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Procedia Engineering 100 (2015) 1324 – 1331

Procedia Engineering

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25th DAAAM International Symposium on Intelligent Manufacturing and Automation, DAAAM 2014

# Production Technology and a Design of Transfer Ports in a Cylinder of a Small-Volume Motorcycle

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**Abstract**

This work deals with the cylinder of the Jawa 50 Pioneer, which has come to the attention of the general public at the present time, primarily because this type of motorcycle is being increasingly used in races. First, it was necessary to map the current state of the cylinder and transfer channels. Subsequently a 3D model of the cylinder was created. Then, the work deals with the structural design of the transfer channels in the aluminium part of the cylinder. Two variant inputs in to the transfer channel were created and the most suitable design was selected to be made. Then a model of the transfer channel was created and stamped in to the body of the cylinder. The conclusion of this work is dedicated to the production of the transfer channels and measuring performance of this modified cylinder. The production of the cylinder was carried out on a CNC milling machine. For measuring torque, the engine brake was used. The main aim of this work is to increase the performance parameters.


Peer-review under responsibility of DAAAM International Vienna

*Keywords:* Jawa 50 Pioneer; Transfer channels; cylinder; Production; Measuring of performance

## 1. Introduction

The small volume motorcycle Jawa 50 Pioneer was produced more than 45 years ago in Slovakia. The original motorcycle was designed for common everyday use and it was available to the general public. When the Jawa 50

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Peer-review under responsibility of DAAAM International Vienna
doi:10.1016/j.proeng.2015.01.500

Pioneer was at its peak this small volume motorcycle raced on the road and in motocross. These motorcycles have become unattractive for racing because new motorcycles are more powerful. The tradition of racing on these motorcycles was restored recently after almost 25 years. This fact was the stimulus for my work. The performance of this motorcycle as it left the factory was measured as 2.6Kw at 6500rpm. This performance was good for normal traffic but for racing was very small. The question was how to increase the performance. The cylinder and exhaust pipe have the greatest impact on the performance of a motorcycle. This work deals with modification of a cylinder of the engine. It will focus on the transfer channels in the cylinder because channels are easier for production, geometry precision, and symmetry. The new racing cylinder will be produced after that, the value of performance will be determined using the engine brake. There are not many publications which are focused on the modification the motorcycle cylinder. Reference [2] is very important and offers basic information about tuning the motorcycle. There is much usable information about design, tuning and adjustment the engine. Reference [9] is very substantial book containing an extensive description of measurement on the engine brake. The design, function, properties and much more information about the two stroke racing engines are described in [4]

Fig. 1. Jawa 50 Pioneer type 21 and type 23 Mustang [5].

## 2. Transfer channels

Transfer channels are used for properly routing the fresh mixture from the space of the crankshaft to the working area of the cylinder. The shape, position and size of the transfer channels have an essential effect on scavenging. Scavenging is crucial for a two stroke engine and is manifested in the performance. When properly modified the transfer channels will improve scavenging and thereby will increase the performance. There are three basic types of scavenging in cylinders in two-stroke engines: transverse, reversible and parallel-flow scavenging [1], [4], [7], [9].

Reversible scavenging (loop flow) is used in most two stroke engines because the design is relatively simple. It is the most efficient way of scavenging so far invented. The name is derived from the motion of the mixture in the working area of the cylinder. Simplified principle: the fresh mixture leaves the transfer channel and it enters into the working area space at right angles. The mixture is compressed by the piston and after the ignition of the mixture the gases expand. The gases leave the working area of the cylinder and then into the exhaust system. The principle of reversible scavenging is evident from Fig. 2. [8], [6].

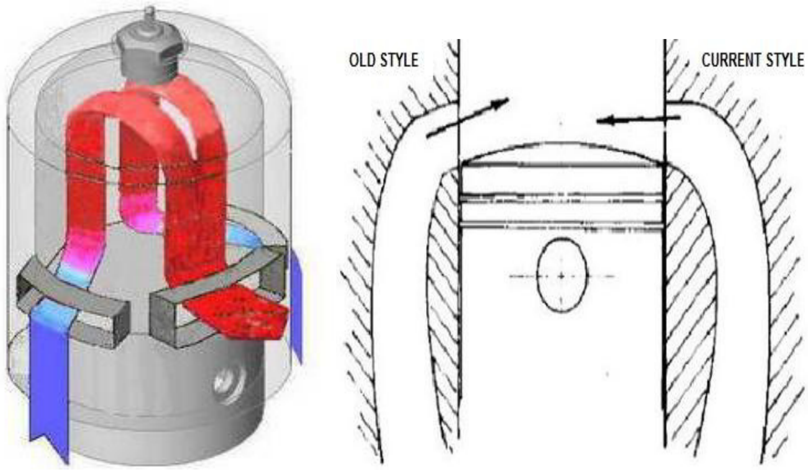


Fig. 2. (a) Principle of reversible scavenging (loop flow) [3]; (b) Routing of transfer channels due to the development of machining technology [2].

