

"Innovative approach to conversion of flexible PU foam residues into polyol on an industrial scale"



Since **1987** H&S is one of the leading suppliers of equipment and technologies for polyurethane processing industry with more than **300** successfully realized projects worldwide.

Our Portfolio



Tank farms for polyol, isocyanate, resins and pentane



Blending stations for mixing polyol
- with additives;
- with CaCO_3



Reactors for generating polyester polyols based on PET, phthalic anhydride and natural oils



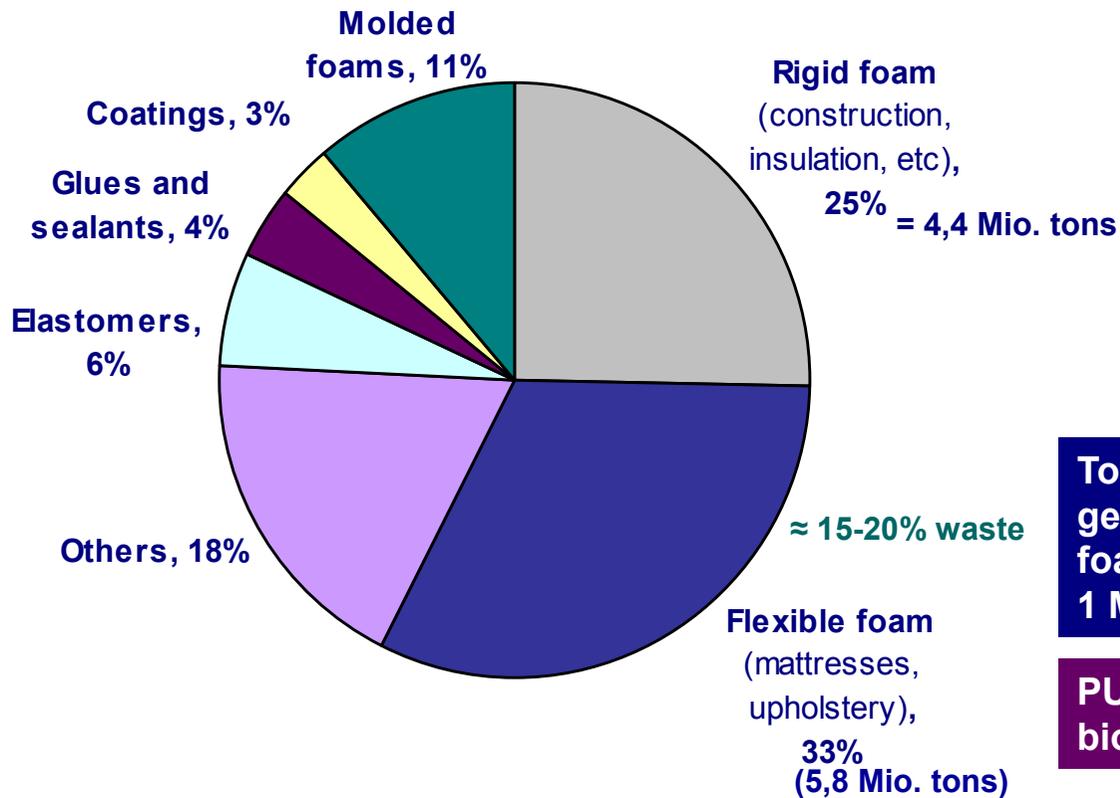
Reactors and technology for polyols recovery out of PU residues

H&S service and support in the field of chemical developments includes:

- testing of the customers PU foam residues
- producing of the polyol samples from flask up to industrial scale in the pilot reactors
- foaming tests and analysis of the physical and mechanical properties of the PU foam
- adjusting the parameters of the polyol according to customers' requirements and specifications
- developing and adjusting of the formulations for PU foam based on polyester polyols and recovered polyols
- comprehensive consultations in all PU issues
- training of the customers personnel by H&S chemists within the framework of common projects
- long-term customer support during presale, start-up and production period



Global situation with rigid and flexible PU industrial residues



Total amount of waste generated during flexible foam production: 1 Mio. tons!

