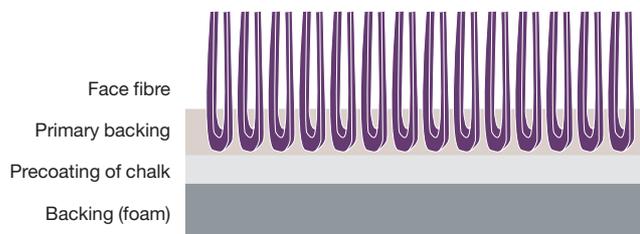


Recycling of Floor Carpeting: Making New from Old

ALI NIKZAD
SULZER CHEMTECH

More than 400 000 t of used floor carpeting are burnt or disposed of in waste dumps in Germany alone every year. Following the development of methods for the industrial recycling of polyamides, the world's first recycling plant for floor carpeting with every kind of face fibres is now under construction in Premnitz (DE). Falling-film crystallization from Sulzer Chemtech is thereby one of the decisive processing steps.



1 *The face fibre of about 60% of all used floor carpeting consists of the polyamides Perlon and Nylon. A new process facilitates the recycling of the Perlon monomer Caprolactam.*

Floor carpeting is a compound of various materials (Fig. 1[■]); however in most cases, the face fibre consists entirely of Polyamide 6 (Perlon) or Polyamide 6.6 (Nylon), two very frequently used polyamides. More than 5 million tons of polyamide are manufactured annually worldwide and employed in the most diverse branches of industry (Fig. 2[■]). Over one half of this amount is spun into fibres for use in the carpet and garment industries. The industrial applications are monofilament yarns and brush filaments, films, sheeting and ribbons, as well as solid semi-finished and injection-moulded products, such as gear wheels (Engineering Plastics).

Polymide 6 (PA) is produced through the polymerization of ϵ -amino caprolactam (Caprolactam), which is derived from oil, i.e. synthesized from a non-propagating raw material. The production process is expensive and pollutes the environment with organic by-products and, in many plants, large quantities of aluminium sul-

phate. Ecological and also economic reasons have therefore favoured the development of a process for the recovery of caprolactam from used floor carpeting, which would otherwise be deposited in waste dumps or disposed of in household waste-incineration plants. The recycling of plastic monomers has been known in chemical process engineering for decades: however, it has only been possible to recover a low quality monomer from used floor carpeting up to now, which could not be employed any more for new carpet.

HIGH-PURITY CAPROLACTAM FROM FLOOR CARPETING

Lurgi-Zimmer AG has in collaboration with other Lurgi companies (LLE for the automatic sorting and LLB for the heat and power plant) developed the first caprolactam recycling plant which enables to offer an economic solution for the utilization of used floor carpeting. Falling-film crystallization is thereby one of the most decisive processing steps (see box, p. 21). It enables the recovered caprolactam

2[■] With about 42% of the total quantity, the floor-covering carpet industry is the most important customer for polyamides.

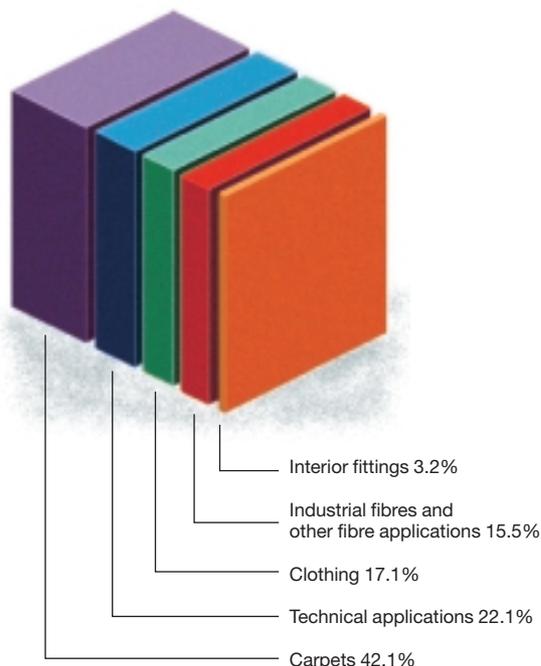
to be purified to a quality which, otherwise, can only be made industrially from crude oil products. The falling-film crystallization process has been developed by Sulzer Chemtech since the 1970s and is especially suitable for the production of high-purity starting products for the manufacture of plastics. Sulzer Chemtech supplied a similar plant to Spain for the production of paraxylene, the basic product for various polyester fibres (see STR 4/96, p. 39). In comparison with other technologies, the principal advantages of falling-film crystallization are the low maintenance, smaller space requirement and lower production costs.

