could result in the fresh mixture escaping directly into the exhaust. An important factor in this flushing system is that the right side of the cylinder must be exactly symmetrical with the left side of the cylinder. This precision of symmetry ensures precise casting and channel milling.
Rinse-out rinse is the most perfect rinse system over the aforementioned. With this option you can use a flat bottom piston. The fresh blend does not escape into the exhaust and is fully utilized, with the associated lower fuel consumption and greater engine power [6].

Figure 3 Reversible flushing system of the two-stroke engine [6]

2.2 Adjustment of the rinsing system to increase volume efficiency

From the knowledge of the timing of the distribution and the flushing of the two-stroke combustion engine, it is possible to conclude that the indicated power output will be the greater the larger the volume of the fresh mixture in the cylinder. This fact proves that the shape, dimensions, and location of the inlet and exhaust channels affect our engine timing and roller filling.
In view of these theoretical knowledge, we have attempted to adjust the area size of the discharge and exhaust channels. These adjustments were made on the ROTAX 122 experimental engine cylinder. The main

purpose of this modification was to increase the amount of feed delivered through the roller flushing system by a possible increase in the size of the permeate and exhaust ducts.

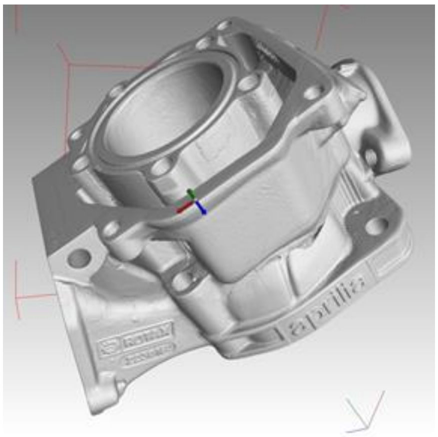

Figure 4 ROTAX 122 Experiment Engine Roller 3D Model

The actual adjustment of the surface size of the permeate and exhaust passages of the cylinder to increase it was accomplished by the gradual mechanical removal of the material by milling and grinding.
It was necessary to use a specialized metering device to know exactly what the channel area increased after the cylinder was upgraded. After consulting with the staff of the Department of Biomedical Engineering and Measurement, we concluded that for this type of measurement it would be best to use a metrology measuring device.
Measurement of the engine cylinder took place in two phases. In the first phase, an untreated, standard engine cylinder was scanned. Following a few days of cylinder adjustment, followed by a second measurement phase at which the modified engine cylinder was scanned. At the end of these measurements, a developed roll shell was generated, followed by determination of the required value.

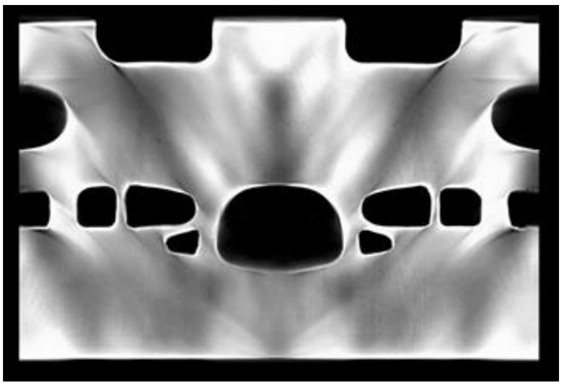

Figure 5 Expanded casing of untreated cylinder

Figure 6 shows a system of discharge and exhaust ducts, wherein the blue color shows the size of the surface of the untreated cylinder channel and the red cross-sections of the through-pass and exhaust passages of the treated cylinder. The spatial difference of these areas before and after the design is expressed in percentage increase.

