Exhaust Emission Distributions in the Exhaust Pipe of an Industrial Gasoline Engine

(Part I The Observation of Pulsation Phenomena in an Exhaust Pipe)

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and Takeo MATSUDA**

Abstract

The pulsation phenomena in the exhaust pipe of a small, single cylinder industrial gasoline engine were investigated. The static pressure at various points along the exhaust pipe changes periodically. The authors recognized that mean static pressures (i,e, the readings of water gauge manometers) in an exhaust pipe were distributed in the fluctuation state.

Regarding the pulsation phenomena, it is important that minus mean static pressures, in an exhaust pipe, exist at various places as shown in the figures.

In terms of actual use, it is of vital importance that such phenomena occur comparatively near the exhaust port of an engine in an exhaust pipe, that is, at places where the exhaust gas temperature is very high.

It is suggested that this facilitates the after-burning of exhaust gasses by using a simple apparatus, that is, this facilitates the cleaning of exhaust gasses by using catalyses or catalyzers and secondary air which can be easily introduced into the exhaust pipe only by using some automatic valves such as reed valves.

1 *Introduction*

Some reports[1)2)] concerning emission distributions and sampling procedures of exhaust gases in the exhaust pipe of small, single cylinder gasoline engines and the dilution phenomena of exhaust emissions in the exhaust pipe near the open end of small, single cylinder gasoline engines have been published. A paper[3)] on the effects that the length of an exhaust pipe has on the back pressure and brake output of an internal combustion engine and others[4)~6)] have also been published.

In this study[7)~11)], the authors inspected the pulsation phenomena, from a different viewpoint, in an exhaust pipe, in order to investigate the mechanism responsible for the dilution phenomena of exhaust emissions near the open end of an exhaust pipe.

It was very important to the successful execution of this study that the mean static pressures along an exhaust pipe of an engine be inspected. The authors investigated the incidence of occurrence of minus static pressures in the exhaust pipe of an engine.

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In this report, only the observation of the pulsation phenomena is described.

2 *Source of Data*

2.1 Apparatus

The engine used to obtain experimental data was a four-stroke-cycle single cylinder air-cooled gasoline engine designed for general use. Table I shows the specifications of this engine.

Fig.1 shows an illustractive drawing of the experimental apparatus and Photo 1 shows a photogrph of a general view of the installation.

Further, Photo 2 shows a photograph of a detailed view of an exhaust pipe located adjacent to the engine's cylinder.

A Froude hydraulic dynamometer, various water gauge manometers, a CO analyzer, several thermocouple-thermometers, a pressure-inspection device and others were used. An exhaust pipe was attached to the engines cylinder, this procedure is shown in Fig.2 as are, the exhaust pipe's dimensions.

Very long pipes were used in accordance with the requirements of this experiment. Taking into consideration flow resistances caused by friction in the pipe and to enable sampling of exhaust gases at various locations on a cross-section of pipe, both 52 mm (inside diameter ID) and 68 mm (ID) steel pipes were used.

Table 1. Engine Specifications

Cycle		4 stroke-cycle
Bore X Stroke mm		75$\varnothing$×62
Stroke Volume cc		252
Compression ratio		6.0
Rated horsepower		5PS/3600rpm
Combustion chamber type		Side valve type
Suction	SO	BT 43°
	SC	AB 53°
Exhaust	EO	BB 86°
	EC	AT 48°

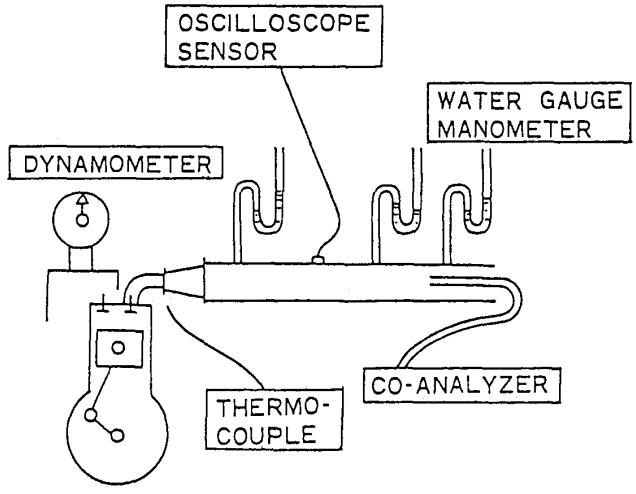

Fig.1. Illustrative drawing of the experimental apparatus.

