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THE NEED FOR A HOLISTIC APPROACH TO SUSTAINABILITY IN NEW PRODUCT DEVELOPMENT FROM THE DESIGNERS PERSPECTIVE

Peter FORD, James MEADWELL and David TERRIS
De Montfort University

ABSTRACT
There are a growing number of tools available to the Product Designer to assist them in making informed decisions on the implications of the choices they make in specifying materials and manufacturing processes for their designs in terms of carbon impact.
Unfortunately some can be misleading, indicating for example that a particular material has a low potential environmental impact, but failing to inform on the reality of the economic viability in its use or how readily available it might be for that use. These tools also have their limits, for example few can cater for the huge variety of company type and address the varied environmental interests of their owners (or lack of it).
There is a need for designers to be fully aware of the broader issues relating to the environmental impact of their work beyond those that can be evaluated by a tool; highlighting the need for the complex range of issues associated with reducing environmental impact to be addressed along with and as creatively as all other design parameters.
This paper takes as a case study, the design of a digital cordless phone undertaken by the author for a major UK telecoms service provider, where a holistic approach to sustainability from the designer's perspective was a fundamental project requirement and uses this as an example of how designers can set their own holistic approach to sustainability in New Product Development (NPD), placing eco-tools in perspective and hopefully providing an inspirational example for student designers.

Keywords: Holistic, sustainability, NPD, environment.

1 INTRODUCTION

It's generally accepted that designers play a fundamental role on the environmental impact of a product in the early stages of the product design process [1], [2]. This is hardly surprising as it is usually the designer who has to assimilate complex design issues ranging from the commercial to the visual to the technical in these early stages, in order to minimise potential compromise on the resulting product; it's only logical that issues relating to the environment and sustainability should be added to this list of requirements, an argument put forward by Rosen et al in 2010 [3].
But where can the designer start in attempting to tackle this growing priority, sustainable design, eco-design, design for environment, design for sustainability, and what tools would you like to use to support you in this? Ramani et al's paper of 2010 [3] cite 210 references to issues concerning design and the environment, the majority of these relating to some form of eco tool for the various design and engineering actors in the process. It is hardly surprising that Spangenburg et al [4] state that Design for Sustainability has made few inroads into the design profession. Is there a disconnect here between academia and the profession? Spangenburg et al [4] make the observation however that design tutors can also be defensive when it comes to sustainability, especially in relation to overcrowded curricula and staff awareness/expertise, a situation also supported by Boks and Diehl [5]; so is this specifically a design issue? Lofthouse points out [6] that many of these eco tools fail as they do not focus on design and do not address the fact that 'designers have their own way of carrying out eco-design'. Radlovic et al [7] confirm this in a 2013 study of the use of eco-design tools by UK product design consultants.
Lofthouse [8] makes the observation that 'product designers involved in eco-design carry out a similar role to their role in regular design'. Radlovic et al [7] also support this, one of their interviewees

stating, 'sustainable design is just good design, its part of it. We don't have to wait for a client to ask, we should be doing it anyway'.

Lindahl [9] contends that designers bring 'crucial competencies' to successful initiatives in design for the environment, perhaps there is a shift in sight, can sustainable become a synonym for smart and intelligent as suggested by Karlsson et al [10]?

This paper proposes that this is indeed the case and that in the clutter of environmental initiatives and eco-tools and the growing demands on product design courses to accommodate and impart increasing amounts of information to students, that it is this core ability of designers to assimilate and balance information in a smart and intelligent manner should be the main focus. There should not necessarily be a differentiation between eco-design and regular design [8], in effect all parameters of the design process can have an environmental consideration and it is from this holistic perspective that designers should consider their role in the sustainability agenda.

The following case study presents an example of how this can be achieved to develop a better, more cost effective and more sustainable product.

2 CASE STUDY

This case study centres on a Private Sector funded research project to design a Digitally Enhanced Cordless Telecommunications (DECT) concept phone for a large UK based producer and retailer of telecoms products (referred to as TP).

