Materials & Products Design/ 10661440

E-Learning Lecture # 9

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Chapter 4

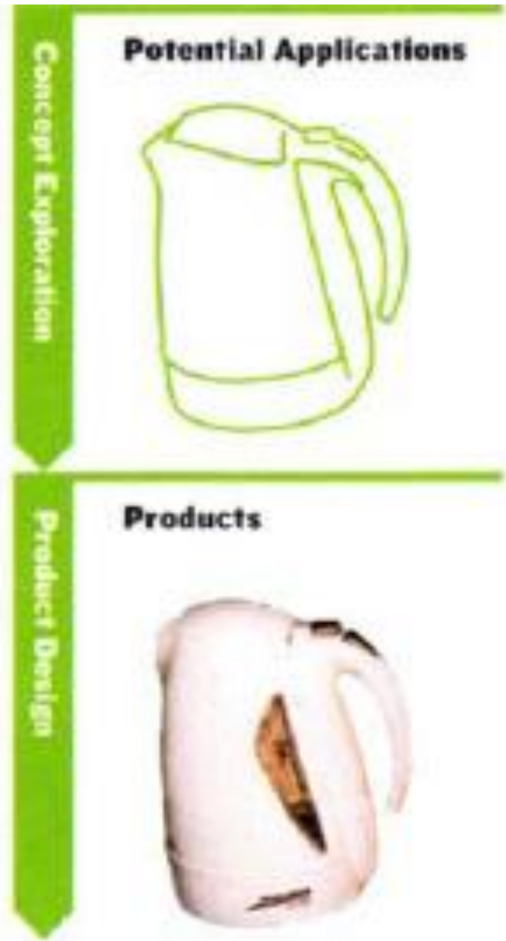
The Stuff... Multi-Dimensional Materials

Materials are the stuff of design. When we speak of "information" for materials what do we mean? **Figure 4.1** illustrates the steps involved in moving a material from the laboratory into a successful product. Tests yield raw data. These are distilled, via appropriate statistical analyses, into data for "material properties": values for properties on which design can safely be based (typically, 3 standard deviations below the mean). A material may have attractive "material properties" but to make it into a product requires that it can be shaped, joined and finished. The characterization of the material

is summarized in a table of such information (4.1, center). This process enables safe, technical design of a product – it is focused on the engineering dimension, so to speak.

That is only the start. Once made, the product will be used – the choice of material is influenced by the nature of the user: children, perhaps, or travelers, or the elderly. Does it comply with legislative requirements that the product must meet (FDA approval, perhaps, or requirements limiting flammability, noise, vibration or bio-compatibility)? Would it survive the use and misuse it will encounter in service? Is it toxic? Information for this – the dimension of use – is as important in guiding selection. People are the end-users for most products and we need to consider their needs early in the design process. There are human needs beyond what we have listed here, but those are considered later in this chapter.

There is more. Manufacturers and their customers are searching for solutions that are sustainable and green. In the world of manufacturing, this is documented by a factory's qualification as ISO 9000 or 14000 – meaning that it has established quality standards and procedures of environmental auditing and responsiveness. This, the environmental dimension, requires yet another layer of



4.1 Confidence in New Materials

The steps in moving a material from the laboratory to a successful product.

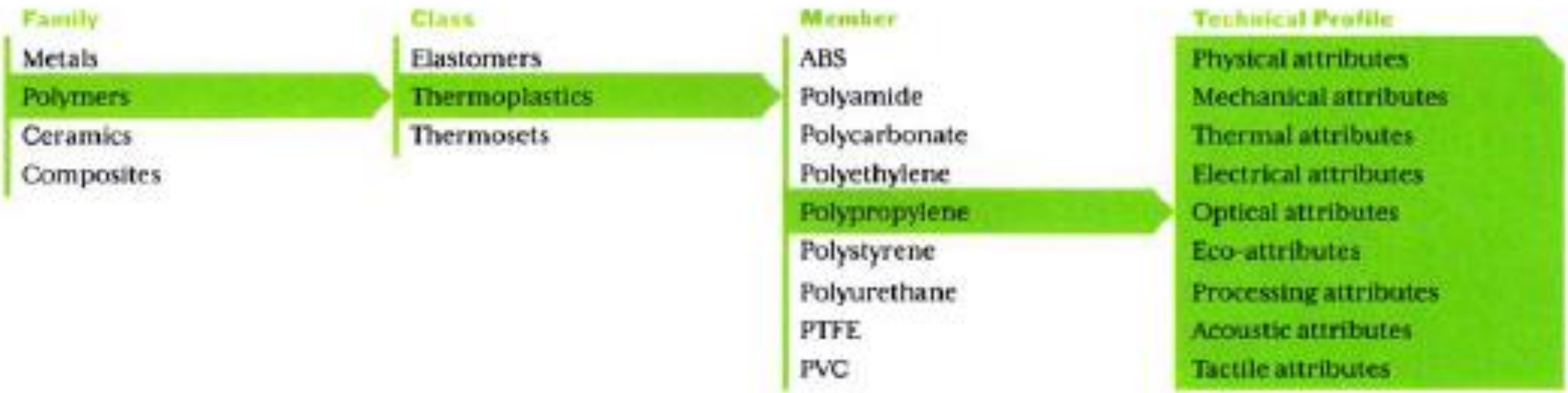
materials information, one relating to product manufacture, use and disposal. And even that is not the end. The industrial design of a product is as much a part of its creation as any other. The characteristics of a material that contributes to industrial design, though harder to document, are as important as the more technical properties. This - creating emotional connection and doing good design – requires a fourth dimension of materials information: that relating to aesthetics and personality.

Given these five attributes, rational and emotional design with materials becomes possible. Carrying the design into production depends - as we said in Chapter 2 -on investment, attracted by a successful business case. But we have enough to discuss without that. Here we explore the five dimensions of materials information: engineering, product use, the environment, aesthetics and emotion.

The Engineering Dimension: Technical Attributes

The scientific study of materials – materials science - seeks to understand the fundamental origins of material properties, and, ultimately, to manipulate them. It has had remarkable success in doing both. The origins of many material properties derive directly from the atomic and electronic structure of the material: among these are density, stiffness, thermal and electrical conductivity, optical transparency and many others. These are now well understood, and can, within the limits imposed by the laws of physics, be manipulated. Composites, one of the great technical advances of the last *50* years, combine the properties of two very different materials: polymers and carbon fibers in sports equipment, elastomers and steel in car tires, metals and ceramic fibers in aerospace components. Here, too, the scientific understanding is deep and the ability to “design” materials is considerable.

Material science has developed a classification based on the physics of the subject (4.2). It is not the only one -architects, for instance, think about materials in other ways.’ The science- based classification emerges from an understanding of the ways in which atoms bond to each other, and (in the case of composites) how mixtures of two different materials, each with its own attributes, behave. But science is one thing, design is another. Is the science based classification helpful to the technical designer? To explore this further we must first look at the technical attributes of materials. The classification of 4.2 - Family, Class, Member - is based, at the first level, on the nature of the atoms of the material and that of the bonding between them (e.g. “polymer”), at the second level on its variants (e.g. “thermoplastic”), and at subsequent levels, the details of its composition. Each member has a set of attributes that quantify its physical, mechanical, thermal, electrical and optical behavior -what we will call its technical profile. Open a handbook or search the web, seeking a material by name, and you will



4.2 Classification of Materials

A classification of materials based on scientific understanding of the nature of the atoms they contain and the bonds between these atoms. The final column shows a list of possible attributes for a spec@ material.