How to make **designs** "warm" or "soft"

When it comes to products that involve human contact, aesthetic qualities such as warmth, appearance, and softness help build product image and brand. Mechanical design and ergonomics can meet functional and usability requirements, through the use of FEA and CFD, for example. But aesthetics generally eludes numerical description.

Many designers judge a product's aesthetic attributes on artistic impression and select materials based on observation, experimentation, and imagination instead of on quantitative procedures grounded in physical principles. Nevertheless, you can quantify certain aesthetic qualities in terms of physical phenomena.

In "What Makes Products Warm?" (Machine Design, Jan. 8, 2009), I described how to quantify the aesthetic attribute of warmth (or coldness). A person's tactile sense of an object's warmth or coldness is defined by the rate of heat conduction at the point of contact between skin and object. Analysis of such contacts shows that this rate is directly related to the product of three of the material's thermal properties: density × conductivity × specific heat gives the so-called lump parameter.

Materials with lump parameter values greater than that of human-body tissue — such as metals — feel hotter (or colder) than their actual temperature because heat transfers at a high rate to (or from) the skin. Conversely, materials having low values — such as plastics and wood — feel less hot (or less cold) than their actual temperature. The lump parameter can be used to compare materials and find those users will perceive as "warmest."

Another vaguely described aesthetic attribute is "softness," the reason rubber-covered screwdriver handles feel softer than plastic ones. Examining the mechanical contact between an object and the human body shows that even though forces are small, there are slight localized deformations in the body tissue and product surface at the points of contact.

When we grasp a hard object, all contact deformation takes place in the bodily tissue. But when the object is soft, some of the deformation takes place in the object, with less taking place in the tissue. Nerve endings in our flesh easily sense these subtle differences and convey a sense of relative softness or hardness.

The magnitude of these contact deformations depends on the mechanical properties of the materials. The elastic modulus describes the degree of elastic displacement taking place in a material under load. Polymeric materials have much-lower elastic moduli than metals or ceramics, and they typically feel softer.

Hardness is a measure of a material's resistance to indentation. A hard plastic, even though it has a relatively low-elastic modulus, has a relatively high hardness. Thus, direct contact gives the impression of a not-so-soft material.

The lump parameter representing tactile softness equals elastic modulus × hardness. This parameter gives designers a way to objectively select materials for specific applications.

For example, foamed polymers with their low-lump parameter are softer and so are commonly used on automobile dashboards. Injection comolding allows manufacturers to produce parts like toothbrushes and USB Flash drives with soft polymers in the gripping area and hard polymers where rigidity is needed.

— *Howard A. Kuhn*

Howard A. Kuhn is an Adjunct Professor at the **Univ. of Pittsburgh, School of Engineering** and Director of Technology at **The Ex One Co.** He spends the rest of his time consulting.

Edited by **Leslie Gordon**