Special reprint from Kunststoffe plast europe 7/2005

HANSER

Special reprint

Christian Decker, Björn Dormann

Solid Metering for Reactive PU Systems

DESMA TEC

KLÖCKNER DESMA Schuhmaschinen GmbH
Desmastrasse 3/5
D - 28832 Achim
Tel. +49 (0) 4202 990-0
Fax +49 (0) 4202 990 501
E-Mail info@desma.de
WEB www.desma.de

Regrind of cork, calcium carbonate, rubber, TPU and physical blowing agents
(photos: Desma)

Filled PU. A process already established in the textile field is increasingly gaining importance for the industrial manufacture of technical articles. A large selection of fillers extends the applications of the re active processing of polyurethane and opens up scope for new product ideas.

Solid Metering for Reactive PU Systems

CHRISTIAN DECKER
BJÖRN DORMANN

The systems mainly used for the production of polyurethane technical articles are high-pressure reaction casting machines. These machines operate in a many different environments, however they are restricted in the choice of PU systems and flexibility of production. Since 1965, Desma GmbH has been developing systems with a unique mixing technology that differs from high-pressure technology. The wide range of applications of different PU systems – together with the possibility of widely varying the parameters from cycle to cycle and during the shot – offers very high flexibility and cost effectiveness, and thereby forms the basis of special applications.

Translated from Kunststoffe 7/2005, pp. 78–82

The self-cleaning system operates with a high-speed mixing screw, which introduces the kinetic energy necessary for mixing the base components and various additives directly in the mixing head. All the valves are arranged in a plane and thereby ensure a reproducible mixing quality. A patented mechanical synchronised control prevents the premature advance of one component by delayed opening of the complementary valve. This is one of the most important aspects of reactive PU processing, particularly for small articles. Fig. 1 shows the schematic design of the mixing chamber with the mixing screw.

i Manufacturer

Desma GmbH
Desmastraße 3-5
D-28832 Achim/Germany
Phone +49 (0) 42 02/9 90-0
Fax +49 (0) 42 02/9 90-501
E-mail: info@desma.de
www.desma.de

This technology is used both for injecting into the closed mould and for casting into the open cavity. Unlike conventional low-pressure mixing systems, this mixing process features physical self-cleaning and the process does not involve solvent cleaners or cleaning agents. The principle is the result of a precisely engineered mixing chamber and screw, the axial relative movement of these components with respect to one another and the conical design in the front region. The contraction of the space and the screw profile at the end of the injection process cause forward discharge of the residual material in the mixing chamber, allowing the colour or formulation components to be exchanged from cycle to cycle.

The modular construction of the mixing heads (Fig. 2) permits different configurations of two to six components and up to six additives, such as pigments or liquids. The user can add, for example, up to 25 % of an antistatic agent or an admixed physical blowing agent as additive. In comparison to high-pressure system, there is much greater control of the significant parameters during the shot, e. g. the mixing rate, mixing zone, injection pressure and throughput. For example, the possibilities during injection and casting can be considerably widened, and critical materials processed in addition to standard PU systems.

Because solids can be metered directly into the mixing chamber, this technology is particularly important for special applications.

Metering Solid

The mixing head for the direct metering of solids into the mixing chamber is based on Desma's original low-pressure mixing system – enhanced with a radial conveying screw for feeding powder or pellet stock (Fig. 3). The solid is fed to the screw in a dry state and then passes to the plane

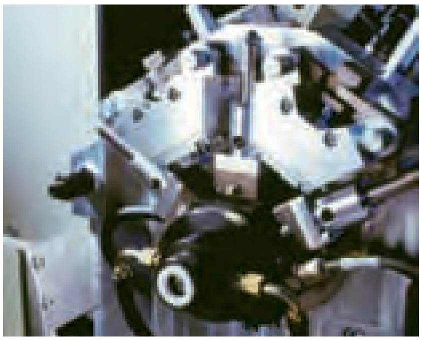

Fig. 2. The mixing head with three component valves and positive synchronisation permits high quality without premature advance of one component

of the valves, where it is mixed with the components and pigments.

In contrast to premixing of pulverised solids in the component tanks, this technology has the advantage that it does not affect the process technology, e. g. the sensitive metering pumps. In addition, the plant operator can obtain much greater proportions of solids in the final product.

From the fact that the amount of filler, like the standard parameters, can be varied from cycle to cycle, this offers great flexibility of producing different articles in direct succession. Since the plant also operates without solid, both unfilled and filled articles can be produced without a production delay. If the mixing head is equipped, for example, for four components and with two additive valves for pigments, the plant can produce completely different PU systems with or without solid in two different colours.

