Chapter 7
Filtering Texture From Biological Surfaces to Technological Surfaces:
Case Study

ABSTRACT

This chapter discusses the impact of absence of a holistic surface-design methodology in the technological realm. The authors show that manifesting designs that merge function, form, and topography to achieve lean performance is currently a bottleneck in the field of tribology. The presented material shows that merging function and topography, while not matured within the realm of manmade surfaces, is advanced in natural designs, especially within the scaled reptiles (Squamata). This prompts many engineers to scour biological analogues for design alternatives. However, the problem of evaluating the viability of a natural surface and judging its suitability for a technological application is frequently encountered. The chapter adresses this problem through a detailed case study that involves extracting metrological information for snakes that engage in rectilinear locomotion.

INTRODUCTION

Theoretical analysis identified several dimensional groups that influence the tribological performance of a textured surface (Ryk, 2002, Ronen et. al.,2001, Golloch, et. al., 2004, Dumitru, et. al, 2004, Hiroki et. al., 2011, Hu and Ding, 2012, Borghi, et al., 2008, Qiu and Khonsari, 2011, Brizmer and Kligerman,

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2012, Eichstät, et al. 2011, Kovalchenko et al., 2005, Liu, et al. 2010). To date, however, there is no agreement on the optimal values to be implemented given a particular surface. More importantly, a well-defined methodology for the generation of textures for optimized surface designs is virtually non-existent. Such a process is still viewed as a "black art" mainly because of the absence of universal standards that rate design and manufacturability from a targeted-performance perspective. That is, the absence of a holistic surface-design methodology that merges function, form and topography to achieve lean performance within a wide range of contact conditions. Such an approach, while in essence, has not matured as of yet within the realm of human surface engineering is advanced in natural designs especially within the scaled reptiles (squamata). Squamate Reptiles present diverse examples where surface structure, texturing, and modifications through submicron and nano-scale features, achieve frictional regulation manifested in: reduction of adhesion (Arzt, et al. 2003), abrasion resistance (Rechenberg, 2003), and frictional anisotropy (Hazel, et al.1999).

Squamata comprises two large clades: Iguania and Scleroglossa. The later comprises 6,000 known species, 3100 of which are referred to as "lizards," and the remaining 2,900 species as "snakes" (Vitt, et al.,2003). They are found almost everywhere on earth. Their diverse habitat presents a broad range of tribological environments. This requires customized response that manifests itself in functional practices and surface design features. This, potentially, can inspire deterministic solutions for many technical problems. Many authors studied appearance and structure of snakeskin in relation to friction (Jayne, 1988-a, Rivera, et al., 2005, Berthé, et al., 2009, Saito, et al. 2000, Shafiei, and Alpas, 2008, Shafiei and Alpas, 2009, Abdel-Aal, et al.,2010, Abdel-Aal and Mansori, 2011, Abdel-Aal, 2012, Gray, 1946, Benz, et al., 2012, Klein, and Gorb, 2012, Schmidt and Gorb, 2012). Results pointed at the relation of surface topography in snakes to tribological performance.

Locomotion of snakes takes place through different modes: rectilinear, concertina, side winding, lateral undulations, and slide pushing. These modes entail the generation of cyclical contraction-relaxation waves of particular muscle groups. The skin of the reptile is the medium that simultaneously generates and accommodates the tractions necessary for motion. Dissipation and transformation of the kinetic energy associated with motion also takes place within the skin. Topology of the skin and its' interaction with the surrounding environment, is, therefore, crucial for control and optimization of the tribological response of during motion.

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