2.1 Project Background

TP produce a range of telecoms products primarily for the UK market which are produced and distributed in their thousands. To meet this demand TP contract a number of Pacific Rim and China based manufacturers to develop and manufacture product to TP's specification. This activity represents a significant tonnage of product being supplied to, distributed and ultimately disposed of within the UK. All of TP's products are fully WEEE compliant and TP does employ staff tasked with being responsible for environmental issues as part of its Corporate Social Responsibility (CSR) strategy. As part of their environmental and sustainability initiatives, TP are subscribers to the Ellen McArthur Foundation Circular Economy initiative and it is, in part, this relationship that was the driver for the project.

2.2 Initial Project Inspiration and Specification

A significant proportion of TP's product range are devices consisting of electronic assemblies clad in an external, plastic, injection moulded casework. The polymer normally specified for these products is Acrylonitrile Butadiene Styrene (ABS), it having the best balance of required cosmetic, mechanical and economic qualities, it is also recyclable.

TP had become aware of a grade of 100% recycled ABS (rABS), produced from a controlled source of recyclate material that was becoming commercially available. If this material could be used in their products then this would go part way to meeting their environmental and Circular Economy initiative commitments; what was not known was how this material would perform against the exacting quality standards that TP's central marketing would require so as not to 'put off' their customers.

Surprisingly little data was available on how this new rABS could and should be used, hence TP commissioning the study.

It was therefore decided to commission work that would determine the characteristics of this new material, its limits and what might be done to mitigate against them.

For this exercise, an existing TP DECT phone (referred to as phone X) was to be used as a basis to determine how potential design changes might be managed.

2.3 Choice of Research Group

Although TP's manufacturing takes place off shore the majority of mechanical and electronic specifications are generated within the UK as is the product design for external shape and configuration; it would be these product designers who would have to address any constraints and conditions imposed by using this new rABS material. However these designers are constantly engaged in the development new products for TP, ranges which are determined years into the future. It was felt that there would be insufficient time for them to be diverted from this core task and that additional, external support be engaged to address this.

However TP were keen that this exercise should not just be about identifying what the limits are in using rABS but to determine how to ‘design around’ or accommodate these limits, as such they felt this research should be undertaken from the designers perspective and therefore contracted a research group (referred to as DR) that could undertake both the materials/process and product design aspects of the project. In effect this would be designers informing business/environmental strategy to, in turn, inform designers.

2.4 Initial Design Research Phase

The primary characteristics evaluated initially were strength, colour and ability to texture.

2.4.1 Strength

Injection moulded test strips were produced to compare tensile strength performance of both virgin and rABS materials, providing data (see Figure 1) to undertake Finite Element Analysis (FEA) on the original product X CAD data from which it was hoped to determine if the clips that hold the two halves of the product together would work less effectively with the new rABS material. The results show that although the rABS and Virgin ABS have similar yield points, rABS has a much more immediate failure point. In turn the FEA shows, theoretically, that with the conventional clip design on product X, there is a potentially high stress point (see Figure 2). Further FEA also indicated that simply making the clips stronger by increasing their thickness would actually be counterproductive, as it would increase stiffness and contribute to failure. Making the clips longer, such that they could flex more easily would resolve the problem, but this would also make it easier for the body halves to separate when subject to a standard drop test. This would necessitate a complete redesign of the method of holding the two body halves together.

