EFFECTS OF REED VALVE CONFIGURATION ON THE CHARGING CHARACTERISTICS OF A CRANKCASE-COMPRESSED TWO-STROKE ENGINE

Kazunori HAMASAKI and Yoshihiro TANAKA

(Received May 31, 1991)

Abstract

Responding to the engine speed, load, opening of the throttle valve, etc., two–stroke reed valve engines have the advantage of controlling the intake of fresh charge into the crankcase. However, the reed valve is installed in the intake passage and yields suction resistances. Studies of the effects of a reed petal on the engine performance have been carried out for reducing the suction resistances. To clarify the influences of the configuration of the reed blocks on the charging characteristics, this paper described the results of firing tests using 5 different reed blocks with similar reed petals. In addition, 4 different reed valves were experimentally installed in models in the steady flow for obtaining fundamental data. The experimental results indicated that each type of reed valve had its own peculiar charging characteristics according to the configuration and the installation conditions.

1. INTRODUCTION

The reed valve intake control method has generalized as the new charge intake system of a crankcase–compressed two–stroke engine. This method has its features of control in response to the engine speed, load, opening of the throttle valve, and so on. The reed valve, however, is installed in the intake passage and yields the suction resistances. Various reed valves in different configuration are used in order to reduce the suction resistance. The effects of reed valve configuration on the engine performance have been studied experimentally by several researchers[1),2)]. These studies dealt with the effects of reed petals, especially reed thickness, reed number, and reed configuration, on the engine performance. We previously studied the effects of the reed behavior on the charging characteristics of a reed valve type two–stroke engine[3)].

The present investigation clarified the influences of the configuration of the reed blocks on the charging characteristics using 5 different reed blocks with similar reed petals. The results indicated that each type of reed valve had its own peculiar charging characteristics according to the configuration and the installation conditions.

2. EXPERIMENTAL APPARATUS AND METHODS

The test engine is an air–cooled two–stroke engine with crankcase–compression and Schnürle loop scavenging system. Its major specifications are shown in Table 1. The schematic arrangement of experimental apparatus, the port area of piston, reed specifications, reed block specifications, and reed block configurations are shown in Fig. 1, Fig. 2, Table 2, Table 3, and Fig. 3 respectively. Experiments were performed using 5 different reed blocks (Table 3) with similar reed petals (Table 2).

Table 1 Test engine specifications

Engine Type	1 Cylinder,Air Cooled, Gasoline Engine
Air Intake System	Reed Valve
Cylinder Bore x Stroke	68 x 59 mm
Stroke Volume	214.3 cm^3
Max.Power/Engine Speed	7.3 kW/3500 rpm
Scavenging Type	Schnürle
Compression Ratio	5.8
Crankcase Comp. Ratio	1.41
Scavenging Port Timing	55deg. BBDC,ABDC
Exhaust Port Timing	81deg. BBDC,ABDC

Table 2 Reed specifications

Material	SUS 631
Young's Modulus	193 GPa
Density	$7.93 \times 10^3 kg/m^3$
Effective Length	32.0 mm
Width	22.0 mm
Thickness	0.20 mm

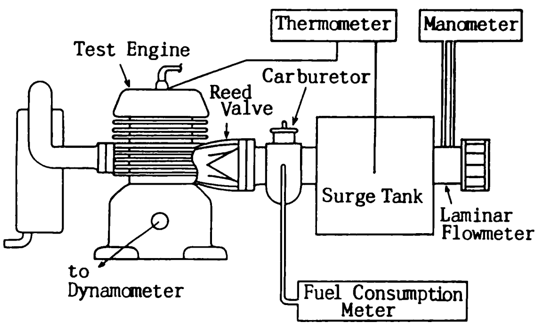

Fig. 1 Schematic arrangement of experimental apparatus

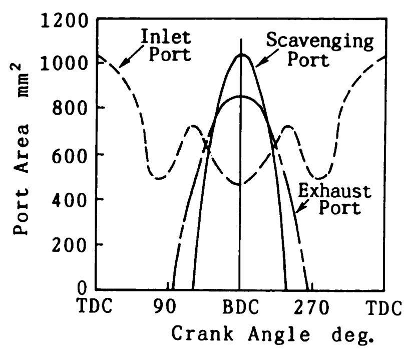

Fig. 2 Port area of piston

Table 3 Reed block specifications

	V304	V302	F902	D602	D302
Material	AC	PMMA	PMMA	PMMA	PMMA
Type	V	V	Flat	Delta	Delta
Number of Reeds	4	2	2	2	2
Reed Block Angle	30°	30°	90°	60°	30°
Port Area (cm^2)	17.6	8.8	8.8	8.8	8.8

