

Optimizing the Cooling Effects of Fins with Slits on an Air-Cooled Cylinder by Increasing Natural Convection

Kohei Nakashima, Takuya Toda,
Soichi Ishihara and Masago Yamamoto
Meijo University

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ABSTRACT

In an air-cooled engine, waste heat dissipates from the cylinder, through the cooling fin, to the cooling air. This cooling air is kept moving by a cooling fan in most utility engines, and by the relative motion in moving motorbikes. However, such cooling becomes less efficient when air is not forced around the cylinder, e.g., in utility engines without cooling fans and in stationary motorbike engines. Here, the temperature may increase in the space between the fins, decreasing the heat release from the cylinder. In an effort to increase natural convection in the cylinder, and so decrease the temperature between the fins, we produced special cooling fins with slits arranged in a fixed equiangular spiral. We tested experimental cylinders, varying the fin slit widths and slit setting positions, and measured the temperature inside the cylinder to determine the heat release from the cylinder. In addition, to analyze the effect of slit fins on cylinder cooling, we also measured the temperature between the fins. Results indicated that slits facilitate cooling: cylinder cooling increased using fins with slits as compared to fins without slits. Furthermore, setting fins with wider slits exhibiting a phase difference to slits immediately above, increased cylinder cooling and decreased cylinder weight.

INTRODUCTION

Almost all small utility and motorbike engines use air-cooling. Air-cooled engines enjoy simpler construction, and so are less expensive and require less maintenance than liquid-cooled engines. However, air-cooling is less effective than liquid-cooling. Engine cooling is especially difficult in utility engines without cooling fans and in stationary motorbike engines. Here, the temperature may increase in the space between fins, reducing cooling. The purpose of this study is the development of an air-cooled cylinder with effective engine cooling utilizing natural convection even when air is not forced around the cylinder. In previous work, we developed a finned cylinder using cooling ports to increase natural convection, and reported its increased cooling effect [1]. In this study, we produce an experimental cylinder having fins with slits in order to more effectively utilize natural

convection. It is commonly believed that slits in fins generate turbulence in the air flow and improve cylinder cooling when air is forced around a cylinder. Indeed, several actual engines with cooling fans have used finned cylinders with slits [2]-[4]. However, there have been no reports on the cooling effects of fins with slits when air is not forced around the cylinder. In this study, using an experimental cylinder with various fin slit widths and slit setting positions in circumference, we measured the heat release from the cylinder and the temperature in the space between the fins, and investigated in detail then the effects of fins with slits on the air-cooling.

EXPERIMENTAL EQUIPMENT AND PROCEDURE

Figure 1 shows our experimental cylinder with six fins and a fin pitch of 10 mm. The fins and cylinder were made of aluminum alloy. The fins were fitted tightly in the cylinder. We compared conventional fins without slits to our experimental fins with slits of widths varying from 6 to 16 mm and an equiangular spiral of 30°, as shown in Figure 1. We compared fins in which all the slits were set in line with the cylinder axis (hereafter called "slit offset 0°") against fins in which the slits were set with a phase difference of 15° to the slits immediately above (hereafter called "slit offset 15°").

Figure 2 shows our experimental equipment. A heater, a stirrer, and a K type thermocouple of 50 µm diameter wire were inserted into the cylinder. Insulator covers were set at the top and bottom of the cylinder. The cylinder was filled with 300 cm³ of heat storage liquid (ethylene glycol) in order to maintain a uniform temperature in the cylinder. To measure the temperature in the space between the fins, we used junctions of K type thermocouple with 100 µm diameter wire, placed between the center fins in all the fins, as shown in Figures 3 and 4.

To measure the heat release from the cylinder, the experimental equipment was set and the cylinder was filled with heat storage liquid. While the stirrer ran, a 300 W electrical heater heated the heat storage liquid to approximately 150 °C. Then the heater was turned off