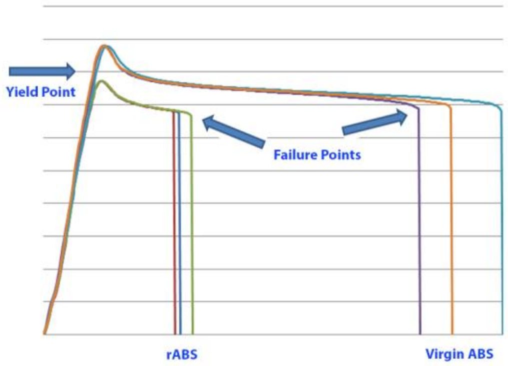

Figure 1. Failure points of virgin and rABS

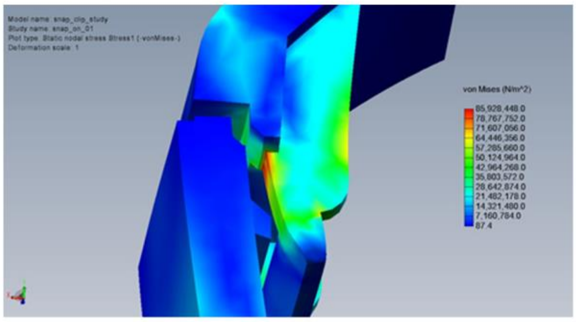

Figure 2. FEA of product X clip stress point

2.4.2 Colour and Texture

Injection moulded test plaques were produced to determine ability to colour (using master batch pigment) and paint. These test plaques were also spark eroded at four different levels.

Figure 3. Colour, paint and texture evaluations

This exercise highlighted a fundamental problem, simply, it is not possible to colour rABS with any degree of success. Figure 3 demonstrates the best attempt to produce white, primary colours yielded similar 'dirty' results. Black or shades of dark to mid grey are the only possibilities.

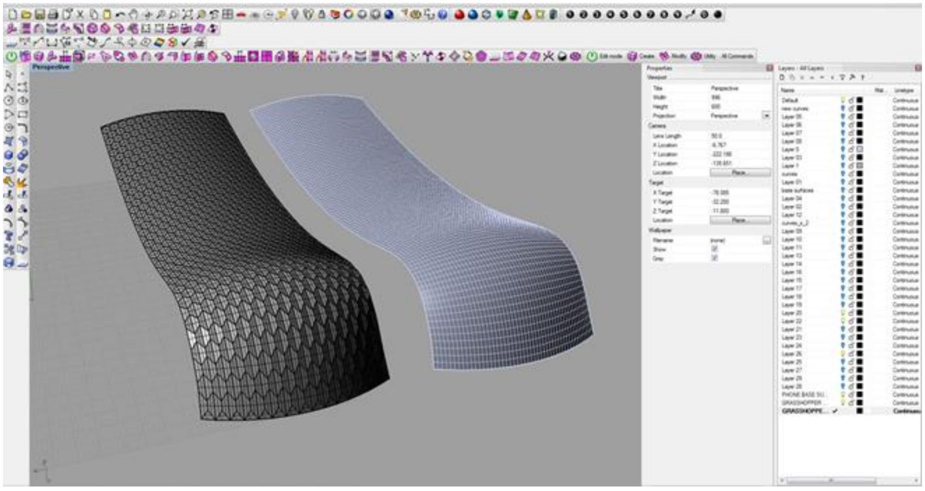

Figure 4. Experimenting with 3D machineable textures

The rABS accepts paint as well as virgin material but this was generally considered by all concerned to be a less favourable route as the paint would contaminate the rABS for further processing and contribute to environmental contamination (even the best available grade of 'eco' grade of paint).
Material inclusions and imperfections could also be seen on the polished sections of the test plaques. These were reasonably well hidden/masked on the textured sections. Attempting a gloss, polished surface on components using rABS was not therefore recommended. The use of texturing looked to have potential but to go beyond the easy effects of spark erosion and photo etching some experimentation was undertaking on applying machineable 3D textures (see Figure 4).

2.4.3 Further Observations and a Radical Suggestion

Although specifically tasked with looking at strength, colour and texture, DR made a number of additional observations, the first being to consider replacing the existing mechanical keypad with capacitive touch features on one side of the main PCB. The existing product X keypad was composed of 21 different components and 5 different materials including metals, elastomers and other polymers all of which were bonded together making for problematic end of life disassembly and disposal (see Figure 5.