2.2 Measurement and Procedure

The pressure, CO concentration and temperature distribution of the gas in the exhaust pipe were measured. Pressure fluctuations in the exhaust pipe were also measured. At this point, several water gauge manometers with a glass U-shaped tube 5 mm ID were used to measure the mean static pressures in the exhaust pipe at various locations.

The distances of these locations from the engine's cylinder were 0.25, 0.5, 0.75, 1.0, 1.25, ... meters. The engine was driven at 3600 r.p.m.

The connecting parts of the exhaust pipe were carefully to prevent the leakage of gas.

3 *Experimental Results*

3.1 Pressure distributions in the exhaust pipe

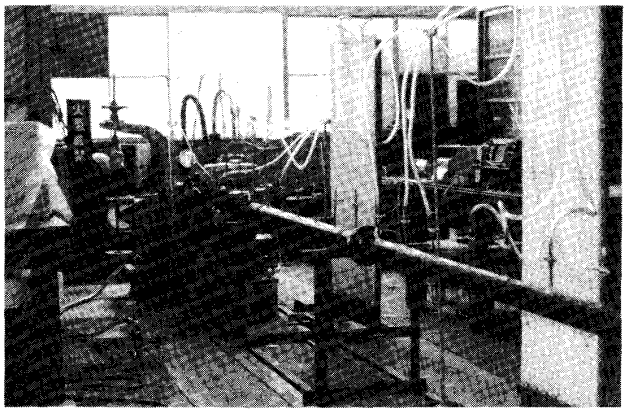

Photo.1. Photograph of a general view of the experimental apparatus.

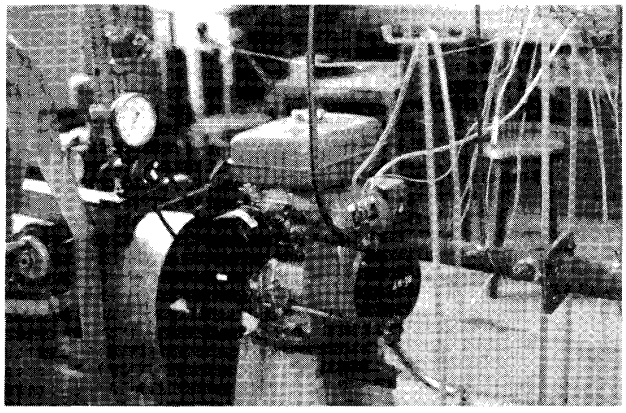

Photo.2. Photograph of the detailed view of an exhaust pipe at the adjacent region of the cylinder of the engine.

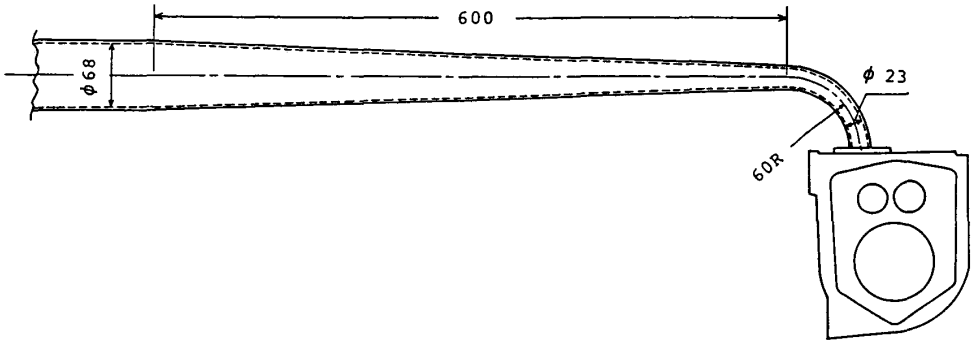

Fig.2. Drawing and its dimensions of an exhaust pipe attached to the cylinder of the engine.

