US-Czech Mutual Ph.D. Program in Friction Materials

Z. Weiss, V. Roubíček
VSB–Technical University of Ostrava, Czech Republic
and
P. Filip, K. Lafdi, M. A. Wright
Center for Advanced Friction Studies, Southern Illinois University, Carbondale, IL, U.S.A.

The mutual program for Ph.D. students was established in 1999 as a basis for research collaboration between the Center for Advanced Friction Studies of Southern Illinois University at Carbondale and the Central Analytical Laboratory of the Technical University of Ostrava, Czech Republic. Two projects were approved and realized, the first project starting in 1999 and the second three-year project in 2001. The program has been funded by two main agencies: the National Science Foundation (NSF) for the U.S. side and the Czech Academy of Sciences (ASCR) for the Czech side. The primary object of the program is to improve the training conditions of Ph.D. students by enabling them to use research facilities and labs at both institutions. The research and corresponding Ph.D. program is divided into two areas. The first area covers the polymer matrix composite friction materials and the second activity is devoted to the carbon-carbon friction composites research. Research work is concentrated on the understanding of friction process fundamentals, the analyzing of real chemical and physical processes on the friction surface, and the tailored design of advanced friction materials.

The mutual research program has brought several positive results. One Ph.D. student has found out the following relation between the vermiculite structure state and the temperature of the friction surface for composites containing vermiculite: (1) Pure vermiculite and vermiculite in phenolic resin bonded composite materials is sensitive to heating history. Basal interplanar spacing $d_{(001)}$ varies as a function of applied annealing temperature. This relation can be used for the estimation of temperature in the vicinity of the friction surface. (2) Pure vermiculite rehydrates if the heating temperature does not exceed 700°C. If embedded in a phenolic resin matrix, the rehydration ability of vermiculite is limited and depends on the vermiculite/resin content ratio. (3) The maximum detected temperature on the friction surface of investigated samples was 900°C.

Another Ph.D. student has developed software for modeling XRD patterns of graphite polytypes with various content of stacking faults and for the estimation of crystallite sizes in carbon materials. Both the effect of crystallinity and degree of structure ordering of carbon matrix are very important parameters from the point of view of friction performance (the coefficient of friction and wear) of carbon-carbon composite materials. A progressive change in the carbon crystallinity could be controlled by a slow increase of heat treatment temperature in which the preferred molecular orientation or stacking order of the basic graphene package would change from the two dimensional (turbostratic carbons) to the three-dimensional order (graphitic carbons). This sudden change usually occurs at higher temperatures (> 2400 °C). This structural transition leads to a significant increase in terms of thermal and mechanical properties of carbon materials.