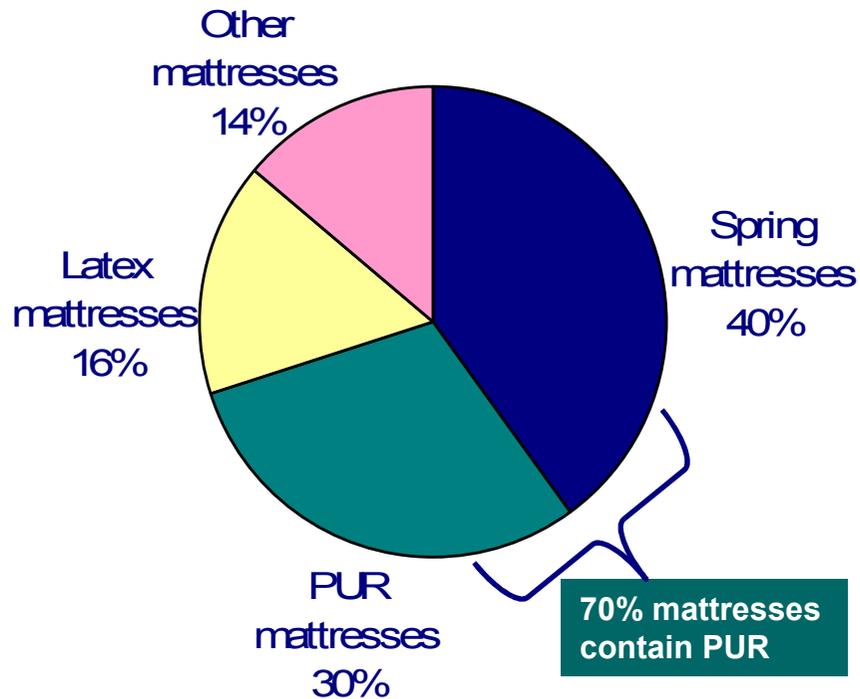
PU waste are not biodegradable !

Global PU production output in 2011: 17,6 Mio. tons.*

* source: PR Newswire

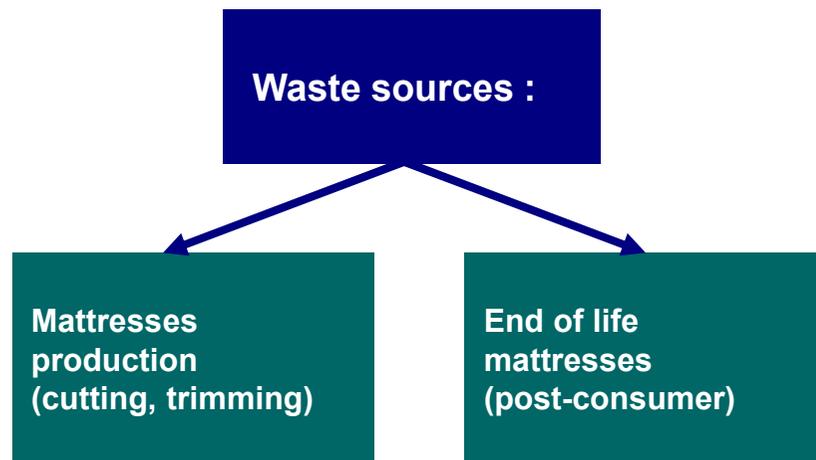
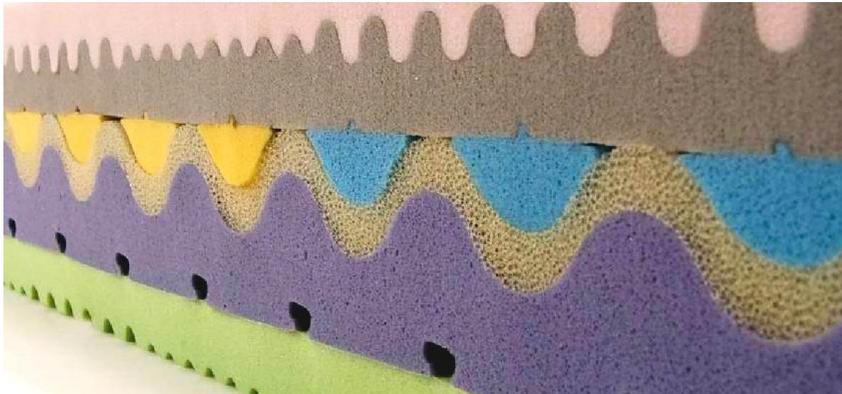
Mattresses market overview