A four–reed valve V304 was originally installed in a test engine. In case of installation of each reed valve, the increase of the crankcase volume was controlled by stuffing the reed valve chamber, and the compression ratio was kept the same value in V304. In the intake system, a surge tank was positioned just upstream of a carburetor, and a laminar flowmeter installed on the surge tank was used to measure the intake air amount. It could be considered that there was no effect on the measuring error of the intake air and the engine performance because the surge tank pressure was under 200Pa and the Hodgson number[4] Ho was above 1.5 throughout the test. The test engine drove an air–cooled eddy current dynamometer and the test fuel was commercial regular gasoline. The experiments were conducted at the wide open throttle and the engine speeds were regulated by controlling the dynamometer.

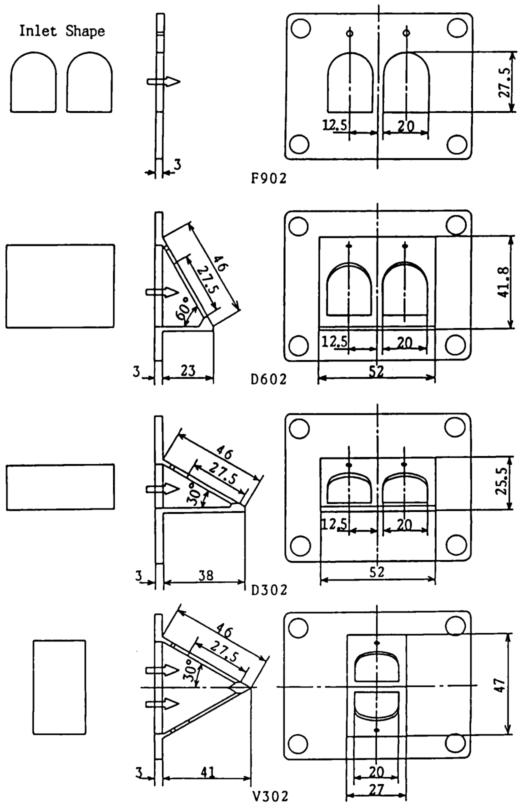

Fig. 3 Reed block configurations

3. RESULTS AND DISCUSSION

3.1 Effects of the reed block configuration on the characteristics of the delivery ratio

The delivery ratio for 3 types of reed valves with different reed block configuration geometrically is shown in Fig. 4. Every reed valve is two-reed type, however, the reed blocks are V, Delta, and Flat type in configuration. In addition, the valve ports are identical in shape and the port area is equal. The variations in delivery ratio show the similar trends among 3 different reed valves, however, the delivery ratio for V302 reed valve is higher than that for D302 and F902 over the wide engine speeds. The delivery ratio for D302 reed valve is approximately consistent with that for F902 at the low engine speeds below 2000 rpm and the high engine speeds above 3700 rpm, and at the middle engine speed around 3000 rpm, the speed at which maximum delivery ratio is measured, the delivery ratio for D302 is higher than that for F902. Watanabe et al.[5] showed that the delivery ratio and the flow coefficient for the long sideways intake port were higher than those for the lengthwise intake port. Then considering the entrance configuration of the reed blocks V302 and D302, it seems that the delivery ratio for D302 is higher than that for V302 because of the equal area and the long sideways entrance configuration of the D302. As shown in Fig.4, however, the delivery ratio for V302 is higher than that for D302. Therefore, it is considered that there is no effect of entrance configuration of the reed blocks on the delivery ratio. The difference in the delivery ratio for V302, D302 and

