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A carbon fibre wheel for a lightweight production sports car

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ABSTRACT

The wheel of a passenger vehicle must be designed to be safe and light. Despite the potential of carbon fibre as an automotive material due to high strength and low weight, the prevalence of carbon fibre reinforced plastics (CFRPs) in vehicle wheels is limited. This study develops a method to design a CFRP wheel for a high-performance roadster. The designed CFRP wheel used as a case study to illustrate the method is offered by an automotive manufacturer as a high-performance option instead of aluminium wheels. Finite element (FE) simulations were performed on the geometry of the wheel. These helped remove problematic geometric profiles prior to the manufacture of a mould. FE simulations were conducted to reduce the mass of the aluminium hubs required for mounting the CFRP wheel to a vehicle. The CFRP wheel mass is 6.4 kg as compared to the original aluminium wheel which weighs 8.1 kg. This initial design passed the dynamic cornering fatigue test (the most stringent strength test for wheels). Thereafter a prototype wheel was instrumented with strain gauges and a bending moment was applied to the hub using a custom-built test rig. The test rig produced a static load equivalent to the dynamic cornering fatigue test (in which the applied bending moment varies sinusoidally). The test rig allowed for the deflection of the load arm to be measured. The comparison of the experimentally measured strains and an FE model which includes the CFRP laminate properties showed good agreement. This study shows that an aluminium wheel for a high-performance roadster can be redesigned using CFRP to be 21 % lighter. A bending stiffness test was conducted on another similar CFRP wheel at elevated temperatures. An 18 % reduction in bending stiffness was calculated when the wheel was heated to 140 °C, this reduction reduced to 13 % once the wheel cooled to ambient temperature. Further study of the effect of temperature on CFRP wheels is required. This study has illustrated a successful method to design CFRP wheels for passenger vehicles to affect a reduction in mass.