Carpet Recycling

Information Sheet

The word carpet comes from the Latin word *carpere*, which means to card wool, the traditional raw material for carpets. By the end of the 18th century, these floor-coverings were familiar items in many homes, and manufacturing processes changed little for 150 years. Then mass production techniques and the arrival of synthetic fibres yielded a textile product of remarkable variety.

Carpets have now become a fashion item. Carpets comprise a small but significant fraction of the waste stream, and there is increasing pressure to keep carpets from landfill disposal.

Carpet construction

Most carpets are made by joining a surface material (face fibre) to a backing layer (see Figure 1, page 3). Face fibres can be synthetic (such as nylon, polypropylene, polyester), or natural (eg wool and sisal).

Nylon (in forms known as nylon 6 or nylon 6,6), a durable and colour-fast material is the most widely used fibre. The primary backing is usually polypropylene, but can also be polyester or jute. Some carpets also have a secondary backing (jute or polypropylene), and a synthetic foam cushion.

Face fibres are attached to the backing in several ways. Wool carpet fibres are often woven into the backing, while others are bonded using styrene butadiene rubber adhesive. In some carpets, face fibres are joined through lamination with a synthetic foam cushion.

Carpets made for commercial use (in offices, shops etc) need different properties from residential carpets. For example, commercial carpet usually needs no padding or underlay, while residential carpet does. Residential carpet is usually supplied in rolls four or more metres wide, while commercial carpet is more often supplied in tiles. Residential carpet is 30-60 per cent fibre (by weight), while commercial carpet rarely contains more than 30 per cent fibre. Residential carpet lasts up to ten years, compared to less than eight years for commercial carpet.

Carpet waste

Annual US carpet production is around 1.25 billion square metres (125,000 hectares). Americans generate approximately 1.6 million tonnes (Mt) of carpet waste and 113,000 tons of underlay each year, around one per cent by weight of municipal solid waste (MSW).

The Office of Environmental Assistance in Minnesota, US reported at the end of 1999 that carpet comprised 2.5 per cent of the state's MSW, and 2.9 per cent of metropolitan MSW. Around one per cent of Canada's MSW is carpet, according to the Recycling Council of Ontario.

Western Europe generates 1.6 Mtpa of carpet waste (900 million m^2, equivalent to 200,000 football pitches). Around 70 per cent is landfilled and 30 per cent is incinerated, mostly with energy recovery. In Germany around 960,000 tonnes per annum (tpa) textiles are sold, half of which is thought to be carpets and curtains.

Waste management

Carpet industry production residues are recycled extensively - for example waste fibres are used to make sound-proofing material for vehicles. However, very few household collection systems cater for post-consumer carpet waste. A 1997 study into US textile recovery schemes only found one accepting carpet.

All waste management options are potentially available for this waste stream - re-use, material recycling, energy recovery and final disposal. Of course, re-use and recycling demand higher levels of collection and sorting, for effective recovery.

Collection

Used carpets are often collected along with bulky household waste items such as furniture and waste electrical items. This can form a useful system for source-separation of waste carpets.

Alternatively, dedicated containers for carpets can be established at neighbourhood recycling points (civic amenity sites).

Carpet Recycling Europe (CRE), an organisation founded in 1998 by European carpet industry associations of 87 carpet manu-

facturers has recovered more than 20,000 t of used carpets through the systems described above. CRE offers a container service for carpets from suppliers and fitters, wholesalers or distribution depots.

CRE also reclaims industrial production waste, collecting carpet industry-specific wastes such as shearing dust, yarn, polyamide (nylon) waste or stock disposal.

Sorting and identification

Recovering carpet waste requires accurate identification and sorting of the face fibre. There are several identification techniques available.

Labelling
Manufacturers often print a brand name on the reverse of their products, providing an effective pre-sort stage.

