Results of an experimental study are presented pertaining to the dependence of the permeability of porous materials on their moisture content during moisturization and desiccation.

Development of a new technology has recently stimulated interest in studies pertaining to filtration of gases through moist porous systems. Interesting is that pulverulent micro-particles of the filtered gas are more effectively precipitated in and retained by moist than by dry porous materials. This applies above all to porous filters protecting the environment against contamination by aggressive substances, also to technological processes involving impregnation of porous materials with various fluids and their desiccation by scavenging with warm air. Filtration of gases through porous materials and the permeability of such materials have been studied by many authors. These studies included, e.g., the dependence of the permeability of porous bodies on the hydrodynamic characteristics of the gas flow through the pores [1, 2]. The study of filtration through moist porous materials has only begun [3]. As far as these authors know, the dependence of the permeability of porous materials on their moisture content has not yet been analyzed.

For a study of this dependence there was assembled the experimental apparatus shown in Fig. 1. The cover plate 1 pressed a porous plate 2 tightly against the beaker 3. The rim of the porous plate was coated with an adhesive, to ensure hermetic sealing. Air was fed from a tank 9 through valve 8, manometer 7, and rotameter 4 to one of the beakers fitting under the porous plate. The air was then drained through the porous plate into the atmosphere. The excess pressure under the porous plate was measured with both a water manometer 6 and a reference manometer 5. The rotameter had been precalibrated against the mass flow rate of air. Atmospheric pressure was measured with a barometer. The apparatus was periodically checked for hermeticity.
Experiments were performed with porous plates made of fireclay ceramic, titanium, and nickel, all having approximately the same effective porosity. The titanium plates and the nickel plates (average pore size 5-7 μm) were impregnated with water distillate under a pressure head in a separate apparatus. The ceramic plate (average pore size 2-3 μm) was impregnated with liquid by action of its own capillary potential. The moisture content in the plates was measured by the weighing method with a model ADV-200M analytical balance. The flow characteristics were plotted first during gradual moisturization of a plate and then during its desiccation at room temperature. A definite mass flow rate of air was established by means of rotameter 4 and valve 8 (Fig. 1). At any particular flow rate were then measured the pressure drops and the corresponding moisture contents during moisturization and during desiccation of a plate. Several series of tests, at various mass flow rates of air, were performed with each porous plate. At each selected air flow rate, accordingly, a plate was moisturized to a maximum level \( U^* \), the same in each case, at which the air stream flowing at the selected maximum rate would begin to eject particles of the liquid from pores. Moisturization to this level \( U^* \) was followed by desiccation of a plate. A true moisture content higher than \( U^* \) cannot be determined accurately at the selected maximum air flow rate. Thus ejection of liquid particles from pores by the air stream limits the hydraulic characteristics of a moist porous plate either with regard to moisture content (at selected air flow rates) or with regard to flow rate (at selected moisture content levels).

The results of experiments with the ceramic porous plate are shown in Fig. 2. According to the graph, the hydraulic characteristics of such a moist porous plate feature a rather appreciable hysteresis between moisturization and desiccation. The hydraulic characteristics of moist porous titanium and nickel plates follow an analogous trend. At a certain mass flow rate of air the pressure drop under the plate with a certain moisture content is larger when this moisture level has been reached during moisturization than when it has been reached during desiccation. In these authors' view, this hysteresis is due to a redistribution of moisture between pores of different sizes in the plate. As is well known, the capillary potential depends on the pore size.

During impregnation of a porous plate with liquid by a pressure head the liquid fills first the macropores, inasmuch as here the capillary potential is lower than in micropores. During impregnation there is not sufficient time to fill the micropores with liquid, inasmuch as moisturization by a pressure head is a rather fast process. Since during filtration of a porous plate most of the air flows through macropores, the permeability of such a plate will sharply decrease during moisturization by a pressure head. During moisturization such a plate becomes, in a way, sealed by the liquid. During desiccation, on the other hand, the liquid from the macropores gradually enters the micropores, where the capillary potential is higher. The amount of moisture in macropores decreases, which immediately affects the pressure drop under the plate while the mass flow rate of air remains unchanged. The permeability of the plate increases. With time, therefore, there occurs a redistribution of moisture between pores, a redistribution which in real porous materials proceeds slower than their impregnation with liquid under a pressure head.

The hysteresis in the hydraulic characteristics of a porous body impregnated with liquid by its own capillary head is due to a lag, in terms of variation of the wetting angle at the surface, between outflow and inflow of liquid, or which is equivalent, between desiccation and moisturization. The wetting angle is known to be smaller during desiccation than during

![Fig. 1. Schematic diagram of the experimental apparatus.](image-url)