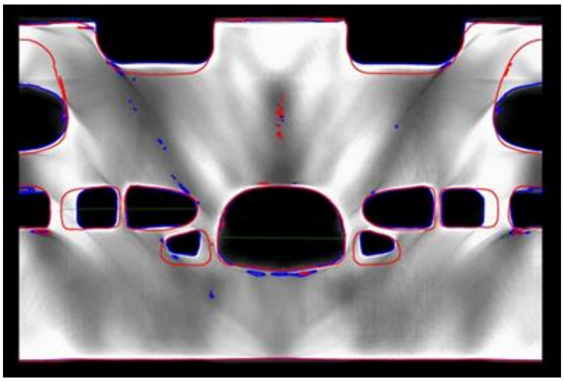

Figure 6 Surface difference before and after design of roller exp. Engine

In order to determine the area size of the inlet and exhaust channels and subsequently to reflect their area difference in percentage, it was necessary to calculate the area contents of indeterminate shapes. This calculation was done through the AUTOCAD 2006 program.
In AUTOCAD, the surface area of the untreated and then the modified cylinder was first determined. After calculating the specific surface area values, the percentage difference was determined. In FIG. Figure 7 lists the permeable and exhaust ducts. Numbers 1, 2, 5, 7, 8 are indicated by the 3, 4, 6 exhaust ducts of the cylinder of the experimental cylinder.

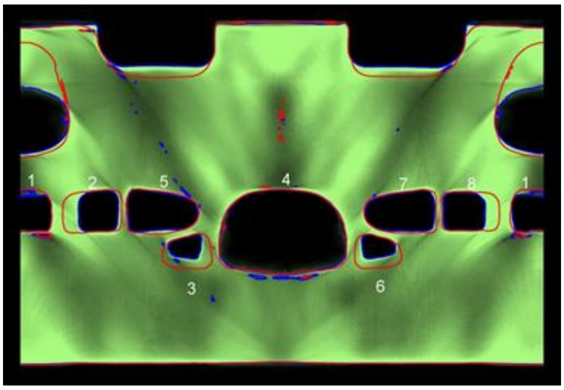

Figure 7 Numeric marking of the release and exhaust ducts of the cylinder

The following table quantifies the specific values of the perimeter and exhaust passage areas before and after the engine cylinder is adjusted.

Table 2 Sizes of the permeate and exhaust ducts of the cylinder

Cylinder	Exhaust channel	Drainage channel
Uncounted cylinder	1123,22 mm^2	1046,26 mm^2
Adjusted cylinder	1238,56 mm^2	1290,17 mm^2
Percent difference	10,26% increase	23,31% increase

3 Description of experimental model and measuring equipment

In significant motorcycle companies, several modifications of individual components for two-stroke combustion engines are proposed in practice. Subsequently, they are verified and tested or improved in engine tests, especially on the power brake. For the measurement, it was necessary to select the model on which the adjustment will be implemented and subsequently to evaluate this adjustment by measurement. The measurement was performed on the power brake.

3.1 Experimental model

The aim is to make the engine specific to its cylinder, while maintaining the standard settings in order to achieve the most efficient output power-torque characteristics of the engine. The Aprilia RS 125 motorcycle was used as an experimental model.
The Italian manufacturer of Aprilia motorcycles has always been a great leader in 125 cubic cubs. This type of motorcycle is one of the best-selling motorcycles on the European market. The Aprilia RS 125 is designed for riders who race in the SportProduction class. This motorcycle is especially suited for beginner riders.

Figure 8 Experimental Model on the testing trial

The Aprilia RS 125 is equipped with a powerful and reliable two-cylinder ROTAX 122 engine. This type of engine can be considered unrivaled in its class. This engine is constantly updated to be able to meet stringent emission standards, without losing performance. The ROTAX 122 is a reference engine for the 125 cm3 class as a propulsion unit.

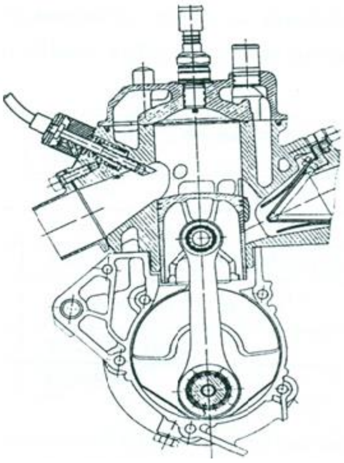

Figure 9 Engine Rotax 122 [7]