Fig.3 shows some of the experimental results for mean static pressures in the exhaust pipe (total exhaust pipe length L=5.5 m, ID=68 mm), Fig.4 (L=11 m, ID=52 mm), Fig.5 (L=13.75 m, ID=52 mm), Fig.6 (L=16.5 m, ID=52 mm), Fig.7 (L=16.5 m, ID=68 mm) and Fig.8 (LOAD 3/4, ID=52mm, L=5.5m, L=11.0m, L=16.5m). Further, Fig.9 and 10 show the static pressure distributions near the open end of the exhaust pipe.

4 *Discussion*

Based on the exhaust opening, pressure waves progress in an exhaust pipe and these progressive waves (positive waves) become negative ones at the open end of the exhaust pipe. These waves are then reflected and come back forward the exhaust port of the engine. Progressive waves (positive pressure) and reflective waves (negative pressure) interfere with each other and consequently cause the mean static pressure to vary as shown in Figs.3, 4, 5, 6, 7 and 8. Pressure variations are caused by the pulsation phenomena.

Practically speaking, it is important that the minus mean static pressures appear comparatively near the exhaust port of the engine in an exhaust pipe. That is, at places where the exhaust gas temperatures are extremely high.

It was proposed and proven that this makes the after-burning of exhaust gases easy by using a simple apparatus. This means that eshaust gases can be easily cleaned by using catalyses or catalyzers and secon-

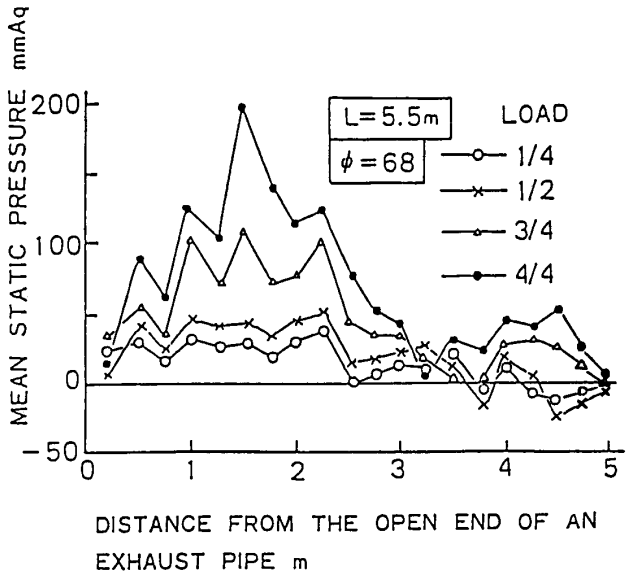

Fig.3. Mean static pressure distributions in an exhaust pipe.

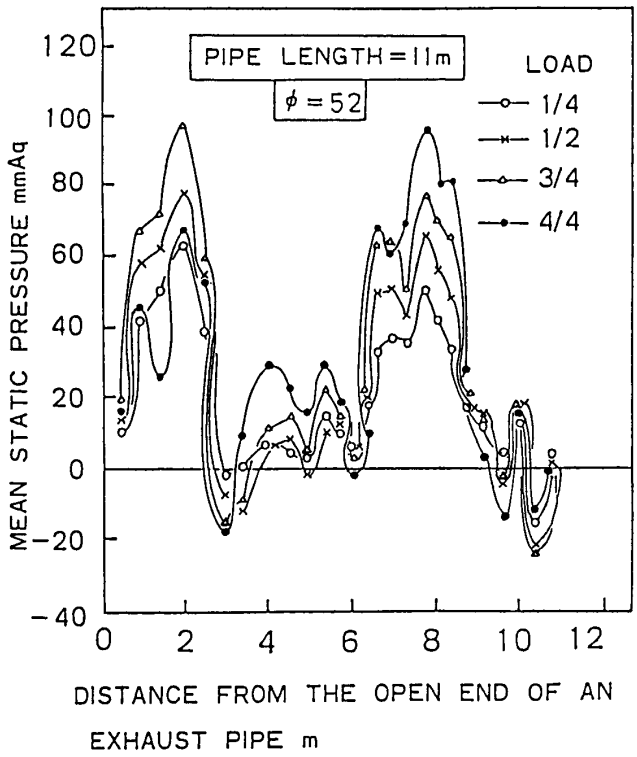

Fig.4. Mean static pressure distributions in an exhaust pipe.