Annual production of mattresses
- in the EU: 68 Mio. pieces
- in the US: 35 Mio. pieces



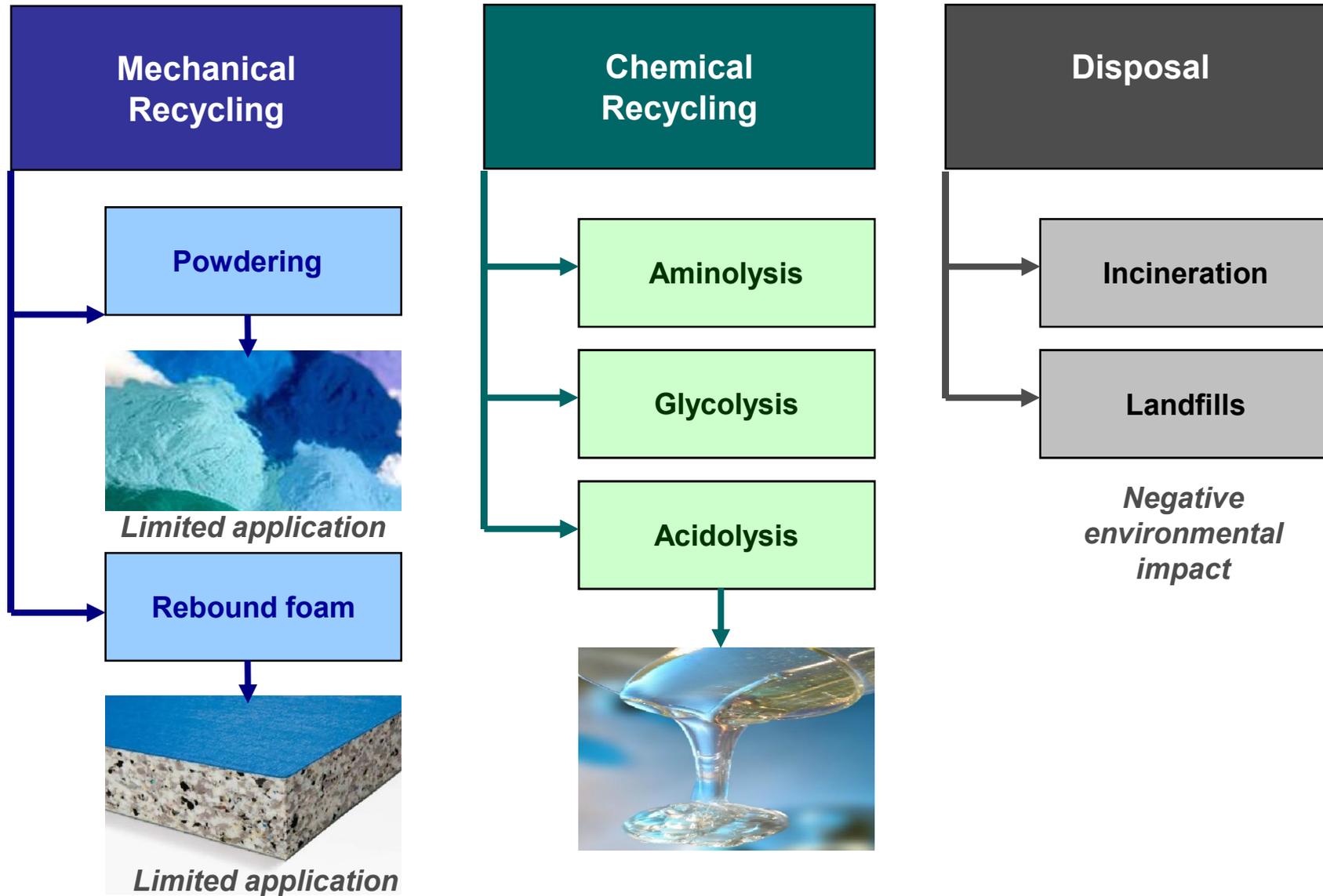
Average mattress lifecycle: 12 years

Mattresses market overview



Environmental impact of mattress life cycles			
Impact	Raw materials	Packaging, transport, site, distribution	End of life
Non-renewable energy	97%	1-5%	-7%
Renewable energy	99%	0-3%	-4%
Depletion of natural resources	97%	1-3%	-5%
Water usage	99%	0-1%	0%
Greenhouse effect	89%	1-3%	5%
Acid rain	100%	1-2%	-6%
Destruction of ozone layer	68%	0-28%	-17%
Aquatic toxicity	4%	0-3%	93%
Human toxicity	40%	0-6%	52%
Terrestrial toxicity	109%	-1-4%	-14%
Hazardous waste	98%	0-1%	-1%
Non-hazardous waste	-4%	0-3%	101%

Ways of flexible PU foam and mattresses recycling



H&S recycling technology for flexible PU foam industrial residues



H&S has developed a technology of generating stable recovered polyols based on an optimized **acidolysis method**.

The final product is a **recovered polyol**, which can substitute a part of the conventional polyol for flexible foam production without quality loss.

Advantages of H&S method compared to other chemical recycling technologies (recovered polyol properties):

- appropriate hydroxyl number for flexible PU foam production
- no blocking of the catalysts reactivity
- good reactivity of the resulted polyols
- no primary aromatic amines



Types of PU foam recyclable with H&S technology

- conventional foam
- conventional foam with filler (CaCO_3)
- HR-foam with SAN polyols

Raw materials



1) Flexible PU foam residues

Clean shredded residues from slabstock production (industrial waste):

- The residues must be free from contaminations of other polymers, paper or metals.
- The foam residues should be separated in case of essential chemical differences, for example MDI and TDI foam, conventional and HR foams, etc.

2) Basic polyether polyol for flexible foam

