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Designers and materials scientists ought says David Bott of EotR Solutions, UK. from the best, the least observed, to

The Apple iPod – a 'design icon'

The iPod is not only a big success for Apple but also arguably one of the best and most potent design icons around at the moment. It is instructive to go behind the image to the heart of the gadget's triumph. The iPod design came from Apple's Industrial Design Group, which is headed by British designer Jonathan Ives. Most of the components are manufactured in Korea, Taiwan, China and Japan. So it is an American success story created by a British designer and mostly built in the Far-East. The look is timeless, almost 'retro', and has been compared to the original portable transistor radios. Indeed, the outside, with its polished metal back plate and smooth white plastic front is strongly reminiscent of the work of Dieter Rams, who designed for Braun in the 1960s – an influence Ives acknowledges.

While sticking to traditional materials on the outside, the iPod makes use of the latest components, such as hard drives and displays, coupled with the intuitive user interface that Apple is famous for.

What the iPod does is to satisfy a well-recognised need – the gadget offers a personal choice of music in all circumstances, yet remains portable and lightweight. The original Walkman, the minidisc and the Rio portable music player all previously exploited this underlying need. But the iPod took the capacity/size ratio into new territory and added the 'design' dimension. On top of that, clever marketing has positioned the iPod as an 'informed geek' product.

What the iPod shows is that when companies and designers understand what customers want and supply it, they can be a part of the game – but when designers encapsulate an emotional response (a perception that the product will make the owner more attractive or more fashionable) on top of this, they can win the game. Constant upgrades, such as the iPod nano or iPod video, with newer materials and more expensive finishes keep the market on edge and 'train' consumers to want even more. And this is not limited to the basic product line – although there are currently only five basic units, there are over 1,000 iPod accessories made by another 200 companies unrelated to Apple.

The ignored

Everyday items are clearly designed and materials carefully selected, but how much thought does the average consumer give to a tube of toothpaste? Most households have at least two toothpaste tubes, yet few consider the technology or the design that goes into this object.

To understand the need for design at all, you need to understand what goes into toothpaste and why it needs protecting. As well as a fair amount of water, toothpaste consists of –

- Menthol, which gives the fresh taste and the characteristic 'tingle' (it affects the pain sensors in the nervous system in the same way as curries)
- Sorbitol and Saccharin – sweeteners
- Dicalcium phosphate – the grit used to grind and polish teeth
- Sodium lauryl sulphate – a surfactant to solubilise the polishings and any other detritus
- Sodium carboxymethyl cellulose – a water soluble polymer used to modify the rheology of the paste
- Sodium fluoride – which strengthens the tooth enamel

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to spend more time communicating with each other, Bott gives a selection of materials used in design, examples of poor integration.

Toothpaste needs its tube for protection from loss of water that can cause the toothpaste to dry out and cake up, loss of low molecular weight organic compounds which can reduce effectiveness or cause a bad taste, and the ingress of oxygen which can make the ingredients cross-link the paste into a solid mass. If you have ever left the top off a tube, then you will be familiar with the crusty mass that builds around the nozzle! However, the driver for evolving tube designs has always been cost – the tube is not what people buy.

Pasty business

In the early days, toothpaste tubes were stamped out of a disc of aluminium, then painted and the logos printed on them. Aluminium is a very effective barrier to both water and oxygen, but was not cheap. The painting and printing processes added cost and complexity.

Next came a thin foil of aluminium laminated between two layers of polyethylene. This made the printing process easier, but there were problems with sealing the tube lengthways and providing a barrier to the paste at the shoulders of the tube. Finally, a multilayer coextrusion of polyethylene (PE) and poly(vinyl alcohol) (PVOH), with tie (adhesive) layers to improve adhesion, was used. PE is a water barrier, while PVOH is an oxygen barrier. While it still had to be printed, this could be carried out 'in-line' and the development made it a single-pass process saving both time and money on tube manufacture.

This example goes some way to showing how much effort is involved in making even an apparently simple product work effectively and at the lowest possible price. This is without mentioning pumps, big caps, and all the other modifications that have been tried and tested by toothpaste producers over the years.

Poor selection

However, even 'gods' get it wrong sometimes. The Apple Powerbook laptop computer has an aluminium body on a metal frame, and shows the danger in favouring design over function. Aluminium is gorgeous to look at, wonderful to touch and conducts heat well – which in practice means it keeps the processor cool but the lap warm. Aluminium is also tough, but not hard – it distorts to absorb impact – and so can be bent out of shape, sometimes with real impact on function, such as not being able to use the sockets or CD/DVD player. The main problem is that small forces on the corners of the laptop caused flexural distortion along the sides – the compression modulus of the aluminium is high but the tensile and (more importantly in this case) the flexural modulus is quite low.

For mechanical performance, a better selection of materials is represented by the iBook that has a polycarbonate body on a magnesium frame. The Apple website says that bulletproof glass is made of the same material – this reference shows the confusion between material and purpose. While it may not stop bullets, the iBook does not conduct heat so well (iBooks have slower and therefore cooler processors) and so is easier on the lap. Polycarbonate looks like a cheap, shiny plastic, and shows scratches and greasy hand prints, but is hard enough to take the knocks received by a laptop computer in normal use. Of course, when it comes to environmental stress, cracking and fatigue, the aluminium will win hands down.

Polycarbonate has a higher modulus (see table below) – it requires more force to stretch it, but it breaks at a fairly low extension. Aluminium needs less force to stretch, but it stretches more before it breaks. A really hard blow would probably shatter the polycarbonate, but it would remain untouched by the smaller whacks that can distort the aluminium casing of the PowerBook.

Outstanding results

When design and materials selection work together, the resulting product is outstanding. However, when design takes precedence over function, the resulting product can disappoint the long-term user. It is important to remember that there are design and materials requirements in the most basic of products making it essential for designers and materials scientists to communicate with each other.

Apple PowerBook with simple wave distortions of the outer case after a fairly small pressure was applied to the corner (right) (Images: courtesy of Spineless Design Ltd) Table comparing the properties of typical polycarbonate and aluminium (bottom)

	Modulus (tensile)	Break strength (tensile)	Strain to break
Polycarbonate	232,000 (psi)	9,200 (psi)	6%
Aluminium	10,200 (psi)	27,000 (psi)	12%

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The author would like to point out that he loves his Powerbook (as well as the other Apple computers and iPods he and his family own!)