Schematic diagrams

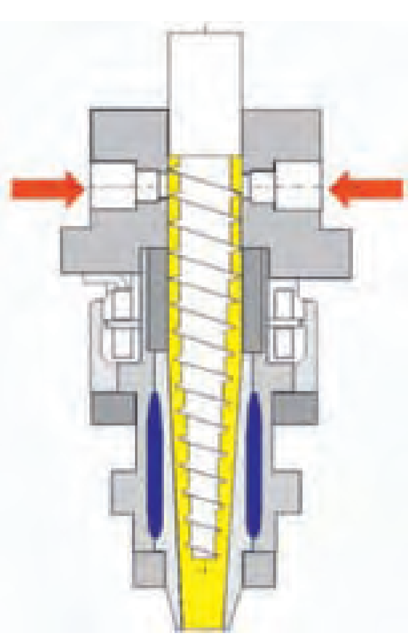

Fig. 1. Construction of the mixing chamber with high-speed screw and valve plane

The maximum solid content is currently limited not by the technology but by the physical properties of the end product. The metered amount depends largely on the density of the filler. Figures 4 and 5 show the weight and volume proportions for cork with a density of 0.1 g/cm^3 and a PU system with a density of 1 g/cm^3. In a range of experiments, the limiting range (No. 6) is reached when some cork grains are no longer wetted with PU and the manufactured product shows defects. The volume proportions in this case are 75 % for cork and 25 % for the PU system; the weight distribution is 75 % PU and 25 % cork.

A test with calcium carbonate and/or cork with a density of 2.8 g/cm^3 provides a different limiting value with the same PU system. The weight proportion of chalk can be increased to over 60 %, which corresponds to a volume proportion of 37 % (Figures 6 and 7). A very hard part is achieved, with high density and excellent surface quality.

Materials and their Applications

A large number of different solids have already been tested. The experiments continually provide new ideas for special applications in which this technology can be used for solid metering. The following classification provides a good basis for the choice of filler:

- recycled materials such as PU regrind or rubber regrind;
- natural additives such as cork, spelt, cherry seeds, walnut shells;
- additives such as barium sulphate and aluminium hydroxide, which affect product properties such as density or flame retardancy;
- fillers that influence processing, e.g. physical blowing agents;

The reasons for choosing a particular solid are various and can be derived from the properties of the additive. The following arguments speak in favour of adding solids to polyurethane products:

- noise reduction,
- reduction of vibrations,
- reduction of fire hazard,
- reduction of weight,
- increase of stability,
- improved haptics,
- reducing the manufacturing and disposal costs,

Solid metering

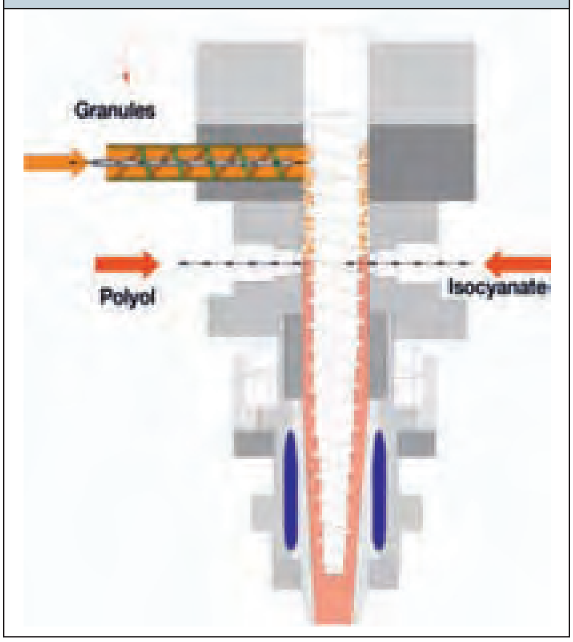

Fig. 3. Mixing head with integrated solid metering

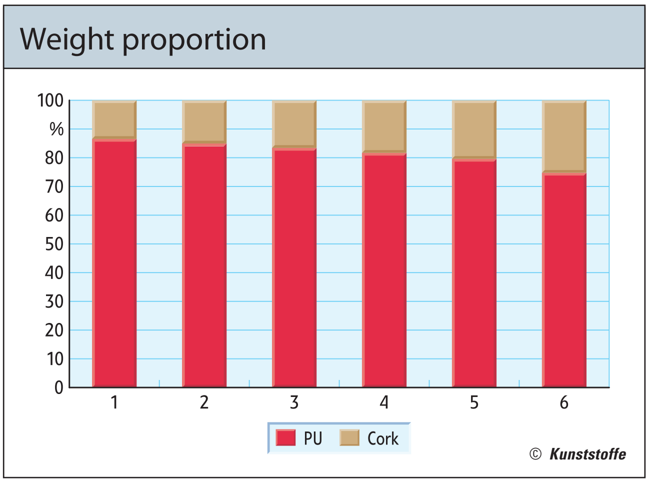

Fig. 4. The limiting range (No. 6) is achieved at a mixing ratio of 25 wt.-% cork and 75 wt.-% PU