Molar mass: 2.000 – 6.000 g/Mol
 Viscosity: 600 - 3.000 mPas
 Hydroxyl number: 36 - 56 mgKOH/g
 Water content: < 0,2 %

3) Carboxylic acids

2 dicarboxylic acids

4) Catalyst

Raw materials	%
PU foam industrial waste	40
Basic Polyol	46
Acids	12
Catalyst	2

Process waste:

water distillate, filtrate: approx. 4%

Recovered polyol properties based on conventional foam

Recovered polyol can substitute:

- up to 20% of conventional polyol for production of bedding and furniture PU foam
- higher percentage for technical foams

Quality specification of the recovered polyol generated out of conventional flexible PU foam residues

Viscosity:	4.000 -7.500 mPas
Hydroxyl number:	45 - 49 mg KOH/g
Acid number:	< 1,1 mg KOH/g
Appearance:	viscous liquid of light brown to dark brown color - depending on the color of the foam residues

No primary aromatic amines !

Properties of the conventional PU foam produced with 20% recovered polyol

produced on a continuous slabstock line (example)



	<u>Foam density 23 kg/m³</u>		<u>Foam density 40 kg/m³</u>	
	Master sample (foam without recovered polyol)	Foam with 20% recovered polyol	Master sample (foam without recovered polyol)	Foam with 20% recovered polyol
Resilience, %	42,6	44,3	47,2	48,7
Hardness, [N]	148,75	146,68	167,30	165,46
Support factor	2,2	2,3	2,3	2,2
Compression set (50%)	2,3	2,4	1,88	1,91
Tensile strength, [kPa]	156	152	158	157
Elongation at break, %	241%	238 %	214%	214 %



no toxic emissions (VOC test) !

Flexible PU foam produced with recovered polyol



Mattress produced out of conventional PU foam with 20% recycled polyol.

Repeatable recycling of the flexible PU foam



The recycling process based on H&S technology enables to convert slabstock foam residues into polyol for **at least 20 cycles** without considerable influence on the chemical and mechanical properties of the recycled polyol and resulted PU foam.