The shape and size of the transfer channels has undergone many modifications and changes. At first modifications were due to the development of machining technology, but more recently it is due to the development of computer equipment and programs. The programs simulate the flow of the mixture. Only big companies deal with flow simulation because it is very complex, for example: KTM, Honda, Suzuki, Yamaha, Blata.

*2.1. Transfer channels*

The cylinder consists of two basic parts, the aluminium die-cast body and cast iron cylinder liner. The cylinder liner is inserted into the cylinder and this ensures sufficient heat transfer during the engine run. The cylinder was designed with two channels for simplicity of production, trouble-free and easy setup of the engine for use in normal traffic. Two types of transfer channels were produced during manufacturing of motorcycles. The first shape of the transfer channels is marked as type 05. This type is seen in Fig. 4. The characteristic of this channel is big compression of the mixture due to narrowing of the channel. Another characteristic sign is the protrusion at the end of the channel. Type 21 is shown in Fig. 5. This channel is not as narrow as Type 05 and does not have the protrusion. Channel type 21 has a bigger window in the cylinder liner because it does not have the protrusion.

Fig. 3. (a) Type 05 channel ; (b) The cylinder with liner.

## 3. Design of transfer channels

The computer program Autodesk Inventor Professional 2011 was chosen for creating the 3D model of the cylinder. Firstly it was necessary to measure all the dimensions of the cylinder. Therefore the old and damaged cylinder was divided into six parts. The measurement of all dimensions was very simple because the individual parts of the cylinder were separated from one another, as you can see in Fig. 4A

The modeling was divided into two parts, first the casing of the cylinder was designed and then the transfer channels. Both parts have very complicated shapes therefore the modeling was divided into two parts. Afterwards the shape of transfer channels was removed from the casing of the cylinder, as shown in Fig. 4B

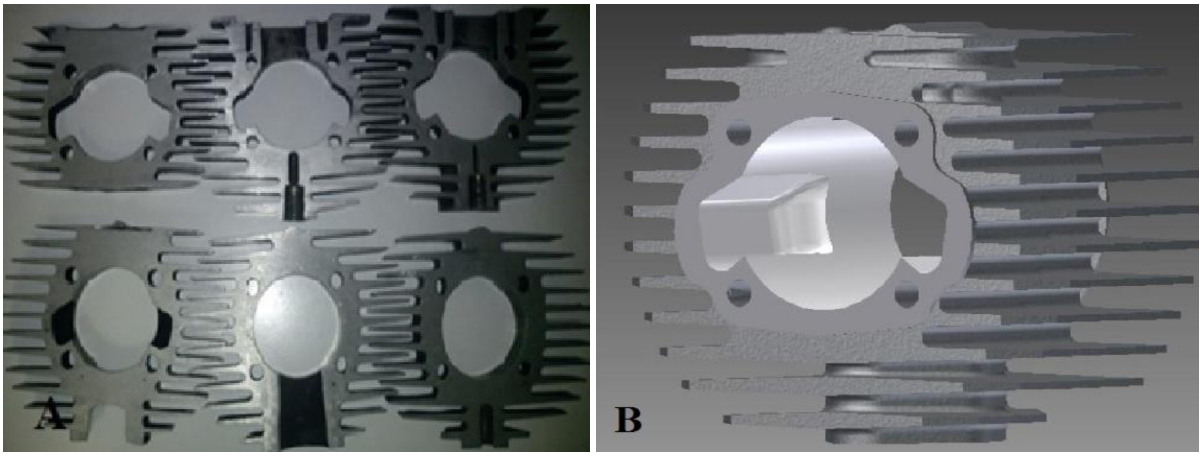


Fig. 4. (A) Shredded cylinder type 21; (B) The cylinder with channels type 21.

