Abstract

Overheating brakes cause brake fade, tyre blowouts and vehicle fires, but no study has investigated the influence of wheel configuration or rim material on these catastrophic failures. Experimental, laboratory measurements of the transient thermal response of heavy vehicle wheel assemblies to $1\ kW - 4\ kW$ of alpine friction braking are presented; comparing brake and tyre temperature when using dual and single wheels with steel and aluminium rims. Lumped mass thermal models were developed and used to interpret the mechanisms by which $2.5\ kW$ of continuous braking heat is dissipated throughout the wheel assembly. The steady state temperature increase of the brake was $3.05\ °C$ (1.9%) higher when using steel versus aluminium rims. The increase in average tyre temperature at steady state was $7.35\ °C$ (30%) higher when using aluminium versus steel rims and $15.8\ °C$ (82%) higher when using single versus dual wheels. The greater thermal conductivity and cross-sectional area of the aluminium rims relative to the steel rims reduce the thermal resistance of braking heat flowing into the tyre; leading to higher tyre temperature when using aluminium rims. Dual rims and tyres have larger surface areas than singles which convect more heat to the air at lower temperatures; leading to cooler tyres when using dual wheels. These results indicate that the risk of tyres overheating, leading to blowout, from extended use of the brakes is increased when using single wheels compared to dual wheels and further exacerbated by using aluminium rims compared to steel rims. Model parameters were estimated for a conceptual carbon fibre reinforced polymer (CFRP)-rimmed wheel and the temperature response to $2.5\ kW$ of alpine braking calculated. The simulated brake temperatures on the CFRP-rimmed wheel were $67.7\ °C - 70.1\ °C$ higher than for the steel and aluminium rims. This is a consequence of the comparatively low thermal conductivity of CFRP, which necessitates that the brake dissipate an average of 42% more heat by convection. These results suggest that improved cooling of the brakes is required if CFRP rims are used on a heavy vehicle.