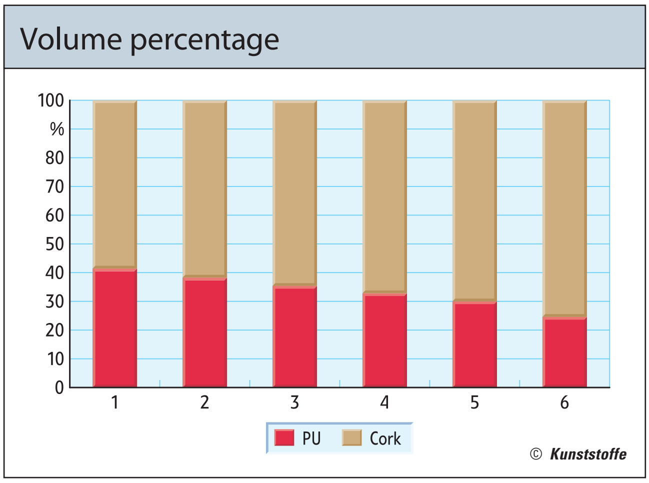

Fig. 5. The limiting range (No. 6) is achieved at a mixing ratio of 75 vol.-% cork and 25 vol.-% PU

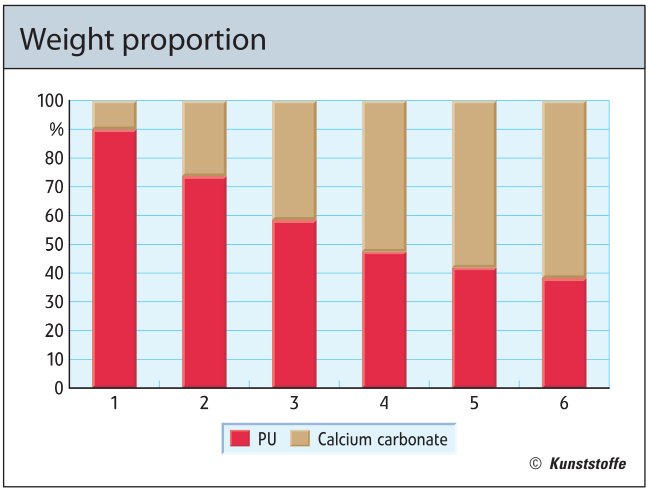

Fig. 6. The limiting range (No. 6) is achieved at a mixing ratio of 61 wt.-% calcium carbonate and 39 wt.-% PU

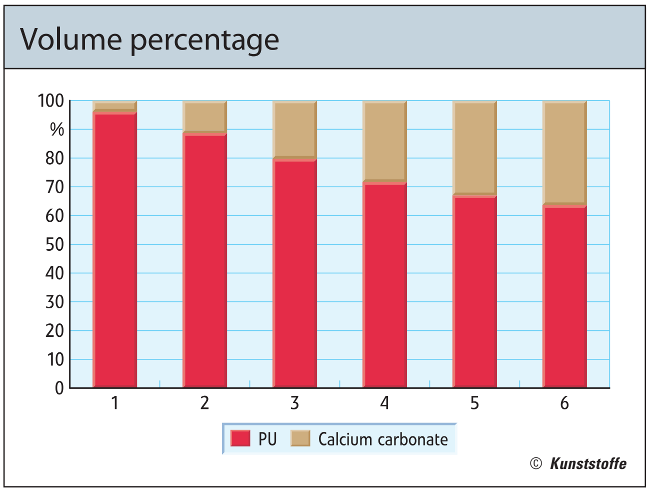

Fig. 7. The limiting range (No. 6) is achieved at a mixing ratio of 37 vol.-% cork and 63 vol.-% PU

- reducing the raw materials consumption,
- design aspects,
- marketing reasons, e.g. in the case of natural materials such as cork.

Cork

Cork is associated with familiar applications such as wine bottle stoppers, orthopaedic shoe soles or handles of walking sticks. Knowledge about the versatility of cork is now so widespread that this natural material is used in many industrial applications such as building, high tech or fashion. In direct comparison to many synthetic substitute materials, cork offers advantages thanks to its typical properties such as, e. g. elasticity, flame resistance, low wear and high insulation against noise, vibrations and heat, and the resulting excellent quality.