The first recycling plant for opera-

tion according to the described process is now being constructed at a cost of 350 million DEM in Premnitz, which is about 80 km west of Berlin (Fig. 3[■]). The plant is to recover more than 20 000 t polyamide fibre agglomerate annually from 120 000 t of used floor carpeting. The contract was awarded by Polyamid 2000 AG; the plant is scheduled to commence production at the end of the year 2000.

USED FLOOR CARPETING COMPLETELY RECYCLED

On delivery to the recycling plant, the floor carpeting will be sorted according to its face fibre (Fig. 4[■]). Carpets that do not contain any polyamide will be shredded and



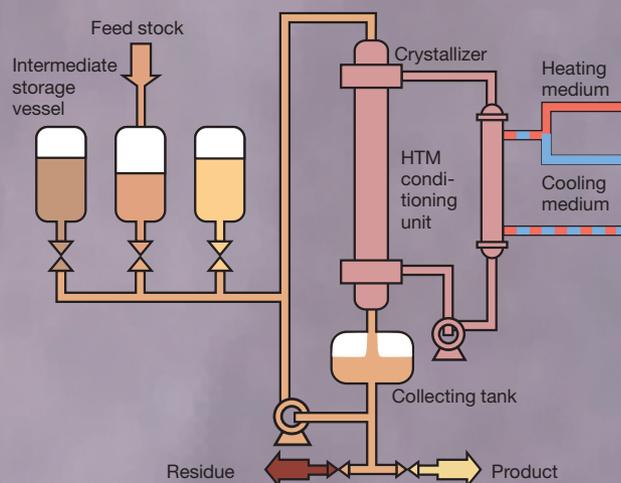
burnt to generate heat energy. The Nylon and Perlon carpets will be separated mechanically into their various constituents, which will then be processed further. The chalk from the precoating and the backing is removed from the system and can be reused by third parties; the other backing material will be sent to the combined heat and power station for incineration: the processing of the PA6 and

PRINCIPLE OF FALLING-FILM CRYSTALLIZATION

Falling-film crystallization is characterized by three phases of operation: At the beginning of the first phase, the collecting tank is filled with molten feed. Both product and HTM circulation pumps are then started. A crystal layer forms in the crystallizer, and the level in the collecting tank falls as the thickness of the crystal layer increases. On attaining the specified level, the crystallization process is halted and the liquid remaining in the collecting tank removed or pumped into an intermediate

storage vessel. In the second phase, the crystal layer is tempered in order to drain off any impurities that adhere to it or are trapped in it. This liquid, also known as partial melt, is collected in a tank and drained off directly or pumped into an intermediate storage vessel as soon as it reaches the specified quantity. In the third phase, the remaining crystal layer is melted off completely. This melt is either the desired pure product or an intermediate product, which is crystallized again in the following stage.

The crystallizer is the key component of the process; it is cooled or heated according to the respective phase.





3[■] The world's first recycling plant for used floor carpeting with every kind of face fibres is being built in Premnitz (DE) and will commence production at the end of the year 2000.

PA6.6 fibres is effected in separate lines.

The PA6 is depolymerized to caprolactam. This is followed by the most important step in the recycling process; the caprolactam-water mixture from the depolymerization is subjected to three-stage distillation and downstream falling-film crystallization. The end product is a high-purity caprolactam which can be polymerized again to PA6 with adjustable characteristics. The structured packings for the distillation and also the crystallizer are supplied by Sulzer Chemtec.