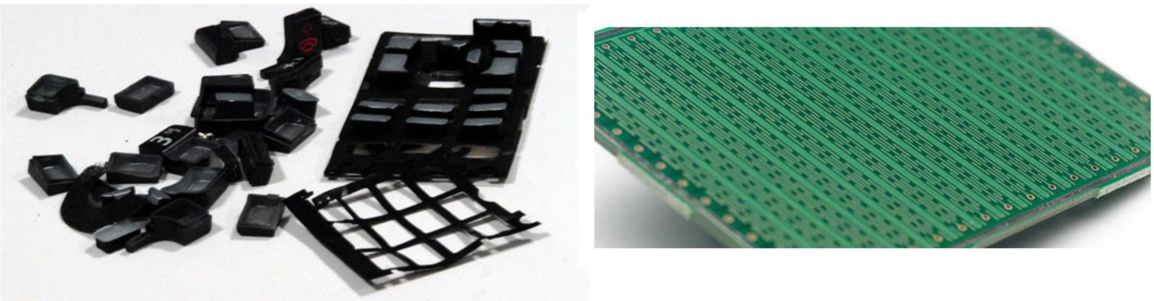

Figure 5. Existing multi-component keyboard (left) and proposed capacitive touch (right)

In addition it was proposed that an 'e-ink' display to reduce power consumption and therefore reduce the number of rechargeable AAA batteries required from 2 to 1. This would reduce weight and material consumption; at one million units, this is considerable.
Further, DR also proposed a radical new approach to construction using heat-shrink material (made possible by using the capacitive touch PCB) to provide colour and graphics, hold the two body halves together (no screws) and make it easy for end of life disassembly (just slit and remove the heat shrink material), (see Figure 6).

Figure 6. Using heat-shrink material to colour and hold together the DECT phone halves

This intrigued TP greatly, even though it was evolving beyond the original task, it was clear to all that there were opportunities here. However TP's marketing team were concerned that this new approach and the lack of a mechanical keyboard would not be acceptable to their customers, it was decided therefore to commission prototypes to determine customer reaction to the heat shrink graphics and the capacitive touch keypad. The main deviation from this point however was that TP no longer saw this exercise as a development of product X but the development of a whole new DECT phone concept with the intention of being as 'circular' as possible in its configuration.

2.5 Prototype Feedback and Second Stage Design Research

The feedback regarding the capacitive touch keypad and 'e-ink' display was positive, but less so with regard to the heat-shrink material which marketing considered gave the phone an odd feel.
While retaining the capacitive touch and 'e-ink' display it was decided to revert to the earlier experimentation with 3D surface textures (see Figure 4) to provide a desirable visual effect while creating a method of masking the imperfections in the rABS. However a resolution of the clip issue was still required.

2.5.1 Clipping and 3D surface texturing

A solution was developed for clipping together the body halves that involved increasing the length of the 3 pairs of opposing clips to make them more flexible but there was a modification to the battery compartment moulding that prevented the clips from disengaging during a drop test – this proved to be extremely successful. In addition the 3D texturing was developed further (see Figure 7).