3.2 Measurement of performance-torque characteristics

To determine the resulting adjustment effect, it is necessary to measure the values of the original and subsequently modified engine. We get these values through the power brake and compare the final values. For the measurement to be valid, it was realized three times in succession under the same weather conditions (air temperature, air pressure, air humidity).
The starting brake is based on the flywheel spin principle of known mass m and moment of inertia y that rotates through the chain transmission. When starting the flywheel, accurate speeds are measured, recording the increase in kinetic energy (measured engine power) over a constant time unit (millisecond). Subsequently, the computer evaluates this portion of work / time and uses the software in the coordinate system to display the power dependence of the torque from the speed of the measured motor at the points of the graph. The duration of one measurement is dependent on the size of the secondary transmission between the motorcycle and the brake. It takes a very short time.
The motorcycle is mounted on a power brake (motor brake), where the rear wheel of the motorcycle is replaced by a flywheel. This flywheel is coupled by a sprocket, clutch, and primary crank shaft transmission.

The signal from the electromagnetic pulse rate sensor of the flywheel is transformed into a transducer.
In the converter, the signal changes to information that enters the parallel PC port. After evaluation in the PC, the power dependency, the torque from the measured engine speed, will be displayed on the monitor.

Figure 10 Measurement of experimental model on power brake

3.3 Device for measuring exhaust and drainage channels in cylinders

On the basis of the objectives set, it was necessary to measure and subsequently analyze the value of the area of the discharge and exhaust channels in the cylinder changed. For this measurement it was necessary to use a special device, which is able to measure and subsequently determine the channel area.
The Department of Biomedical Engineering and Measurement is equipped with a Metrotom from CarlZeiss. This advanced measuring device enables non-destructive, non-contact measurement of the component using X-ray radiation.

With this device, it is possible to obtain information about the external geometry and the volume of the component by one measurement. After scanning the component using CT (CT), we get an image of the entire component, which can be viewed from either side and in any possible cross-section. During the measurement, the component rotates 360 degrees around the vertical axis.
The result of the measurement is the 3D image of the component and its interior. The device allows for the measurement of components made of light alloys such as aluminum, magnesium or plastic components as well.

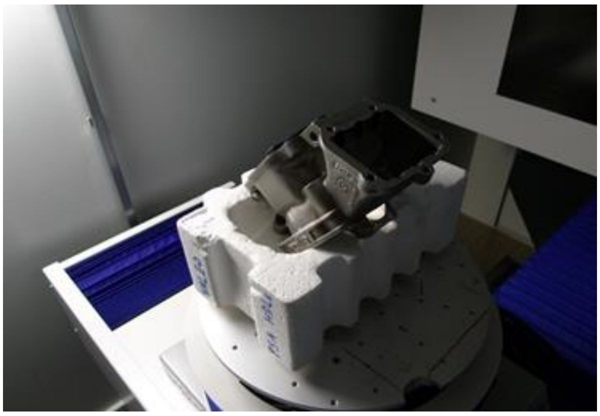

Figure 11 Measurement of the engine cylinder using a metrotoma

4 Experimental results

Checking performance and torque parameters is a major step in modifying engines that are designed for motor sport. Backward verification of the impact of editing is important when judging its accuracy. Each major activity adjustment produces adequate changes and therefore the best way to record the changes is to measure the characteristics of the combustion engine through the relevant device. The original ROTAX 122 engine cylinder, when fitted with the original Dell' Orto PHBH BD carburetor with the # 132 without airbox suction system and with the MP Furtom exhaust system, measured the maximum power Pmax 31.0 k at 11,210 rpm, min-1 and maximum torque Mk20.69 Nm at 9619 rpm. The values are shown in the chart, where the green curve represents the power and the gray torque of the unmodified engine.

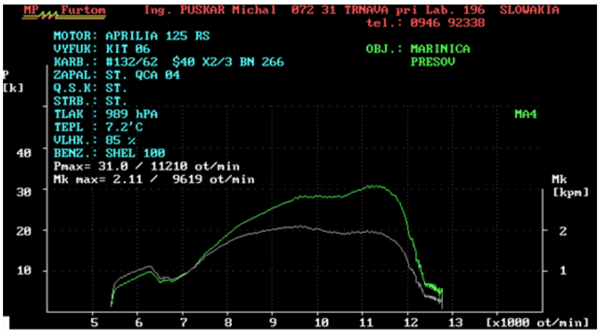

Figure 12 Running and torque of the unmodified engine

By maintaining the design limits for the strength and life of the cylinder and piston, the cylinder was subsequently modified to increase volume efficiency.
Upon completion of the modification, the cylinder was mounted on an experimental engine while maintaining

a 13.5: 1 compression ratio and timing of the discharge and exhaust channels.