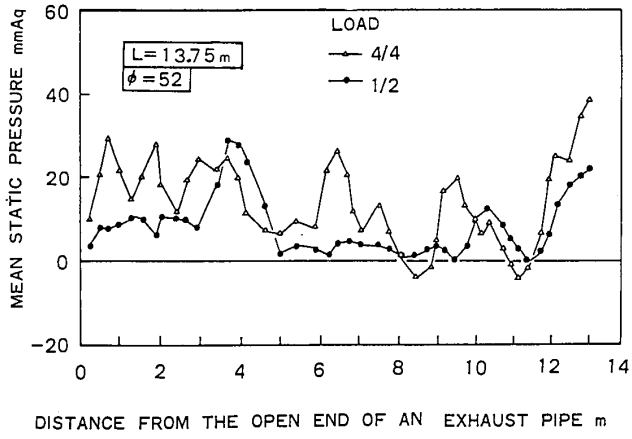

Fig.5. Mean static pressure distributions in an exhaust pipe.

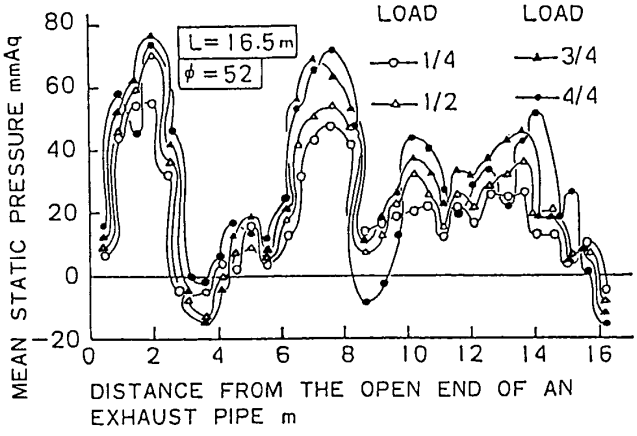

Fig.6. Mean static pressure distributions in an exhaust pipe.

dary air which can only be easily introduced into the exhaust pipe through various automatic valves such as reed valves.

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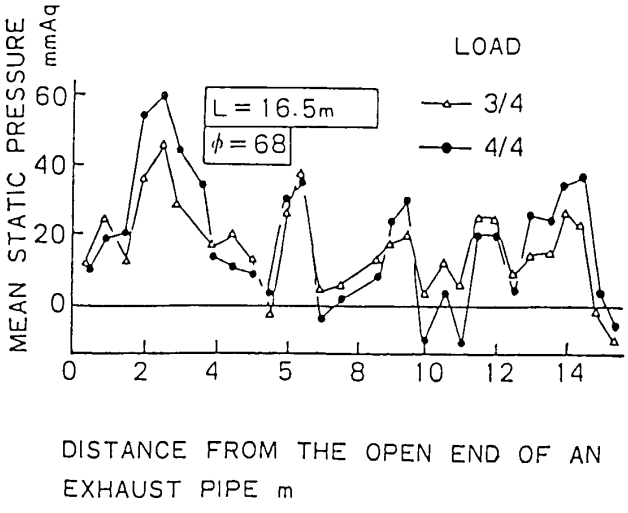

Fig.7. Mean static pressure distributions in an exhaust pipe.

