INFLUENCE OF POROSITY ON THE VISCOUS FRICTION OF A GRANULAR MEDIUM

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There are now few research and industrial spheres of activity in which problems related to the mechanics of granular bodies has not appeared in one form or another. In the field of mining, typical examples of this class of materials include shattered rock, coal, ore, soils, as well as products that are obtained in the processing of commercial minerals. Granular (noncohesive) material is processed in large volumes using different types of equipment and by means of different technologies that require knowledge of the deformation properties of these types of materials. Problems related to the behavior of granular material that are affected by vibrations are extremely important in the mining industry.

Granular materials are characterized by two basic properties: porosity and viscous friction. Porosity, a typical feature of all granular material, is determined by the volume of pores as a percentage of the overall volume of the material. Since granular media are dilational, their porosity is not constant and instead depends on the relative position of the particles. Viscous friction is determined by the dry friction between the particles.

The appearance of frictional forces in the relative displacement of particles is the result of mutual engagement of particles and their subsequent slippage along contact surfaces. Unlike solids, conditions on the contact surfaces of granular media remain constant, inasmuch as it is always possible for the particles to move relative to each other. Whereas the friction coefficient of a pair of solid bodies is a constant, in the case of granular medium it will be expressed in the form of a more complex relation the nature of which depends on the state of the material.

Two basic methods are usually used in the experimental determination of the viscous friction coefficient, either on the basis of the angle of repose [1] or on the basis of the strains observed in a shearing test of the material [2], i.e., a shift relative to a fixed plane. Curves representing the values of the friction coefficient that are obtained in a shearing test are presented in the form of dependences of these values on the displacements of one part of a granular sample relative to the other.

The test results indicate that the viscous friction coefficient is not a constant quantity, but instead depends on the state of the material. That is, where the material is initially closely packed, there is a pronounced ascending segment of the curve followed by a descent after which it levels off to a constant value; in a case of friable packing the curve will contain only an ascending segment besides leveling off to a constant value. The test results demonstrate that each initial state of a granular material has associated with it its own curve expressing the dependence of the friction coefficient on displacement.

In such a load scheme, the process of monitoring the density (porosity) of the material in the zone of shearing involves technical difficulties, though it is a sufficiently simple step to measure the total ascent of one part of a sample relative to another part (due to dilatation). The difficulty of determining the porosity of the material in a zone of shearing is that both the thickness of the deformed zone of shearing as well as the distribution of the extension strain within the zone are not known.

In [3] a loading device was used in the experimental study of transient structures in a granular medium. The device made it possible to generate large shearing strains throughout the volume of a material.

A loading device proved to be also appropriate in the present work for the experimental study of the influence of porosity on the viscous friction of a granular medium. In this device the porosity of the material could be maintained constant while the material was subjected to continuous deformation. Through simple readjustment the material could be brought to a...
state with different porosity. The new porosity remained constant in each experiment no matter how long the deformation was maintained.

Figure 1a, b shows the functional diagram and a corresponding loading device. Granular material is poured into the flexible cylindrical shell 1 the bottom of which is covered with a rubber sheet that is uniformly stretched and attached to the shell. The loading device is in the form of a set of detachable templates 2 with elliptical pores into which the shell is inserted. Following installation, the chamber is in the form of a right elliptical cylinder with semiaxes $a > b$. Loading is performed by rotating the templates about the fixed chamber. The chamber is maintained in this state by means of flexible tie rods 3 the ends of which are fastened to the upper part of the chamber and to the fixed posts 4.