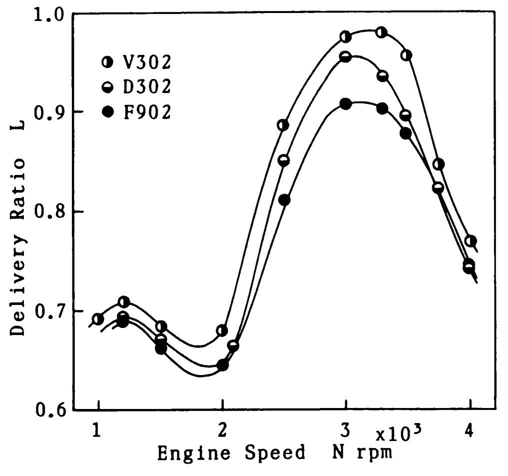

Fig. 4 Comparison of delivery ratio for two–reed type valves V302, D302 and F902

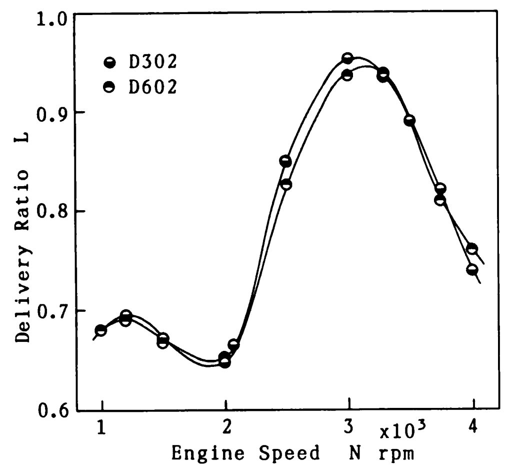

Fig. 5 Delivery ratio for Delta type reed valves

F902 is the difference of the resistance of suction flow.

Figure 5 shows the delivery ratio curves for D302 and D602 Delta type reed block. Although the delivery ratio for D302 is slightly higher at approximately 2500~3000 rpm, the trends of two delivery ratio curves are found to be consistent over the complete engine speed range. The reed blocks D302 and D602 are 30° and 60° respectively in reed block angle, i.e., in angle to the suction flow. Nevertheless, it can be seen that for the Delta type reed valves the effects of the angle on the delivery ratio are negligible, since both delivery ratio curves show the consistent trends.

Figure 6 shows the correlation between the engine speed, N, and the brake mean effective pressure, Pme, of 3 types of reed valves with different block configurations. The variation in Pme is observed the similar tendency to the variation in delivery ratio shown in Fig.4. Furthermore, the values of Pme for D302 and D602 Delta type reed valves also showed the similar tendency to the variation in delivery ratio shown in Fig.5. Thus, the output characteristics of a crankcase-compressed

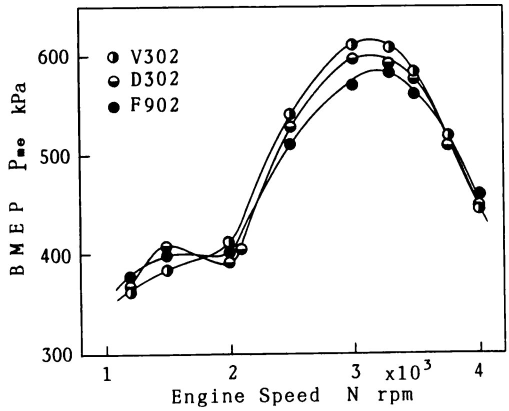

Fig. 6 Comparison of BMEP for two-reed type valves V302, D302 and F902

two-stroke engine are confirmed to be depended upon the delivery ratio, and it is considered that for the Delta type reed valves there is little effect of the reed block angle on the output characteristics, as well as the delivery ratio. Blair et al.[1] showed that for the V type reed valves the effects of the block angle on the delivery ratio were negligible.