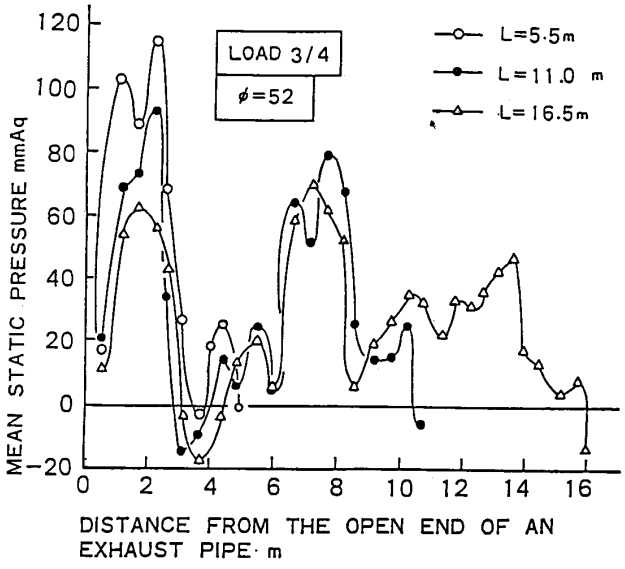

Fig.8. Mean static pressure distributions in an exhaust pipe.

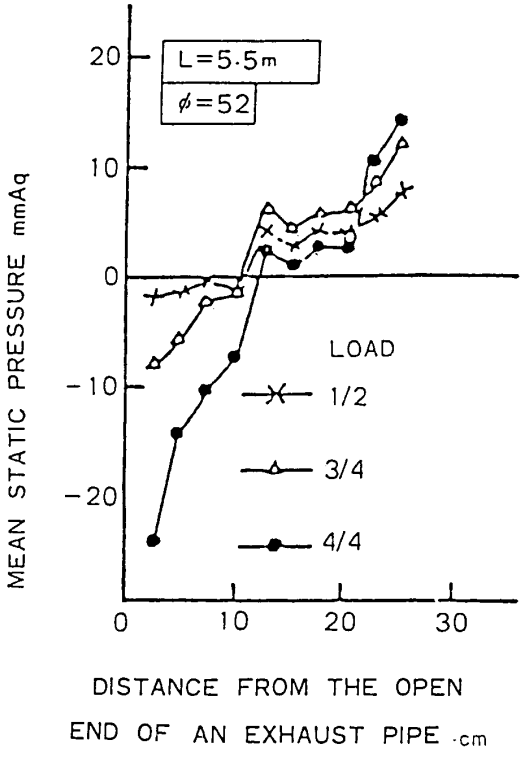

Fig.9. Mean static pressure distributions near the open end in an exhaust pipe.

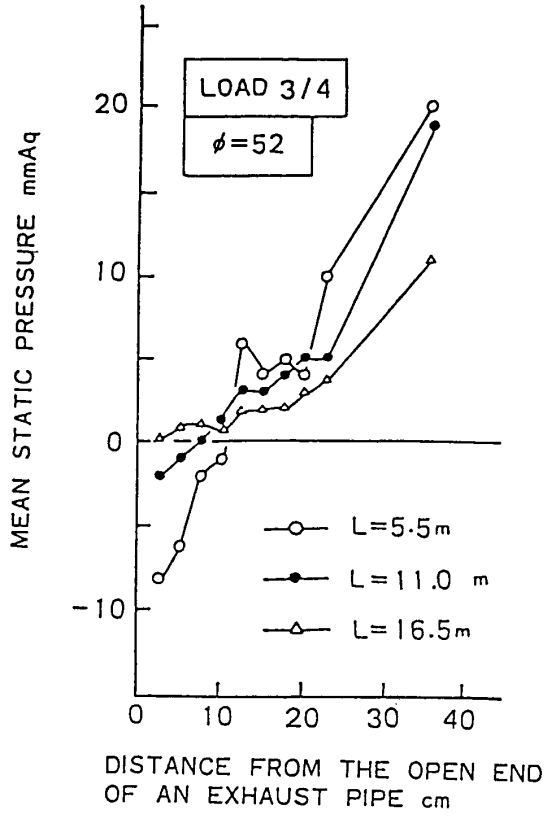

Fig.10. Mean static pressure distributions near the open end in an exhaust pipe.

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