Chapter 1
Surfaces and Function

ABSTRACT

This chapter reviews the origins of surface-system considerations. It highlights the fundamental role a surface plays in preserving the structural integrity of a tribological system and the crucial role of surface texture in maintaining the state of a rubbing material. Here the authors make the case for custom engineering of texture. It is shown that the idea of engineering textural features, while being fundamental, is not easy to implement. They discuss the complexity of the factors involved and how they render the customization process industrially demanding. The main emphasis is on one fundamental factor, namely, the absence of a texture design paradigm that caters to the multi-functionality requirement for futuristic surfaces.

THERMODYNAMIC PERSPECTIVE

Everything that is interesting in nature happens at the boundaries: the surface of the earth, the membrane of a cell. The moment of catastrophe, the start and finish of a life. The first and last pages of a book are the most difficult to write. (Humphrey 1999)

Matter is a general term that describes any physical substance. There are several approaches that one can adopt to define matter. We can describe matter in terms of its physical and chemical structure (atoms and subatomic particles). We can also use its behavior for description. Alternatively, moreover, we may base our definition on defining characteristics or traits.

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In bulk, matter can exist in different forms, or states of aggregation, known as phases. These depend on ambient conditions (pressure, temperature and volume). A phase is a form of matter that has a relatively uniform chemical composition and physical properties (such as density, specific heat, refractive index, and so forth). These phases comprise the three familiar ones (solids, liquids, and gases), in addition to the rather exotic states (such as plasmas, super-fluids, super-solids, and the so-called Bose–Einstein condensates, etc.).

In free-form, phases of matter exist under equilibrium with their surroundings. This equilibrium is defined by the intensity levels of a so-called fundamental energy potentials (mechanical, thermal, chemical, etc.). Shaping of matter into a form suitable for a technological application (e.g. crankshaft, surrendered, etc.) involves deliberate upset of the original equilibrium state. Any shaping process includes a change of phases, volumes, and internal structures. After shaping is completed, the new object settles into a new equilibrium state. The state meanwhile may undergo disturbances due to operation of the object. Changing the original equilibrium state of matter, along with frequent disturbances while usage, upsets the balance between the energy potentials. This, in turn, triggers an exchange between the newly formed object and its surroundings. The goal of that exchange is to reestablish a stable equilibrium state suitable to the new environment induced by shaping. Depending on the state of the object the magnitude, intensity, and direction of the interaction with the surroundings may change continuously. This change manifests itself in terms of forces and changes in properties or structure of the object. That change may extend to affect the surroundings as well. In all, inducing a change in matter from a free-form to that of an object triggers a communication between the energy potentials within the object and its surroundings. This communication reflects changes in the gradients of those energy potentials due to the activity of an object. Our notion of the dynamics of that communication, traditionally, have evolved in terms of a system-surrounding paradigm. Such a paradigm is fundamental to all analysis pertaining to behavior of technological objects and the quantification of changes in their state.

The mechanistic steps describing the communication, and evolution of system changes, involve energy transformations. Energy transformations, in turn, are governed by conservation principles. Conservation, meanwhile, is fundamental to thermodynamics. It is not a surprise, therefore, that our motion of the system and its components has strong thermodynamic roots. To this end, it is beneficial to first review the basic definitions of the system-surroundings paradigm and implied information exchange from a thermodynamic perspective.

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