RELATIVE PERMEABILITY MEASUREMENTS FOR TWO PHASE FLOW IN UNCONSOLIDATED SANDS

by
S. Abaci and J. S. Edwards, Department of Mining Engineering, Nottingham University. University Park, Nottingham NG7 2RD
and
B. N. Whittaker, Department of Mining & Mineral Engineering, Leeds University. Leeds

ABSTRACT

This paper presents the results of laboratory measurements of relative permeability for two phase flow in partially saturated samples of unconsolidated sands. Relative permeabilities for tap water and air, de-aired water and nitrogen were measured using a steady - state technique. Three different sand samples (fine sand, heterogeneous sand and coarse sand) were tested.

1. INTRODUCTION

Much research has been carried out in order to solve problems dealing with the movement or migration of fluids through porous, permeable media. Many researchers have studied the nature of fluid flow and its relationship to their own problems.

Fluid flow through porous, permeable material is a complex transport process. The flow of incompressible single phase fluids through permeable media is governed by Darcy's law which is valid for laminar flow of fluids. A measure of the capacity of a permeable material to transmit fluids is given by a transport coefficient - the permeability of the medium. In Darcy's equation for single phase flow this transport coefficient is called the specific permeability. However, if the permeable medium
contains more than one fluid, an effective permeability to each fluid phase must be defined, where the effective permeability of a permeable medium is a measure of the ability of the material to conduct one fluid phase of a multiphase fluid system. In the case of a multiphase fluid system existing in the medium, the ability of each fluid to flow is reduced by the presence of the other fluids in the system. The effective permeability for all fluid phases is less than the specific permeability for single phase flow.

Another important property governing multiphase flow through porous media is the relative permeability which is defined as the ratio of the effective permeability of the porous medium to the specific (absolute) permeability of the material. The relative permeability is a function of the system of the two or more fluids and the porous material and is used to describe quantitatively the simultaneous flow of multifluid phases through a porous medium. The relative permeability is dependent upon the fluid saturation levels, because part of the pore space in the porous medium is occupied by one fluid of the multiphase fluid system, so that flow of another fluid is impeded and reduced.

A number of measurement techniques for the determination of relative permeability of porous media have been developed and are described in the literature. Generally, two kinds of laboratory measurement techniques are used to determine relative permeability:

a) Steady state methods; a fixed ratio of two phases is driven simultaneously at constant rate and pressure through the medium until saturation and differential pressure along the sample become constant.

b) Unsteady - state methods; the quickest laboratory methods in which a gas phase only is injected into the sample, and saturation equilibrium is not attained. This technique involves displacing in-situ fluids by injection of the gas phase.

The steady state method has been used to determine the relative permeability of unconsolidated materials to gas and water in this research. Different grain sizes of sands were chosen as a porous medium and the relative permeability determined. Air and nitrogen were used as gas phases, water and de-aired water for liquid phases.