ABSTRACT

Background of this work was the fact, that existing wear models are not applicable to all common tribological systems. For that purpose, based on the Finite Element Method, a tool should be created, independent of tribological systems, which is able to interpret the basic wear mechanisms of two rubbing bodies.

To model the sliding wear by the aid of the Finite Element Method (FEM), a detailed investigation of the existing wear mechanisms and the material properties to characterise the contact conditions between fiber reinforced polymers-steel-sliding pairs, had to be performed. The friction and wear properties of such a tribological system were evaluated by wear tests based on the pin-on-disc principle at temperatures varying from room temperature up to 180°C. A mechanical characterisation of the materials was done by tensile, compression and shear tests. Furthermore, the worn surfaces of the specimens were investigated by several microscopic methods. The main result of these investigations is focussed on the strong dependence of the amount of wear and the wear mechanisms on the fiber orientation and the testing temperature.

To calculate the stress state in the contact zone, a three dimensional anisotropic contact algorithm was developed. To revise this contact algorithm, ball indentation tests on unidirectional carbon fiber reinforced PEEK composites have been carried out. There was a very good correlation between the experimental and the modelled results.

In the further lapse of this work, this algorithm was pulled up to model real contact states. A micromechanical characterisation of the materials as well as the evaluation of the wear mechanisms occurring under contact of a single roughness asperity were performed by micro-hardness and scratch tests. The results of the stress analysis confirm the experimentally detected failure and wear mechanisms under single roughness asperity loading respectively. Under normal fiber orientation overloading in the fibers and the fiber/matrix interface occured, which leads to fiber cracking and fiber/matrix debonding. Under parallel and antiparallel fiber orientation, the fibers were mainly subjected to bending. Furthermore, shear stresses at the fiber/matrix interface can result in fiber/matrix debonding.

The results of the thermal model of the CF/PEEK-steel sliding pair could show, that in the contact zone the temperature exceeds the melting temperature of the matrix. Additionally the heat flow was strongly influenced by the fiber orientation. The definition of Peclet numbers for anisotropic composite materials could show, that, dependent on the fiber orientation, slow and fast sliding systems had to be distinguished.

The present work could show, that the Finite Element Method is an appropriate tool to charaterise sliding wear mechanisms by evaluating existing stress states in the contact zone of two rubbing bodies. One last task is the determination of a characteristic parameter to estimate the amount of wear as a function of the stress states in the micro-range.