Volume efficiency as an environmental strength of moulded pulp protective packaging

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Abstract

In recent years moulded pulp has emerged as an environmentally friendly material for protective packaging for consumer electronics (CE). Its green image is based on material recycling, both in the production and the end-of-life phase. Until now the 'use phase' of protective packaging (the distribution of the packed product) has not been addressed in environmental statements. As this paper shows, this phase has a major impact in the life cycle.

1 Introduction

Over the last decades moulded pulp has emerged as a serious competitor in the protective packaging market. Since WWII expended polystyrene (EPS) has been most widely used as a protective packaging material for durable consumer goods. From the mid-eighties on, environmental concerns with the public and governments grew. EPS is based on non-renewable materials and there was no recycling system for *post-consumer* EPS in most countries (in many countries there still isn't). Among others several paper-based materials emerged as alternatives, such as moulded pulp, Beeboard® and several corrugated designs.

In eco-design of CE products packaging gets a serious amount of attention. Philips Consumer Electronics for instance has made distribution and packaging one of its five focal areas in eco-design [1]. From a purely scientific point of view distribution and packaging are not major contributors to the total environmental impact of CE products. The major factor is the energy consumption during the use phase of the product, which accounts for up to 80% of the environmental impact. Yet environmental improvement of protective packaging usually also means reduction of the costs. Money saved on packaging and distribution ends up directly with the manufacturer. Thus packaging improvement constitutes the most important one of a limited number of potential win-win opportunities for original equipment manufacturers.

In eco-design of packaging, the environmental focus usually is on material recycling. The major advantage of paper-based packaging is considered to be its good recycling qualities. It is, usually to a large extent, made from recycled material and can in turn be recycled very easily. In countries with a good post-consumer waste paper collection system, such as the Netherlands, this actually happens, which cannot be said for all materials that can be easily recycled in theory (such as EPS).

Large general surveys on consumer packaging perception show a serious focus on recycle aspects [2]. This focus on material recycling is also shown by environmental legislation concerning packaging. The fees for the Grüne Punkt system in Germany are entirely based on the cost of material recycling.

2 Life Cycle Assessments

LCAs on protective packaging published so far also strongly focus on production and end-of-life [e.g. 3]. Proper calculation of the environmental impact should include all stages of the life cycle. Hence the 'use phase' of the packaging has to be investigated, this is the transport of the packed product from the factory to the customer. This is a new approach for packaging eco-design, focusing more on the entire distribution chain, instead of just material production.

There are several ways in which the environmental impact of the distribution phase can be allocated to the packed product and the packaging, for instance based on weight, volume, or economic value. A closer examination of the modes of transportation can reveal the influence of the packaging on the environmental impact caused by distribution. This way the proper way of allocating can be determined.

Transportation of CE products is mostly done in containers by ship and by truck. A large percentage of the transported volume is caused by cushioning material (approximately half, depending on the size and fragility of the packed product).

The most widely used sea container measures 40 feet, and has a content of approximately 60.000 litres. The maximum payload is approximately 27.000 kg.

Product type	Number of products	Average Volume of the package (l)	Average total weight prod. + packaging (kg)	Average density of the product (g/l)	Average density of the package (prod. + packaging) (g/l)
Audio sets	4	34.76	12.12	304	147
DVD	5	34.74	5.36	413	152
DVDR	4	52.8	9.00	443	171
HPR*	4	1.59	0.57	502	358
Cell phone	5	1.52	0.52	1187	346

Table 1: Densities of (un)packed consumer products. Based on Benchmark reports by Philips 2000-2002. *Human Powered Radio.

This means that the maximum average density of its content can be 450 gram/litre to fill its volume completely. This same calculation can be made for transport by truck. Trucks have a maximum density of the payload of 190 to 350 gram/litre depending on the truck. CE products themselves have densities of 300 to 1500 gram/litre disregarding their packaging (see table 1). CE packages show a much smaller range. They have densities of 100 to 400 gram/litre. Hence volume is the limiting factor in most cases.

As volume is the limiting factor, the environmental impact of transport should be allocated to packed product and packaging on basis of volume, and not on basis of weight. If this is applied in the LCA of protective packaging it becomes clear that the influence of the use phase on the total impact is very large. In fact in an example calculation done on a moulded pulp cushion for a VCR player produced in Eastern Europe and sold in Western Europe, this phase was by far the most important (around 80% of the total impact, depending on the environmental indicator used).

3 Discussion and conclusions

Of course a smaller packaging only has a positive influence on the environmental impact if the difference in volume is large enough to allow more products in one unit of load. Yet always judging smaller packaging as more environmentally friendly is much closer to the truth than ignoring the volume factor. It could be argued that part of the added volume is unavoidable. Even a theoretical perfect cushion requires a certain amount of volume. Therefore it might be better to allocate the environmental impact on the basis of inefficiency, i.e. additional volume added on top of the theoretical required minimal cushioning. This would reduce the importance of the 'use phase' slightly, but it will remain one of the most important factors.

Not all packaging solutions perform equally well in the distribution phase. An environmental comparison between two or more packaging options should incorporate this difference. The efficiency of a packaging material is therefore of direct influence on the environmental performance of the packaging. This efficiency is usually expressed in the *cushion value*, that comes from the following formula: $C = G \cdot t / h$. Here *C* represents the cushion value of the material. *G* represents the maximum level of deceleration a product can withstand during impact, i.e. its fragility, expressed in a number of times g. Then *t* is the thickness of the cushion and *h* is the drop height. A theoretically optimal cushioning solution would have a cushion value of 1. The cushion value *C* of a material is a multiplier of the theoretical required thickness, caused by this inefficiency of the cushioning material. Hence the lower the cushion value is, the more efficient the material. There are substantial differences between the C-values of different packaging materials; Beeboard 1.5-1.8, Moulded pulp, 2.0, EPS 2.5, EPP 2.7, EPE 2.8, Corrugated 3.8, Air cushions 5.0. These are average values as for instance with moulded pulp it is depended on the quality of the recycled paper (which is subject to seasonal changes), and with plastic foams it depends on the density. As this list shows, moulded pulp is in principle a more efficient cushion than for instance EPS. Yet, due to the use of recycled raw material the properties of the material vary. Therefore Delft University of Technology has started a research program focusing on moulded pulp geometry, with the aim of optimising the properties of moulded pulp. A first publication is Gurav, SP, et al. [4].

4 Literature

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