Carpet Component Identification Code (CCIC)
The CCIC was developed by the US Carpet & Rug Institute to identify the construction of a carpet. The code is either printed directly on the back of the carpet or on an attached bar-code. However, the code was only introduced in 1996, so marked carpets are unlikely to become waste yet.

Near infrared (NIR) sorting
The most accurate, reliable identification technique uses NIR spectroscopy. The carpet is illuminated and, by analysing the light reflected, it is possible to identify the face fibre.

One example of NIR equipment is CarPID, a portable instrument for the fast identification of fibres - nylon 6, nylon 6,6, polyester (PET), polypropylene (PP) and wool. The device is placed on the carpet face, the operator presses a trigger and a light indicates the dominant fibre type.

Automatic NIR sorting
A fast NIR system can identify face fibres within hundredths of a second. With the help of a transport system, carpets are automatically sorted using a stationary identification device.

Melting point identification
This simple, cheap approach distinguishes between fibres according to their melting points. A typical tool uses two heated probes; one heated just above 180°C, the other just above 220°C. Aluminium foil is placed on the carpet face and the hot probes applied. After ten seconds, the probes are removed and the aluminium foil is peeled away. If the device melts one dot onto the face of the carpet, it is nylon 6, two dots indicates polypropylene. No dots mean that the textile is either polyester, nylon 6,6, wool, cotton or acrylic. A third probe can be added to distinguish between other groups of carpets.

Recovery

Most carpet waste comprises potentially usefully materials such as cotton, polyester (polypropylene) and nylon, and manufacturers, suppliers, recyclers and academic institutions are actively pursuing ways to recycle carpet waste.

The following recovery options exist for carpet waste:

direct re-use
Good quality used carpet can be sold or given to charities.

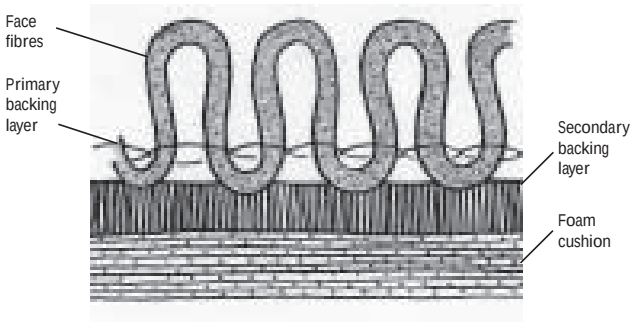
recycling into new carpet face fibre
Face fibres can be shaved from the backing, or the entire carpet can be shredded, pulverised and screened. This option is com-

World's first automatic carpet sorting plant

In May 2000, in Kerpen , Germany, the world's first automated sorting system for post-consumer carpet was opened. This US$0.5 million facility can sort 27,000 tpa carpet. The carpet is attached to a clamp that unrolls and caarries it to a rapid NIR device which identifies the face fibre.The carpet is then transported automatically to an appropriate container.

At present, nylon 6 from the Kerpen plant is baled and shipped for recycling at Evergreen Nylon Recycling in Georgia, US. CRE sorts into five separate piles (nylon 6, nylon 6,6, wool, polypropylene and other). Hand-picked decent scraps are also salvaged for re-use, as packing materials for items shipped to Africa. These carpets then have two extra lives, as packaging materials and eventually as carpet.

Figure 1 Typical carpet construction



monly used to convert nylon 6 back to the raw material, *caprolactam* - this can be re-used to produce many products.

recycling fibre into other products
Mixed materials can be downcycled into secondary applications, eg geotextiles, parking barriers, or substitute wood. A process to produce sound insulation mats involves several steps in this procedure:

- sorting carpets by face fibre
- tearing fibres from the carpet
- mixing fibres in the desired proportion
- production of a loose mat
- heating the mat until the polypropylene fibres melt (thermobonding)
- addition of salts to make the material fire-resistant

recycling carpet backing
Once separated during face fibre recovery, backing material is extruded into new carpet backing (or downcycled into other products). However, most backing is simply burned or landfilled.