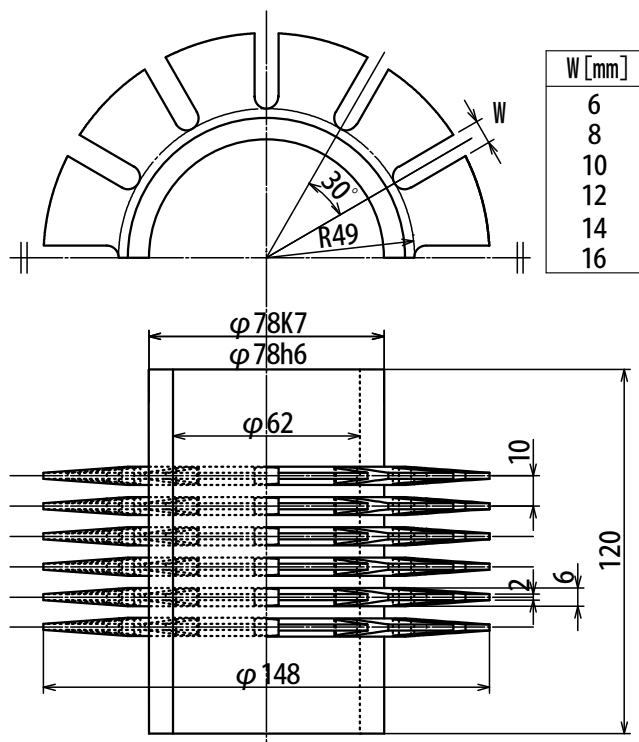


Figure 1 Experimental cylinder

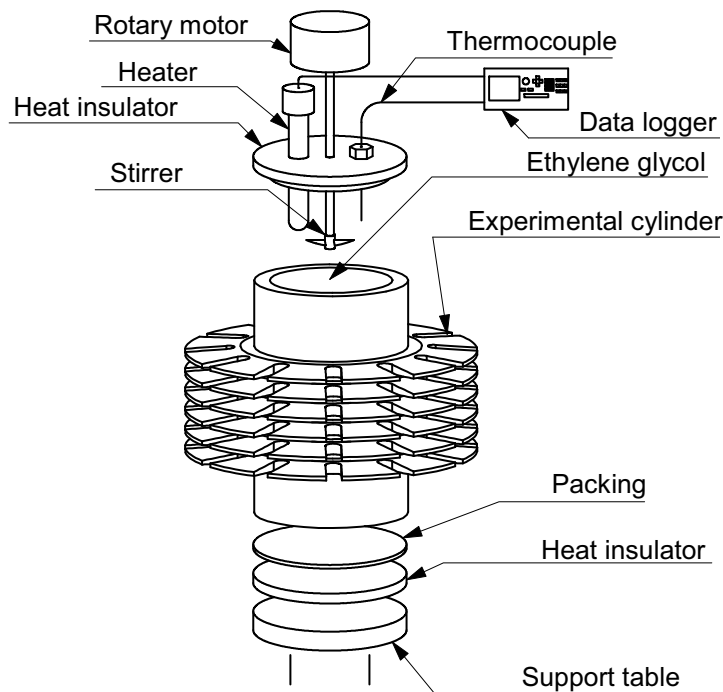


Figure 2 Experimental equipment

and removed, and as quickly as possible a plug was inserted in the insulator cover in place of the heater. Cooling at room temperature decreased the temperature

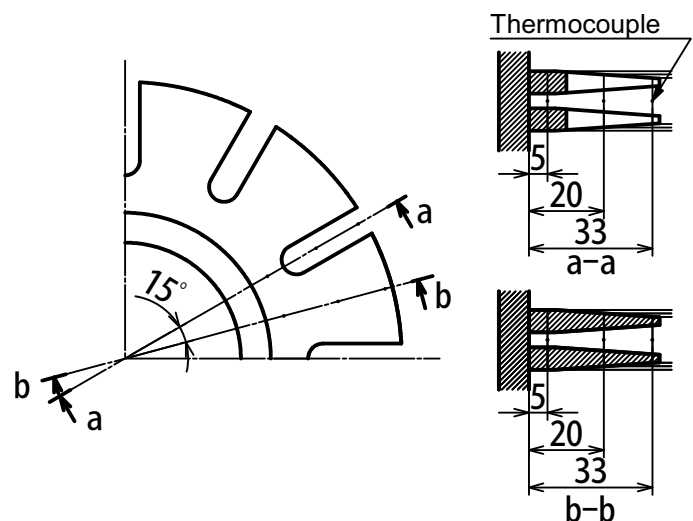


Figure 3 Measurement positions of temperature in space between fins with slits for offset 0°

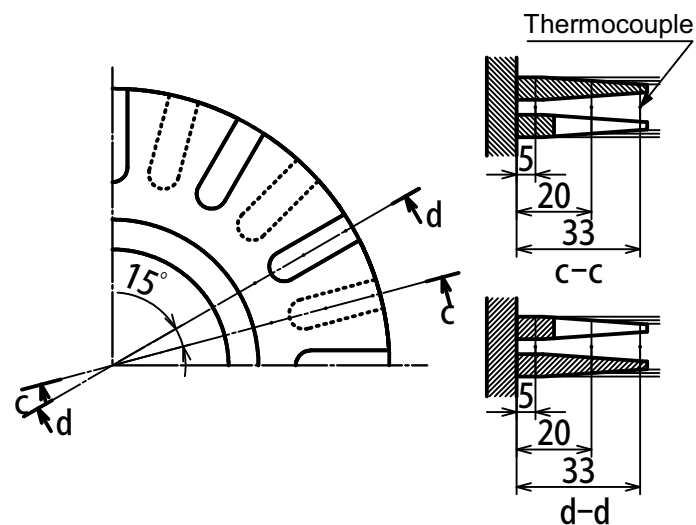


Figure 4 Measurement position of temperature in space between fins with slits for offset 15°

of the heat storage liquid to 120 °C. At 120 °C, we started recording the temperature as it fell to room temperature. The heat release from the cylinder was obtained by multiplying the heat capacity of the heat storage liquid by the difference between 120 °C and the temperature after 10 minutes from the start of recording. Experiments were carried out at an ambient temperature of 24 ± 1 °C. The measured temperature was accurate to within ± 0.4 °C in this experiment. We estimate that the calculated heat release from the cylinder was accurate to within ± 2 %.

To measure the temperature in the space between the fins, a 50 W electrical heater heated the heat storage liquid while the stirrer ran. When the temperature between the fins stabilized, it was recorded. We continued heating while recording the temperature. The following temperature data between the fins was obtained by subtracting the atmospheric temperature from each measured temperature.