3.2 Effects of the reed number on the characteristics of the delivery ratio

It was previously shown that in the two-reed type V302, D302, and F902 the delivery ratio for V type reed valve V302 is higher than the others over the wide engine speeds. Then the delivery ratios for V type reed valves V302 and V304 are shown in Fig.7. The reed valve V302 has two reed petals, whereas V304 has four reed petals. At low engine speeds below 2000rpm, the delivery ratio for standard reed valve V304 is higher than that for V302, on the other hand the delivery ratio for V302 is higher at middle or high engine speeds. For this reason, it is considered to be as follows. The requisite air flow for engine is subject to restriction due to the venturi diameter of the carburetor and the sectional area of passage between the carburetor and the crankcase. In the case of a reed valve type engine, the reed valve open area imposes restrictions on the air flow in the sectional area of the passage. The reed lift is generally low at low engine speeds. Therefore, in a two-reed type valve the open area is small and the air flow per cycle is a little. However, the reed lift becomes high at middle or high engine speeds and the open area for a four-reed type valve is too large. Then, it seems that the sufficient air flow is obtained by the open area for a two-reed type valve. Consequently, increasing the number of reeds and enlarging the port area, on the contrary the delivery ratio becomes lower in some cases. It is necessary to determine the number of reeds and the port area in relation to the stroke volume.

3.3 Considerations in steady flow experiment

A steady flow experiment was performed to obtain the fundamental data of the charging characteristics depended on the difference of reed valve configuration. The schematic arrangement of experimental apparatus is shown in Fig.8. The reed valve installed in a engine opens in case of negative pressure, however, this experiment was carried out to vary the reed lift by varying the positive pressure in the surge tank B. The intake air flowed into the reed valve was measured by the flowmeter which was installed in the surge tank A. Five different reed valves were used in the experiment, that is, those were V304, V302, F901, D601, and D301. F901, D601, and D301 are one-reed

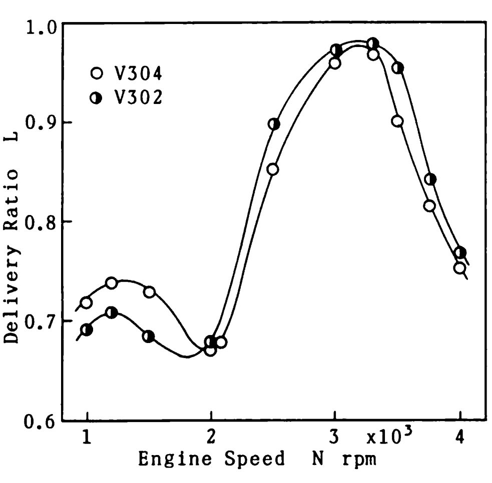

Fig. 7 Delivery ratio for V type reed valves by the difference in number of reeds

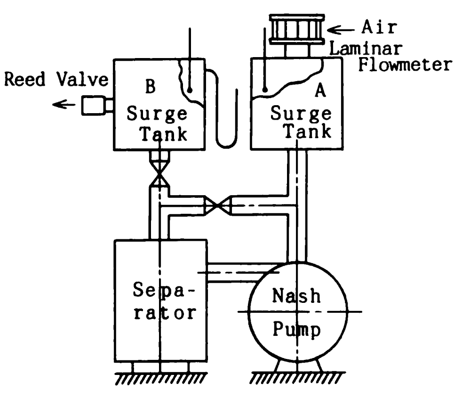

Fig. 8 Experimental apparatus for steady flow

type valves which are remodeled F902, D602, and D302 respectively. The reed block angle for one–reed type valve is the same angle for two–reed type valve. The air discharge models of reed valves were investigated two types as shown in Fig.9. One is the model of discharge from the all open area (model A) and the other is that of discharge from the front open area alone (model B). The model A shown in Fig.9 is hardly seen in the reed valve installed in a engine and the side open area of the reed valve is restricted to some extent. The reed valve of the test engine is nearly the model B. V304 was experimented on the model A alone.

Figure 10 shows the air flow measured by the flowmeter of the surge tank A for the difference between the upstream pressure and the downstream pressure of the reed valve. In the case of model A, the air flow for F901 is the largest in the one–reed type valves. Then the air flow is large in order of D601 and D301, i.e., it shows that the air flow increases when the reed block angle is larger. The larger the reed block angle, the stronger the force on the reed at the same different pressure.

