Announcing the Final Examination of Mohammed Almaghrabi for the degree of Master of Science

Time & Location: November 2, 2016 at 3:00 PM in Engineering I 288
Title: Forced Convection Cooling of Electric Motors Using Enhanced Surfaces

Electric motors are extensively engaged in industrial and commercial applications such as automobiles, energy-conversion systems, elevators, electronic devices, machine tools, and aircraft carriers. Due to the significant internal heat generation, it is usually a challenge to design and manufacture high efficiency, high reliability, and low cost electric motors with superior performance. One of the efficient ways to dissipate the heat generated in the electrical motor is by using extended surfaces (i.e. heat sinks). These surfaces are extruded from the stator and air is drawn though them by a cooling fan. This cooling approach is simple to be implemented and has zero carbon emission to the environment. Air is allowed to flow in the mini rectangular cross sectional channels in between the ribbed fins. This project is intended to study numerically the effect of varying ribs spacing and ribs heights on heat removal efficiency, accounting for the relative change in heat transfer coefficient and pressure drop compared to those for a smooth flow channel. The study is conducted to simulate the airflow field, and heat transfer for a plate heat sink using ANSYS V.16.

The domain considered in the present work is a simple design of an electric motor annulus. The electric motor annulus consists of an array of ribbed fins. Heat source is represented as a uniform heat flux of 12250 W/m² at the bottom surface of the heat sink base. Through the simulations, the rib height \( e = 0.05, 0.1, 0.2 \text{ in mm} \) and spacing \( p = 1, 2, 3, 4, 5 \text{ in mm} \) between the ribs, the channel width \( W_{ch} = 2, 6, 10 \text{ in mm} \), and the rib configuration (solid and inline ribs) are varied to study their effect on the performance of the heat sink for a Reynolds number range from 3133 to 12532.

To assess which rib configuration is best, a figure of merit (named as thermal-hydraulic performance) is used which is defined as the ratio of heat transfer enhancement to the increase in pumping power due to the presence of the ribs. The highest thermal-hydraulic performance value out of all the transverse cases at \( W_{ch} = 2 \text{ mm} \) in this study was 1.07 at \( e = 0.05, p = 4, \text{ and } Re = 3133 \) which means only a 7% enhancement is obtained. These set of cases are suitable for increasing the rate of heat transfer while ignoring the pressure drop penalty. Different parameters are tested to get a better thermal-hydraulic performance. Changing the channel width to 6 mm increases the thermal-hydraulic performance by about 23%. Therefore this channel width is used for the inline ribs configurations with seven different opening ratios (10% to 70%). The inline ribs are investigated at two different Reynolds number (3133 and 12532). At an opening ratio of 50% the highest thermal-hydraulic performance of 1.18 and 1.22 were found at \( Re = 3133 \) and \( p = 5 \), and at \( Re = 3133 \) and \( p = 1 \), respectively. These simulation results show that with proper channel and ribs configuration, one can achieve about 22 % increase in the thermal-hydraulic performance ratio over that of the smooth channel.

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Committee in Charge:
Louis Chow , Chair, Mechanical & Aerospace Engineering
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Approved for distribution by Louis Chow , Committee Chair, on October 17, 2016.

The public is welcome to attend.