### *3.1. Design of improved transfer channels*

During the design it was crucial that the new transfer channels fit in to the casing of the cylinder. This presumption was very restrictive. The transfer channels from modern racing motorcycles cannot be implemented into the casing of the cylinder due to its small dimensions. During the design we cooperated with engine designers. Two input shapes of the two-channel version were designed and we needed to choose the best shape.

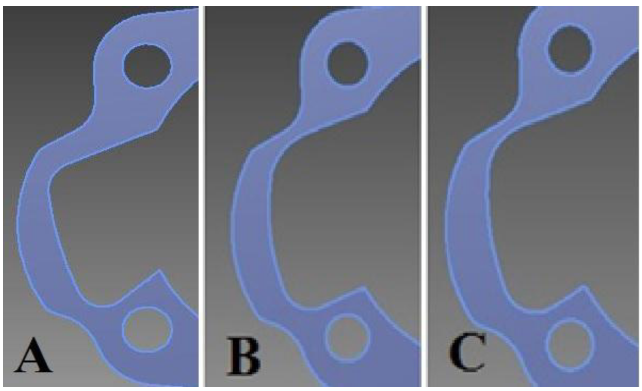


Fig. 5. Shape of the input channel A – variant I, B – variant II, C – Final shape.

The consultation with the specialists was needed for selecting the best version. The input shape B was chosen and was modified. The lower angle was raised by 5° as you can see in Fig. 5C. Then the 3D model of the modified transfer channel was designed. The transfer channel is narrowed by about 3° and the bottom edge is raised by 1.5mm at the outlet. Afterwards the shape of the transfer channels was removed from the casing of the cylinder.

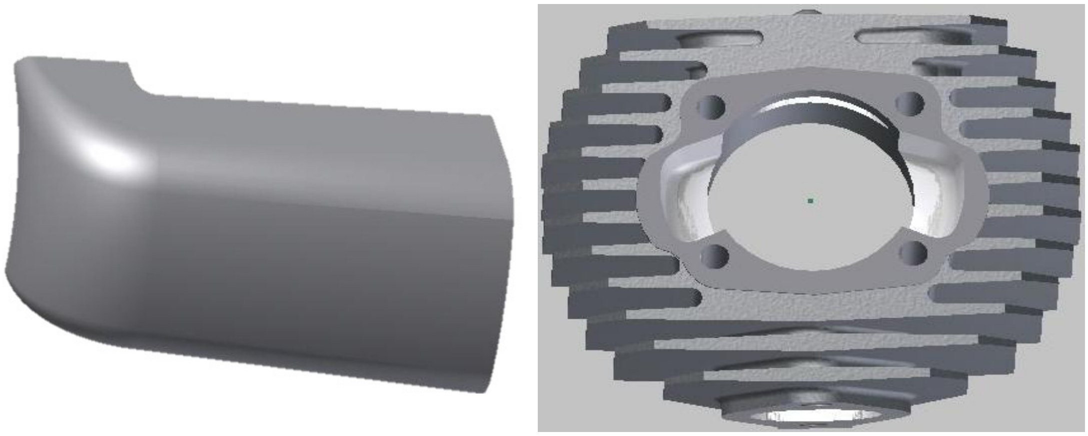

Fig. 6. (a) Optimized of channel; (b) The cylinder with stamping of transfer channels.

## 4. The four-channel version

The four-channel version of transfer channels was designed to increase the effectiveness of scavenging. This method of scavenging causes an increase of the volume of transfer mixture and generates two streams which are separated. The streams may be directed in various directions. The correct direction of the transfer channels is essential for good scavenging. Incorrect direction of the mixture in the four-channel version may create worse scavenging than the correct direction of the mixture in the two-channel version. The four-channel version is limited mainly by the distance between the bolts and serial transfer channels in the cylinder. The distance between the bolts was chosen poorly during production of the cylinder of this motorbike. Creating the right shape of the transfer channels is very difficult due to this limit. The suitable shape has to fit into the mass-produced cylinder.

