1 Wheel arch CFD analysis

The flow fields in and around the wheel arches were modelled using Flite 3D, a steady state compressible solver capable of modelling supersonic flow conditions (1). The front wheel arch was investigated at two speeds, Mach 1.0 and Mach 1.3 (Figure 1), approximately equivalent to 340 $m \cdot s^{-1}$ and 440 $m \cdot s^{-1}$ respectively. To reduce computational expense in the CFD modelling of the rotating wheel, a fixed tetrahedral mesh was utilised with no slip boundary conditions applied on solid surfaces corresponding to their relative motions in the moving car reference frame (1). The model assumed no particle entrainment, i.e. a solid ground and air free of particles. The front of the wheel arch only experienced accelerated flow near the forward lip of the arch, which was most likely due to suction from the faster flow outside of the wheel arch. The flow in the rear half of the wheel arch was predicted to be significantly faster at Mach 1.3 than at Mach 1.0, which was caused by a reversal in the flow regime near the rear arch lip, shown by the velocity vectors in Figure 2. The flow velocity in the rear half of the arch at Mach 1.3 ranged from approximately 100 $m \cdot s^{-1}$ to 200 $m \cdot s^{-1}$. Any particles entrained in the flow would strike the wheel arch at a relatively low impingement angle, indicating a harder material would be more suitable in this region (2). The stagnation point highlighted in Figure 1 and shown in more detail in Figure 2 indicated a tough, rather than hard, material would be best suited at this point, to avoid the intersection of Hertzian cones typical of brittle materials at high impingement angles (2, 3).

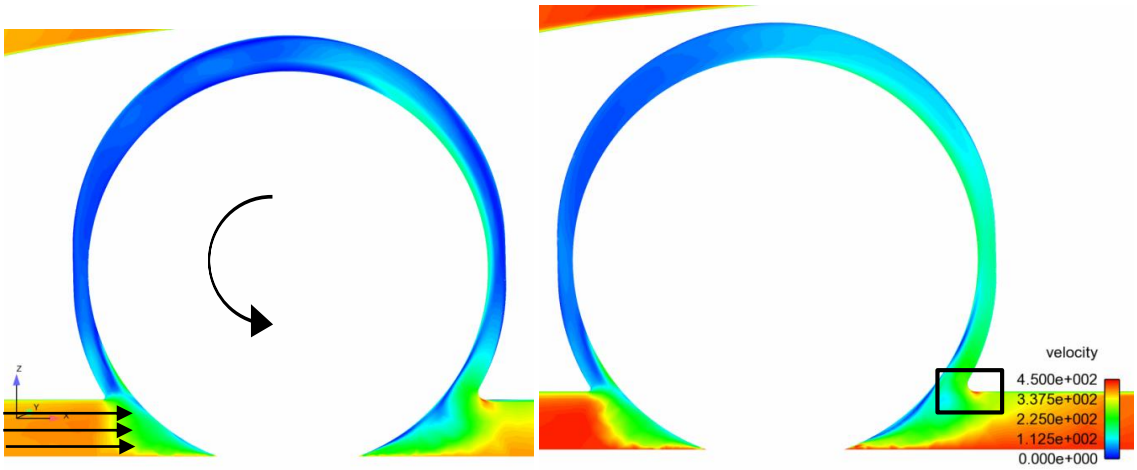

Figure 1: Velocity ($m \cdot s^{-1}$) contour plots on the centreline of a front wheel. Mach 1.0 (left) and Mach 1.3 (right). Wheel rotation and upstream velocity vectors are represented using arrows. The region highlighted by a black box is shown in more detail in Figure 2.

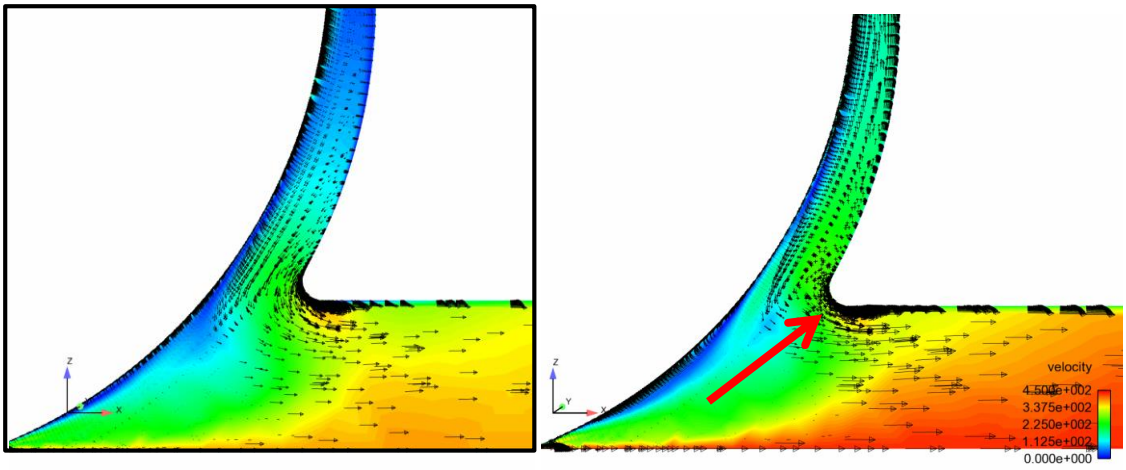

Figure 2: Velocity ($m \cdot s^{-1}$) vectors, wheel centreline. Mach 1.0 (Left) and Mach 1.3 (Right). The 90 deg impact angle at the stagnation point is indicated by the red arrow.

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2. Hutchings IM. Tribology: Friction and Wear of Engineering Materials. UK: Edward Arnold; 1992.
3. Fischer-Cripps AC. Hertzian Fracture. Introduction to Contact Mechanics. 2nd ed2007. p. 115-36.