ECOEFFICIENCY BY POLYAMIDE RECYCLING

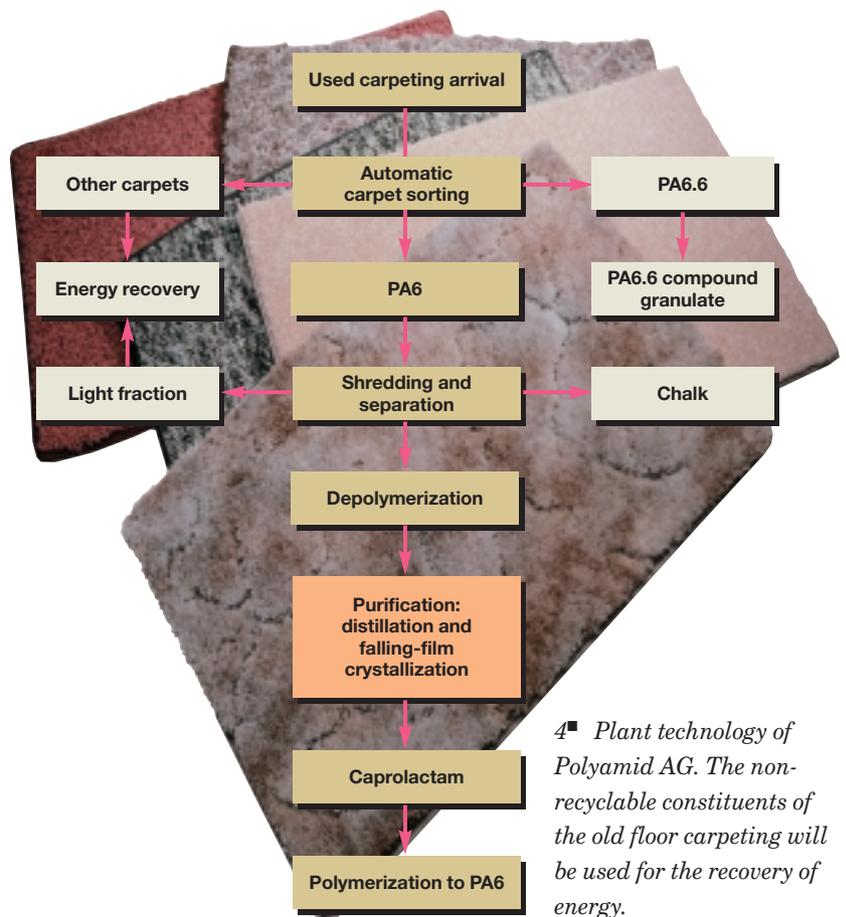
The recycling process must be financially worthwhile. There are various factors that contribute to this in Premnitz. On the one hand, the energy balance is more favourable than with the production of caprolactam from crude oil, because the incineration of the remaining substances and residues provides the energy for the recycling (steam for the depolymerization, surplus steam is converted into electric energy at a neighbouring power station). In addition, no by-products such as solvents and sulfur compounds have to be disposed of. The recycling

operation is conducted in a closed circuit and under the most modern environmental protection regulations: there is no danger of air and water pollution. The 120 000 t of used carpet to be processed annually in Premnitz will yield 10 000 t PA6 granulate for textile applications, 13 000 t PA6.6 compound for technical applications, as well as 48 MWh energy from the incineration process. The price for high-purity polyamide on the world market is relatively high. The 600 000 t

polyamide which could be recovered from all the resultant old carpet worldwide has a market value of about 2 billion DEM. Ω

FOR MORE DETAILS

Sulzer Chemtech AG
 Ali Nikzad
 Postfach
 CH-9470 Buchs
 Switzerland
 Telephone +41 (0)81-755 45 31
 Fax +41 (0)81-755 45 00
 E-mail ali.nikzad@sulzer.com



4[■] Plant technology of Polyamid AG. The non-recyclable constituents of the old floor carpeting will be used for the recovery of energy.