PU foam
Nr 1 (initial
pure foam)

Recovered
polyol Nr 1

PU foam
Nr 2

Recovered
polyol Nr 2

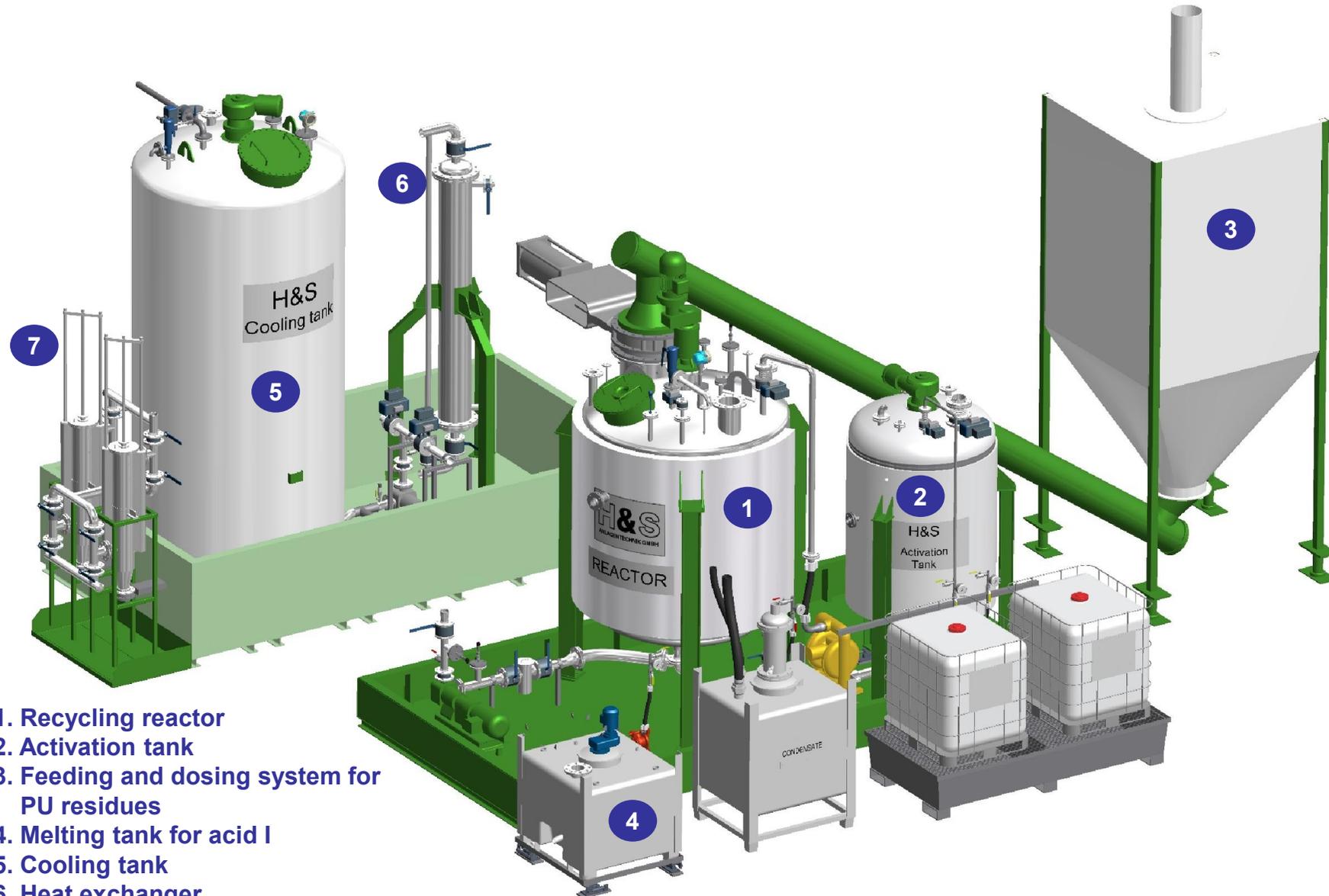
PU foam
Nr. 3

...

