

The past few years have seen an increase in the size of footwear ranges but a reduction in volume per model or colour. This has led to higher production costs and increased customer influence on the design of the final product. The problem for manufacturers is how to increase flexibility while controlling costs. One such problem is that of colour changes when moulding TPU.

Quick colour changing for TPU

The easiest colour change method is to use pre-coloured granular material for direct processing without any additive. This can either be pre-mixed masterbatch direct from the supplier or self-made with tumbler or large mixing bins. A more advanced method is to colour the material directly at the machine with solid colours (Figure 1).

The same principle can be applied with liquid colours but using a different type of pump (Figure 2). The unit shown here is designed to pump up to 5% of liquid colour directly into the feed hopper.

The amount of colour added depends on the type of dosing. The following standard values for TPU can be taken as a good general guide:

- Colour granulate 1.0 to 4.0%
- Colour paste 0.5 to 1.0%
- Colour pigments 0.2 to 0.5%

Existing techniques, however, waste both time and material, as all material feed units filled with one colour must be emptied before the process can restart with a fresh one (Figure 3).

If the masterbatch method is used with either solid or liquid colours the whole injection unit has to be cleaned, from the hopper feeding the screw through to the injector nozzle itself. Special cleaning granules must be used for a totally effective clean, and these are expensive. Any residual colour will be visible in early mouldings of the next colour as thin stripes or areas of shading.

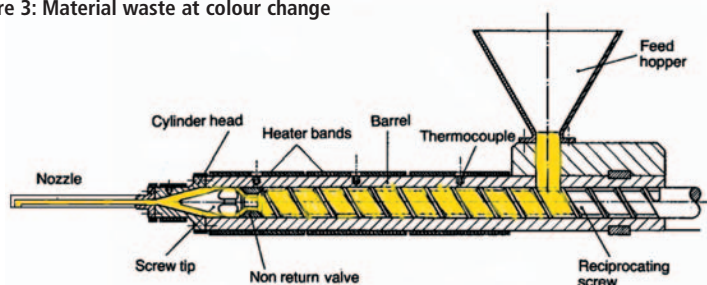
Figure 1: Dosing unit for colour granules



Figure 2: Dosing unit for liquid colours



Figure 3: Material waste at colour change



Cost factors

The time wasted is also an argument for less optimised colour changes as the interruption to production also costs money. Today's thermoplastic moulding machines do not need

operators for normal running. But, at colour changes they do, and this further cost can be added to approximately 30 minutes downtime. A rough calculation shows what the cost impact can be (Figure 4).

Figure 4: Estimated cost per colour change (US dollars)

Lost material (TPU)	8kg @ \$4.00 per kg	\$32.00
Cleaning granulate (CG)	10kg @ \$3.00 per kg	\$30.00
Time lost / operator cost	30 min @ \$50.00 per hr	\$25.00
Production loss	6 parts per minute	180 parts total
Cost of waste (TPU)	8kg	\$8.00
Cost of waste (CG)	10kg	\$10.00
		\$105.00

The total of \$105.00 plus loss of 180 parts is purely an indication. If colour changes are made once a day on one machine working 220 days per year, the total loss could be as much as 36,000 parts and about \$23,100. However, there are some soft factors that cannot be calculated directly. Quality of change is dependent on the operator and human factors can never be fully quantified. On the other hand, quality will not be as consistent as demanded.

Twin injection

There is an alternative—a second injector. This is a good solution if colours are relatively limited and an injector is able to have a fixed injection time. If the latter cannot be guaranteed, the material itself would in any case vary due to variable heating and waiting time between individual shots. If this can be achieved, production will be smoother—but at the initial cost of two injectors.

Colour limitation can be resolved by using an injector for each colour. Desma technology can now effect up to four colours through two injectors. This is cost effective in terms of productivity, less material waste and other ancillary factors.

Colour injection

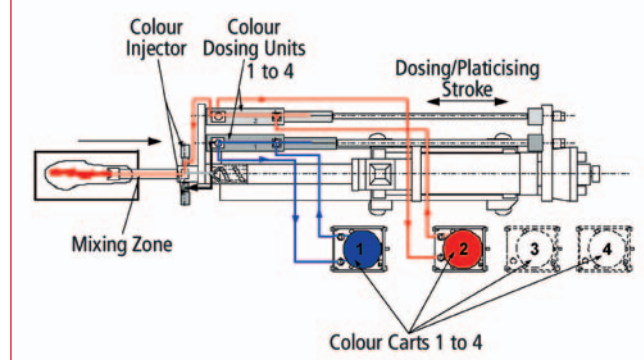
The principle is based on colour dosing at a point closest to the mould cavity. Preparation of the neutral thermoplastic colour material is done in the normal manner via a special 24D/65mm screw to provide smooth heating and plasticising. While the material can be injected with conventional technologies, the DESflow principle where it is cast on to the bottom plate of the open mould cavity, appears to work extremely well (Figure 5).

Figure 5: Casting by the DESflow process



The actual injection is performed by a patented unit which delivers an exact dosing of the additive. The colour is injected into the hot thermoplast after plasticising so that the two phases inter-mix (Figure 6).

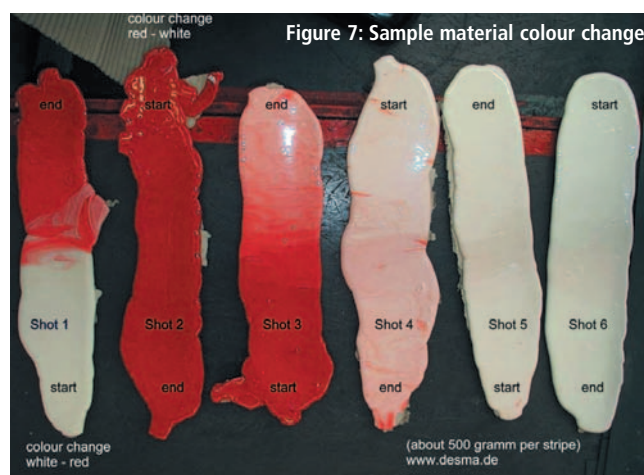
Figure 6: Diagram of the colour-dosing device



The colours constantly recirculate within the system in order to remain stable. The colour injector in the nozzle area is able to resist the strong pressures during TPU injection and the colour-dosing stroke is coupled to that of the TPU to guarantee an exact amount of colour. The resultant mix is cast into the open mould via the nozzle at the end of the injector.

The amount of included material within the mixing and nozzle zone behind the injector is about 200gms, which reduces rinsing to a minimum and results in less waste and downtime. The latter depends very much on the capacity of the injector. A standard 65mm diameter injector takes from around 20 to 240 seconds.

With careful control of the necessary part volumes, it is possible to reduce overall material loss to between 250 and 400gms depending from which colour the change is made. White to red indicates a level of around 350gms, while the other way round, it becomes about 1500gms due to the inherent strength of red pigment (Figure 7).



This shows the colour change from white to red and then from red to white. Each strip weighs approximately 500gms and requires about 15 seconds to be cast. The change of these two colours is extremely critical. Standard colours such as black, brown and dark green, etc, are far less so and can be changed at greater speed and with less waste. Whatever the colours involved, this new injection technology is yet another advance in footwear manufacture.

All images courtesy of Klöckner Desma Schuhmaschinen GmbH