World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:14, No:12, 2020

Thermal Characterisation of Multi-Coated Lightweight Brake Rotors for Passenger Cars

Authors : Ankit Khurana

Abstract : The sufficient heat storage capacity or ability to dissipate heat is the most decisive parameter to have an effective and efficient functioning of Friction-based Brake Disc systems. The primary aim of the research was to analyse the effect of multiple coatings on lightweight disk rotors surface which not only alleviates the mass of vehicle & also, augments heat transfer. This research is projected to aid the automobile fraternity with an enunciated view over the thermal aspects in a braking system. The results of the project indicate that with the advent of modern coating technologies a brake system's thermal curtailments can be removed and together with forced convection, heat transfer processes can see a drastic improvement leading to increased lifetime of the brake rotor. Other advantages of modifying the surface of a lightweight rotor substrate will be to reduce the overall weight of the vehicle, decrease the risk of thermal brake failure (brake fade and fluid vaporization), longer component life, as well as lower noise and vibration characteristics. A mathematical model was constructed in MATLAB which encompassing the various thermal characteristics of the proposed coatings and substrate materials required to approximate the heat flux values in a free and forced convection environment; resembling to a real-time braking phenomenon which could easily be modelled into a full cum scaled version of the alloy brake rotor part in ABAQUS. The finite element of a brake rotor was modelled in a constrained environment such that the nodal temperature between the contact surfaces of the coatings and substrate (Wrought Aluminum alloy) resemble an amalgamated solid brake rotor element. The initial results obtained were for a Plasma Electrolytic Oxidized (PEO) substrate wherein the Aluminum alloy gets a hard ceramic oxide layer grown on its transitional phase. The rotor was modelled and then evaluated in real-time for a constant 'g' braking event (based upon the mathematical heat flux input and convective surroundings), which reflected the necessity to deposit a conducting coat (sacrificial) above the PEO layer in order to inhibit thermal degradation of the barrier coating prematurely. Taguchi study was then used to bring out certain critical factors which may influence the maximum operating temperature of a multi-coated brake disc by simulating brake tests: a) an Alpine descent lasting 50 seconds; b) an Autobahn stop lasting 3.53 seconds; c) a Six–high speed repeated stop in accordance to FMVSS 135 lasting 46.25 seconds. Thermal Barrier coating thickness and Vane heat transfer coefficient were the two most influential factors and owing to their design and manufacturing constraints a final optimized model was obtained which survived the 6-high speed stop test as per the FMVSS -135 specifications. The simulation data highlighted the merits for preferring Wrought Aluminum alloy 7068 over Grey Cast Iron and Aluminum Metal Matrix Composite in coherence with the multiple coating depositions.

Keywords : lightweight brakes, surface modification, simulated braking, PEO, aluminum
Conference Title : ICSRD 2020 : International Conference on Scientific Research and Development
Conference Location : Chicago, United States
Conference Dates : December 12-13, 2020