Fabrication, evaluation and design of high performance C-fiber reinforced ceramic friction materials

The University of Bayreuth employs a very special test bench for C-fiber reinforced ceramic materials: On a nationwide unique dynamometer, large brake discs with a diameter up to 1 m can be studied at speeds up to 2500 rpm in combination with different counterparts, e.g. conventional or ceramic brake pads. Since the completion of this test rig several research projects were successfully realized.

C-fiber reinforced SiC (C/SiC) ceramics derives from aerospace applications, like heat protection systems. In the 1990s, researchers from the German Aerospace Center thought about new approaches regarding to this light weight (~ 2 g/cm³), damage tolerant and hard material. They studied the wear behavior in order to develop a new friction material, which is suitable for brake discs in passenger cars. Finally, they succeeded and today, more than 150,000 brakes are manufactured by the industry.

Ever more demanding

Due to the challenges of the current century, the demand of lightweight and high temperature stable materials rises steadily. In order, to fulfill these requirements in terms of ceramic friction materials, in 2009, a tribological test rig was designed at the University of Bayreuth. On this nationwide unique dynamometer, large brake discs with a diameter up to 1 m can be studied at speeds up to 2500 rpm in combination with different counterparts, e.g. conventional or ceramic brake pads.

In order to improve the dynamometer, fly wheels were added in the end of 2015 (Fig. 1). Now, inertia moments of about 150 kgm² are possible and the maximum braking force was increased to 50 kN per pad.

Fig. 1: Self designed dynamometer for high performance friction studies (with a steel fly wheel and a 1 m ø steel brake disc)

Stop brakes can be realized to simulate a braking event, e.g. from v_{max} = 150 km/h to 0 km/h with an inertia mass of a 1000 kg car.

Furthermore, tests at constant speeds are possible as well.

Findings proof success

During the last years, many experiences for emergency and services brakes were obtained, with C/SiC, organic and metallic materials. C/SiC ceramics show low wear and suitable coefficient of friction, even for high loads above 50 MPa and could act as a small, high loaded material for holding and emergency brakes in the future, e.g. for e-cars (Fig. 2).

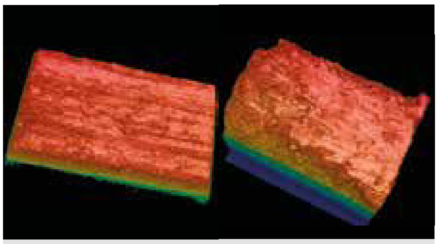

Fig. 2: Surface topography of wear resistant C/SiC material after a stop brake from 20 m/s with 50 MPa braking pressure (left); state of the art material at the same conditions fails (right)

Finally, by applying CAD, braking materials can be transferred into models of the desired friction components for the industry. Calculations of the expected loads and tensions were already used to optimize the design of friction pads for brakes (Fig. 3).

Therefore, the University of Bayreuth can offer suitable material research and development, tribological investigations close to the desired application and the design of the new components for the end-users.

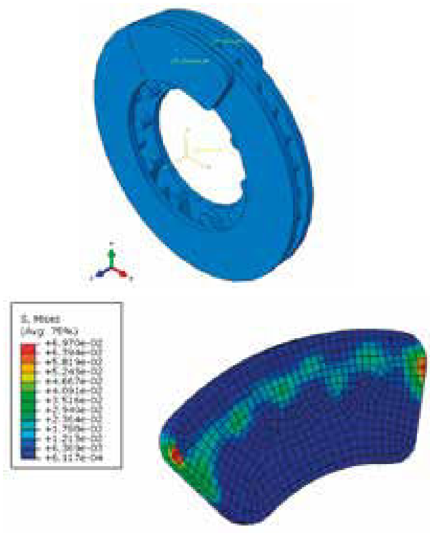

Fig. 3: FE-model of a brake disc (ø 380 mm) and brake pad calculated by FEM-software z88® (above); shear stresses after braking in a ceramic brake pad (~ 150x80x10 mm³) (below)

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