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Technical Notes

A study of stratified scavenging type in two cycle gasoline engine

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1. Introduction

In order to develop the next generation of two cycle engines, there are many problems to be tackled such as new charge short circuiting, irregular combustion at low load, the reduction of exhaust gas emissions, lubrication, etc. The most immediate problems are increased fuel consumption and the emission of highly concentrated HC, caused by short circuits of fuel during scavenging.

It is not an exaggeration to say that the overall performance of a two cycle engine is determined by its scavenging performance.

In order to solve the above problems, we have invented a new scavenging type which is designed to achieve perfect stratified scavenging. With this type we have achieved favorable performances that exceeds that of the Schnürle scavenging type. In this paper, we report on this new type.

2. Combustion stability of the Schnürle scavenging type

The specification of the experimental single cylinder engine is shown in Table 1.

The indicated maximum pressure ($P_{\max}$) fluctuation at low load with the Schnürle scavenging type is as shown in Fig. 1. The misfiring rate of 8% indicates poor combustion stability at low load. As we visualized the steady flow inside the cylinder with a laser light sheet, we discovered that the in-cylinder flow is not symmetrical, and therefore rather unstable, despite the symmetrical port shape. This caused us to believe that stable formation of the air–fuel mixture in each cycle was difficult to obtain.

3. Concept of asymmetrical scavenging port

3.1. Concept of asymmetrical scavenging port

The in-cylinder visualization experiment revealed that the in-cylinder flow was not symmetrical. So we thought of artificially creating asymmetrical flow that would form stable in-cylinder flow. At the same time, we adopted the concept of uniflow scavenging type, whereby a series of swirls is created by new charge on the intake side (the sub-port side) of the cylinder, and these swirls push out the residual gas, causing stratified charge (Fig. 2).

3.2. Influence of ignition and injection positions

In order to confirm that a stratified new charge is created as intended through asymmetrical scavenging, the ignition and injection positions were shifted from the cylindrical center to the sub-port side. The result are as shown in Fig. 3.

The torque is larger when the ignition and injection positions are shifted. This is because the stratification produced by the asymmetrical scavenging increases the amount of new charge on the sub-port side of the cylinder.

4. Comparison with Schnürle scavenging

4.1. Comparison of scavenging efficiencies

Fig. 4 shows a comparison of the scavenging efficiencies of the Schnürle scavenging and asymmetrical scavenging type. In the case of Schnürle scavenging, on the side having high delivery ratio, where the flow velocity is

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Table 1
Specification of experimental single cylinder engine

Bore × Stroke	68 × 60.5 mm
Displacement	219.7 cc
Compression ratio	10.0
Scavenging system	Port scavenging with external scavenging pump
Lubrication system	Wet sump
Fuel supply system	Direct injection

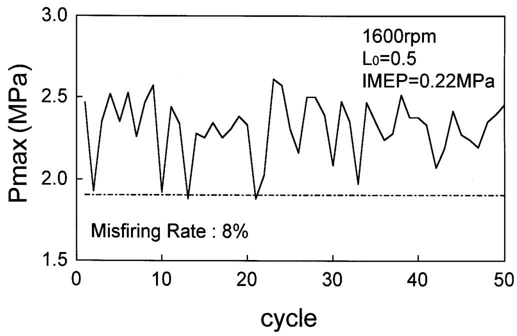

Fig. 1. P_{max} fluctuation of Schnürle scavenging type.

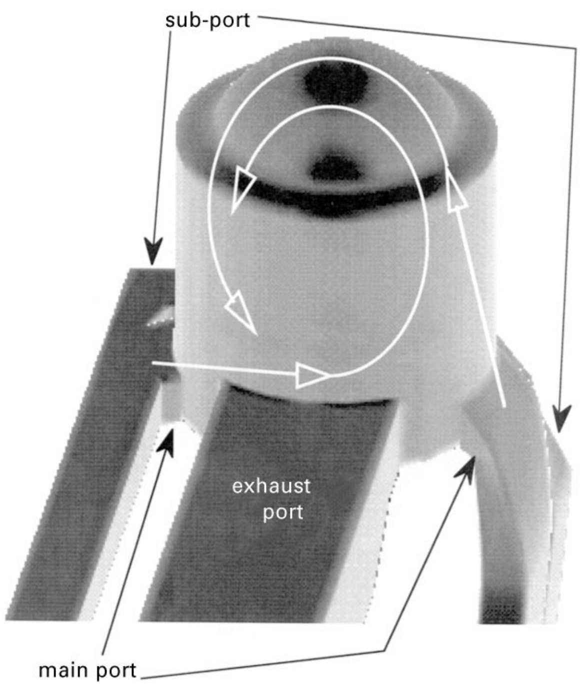

Fig. 2. Flow of asymmetrical scavenging port.

high, the residual gas is taken in a twisting circular movement toward the center of the cylinder, indicating low scavenging efficiency. Whereas with the asymmetrical scavenging type, high scavenging type, high scavenging efficiency is obtained frow low delivery ratio to high delivery ratio.