Figure 13 Performance and torque of the modified engine

In Fig. 13 shows the performance and torque of an experimental engine with a modified cylinder. The graph shows that in the engine speed range 10500-11500 rpm. the performance and torque are not continuously rising. The problem can be solved by adjusting the shape of the spark curve.

5 Optimization of the ignition curve

The computational technology enables the curve shape to be programmed in virtually unlimited range. It is possible to create a myriad of variants of curves that significantly affect the output power - torque characteristic as well as emission generation. From theoretical considerations and experience, increasing the pre-ignition results in an increase in engine output, more efficient fuel utilization, and hence improved combustion. The limit for the increase of the pre-ignition stages is the detonation burning and the hard operation of the engine. A constant supply of fuel is assumed. Following these theoretical considerations, the entire standard ignition curve was shifted 2 degrees to the right (to the plus values).

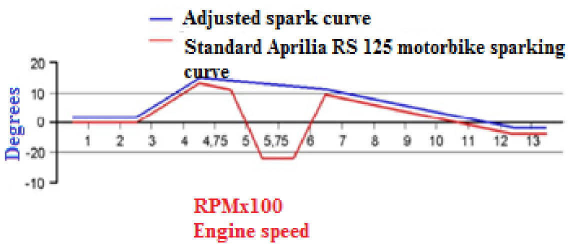

Figure 14 Shape of the ignition curves

Figure 15 shows graphically the power and torque dependencies at engine speeds, using a modified spark curve. This graph is output from the power engine brake. On this modified engine, the maximum power Pmax 33.6 k at 10 913 rpm and the maximum torque Mk21.69Nm at 10 912 rpm were then measured. The red curve on the graph shows the maximum power and the gray curve torque of the modified engine with an optimized pre-ignition map.

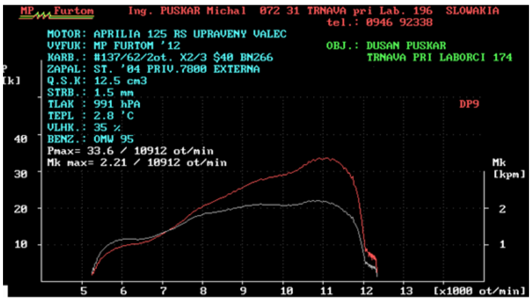

Figure 15 Performance and engine torque with modified pre-ignition

Table 3 Performance characteristics of the unmodified and modified engine

Engine	Max. power/ eng. speed	Max. torque/ eng. speed
Standard cylinder	31,0h/ 11 210 eng.speed	20,69 Nm/ 9619eng. speed
Adjusted cylinder	33,6h/ 10 912eng.speed	21,67Nm/ 10 912eng. speed
Adjusted cylinder + curve	33,6h/ 10 913eng. speed	21,69Nm/10 912 eng. speed
Difference	2,6h	1,0 Nm

6 Conclusion

This research was aimed at increasing the output power of a two-stroke combustion engine while retaining basic engine settings (13.5: 1 compression ratio as well as carburetor diffuser diameter).

The roller treatment has improved its rinsing process. In the field of the economy, this adjustment affects in particular the efficiency of the fuel used, which consequently also relates to the positive environmental relation, whereby the combustion engine produces lower pollutant emissions into the air, resulting in a better combustion of the engine.

Almost all major motorcycle manufacturers are relying on the theory that the engine's maximum power is in the range of 11000-13000 rpm when increasing the performance of a two stroke combustion engine. From this, it can be concluded that a two-stroke combustion engine is not able to fully utilize its power potential at low revolutions below 11,000 rpm.

By measuring the performance brake, we have come to the conclusion that the engine thus modified is able to utilize its power potential even at lower revolutions than 11,000 rpm. The roller, which was modified and subsequently mounted on the experimental engine, exhibited maximum power and torque at about 10,000 rpm. From this fact it can be stated that even at lower revs it is possible to achieve high engine power. The engine, which is able to use its power potential at lower revs, is better in terms of service life, because by reducing the engine speed, it increases its service life and thus its overall reliability.

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