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Section 1: Computer simulation

Simulation of deformation and destruction of brittle porous materials of composite composition under dynamic mechanical and thermal influences

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A part of refractory materials applied, for instance, for manufacturing the lining of metallurgic heat generating units or casting moulds, in terms of their structure are composite ones and characterized by multilevel pore structure (contain pores which typical sizes may vary within several orders of magnitude). Due to the special features of manufacturing technique for products made of these materials (including the process violation or operation conditions), their pore space may contain some amount of liquid. Under the high mechanical and thermal influence upon these materials, for example, upon their contact with molten metal, the significant thermal stresses and strains are formed inside them. The pore liquid, being heated up to the high temperatures within the short time intervals, will significantly increase the pore pressure and therefore may substantially contribute to the change of the local stressed strained state of material. With the small amount of liquid in refractory material, it provokes forming the damages that, however, do not result in the crucial destructions and violations in the product's performance. However, in case of a water saturated material, the influence of pore liquid can be comparable to the proper thermal stresses in matrix and can initiate the microscopic brittle crushing of material leading to the failures in the product's performance, accidents and losses. Thus, the investigation of mechanical behavior and destruction of the porous water bearing heat resistant and refractory materials under the strong thermomechanical influence is an important scientific challenge, which has a great practical importance. Carrying out the experimental researches aimed to obtaining the assessment of the pore liquid contribution to the stressed strained state of porous matrix and to the condition of destruction is a rather difficult task. Therefore, in this proceeding, this task is being settled with the use of computer modeling by the discrete element method.

In order to solve the task on the base of developed by the authors method of the homogeneously strained permeable discrete elements, the double-level bound thermomechanical model of the porous composite material is developed. This model considers: a) mechanical interaction of the pore liquid and the solid-phase matrix, as well as redistribution of liquid within the pore space of material; b) thermal expansion of the matrix and the pore fluid, as well as the conductive transfer of heat by the filtered liquid within the matrix.

With the use of the constructed discrete elemental model, the preliminary calculations are carried out, which allowed revealing the influence of pore liquid on the strength and fracturing behavior of refractory materials under the strong dynamic and thermal influence. In particular, a possibility of creating the generalized curves for dynamic value of refractory strength (including the case when the liquid is present in the pore space) under mechanical and thermomechanical stress from non-dimensional parameter analogous to Darcy number is discussed.