The fact that cork can be converted into almost any shape and size makes it so attractive for users. For example, shoe soles (Fig. 8) and handles for bicycles and fishing rods are familiar. A special application is the embedding of tram rails (Fig. 9), which are used particularly in historic city centres, where cork makes an important contribution to reducing the rolling vibrations.

PU Flour

Polyurethane is probably one of the plastics industry's biggest successes. However, the industrial processing of polyurethane, along with many advantages, has a serious disadvantage: waste. All the machinery available on the market produce waste as a result of the necessary cleaning of the mixing chamber, and this waste must be disposed of. The products produced from polyurethane must be freed of flash or excess material. At present, this waste must be disposed of expensively.

This problem can be avoided in the case of many products. If the PU residues are ground up and added proportionally to the polyurethane emerging from the mixing head, the waste is processed into a new product. With many products, this variant does not impair the properties, even when added in a proportion of 15 % PU flour. The shoe industry already makes widespread use of this side benefit. Not only does it contribute to a clean environment but also makes production more cost effective.

Fig. 8. Example of a cork/PU shoe sole with a proportion of 15 wt.-% cork

Fig. 9. The rail bed cast with cork/PU reduces the rolling vibrations of the tram

Rubber Regrind

In view of the constantly growing landfill volumes of waste rubber tyres, the search for further applications for this material is an important undertaking. The waste rubber is separated from the metal components and then shredded and milled. The grain sizes can be varied and the regrind therefore has a wide range of uses.

The regrind or powder can be added to the reactive polyurethane by solid metering and thus serve for producing plastic mats, insulating slabs, shoe soles and other products. Because of the very inexpensive market prices, this raw material has the potential for cost reduction.

Fig. 11. The manually guided casting head ensures high flexibility during production

Barium Sulphate

Natural barium sulphate ($BaSO_4$) is the barium salt of sulphuric acid. The colourless, barely water-soluble powder occurs naturally as barytes. Synthetic barium sulphate is a filler of high purity, offering more advantages than natural barium sulphate. $BaSO_4$ is resistant to high temperatures and light. It is used as a white pigment in artists' colours and coating materials, in thermosets and thermoplastics, as an X-ray contrast medium and generally as a filler in plastics, paper or rubber.

Aluminium Hydroxide

Inert aluminium hydroxide is used, for example, as a solid and is obtained from a sodium aluminate solution. It is widely used in industry as a flame retardant or as an additive in vaccines. It is easily dispersible in water and can therefore be used in dispersion-bound paints and coatings.

An interesting application for aluminium hydroxide is its use as flame retardant. In a fire, aluminium hydroxide liberates water and can thereby remove the heat from the surroundings. The compound is environmentally friendly, halogen-free, non-toxic, and therefore versatile in use. As a plastics additive, aluminium hydroxide is used in automotive and aeronautical engineering, in goods transport and building technology.

PET Flakes

PET bottles and their disposal are part of everyday life. A modern recycling process can produce new PET bottles from used bottles. But the PET bottles can also be reused without recycling. By shredding the PET bottles and precisely metering the resulting PET flakes to the polyurethane just emerging from the mixing head, this mixture is processed, e.g., into splash guards or foot mats for heavy goods vehicles (Fig. 10).

Calcium Carbonate

Calcium carbonate ($CaCO_3$), better known as lime or chalk, is widespread on earth. In the plastics processing industry, $CaCO_3$ is used in conjunction with polyurethane as a filler in the production of seals for sewer pipes or as a potting compound for electrical equipment.

Fig. 12. The robot-guided mixing head operates flexibly and with high productivity

Fig. 10. Foot mat as an example for the use of PET as filler

The Systems

Various system types are available for processing by casting (into the open cavity). The types are currently used in industry:

- manually guided casting head (Fig. 11): for high flexibility;
- casting head guided on a linear axis: for high productivity;
- casting head guided by a robot (Fig. 12): for flexibly and high productivity.

Summary

Solid metering in the processing of reactive polyurethane systems offers a technology that greatly expands the scope of this application. The focus is on modification of the physical properties of the end product. There is an economic advantage from the use of recycled materials from the company's own or external production. The disposal costs that would otherwise occur are eliminated, the proportion of expensive raw materials that make up the cost of the article is reduced, and novel aspects are gained for the technical design, styling and marketing of the PU products. ■

THE AUTHORS

DIPL.-ING. CHRISTIAN DECKER, born in 1967, has been chief department head of development and design at Desma since 2001, with responsibility for complete product development; c.decker@desma.de

DIPL.-ING (FH) BJÖRN DORMANN, born in 1973, has been head of the pilot plant at Desma since 2002 with responsibility for new process engineering developments; b.dormann@desma.de