The engine designers recommended creating new transfer channels irrespective of the existing mass-produced transfer channels. The original transfer channels will be filled using TIG welding. The machining will start in the cylinder without the original transfer channels. This fact influenced the design of the final transfer channels. The direction of the transfer channels was partly taken from the cylinders of modern racing motorcycles. The main sign is that expansion and the transitions between the radii are smooth. The bottom edge goes directly above the axis of the cylinder and the outlet angle is very important. Its value is 5°, as you can see in Fig. 7B and 7C

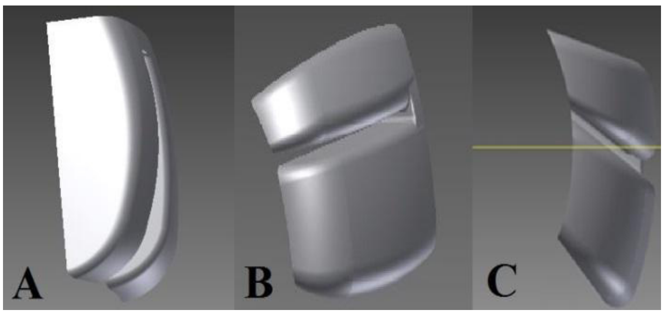


Fig. 7. View of the four-channel version A Upper side, B – from side, C - front side.

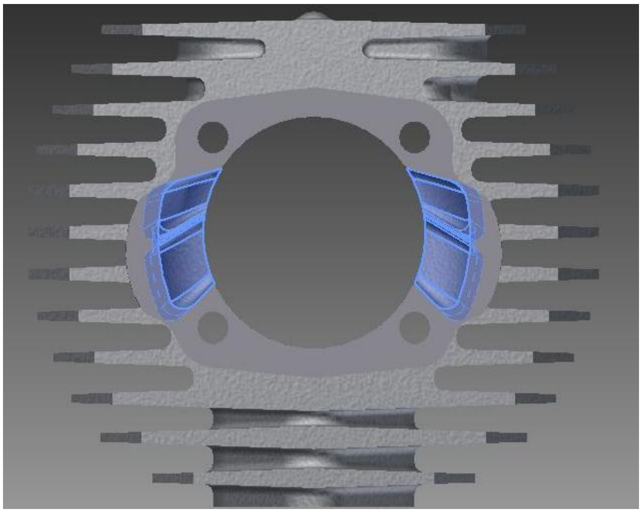

Fig. 8. Four-channel version.

## 5. Manufacture of transfer channels

It was necessary to manufacture the designed transfer channels. It was decided to use a three-axis CNC milling machine due to the complexity of the shape of the transfer channels. The tool-paths were programmed using Catia V5R and the machining technology was designed in the program [11]. The NC program was generated for this milling machine after a successful manufacturing simulation [12]. A simple clamping jig was made to clamp the cylinder into the milling machine. This clamping jig was clamped into the machine vise. The cylinder was secured using the clamp for safety reasons.

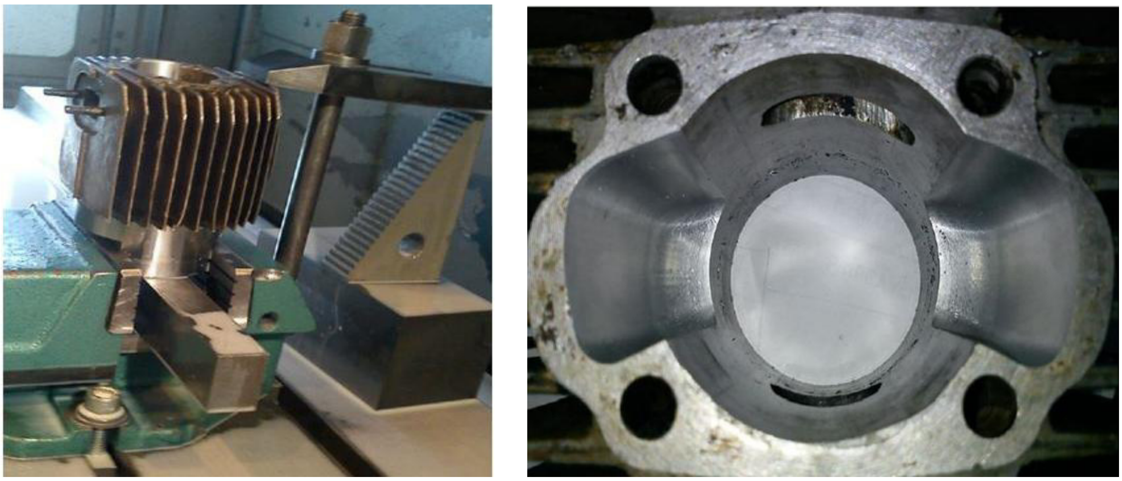

Fig. 9. (a) Manufacture of the transfer channels; (b) the transfer channels.