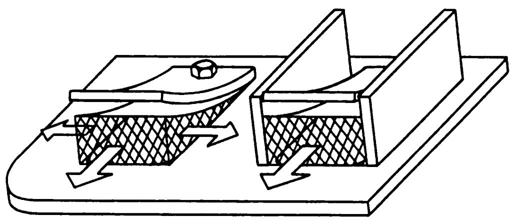

Fig. 9 Discharge models of reed valves

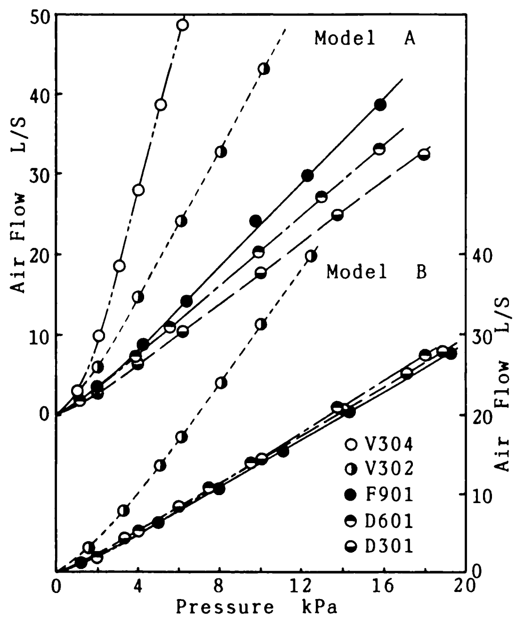

Fig. 10 Relationship between differential pressure and air flow by discharge models

Accordingly, it seems to be high reed lift. Assuming that the air flow for two–reed type valve is twice as much as that for one–reed type valve, it is clear that the air flow for F901 is larger than that for two–reed type valve V302 and D601 is nearly equal to V302, although D301 is smaller than V302. Therefore, in the case of the reed valve installed so as to discharge from the all open area, the Flat type reed valve has the largest air flow, then the air flow is large in order of V 30°, Delta 60°, and Delta 30°. Comparing V304 with V302, V304 is below twice the air flow for V302 at low differential pressure. However, V304 is about twice the air flow for V302 when the differential pressure is above 6kPa. It is considered that the low differential pressure and the low reed lift cause the mutual interference of the flow from the side open area, but the interference of the flow from the side open area is hardly caused at high differential pressure and high reed lift. On the other hand, in the case of model B, the air flow for one–reed type valves is not found a great difference at the same

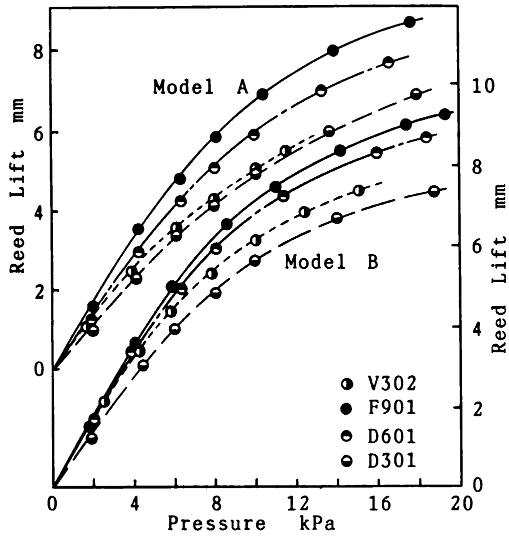

Fig. 11 Relationship between differential pressure and reed lift by discharge models

differential pressure. However, if examined in detail, the air flow for F901 is generally smaller than the others. The air flow for V302 is twice more than that for one–reed type valves in the experimental range from 0 to 14kPa. In the relationship between the reed lift and the differential pressure shown in Fig.11, the reed lift is high as the reed block angle is larger in both cases of model A and model B. In the case of model B, then, the difference in air flow can not be explained by the reed lift. If the flow coefficient is defined in the case of the variable open area also, it seems that the difference in flow coefficient exerts considerable influence on the air flow. Comparing V302 with D301 whose reed block angle is 30° either, the high reed lift for V302 is presumably due to the lowness of the entry loss coefficient[6] in both discharge models. Through the examination of an experiment on steady flow in model B mentioned above, it is found that in the case of the test engine the air flow is much discharge from the front open area and the discharge from the side open area is considerably subject to restriction.

