



Cleaning up after Polyurethane

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The wide variety of polymers and other materials used to produce shoe soles can be divided into five basic types:

Thermoplastics	PVC, TPR, EVA, TPU, POE
Skins	Leather
Sheet material	Rubber, EVA
Pre-forms	Rubber
Reaction moulded	Polyurethane

With most of these the final shape of the sole unit is made by cutting, injecting or compressing a fully pre-formulated and manufactured material. The odd one out is PU where two liquid components have to be mixed using special machines and then poured or injected into a mould. The final polymer and shape of the sole is formed by the reaction in the mould which, in effect, becomes a reactor.

Cutting and shaping sole units from skins or sheet material obviously creates no mould contamination, as there is no mould. Likewise the injection moulding

process used for PVC, TPR, TPU and POE is essentially clean and does not produce any mould fouling. Injection moulding EVA is slightly different as the EVA is cross-linked in the mould after injection and so a degree of fouling does occur. Compression moulding of rubber compounds does lead to some fouling but, again, at a fairly low level. It is true to say that it is possible to run EVA injection and rubber compression moulds and only have to clean them once or twice a year.

The situation with PU is very different due to the fact that a reacting system is being handled. Liquid reacting PU is a very good adhesive that bonds well to most materials, including metals, so the mixing screws in the processing machines gradually become fouled with a build-up of reacted material. To prevent the PU from sticking to metal or epoxy moulds, it is necessary to use a release agent and there is always some inter-reaction between this and the PU that leads to relatively rapid mould fouling. There are,

therefore, two key areas that require cleaning—the mixing screws and the moulds.

Cleaning Mixing Screws

There are three types of machine for producing PU sole units:

- High pressure impingement mixing
- Low pressure with high speed self-cleaning screw
- Low pressure with moderate speed screw.

High pressure impingement mixing machines do not have a mixing screw and the mixing chamber is cleaned by a movable piston after every shot so there is no need for an additional cleaning operation.

Low pressure machines with high speed self-cleaning screws (e.g. Klöckner Desma), have the advantage that after every shot the mixing screw with a cone shape is pushed forward close to the mixing chamber wall in order to ➤

WORLD FOOTWEAR



Mould cleaning with sodium bicarbonate



PU and EVA moulds before and after cleaning



remove most of the excess material. This means that no flushing agent is needed if the machine is stopped. The screw does eventually become fouled and so must be regularly changed every 1-4 hours and cleaned.

Low pressure machines with a moderate screw speed (e.g. Gusbi) are different in that if the machine stops for more than 30 seconds then it is necessary to flush the mixing chamber and screw in order to push out the excess material clinging to the screw and prevent it jamming up. Again, in normal operation the screw becomes fouled and needs changing after 2-8 hours.

So there are two issues here: solvent flushing of the mix heads and—for all low pressure machines—the need to clean the screws after a few hours operation.

Flushing agents

From the early days of PU the main flushing agents were methylene chloride or Genklene. The latter is now banned and methylene chloride, whilst still permitted, needs care in use as it evaporates, adding to the 'solvent to the atmosphere load', which is not environmentally friendly. Alternatives like di-limonene water based systems and low molecular weight polyols have been evaluated to replace methylene chloride and, whilst widely used, are not as efficient. Methods to capture the methylene chloride used during the flushing agent have therefore been introduced by some manufacturers.

If machines are used efficiently, as with the sole moulders in the Marche region of Italy, several flush shots would be needed at the start of the shift when setting the machine up, after which they would normally run for 4-8 hours without further flushing.

To clean the mixing screws when they are badly fouled, it is necessary to use a solvent that will dissolve cured cross-

linked polyurethane and the two commonly used materials are d-methyl formamide (DMF) and n-methyl pyrrolidone (NMP). Both work well but NMP is more widely used as it has a lower toxicity than DMF which is very caustic and great care needs to be taken in its use. NMP is also water-soluble. The cleaning method is very simple and involves soaking them in a bath of NMP for 2-3 hours followed by a vigorous scrubbing to remove any debris, a final wash in water and then drying. This method works for all types of mixing screws.

