Chapter 2
Fundamentals of Sliding Interaction of Surfaces

ABSTRACT

This chapter reviews the laws governing the friction behavior of objects. The material starts with a historical view of the evolution of friction laws and how they shaped the science of tribology. The second part of the chapter provides a generalized overview of the mechanics of contact between complying solids. Major contact models are listed, and formulas for calculating area of contact, contact forces, contact stresses are also developed. Finally, the chapter applies the presented information to the contact of biological species. The information presents a summary of the major rules in biological attachments, their adhesion and friction, along with their contact mechanics.

INTRODUCTION

Friction is essential to performing numerous daily tasks. Interacting with frictional phenomena is natural. Rubbing hands seeking warmth on a cold morning takes advantage of frictional effects. Walking, ironing, and combing of hair are but some examples of friction driven daily activities. Frictional phenomena occur in and around all living beings. Our sense of texture is a friction-based function. Vibrations, resulting from sliding of human fingers on a real surface, cause the resonance of mechanical receptors, that match the frequency of the vibrations. The receptors in turn generate signals to the brain conveying the sense of roughness or smoothness.

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Friction is also essential to many manufacturing operations. Surface generation by turning, milling and shaping for example are frictional processes. Some winter sports, such as skiing and bobsledding, depend on friction especially when high performance is required. Ice at low temperatures offers high resistance to motion due to a high coefficient of friction. When friction increases it leads to higher temperatures that cause melting of a thin layer into water. This melt layer lubricates the contacts and causes a drastic drop in friction whence less resistance to motion. Pedestrian slippage accidents constitute another example of the role friction assumes in daily life. In all, friction is a naturally occurring phenomenon that affects life activities to a greater extent than commonly thought. It is no accident that such a phenomenon and associated effects has been the subject of numerous investigations that date perhaps to existence of man on the planet.

Friction takes place between any two contacting surfaces. It can be external or internal. External friction is friction between solid bodies. It is the manifestation of the forces that resist the movement of a solid object upon embarking on motion. Thus friction may retard or completely halt movement of complying solid bodies. Internal friction, on the other hand, denotes energy losses inside of a body (solid, gas, or a liquid) due to the resistance of motion between the elements making up the material while it undergoes deformation (fluid friction is also used to describe the friction between layers within a fluid that are moving relative to each other).

Conventionally, friction is regarded as an undesirable effect since it is associated with wasted energy. However, in practice, whether friction is to be deemed undesirable or favored depends on the application. For example, playing the violin requires friction. In the case of brakes, high friction is desirable to dissipate the kinetic energy of a moving vehicle whence halting its' motion. Meanwhile, friction between pen and paper is not as desirable since high friction causes difficulty in writing.

Historical Prospective

Since surface interactions dictate or control the function of many devices developed by man, tribology has been of central importance for thousands of years, even though this has not always been generally recognized [4]. It is the engineering aspect of friction which has the longest history. The first practical aspects of friction, namely the use of frictional heating in the lighting of fires, has its roots in prehistory. More than 400 000 years ago, our