Development of a Compact Falling Needle Rheometer (FNR) Device for Investigating Temperature Dependence of Flow Characteristics of Blood

Takuro Yamada[1], Hideki Yamamoto[2, C], Kimito Kawamura[3], Eiji Tamura[4] and Masato Atsugase[2, S]

[1]*Faculty of Environmental and Urban Engineering, Kansai University, Suita-shi, Osaka, Japan*
[2]*Graduate School of Science and Engineering, Kansai University, Suita-shi, Osaka, Japan*
[3]*Asahi Quality and Innovations Ltd., Moriya-shi, Ibaraki, Japan*
[4]*Nippon Steel Technology Co. Ltd., Amagasaki, Hyogo, Japan*
yhideki@kansai-u.ac.jp

We have developed a compact high-accuracy Falling-needle Rheometer to measure the flow characteristics of human blood and have created shear rate-shear stress diagrams (γ-τ diagrams) of blood in humans and many other mammals to analyze the flow characteristics of blood, which is a non-Newtonian fluid. Then we developed the constitutive equation for γ-τ based on blood viscosity measurement data from 50 healthy humans and published the results in a paper. As a result, for example, in CFD (Computational Fluid Dynamics), it is now possible to analyze the local pressure distribution inside an aneurysm, which has previously proved difficult because the blood viscosity, a non-Newtonian fluid, has been solved as a constant, and as a result, it is expected that CFD will be used to predict aneurysm rupture.

Blood from the human body is collected in a vacutainer tube containing EDTA. The blood is then transferred to an acrylic measuring cell for measurement. A polypropylene needle with a diameter of 2 mm and a length of 20 mm is dropped from the top of the cell, loaded with a sinker to a specified density, and the terminal velocity is measured to four decimal places. By measuring the terminal velocity and blood density, the shear rate (γ) of the needle in gravity is obtained. The shear stress (τ) is known and can be plotted on a γ-τ diagram because it can be calculated from the difference between the gravity of the measurement location, the blood density, and the density of the needle. Furthermore, by dropping eight needles of different densities, a γ-τ diagram for each specimen is completed. In this way, a blood viscosity diagram of blood can be obtained. This time, we modified the device to enable this measurement at different temperatures, and we report on the modifications.