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NOTES AND NEWS

Report on
Chemical Engineering in Medicine and Biology Symposium

THE 33rd Annual Chemical Engineering Symposium of the American Chemical Society was held at the University of Cincinnati, October 20–21, 1966. With the aim of demonstrating the extent of chemical engineering involvement in the life sciences, twenty-one papers were presented in areas such as blood flow and oxygenation, evaluation of mass transfer coefficients for glucose in the eye, artificial kidney analysis, artificial membrane production, bacteria separation by ion exchange resins, mathematical modeling of drug distribution and carbon dioxide respiration, analysis of water in frozen tissues, electrophoresis and finally the study of life support systems in space capsules.

The morning session on October 20 was devoted to hemorheology and hemoxygenation studies. Drs. Tien, Rahn, and Cerny of Syracuse University presented their work on "Determination of the Flow Properties of Blood under Continuous and Oscillatory Motion". The shear stress–shear rate behavior of human blood was determined using a Weissenberg Rheogoniometer. Measurements were made over the range of shear rates from $3{\cdot}2 \times 10^{-3}$ sec^{-1} to $2{\cdot}6 \times 10^{3}$ sec^{-1}. The hematocrit of the samples ranged between 40 and 50 per cent. The blood exhibited Newtonian behavior above 10^{3} sec^{-1}. Below this shear rate the behavior was markedly non-Newtonian. The possibility that blood has an infinite viscosity at zero shear rate was proposed and supported by the data at extremely low shear rates. The log–log plots of viscosity vs. shear rate seemed to tend towards a constant slope at low shear rates, indicating a power-law model may apply for blood in this state, where the effect of the formation of reversible aggregates of red cells becomes important. This is borne out by a similar plot for blood with a hematocrit of 63 per cent, where such a constant slope line is even more evident. Linear plots of shear stress–shear rate at low values of shear rate indicate a yield stress does exist, but the possibility of such a curve convexing rapidly to the origin at even lower shear rates cannot be eliminated.

Another biorheology paper in the morning session was "Dynamics of Arterial Blood Flow (Digital Computer Simulation)" by Drs. Fairchild (Monsanto), Krovetz (University of Florida) and Huckaba (Drexel).

Three dynamic mathematical models of arterial blood flow were investigated. Two of these models were shown to predict satisfactorily, but separately, the effects of fluid viscosity and wall elasticity. A third model which combines and extends the other two was formulated.

The first model, called the Transient Poiseuille Model, was based on the assumptions of Newtonian flow in a rigid, cylindrical tube. The second, designated Lambert's Model, described the flow of an ideal fluid in an elastic tube. Basic partial differential equations for these two models were approximated by systems of differential-difference equations.

Specific solutions were computed with an IBM-709 Computer, using the Adams–Moulton–Shell method for numerical integration. Solutions for the third model, referred to as the More General Model, were not obtained, because it is so complex.

Flow and pressure measurements were made in rigid and elastic tube models, and in the femoral artery of a dog. These data compared with computed solutions, showed that the Transient Poiseuille Model is applicable when the rigid tube assumption is met by the physical system, and the Lambert's model will predict the initial step response in an elastic tube.

Continuing in the Biorheology vein, the paper by Drs. Reneau (Clemson), Bruley (Clemson) and Knisely (Medical College of South Carolina) combined hemorheology and hemoxygenation in a study, "Oxygen Diffusion and Consumption in the Human Brain". Transport models were derived which describe the kinetics, diffusion and flow processes associated with oxygen supply of tissue surrounding the capillaries of the brain. The mathematical model consisted of two simultaneous partial non-linear equations describing the flow and oxygen diffusion of blood within the capillary and the transport across the wall into the surrounding brain tissue. The digital computer solutions were oriented to help answer questions such as the critical oxygen concentrations under normal conditions. The solutions simulated abnormal conditions so that the following questions could be posed and "answered". Can the fact that arterial hypoxia occurs at a higher oxygen concentration than venous hypoxia be attributed to the existence of longitudinal gradients? How do diseases such as anemia affect the oxygen supply to the brain? What effect is produced in the tissue by changes in velocity and velocity profile of blood flowing through the capillaries? What is the tissue oxygen concentration response to a change in the oxygen concentration of arterial blood? What is the largest change that can occur without a loss of consciousness in a given period of time?

The complete Proceedings of the Symposium on Chemical Engineering in Medicine and Biology will be published by Plenum Press, 227 West 17th Street, New York, New York and should be available in June, 1967.

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