Recovered
polyol
Nr 20

PU foam
Nr. 21

Flexible PU foam recycling plant: 3D model



1. Recycling reactor
2. Activation tank
3. Feeding and dosing system for PU residues
4. Melting tank for acid I
5. Cooling tank
6. Heat exchanger
7. Filtration system

Technology in industrial scale

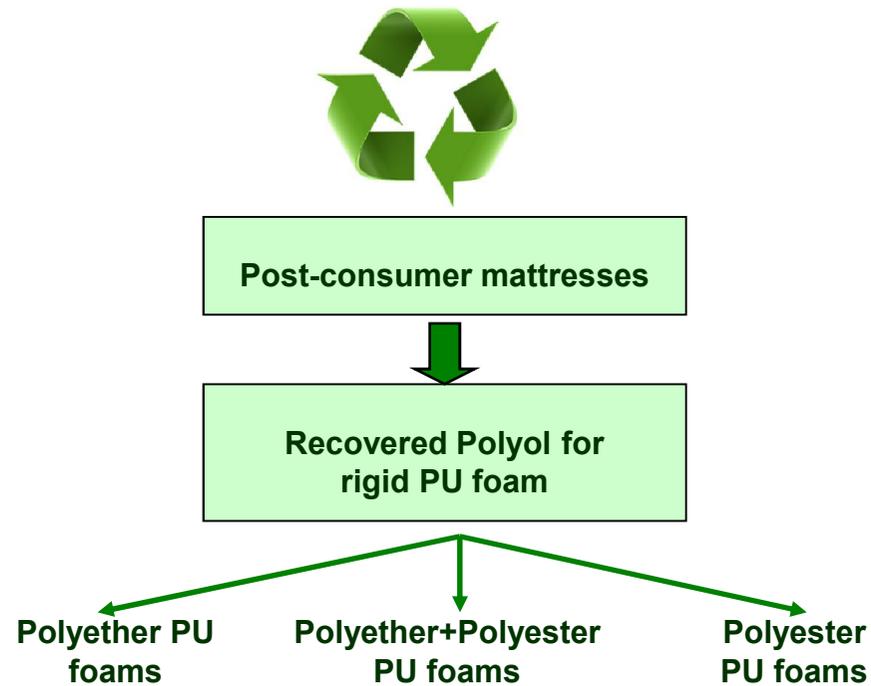


Annual production capacity (example):

5t Reactor – 2.400 t/a

(5 t/batch x 2 shifts = 10 t/day x 250 days/a = 2.500 t/a -4,0% waste = 2.400 t/a of recovered polyol)

Raw materials recovery



Pipes insulation



Shells



Insulating panels



Spray foams

Recovered polyol properties based on post-consumer flexible PU foam



Recovered polyol out of post-consumer flexible PU foam (mattresses) can substitute:
- up to 50% of conventional polyol for production of rigid PU foam

Quality specification of the recovered polyol generated out of post-consumer flexible PU foam for application in rigid PU foam

Viscosity:	5.000 - 20.000 mPas
Hydroxyl number:	50 - 250 mg KOH/g
Acid number:	0,5 - 3,5 mg KOH/g
Appearance:	viscous liquid of dark brown color

No primary aromatic amines !

Conclusions



H&S recycling technology for industrial flexible PU foam residues enables:

1. Reduction of manufacturing costs
2. Excellent quality of the PU foam produced with recovered polyols
3. Perfect solution for industrial scrap utilization
4. Competitive advantage in the market
5. Independence from supply chains
6. Best way of implementing enterprise sustainability concept

H&S development of post-consumer mattresses recycling is targeted to:

1. Reduction of post-consumer PU waste
2. Recovery of polyols for new applications (rigid PU foam)



Thank you for your attention!

Contact information



Headquarters:

H & S Anlagentechnik GmbH
Sandstrasse 19,
27232 Sulingen, Germany

Phone: +49 4271 10 11
+49 4271 66 06

Fax: +49 4271 25 76

e-mail : info@hs-anlagentechnik.de
www.hs-anlagentechnik.de