Cleaning moulds

A build up of deposit on the mould surface from the inter-reaction between the reacting PU and the mould release occurs over time. The rate depends on the type of PU system and mould release being used. However, it always occurs relatively rapidly and soon masks design details in the mould. It is, therefore, necessary to clean the moulds frequently in order to maintain consistent quality. Although most PU moulds are made from cast or machined aluminium, a significant percentage uses metal filled epoxy.

In the early days cleaning material used for metal moulds was DMF but this has fallen from favour due to the health and environmental defects mentioned above. NMP has replaced it and can be used on both metal and metal filled epoxy moulds. As it is necessary to remove both the build-up on the mould surface and any excess mould release, the NMP is normally mixed with a solvent and the mould cleaned in exactly the same way as for mixing screws. It is then re-coated with a heavy layer of mould release before returning to storage or production. Whilst this method works extremely well, it is labour intensive and uses a large amount of expensive

NMP/solvent mixture.

Mechanical methods have, therefore, been developed to clean moulds on the principle of light shot blasting assisted by air or water. Early versions used a range of abrasive materials which all had to have the ability to remove the debris without abrading the mould surface and included such oddities as ground walnut shell. Recently, there has been a strong move towards more environmentally friendly materials and the current choice of abrasive is sodium bicarbonate—which is a safe, environmentally friendly product that is also soluble in water. Two of the leading companies supplying equipment for sodium bicarbonate mould cleaning are BICARjet S.r.l. and STS Srl.

BICARjet

BICARjet is a joint operation between MAINECO and the multinational Solvay group, a producer of sodium bicarbonate. Using their extensive technical knowledge they have developed a wide range of efficient cleaning solution systems that will not damage the surface of many types of material, including aluminium, and so are an ideal medium for cleaning footwear moulds.

The blasting technology is based on three factors:

- Low pressure compressed air (< 8 bars)
- Water
- NFMUSPO, a specific grade of synthetic sodium bicarbonate

It also offers many advantages:

- Delicate treatment of a very wide range of surfaces
- Lower cleaning operation time
- High level performances and results
- Controlled blast media consumption
- Easy-to-use and versatile equipment
- Environmentally friendly cleaning

solution non-toxic and non-hazardous for people

The left-hand photo opposite shows how the blast of sodium bicarbonate is used to clean a mould. It is normally carried out inside a glove box as in the right-hand photo.

STS

This company has developed its own system for mould cleaning based on sodium bicarbonate bought from Church & Dwight. They offer an interesting package of all the units required for mould cleaning in a machine called the SoleBox, shown on page 37.

SoleBox is specially designed for soft cleaning of moulds and for the most efficient removal of debris and residual materials from PU, EVA and Rubber moulding operations. It is equally efficient when used with moulds made of aluminium, steel or other materials. Due to the softness and friability

characteristics of sodium bicarbonate, it disintegrates on impact after working. The substrate is not damaged and keeps both its brightness and surface finish for a long time. Sodium bicarbonate can, therefore, only be used once and creates a heavy dust-load compared with other media.

SoleBox is one of the few systems capable of working with a special filter and pre-separator unit that guarantees good visibility inside the cabinet and long term, problem free operation. Its features include:

- A cabinet equipped with a blast hose and nozzle, air gun, large door with inhibitor switch, pedal control for the delivery unit and large window with an 'inlet air-knife' for good visibility
- A switchboard providing simple control units and indicators for all system functions
- A delivery unit supplying constant

and precise quantities of the blast media

- A high efficiency pre-separator cyclone that removes 93% of all used media and dust, and ensures long term filter capacity
- A cartridge filter unit with automatic reverse air pulse cleaning and monitor gauge for problem free operation (clean air is emitted)
- Hoppers with butterfly valves and plastic waste bags for the simple disposal of used media and dust

The efficiency of the process is shown in the three photos opposite featuring respectively PU, Rubber and EVA moulds before and after cleaning.

Therefore, whilst polyurethane due to the nature of its processing is unique in its need for cleaning, many simple and efficient methods are now available to cope with all the demands of the production system. 



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