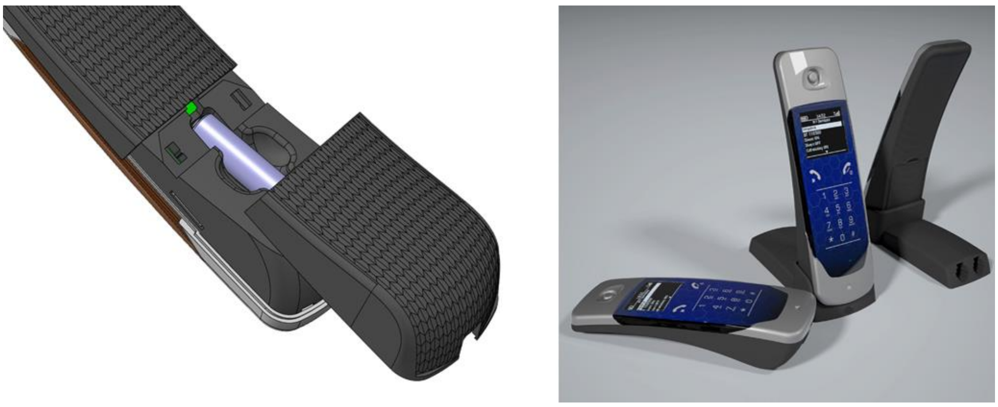

Figure 7. Development of clipping and 3D surface texturing on final design

3 CONCLUSIONS

What started as an evaluation of the strength, colour and texturing characteristics of 100% recycled

ABS in order to identify the constraints imposed on designers and to develop insights on how to address these limits, evolved into the full design development of a concept DECT phone driven by the need to be more circular in its conception.

This case study presents a few key features of the complete project which also extended to include packaging, mechanical performance, heat performance and accelerated environmental exposure conditioning.

An LCA of the final product indicated worthy reductions in energy consumed to both produce the product and in the products operational life (and associated carbon reductions). In addition the product had significantly improved end of life credentials, proving easy to disassemble and with the potential for re-using a high proportion component parts and materials and at the same time reducing component count and manufacturing cost compared with product X.

What's key in this exercise is the role played by the designer; DR acted as research investigator, project manager and the generator of design solutions- undertaken iteratively one with the other. All of these tasks however could be classed as 'regular' roles for the designer, but each task being endowed with a more environmental perspective or context. In this manner designers can have a holistic perspective on their environmental responsibilities, linking sustainability with smart and intelligent thinking [9], [10].

REFERENCES

[1] Ramani K. Ramanujan D. Bernstein W.Z. Zhao F. Sutherland J. Handwerker C. Choi J. Kim H. and Thurtson D. Integrated sustainable life cycle design: A Review. *Journal of Mechanical Design*, Vol. 132, 2010, pp.091004-1-091004-15.

[2] Bergen J. and Verhulst E. Ecodesign integration in education: the utility of an existing multidisciplinary design methodology. In *International Conference on Engineering and Product Design Education.* Brighton, September 2009, pp.396-401.

[3] Rosen M.A. and Kishawy H.A. Sustainable manufacturing and design: concepts, practices and needs. *In Sustainability,* Vol. 4, 2012, pp.154-174.

[4] Spangenburg J.H. Faud-Luke A. and Blincoe K. Design for sustainability (Dfs): the interface of sustainable production and consumption. In *Journal of Cleaner Production.* Vol. 18, 2010, pp.1483-1491.

[5] Boks, C. and Diehl, J. Integration of sustainability in regular courses: experience in industrial design engineering. In *Journal of Cleaner Production*, Vol. 14(9-11), 2006, pp.932-939.

[6] Lofthouse, V. Ecodesign tools for designers: defining the requirements. In *Journal of Cleaner Production*, Vol. 14(15-16), 2006, pp.1386-1395.

[7] Radlovic P.F.M. Lemon M. and Ford P. Design for the environment in UK product design consultancies and in-house design teams: an explorative case study on current practices and opinions. In *The International Journal of Design Management and Professional Practice.* Vol 6, 2013, pp.102-111 .

[8] Lofthouse, V. Investigation into the role of core industrial designers in ecodesign projects, *Design studies,* Vol.25(2), 2003, pp.215-227.

[9] Lindahl, M. *Engineering Designers' Requirements on Design for Environment Methods and Tools*, Dissertation, 2005, Faculty of Industrial Engineering and Management, Royal Institute of Technology, Stockholm, Sweden.

[10] Karlsson, R. and Luttrop, C. EcoDesign: what's happening? An overview of the subject area of EcoDesign and of the papers in this special issue. In *Journal of Cleaner Production*, Vol. 14, 2006 pp.1291–1298.