ABSTRACT

Improved thermal performance of brakes can be achieved through the redesign of the ventilated core between the two frictional surfaces of disc brakes. A novel wire-woven bulk diamond (WBD) core has shown to increase the cooling performance. This study measured the thermal performance of a solid, pin-finned and WBD disc over a range of speeds simulating a medium-sized truck descending at a constant speed with a fixed braking power input. The braking power was held constant at 2 kW for 3 speeds of 100 rpm, 150 rpm and 250 rpm corresponding to a vehicle speed of approximately 20 km/h, 30 km/h and 50 km/h respectively. The WBD disc was found to reduce the steady state operating temperatures of the braking surface by 5.8%, 8.6% and 16.2% for the operating speeds of 100 rpm, 150 rpm and 250 rpm respectively over those observed for the pin-finned disc; and 4.4%, 12.5% and 32.9% when compared to the solid disc. Finite difference method temperature prediction models were developed for the solid, pin-finned and WBD discs to extend the experimental results to compare the thermal performance of the discs over a wider range of braking powers and speeds and provide insight into the physical interpretation of the experimental results. The temperature prediction models demonstrate a good correlation to the experimental data within 0.46%-3.65% (1.6-13.1 °C). Faster speeds improve the brake disc cooling; the increased cooling with increased rotational speed is more pronounced for the pin-finned disc compared with the solid disc, and most pronounced for the WBD disc. This is because the contribution of the steady state convective heat transfer to the total heat transfer from the ventilated channels of the pin-finned and WBD increases with speed. The convective cooling from the ventilated channel for pin-finned disc is relatively low at ~11% at 50 rpm but increases to ~45.1% at 600 rpm. Similarly, the WBD starts at 50 rpm with a steady state convective heat transfer from the ventilated channel of ~17.1% and increases to ~60.1% at 600 rpm. It was found that at high braking powers, low speeds and short durations the thermal response was primarily influenced by the thermal capacity of the disc whereas at low braking powers, high speeds and longer durations the thermal response is primarily dictated by the cooling capacity of the brake disc.