Benefits of recycling carpets

Recycling waste carpets helps:

- reduce energy consumption
- reduce demand for raw materials (especially petroleum and chemical products) used to manufacture synthetics
- reduce effluent emitted when manufacturing new materials

Carpet waste recycling rates are growing, as landfill disposal becomes costlier, and as extended producer responsibility (product stewardship) becomes a more real prospect. Recycling carpet underlay remains more common than carpet waste (an estimated 57,000 tonnes of underlay were recycled last year in America - half the available post-consumer scrap). This is attributed to the homogeneity of polyurethane foam used to produce underlay in America, and to the established markets and collection infrastructure for used material. In other parts of the world (such as the UK) underlay is made using latex and rubber crumb (which is often recovered from scrap tyres).

Sorting residues
Caprolactam is a relatively light molecule compared to nylon 6 and is removed from the reactor with steam vapour while carpet backings, dirt and impurities remain in the reactor. This by-product - high in calcium carbonate and polypropylene - can be used in for example cement production. This means that residual organic material (fibres and latex) are substitute fossil fuels, but the chalk filler content can also be recycled.

World's first large nylon 6 carpet recycling plant

In November 1999, Evergreen Nylon Recycling (ENR) opened the world's first large-scale commercial nylon 6 recycling venture. The US$85 million facility in Augusta, Georgia diverts more than 91,000 tpa post-consumer carpet waste from landfills. The venture will reclaim nearly 20 per cent of all discarded nylon 6 carpet, producing caprolactam. This material is used in carpets, engineering plastics, automotive parts, sporting goods, films and packaging. The facility will produce more than 45,000 tpa caprolactam with the same performance and aesthetic qualities as virgin caprolactam. The facility saves 700,000 barrels of oil each year compared to conventional caprolactam production - enough energy to heat 100,000 medium-sized US homes for a year. Carpet collection is already underway in 75 metropolitan areas across America.

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Other carpet management options

Carpet leasing scheme
Interface Inc in Atlanta, US makes carpets and carpet tiles, and is pioneering carpet leasing - installing and maintaining carpets for a fee rather than selling them outright.

This is the logical conclusion of the producer responsibility concept, where customers pay for the service they want rather than the product itself.

Interface is the world's fourth largest carpet-maker and this Evergreen Lease is part of a long-term goal to eliminate non-renewable resources and harmful by-products.

Carpet re-use programme launched in Canada
Project Magic Carpet in Toronto, Canada identifies business and government sites about to replace carpet tiles, and works with them to recover useful material.

Instead of paying to landfill the waste, companies can donate the value of the tipping fee to the charity, in return for a tax receipt. The scheme offers re-usable materials to community agencies and not-for-profit organisations at a fraction of the original cost. In addition to diverting material from landfill and providing low-cost responsible flooring, proceeds from the project support social and educational charities.

Earth Square programme
Carpet tile manufacturers Milliken has introduced a scheme to recover, clean and refurbish their product. New colours and patterns can be added in this closed-loop process. If the customer has a large enough quantity of carpet tiles, these will be collected at a significantly lower cost than the alternative disposal fees. While the company would consider leasing carpet tiles, there is as yet little enthusiasm from potential customers.

Conclusions

Carpets are functionally simple items and have long been disregarded as an element of the waste stream. Despite their presence in our homes for many generations, these floor-coverings are now relatively sophisticated, engineered commodities.

Although it might be argued that the environmental impacts of carpets, during use and disposal, is hardly likely to be large, any product which contributes millions of tonnes each year to the world's landfills cannot be ignored.

The carpet sector is one example where industry has chosen to move forward in many parts of the world, seeking to increase levels of resource recovery, before policy-makers decide to force the pace.

In the apparent absence of landfill bans, deposit-refund schemes, environmental taxes, producer responsibility regulations and any other carrots and sticks, this sector is one in which truly innovative ideas have appeared within the last ten years.

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