It was necessary to produce the windows of the transfer channels in the insert after manufacturing the cylinder casing. The insert was manufactured using a conventional milling machine. This operation was not complex due to the simple shape of the transfer windows. The shape of the exhaust window was modified as was the shape of the intake window. The finished insert was inserted into the casing of the cylinder. The transitions must be smooth between the transfer channels and transfer windows in the insert. The finished cylinder was ground to the diameter for the piston. The finished cylinder after grinding is shown in Fig. 15. This assembly was fitted into the motorcycle engine.

Fig. 10. The finished cylinder.

## 6. Measuring the performance

The measurement was carried out using the engine brake. The engine brake measures the performance on the rear wheel of the motorcycle. The real performance of the engine is reduced due to the passive resistances which act during measurement [10]. A lot of exhaust pipes were used during measuring. The exhaust pipes have a big effect on the performance of the engine.[9] The performance achieved by the engine was 4.34kW and torque 5.54Nm when using the correct exhaust pipe, as shown in Fig. 11(a),(b). The graphs show the difference between using the racing cylinder head with a combustion chamber and a normal cylinder head. The blue curve represents the racing cylinder head.

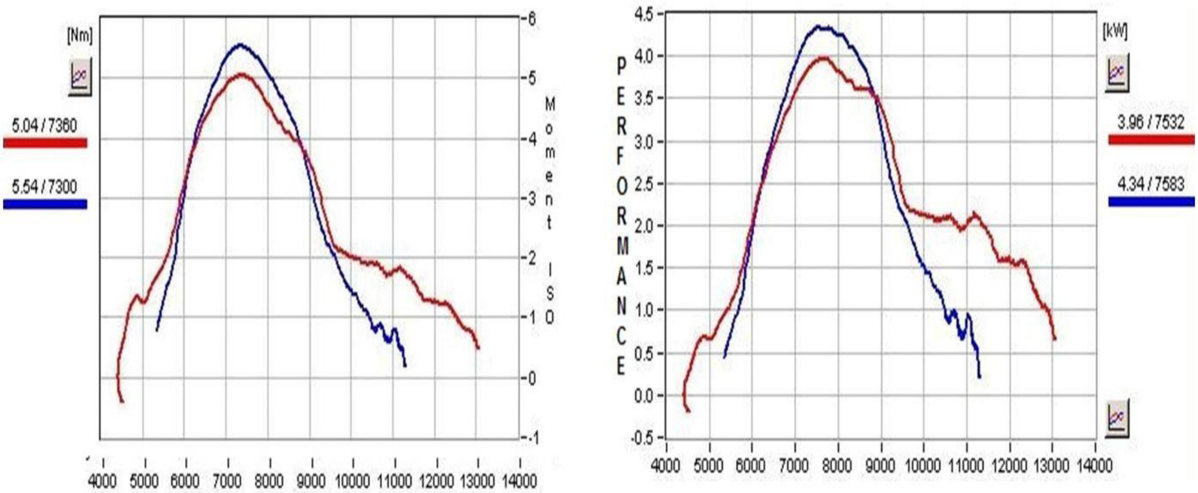


Fig. 11. Measurement of the engine brake (a) Torque; (b) Performance.

## Conclusion

The small volume motorcycle Jawa 50 had low performance because the cylinder was developed for common everyday use. The main aim of this work is to increase the performance parameters of this motorcycle so that it is competitive in races. The transfer channels were modified and thereby the performance was increased. The two-channel version is assumed to increase performance two-fold. The expected values of performance are 4 kW and torque 5Nm at 8000 RPM. The prerequisite was confirmed by the measurement on the engine brake. The values of performance are conditional on using a suitable shape and timing of the exhaust window, but the exhaust pipe has the greatest impact on the performance of the engine. The motorcycle is more powerful and thereby will be better for races.

The four-channel version is assumed to increase performance by two to three times. The expected values of performance are 6-7 kW and torque 5-6Nm at 11000 RPM. This assumption could not be confirmed because the four-channel version was not produced.

## Acknowledgements

This paper is based upon work sponsored by project "Regionální technologický institut" no. CZ.1.05/2.1.00/03.0093.

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