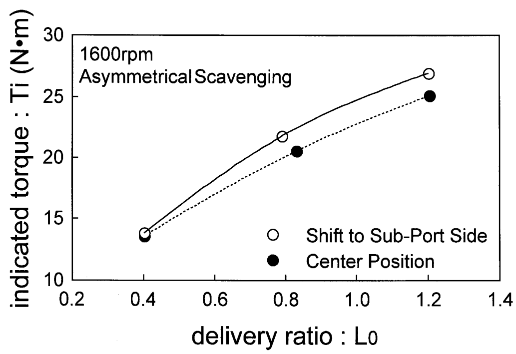

Fig. 3. Influence of ignition and injection positions.

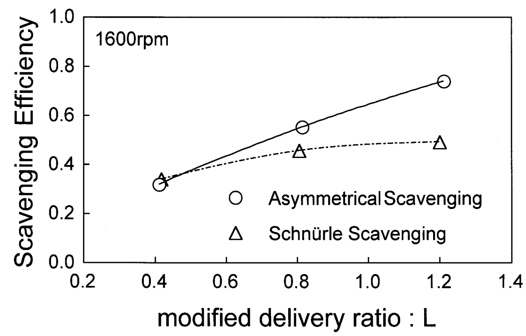

Fig. 4. Comparison of scavenging efficiencies.

4.2. Comparison of partial load performance

A comparison at partial load levels between the asymmetrical scavenging and Schnürle scavenging type is shown in Fig. 5.

In the case of Schnürle scavenging, the port shape is such that the performance in the low load range is emphasized, so no significant emission reducing effect is observed even at low load levels. When asymmetrical scavenging is employed, however, it is possible to drastically reduce emissions. We believe this is because stratification of the new charge and the residual gas was accelerated. However, in the high load range with a large amount of air, the emission of NO_x increases. This is a problem that has to be solved because the two cycle engine always contains O_2 in its exhaust gas.

4.3. Light load combustion stability

P_{max} and IMEP fluctuations of the asymmetrical scavenging type in the extreme light load range are shown in Figs. 6 and 7. As shown in these figures, with asymmetrical scavenging, the misfiring rate is 0% even in the extreme light load range. Also the IMEP fluctuation is extremely stable at 3.3%. As such, very good results have been obtained with regard to the light load combustion stability.

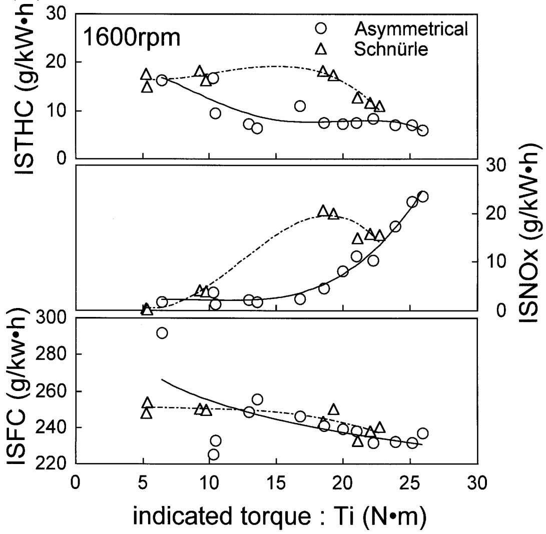

Fig. 5. Comparison of partial load performance.

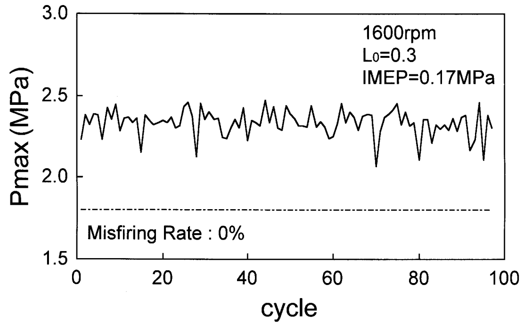

Fig. 6. P_{max} fluctuation of the asymmetrical scavenging type.

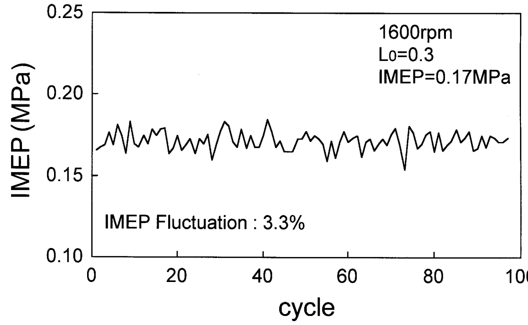

Fig. 7. IMEP fluctuation of the asymmetrical scavenging type.

5. Summary

In order to solve the problems inherent in conventional two cycle engines, we aimed at achieving perfect stratified scavenging, and in the course of our research we invented a new scavenging type with a new stratified charge to push out the residual gas. Combining this asymmetrical scavenging type with direct injection, we obtained the following results:

1. The asymmetrical scavenging type emulates perfect stratified scavenging and achieves good specific fuel consumption and HC emission level comparable to that of four cycle engine.
2. By emulating perfect stratified scavenging, irregular combustion at light load levels caused by large amounts of residual gas can be prevented.