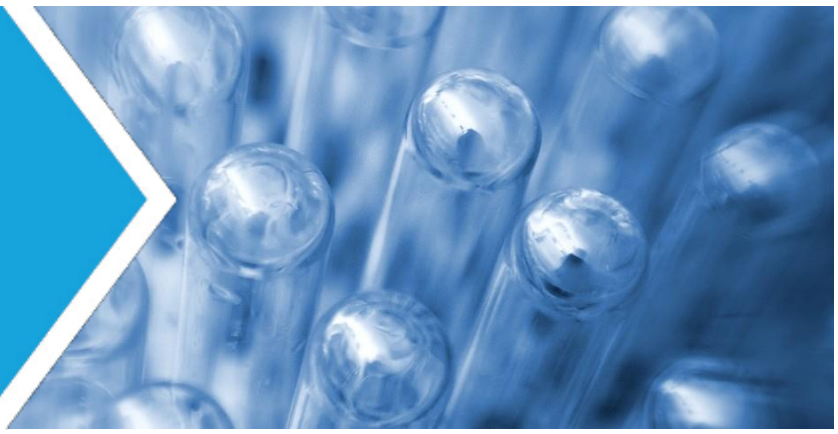
FACT SHEET

Recycling and Recovery of Polyurethanes



MATERIAL RECYCLING

A variety of tailor-made material recycling processes exists for polyurethanes (PU). One fast growing technology is "particle bonding". It uses a high proportion of waste material in the recycled product, in many cases approximately 90%.

Recycling by particle bonding can be applied to flexible foam (see separate ISOPA Factsheet on Comfort Foam) as well as other polyurethanes such as rigid foam. In fact, particles of any PU material can be used. This type of recycling is then often called "adhesive pressing" or "particle composite processing".

High quality material recycling of PU can only be done with a chemical reaction between newly added isocyanate and existing free OH groups within the EoL PU. There are a sufficient number of free OH groups available to bond small PU particles from EoL PU with newly added polymeric isocyanate of PMDI or PTDI type.

Technology

Three different types of material recycling technologies, re-bonding, adhesive pressing and compression moulding are described here.

Description

The re-bonding flexible foam process foam has the following steps: collection and sorting, shredding, coating with adhesive binder, compression to desired density and shape, activation of adhesive binder, curing of adhesive binder and conversion into re-bonded foam parts.

The adhesive pressing recycling route, not dissimilar to the chipboard process, is not only applicable to polyurethanes, like rigid foams or elastomeric materials, but has also proven to be applicable to other post-consumer plastic waste such as waste fibres, paper and scrap rubber. The key to adhesive pressing is the powerful binder, polymeric diisocyanate (PMDI), one of the major polyurethane raw materials, applied at the 10% weight level.

Particle composite processing is making use of dedicated polyurethane systems at an additional level range from about 30% to approximately 70% by weight. It is thereby "dosing the gap" between filler technologies (see separate ISOPA fact sheet: Reuse and Reprocessing) and the adhesive pressing process.

Technology Status

Many different types of re-bonding equipment are on the market depending on feed quality, throughput, batch or continuous operation and article shaping.

Compression moulding technology is capable of producing high performance recycled products from Reinforced Reaction Injection Moulding (RRIM) and RIM polyurethane granules.

PU Specifics

Compression moulded parts are free from internal stresses and display improved heat resistance, sag value and torsion modulus compared to the original material. Good flowability of RIM polyurethanes in the compression moulding
process allows the production of complex shaped

products and high quality flat parts. Acceptable energy efficiency can be achieved through short processing cycles. Compression moulded parts contain close to 100% recycled material.

Important Technologies

Recently, the feasibility of grinding flexible foam to produce a very fine powder, to be added as filler to new foam, has been established and commercialized. The technology is still in the early growth stages. Companies such as technology or equipment suppliers claim that fillers can be incorporated into new foam at a level of up to 15%.

RIM and reinforced RIM polyurethanes are ground into fine particles and subjected to high pressure and heat to generate a material which is ideal for automotive applications. The grinding techniques and compression moulding process need to be controlled accurately for individual applications. While there can be a small reduction in elongation or impact resistance, optimum timing, pressure and temperature can preserve the valuable properties of the original polyurethane. The use of finely ground polyurethane powder in the compression moulding process allows for property recovery of up to 100%.

Input Characteristics

Recycling initiatives have focused on two market areas: production trim from polyurethane processing and polyurethanes retrieved from scrapped car vehicles.

Market & Costs

Although compression molding technology has been developed for polyurethanes, its ability to accommodate a wide range of wastes has helped to support its commercial viability. An additional driving force to use this technology is the desire of some automotive companies to use parts with a high content of recycled materials due to legislative pressure from the end of life vehicle directive. Current processing capacities exceed 10 000 t per annum.

Ecology

Automotive and comfort EoL foam may contain flame retardant products, which are classified as persistent organic pollutants (POP). The United Nations Environment Program (UNEP) protocol allows for the recycling of POP containing substances under certain conditions until a sunset date. These exemptions from destruction of POP compounds have been transposed into EU POP Legislation 850/2004.

Limits

Furthermore, critical issues are the economic value of recycling and exposure to human and health risks. Material recycling is practiced in the EU market in the case of plastics from electrical /electronic applications, but may not be supported by the majority of environmental authorities.

Limits of material recycling are mostly reached by physical substitution ratios as recycled PU does not have the same physical strength as the same article produced from primary raw materials: polyol and isocyanate.

The case of PU carpet padding shows that the requirements of the POP protocol cannot be met due to potential penta and octa PBDE content in the EoL foam and closed loop becomes open loop with significant emissions.

Products

The largest product outlet of material recycling is re-bonded foam. Its relative high density and excellent resilience make it suitable for applications including vibration sound dampening, flooring, sport mats, cushioning, packaging and carpet underlay.

The quality of re-bond depends on several factors like types and grades of the foams used, particle

size and uniformity of the shredded foam pieces, required density of the end product, quality of the binder and binder/foam ratio.

Boards made from automotive parts can have a wide range of properties. Those made from flexible integral skin parts form rubber-like mats, while RIM parts form elastic boards and headliners can be used to make stiff, self-supporting boards.

Conclusions

The European North American flexible scrap foam alliance plays a major factor in the successful, sustainable and flexible PU recycling industry in Europe. A large internal market for scrap trim in Europe does not exist.

References

See Fact Sheet List of References and suggested Reading Material

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