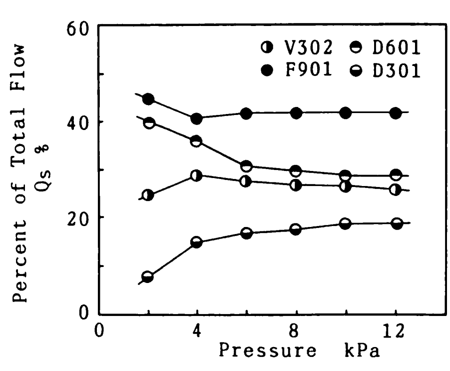

Fig. 12 Rates of discharge from side open area

On the assumption that the air flow discharged from the side open area is the difference of the air flow between model A and model B, the proportion of air flow discharged from the side open area, Qs, is shown versus the differential pressure in Fig.12. Qs increases with differential pressure when the reed block angle is small such as V302, D301 and at the differential pressure above 8kPa, Qs is approximately constant. At the same reed block angle, Qs for V type reed valve is larger than that for Delta type reed valve. On the other hand, Qs decreases with differential pressure when the reed block angle is large such as F901, D601 and at differential pressure above 8kPa, Qs is approximately constant. It is indicated that Qs for F901 is approximately constant except at rather low differential pressure, and is large compared with other type reed valves.

Consequently, when the reed valve is installed in a engine, a Flat type reed valve is suitable for the case without restriction of discharge from the side open area and a V type reed valve or a Delta type reed valve being small reed block angle is suitable for the case imposed restrictions on the side open area.

4. CONCLUSIONS

Experiments were carried out in order to clarify the influences of the reed valve configuration on the charging characteristics of a small two–stroke engine using five different reed valves. In addition, through the examination of steady flow experiment with reed valve models, the following results were obtained:

(1) A V type reed valve is suitable in cases the air flow is not discharged from the side open area or the discharge from the side open area is subject to restriction. In such cases the air flow and the delivery ratio of a Flat type reed valve are smaller than the other types of reed valves.

(2) A Flat type reed valve, which is large air flow and proportion of discharge from the side open area, is suitable for the case of installation to discharge from the all open area.

(3) If the flow from the side open area of a reed valve is subject to restriction like a test engine, with Delta type reed valves there is little effect of a reed block angle on the charging characteristics and the output.

ACKNOWLEDGMENTS

The authors would like to thank the Yamaha Motor Co., Ltd. who supplied the test engine and numerous spare parts, and also Mr.Masaki Kamimura, Mr.Takeshi Ohba, and Mr.Kenji Abe for their cooperations in the experimental work.

REFERENCES

1) Blair, G.P., Hinds, E.T. and Fleck, R., Predicting the Performance Characteristics of Two–Cycle Engines Fitted with Reed Induction Valves, SAE Paper, No.790842 (1979).

2) Fleck, R., Blair, G.P. and Houston, R.A.R., An Improved Model for Predicting Reed Valve Behaviour in Two–Stroke Cycle Engines, SAE Paper, No.871654 (1987).

3) Hamasaki, K. and Tanaka, Y., The Reed Behavior and Charging Characteristics of a Reed Valve Type Crankcase–Compressed Two–Cycle Engine, Trans. Jpn. Soc. Mech. Eng., (in Japanese), Vol.52, No.477, B(1986), p.2306.

4) Hatta, K., Asanuma, T. and Matsuki, M., Measurement Handbook on Internal Combustion Engine, (in Japanese), (1984), p.55, Asakura.

5) Komotori, K. and Watanabe, E., A Study of the Delivery Ratio Characteristics of a Crank––

Case–Scavenged Piston Valve–Inlet Port Two–Stroke Cycle Engine, SAE Trans., Vol.78 (1969), p.608.

6) Massey, B.S., Mechanics of Fluids, (4th ed.), (1979), p.201, Van Nostrand Company.