Bulletin of Prosthetics Research

PROSTHETIC AND SENSORY AIDS SERVICE

BPR Spring 1964

PROPERTIES OF FLUID FLOW APPLIED TO ABOVE-KNEE PROSTHESES

ANTHONY STAROS, MSME; EUGENE F. MURPHY, PHD

An understanding of some of the key principles of fluid mechanics is necessary for full appreciation and wise prescription from the armamentarium of hydraulic and pneumatic s systems which are increasingly becoming available in prosthetics. A review of the differences between mechanical friction and fluid friction will help to define the underlying principles of these fluid-controlled mechanisms. (Numerous textbooks are available for the serious student.) Then the internal structure and the possible adjustments of some specific models will be described briefly. Very shortly, the journal Artificial Limbs will devote a special issue to a comprehensive and detailed discussion of all the mechanisms which were studied in detail by an ad hoc committee appointed by the Committee on Prosthetics Research and Development of the National Academy of Sciences—National Research Council.

MECHANICAL FRICTION

Mechanical static friction is the force which resists any external force that tends to cause the sliding of one body over another with which it is in contact, as in Figure 1. It eventually reaches a maximum at which sliding is imminent. This limiting static frictional force is directly proportional to the perpendicular or "normal" force pressing the two bodies together. It is possible to determine limiting static mechanical friction by measuring the force that must be used to overcome the friction with a given clamping force. Thus, the ratio of the frictional force to the perpendicular force pressing the two bodies together gives the static coefficient of friction, f = F/N, which is related to the materials involved. Thus the static coefficient of friction is constant for any two particular surfaces, e.g., approximately 0.15 for steel on steel and 0.50 for leather on iron. By means of tables of such coefficients it is possible to estimate in advance what the friction would be between two bodies, such as a metal bar on a wooden socket.

The coefficient of friction between dray surfaces depends considerably on the nature of the surfaces. (The coefficient also is affected by their roughnesses, such as those of metals machined with a coarse or a fine tool, polished, or allowed to rust. The coefficient of friction between wooden blocks depends on the relative direction of the grains of the two blocks to each other and to the direction of potential motion.) Also, the value of static friction may be affected by the length of time the bodies are in contact. Thus the published tables of coefficients often supply ranges rather than precise values.

The coefficient of friction for the same two surfaces will differ, however, depending upon whether the bodies are stationary or in motion. To start a body sliding over another requires a certain force, but to keep the same body moving at a constant speed requires only a lower force. Indeed, starting friction (also called limiting static friction or "stiction") is always greater than sliding (kinetic) friction. Thus the same two materials, without changes in rubbing surfaces, will have two different coefficients of friction: (1) a coefficient of starting friction and (2) a lower coefficient of sliding friction. Once in motion, however, the coefficient of kinetic friction remains constant even though the velocity may change, a major point in prosthetics.

The lower value of sliding or kinetic friction is important, even crucial, in many aspects of everyday life. Skidding of an automobile tire on the pavement or of a crutch tip on the sidewalk begins when the limiting static friction is exceeded, but becomes even worse as the frictional resistance drops to the sliding or kinetic value.

To continue reading, please visit http://www.rehab.research.va.gov/jour/64/1/1/40.pdf