Light-Weight Brake Rotors

Braking Components

From their first patenting, brake rotors have invariably featured the use of gray iron. Gray cast iron, with a well dispersed matrix of lamellar graphite proves indispensable for use in friction braking applications. The thermal characteristics of iron allow for adequate dissipation of heat energy from friction. Cast iron is an ideal material with good fatigue resistance at elevated working temperatures, just the conditions present in braking.

Environmental Concerns

The automotive industry is under increasing pressure to continue reducing vehicle fleet emissions and achieve CO_2 compliance. In 2016 the European Union committed to the Paris agreement COP21. Similar legislative coverage is present in SAFE vehicle rules in the US and the China 6A standards.

Reporting of CO_2 emissions according to the new WLTP procedure will bring with it greater focus. The Worldwide Harmonized Light Vehicles Test Procedure offers a more accurate test and the industry consensus is that a greater CO_2 measurement will result. These factors not only necessitate the portfolio shift to Electric Vehicles (EVs) for OEMs but also component light-weighting.

A new emissions target of 95 g CO_2/km was set by the EU from 2020. If a car manufacturer exceeds the yearly emissions target, they must pay € 95 per excess gram of CO_2 for every newly registered passenger car in that current year. To avoid penalty payments in the future it is vital for OEMs sufficiently invigorate portfolio development to this end.

Light-Weight Brake Rotors

With a focus on reduction of the use-phase environmental impacts, brake rotors are now frequently designed as two-piece assemblies. Light-weight rotors are typically constructed of aluminium and iron with a variety of connection methods. Reduction of component and sub-assembly mass can be achieved via a number of design methodologies.

Advantages of Light-Weighting

Rotor mass reductions decrease fuel consumption and exhaust emissions by virtue of a lighter vehicle to accelerate and move. For EVs, a range extension is given, along with additional design space for advanced electronic support and safety systems.

Disadvantages

Performance challenges exist for manufacturing brake rotor assemblies, given the power of braking. The design for manufacture must include attainability of mounting tolerances which is critical to NVH behaviour. Light-weight components are often more complex in design and substantial in cost.

Such multi-material assemblies do also offer marginal difficulties with segregation at end-of-life recycling. Lower use-phase carbon intensity comes with increased carbon intensity at the manufacturing stage. Detailed Life Cycle Analysis (LCA) modelling can be used to assess environmental contributions at each stage.

Which Materials?

Appropriate material selection is critical for component performance. Lightweight materials and methods must provide sufficient strength to the brake assembly for torque loading and appropriate thermal transfer characteristics.

Riveted aluminium hub assemblies were previously championed by BMW. Aluminium has low density, high specific heat, high thermal conductivity and is corrosion resistant through the formation of a dense oxide layer. The principal benefit of using an aluminium hub is the weight saving. The savings typically will be around 15 %. MFG plans Start of Production (SOP) at the end of Q3 2021 for a range of 23 aftermarket brake rotors with riveted aluminium hub construction.

Brembo in collaboration with Daimler, developed light-weight sheet steel brake rotor assemblies offering a 15 % mass reduction. Specialised manufacturing processes form the 2.5 mm steel sheet into hubs for assembly with the rotor. These market disrupting components, for which EURAC Group is currently qualifying an aftermarket equivalent design, are proliferating across EU markets.

Future Shifts

Now is a time of rapid change and system re-development, an area MFG sees as the core of it's long term strategy. From vehicle electrification to optimisation and improved reliability of systems, one thing that is increasing is component and brake system complexity. Modern advancements in manufacturing such as innovative materials, polymers, bio-composites and additive manufacturing techniques could all offer a competitive edge in such an area. Moving away from conventional manufacturing technologies to more advanced and novel strategies may alter price mechanics for OE, OES and AM components.

A convergence of market forces, from disruptive technologies and environmental pressures, MFG intends on staying ahead of the curve. Readiness and agility to adapt to new technologies and regulatory requirements are at the heart of MFG's long term vision for success. This is an interesting and exciting time for braking and the automotive industry more generally.

Co-Casting of Aluminium Hubs

EURAC is collaborating with DISA and the Technical University of Denmark to assess the viability of a unique co-casting method. This method allows for the casting of aluminium hubs around part-machined iron rotors and can be achieved using an automatic greensand moulding system. Phase 1 of the experiment was conducted March 2021. Aside from

appreciable cost incentives and process flexibility, this opens up competency into other rotor and component designs. If this methodology proves to be technically viable, then the process can be probed for cost suitability with potential EU and global customers.

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