

Mixing Thermoplastic Compounds and Masterbatches

by Pravin Mistry - [PREA](#)

Following from the previous article on formulations:

Firstly, we need to know the difference between Compound and Masterbatch/ Concentrates:

- Compound is compounded as a whole and purchased ready to use straight away 'as is.'
- Whereas a Masterbatch is a pre-dispersed colour or additive concentrate that is let down with natural polymer in ratios from 1 to 5 %.

There are different ways of mixing thermoplastics for compounding (Compounds & Masterbatches / Concentrates). The choice of blender type and size are many and varied, the most common being Tumble, Ribbon or High-Speed Blenders. Blends can be as little as 25kg to 5 tonnes plus, depending on the size of the blending vessel being used, though typically they are sized to make between 100 to 500kg batches.

Most Compound blends involve pellet feed and contain pigment levels of less than 1% and these are often made in Tumble or Ribbon blenders because they do not normally need high speed mixing to develop or homogenise the blend.

Masterbatches on the other hand, because they have pigment loadings of up to 70% and are usually made using powder polymers, need high speed mixing in order to develop and homogenise the pigments within the blend.

Mixing can take place off line or on line. Both – (Compound & Masterbatch) are considered batch procedures where materials are mixed with polymer (in powder or pellet form) with the additives e.g. colours, fillers etc. These can be just single blends or multiple blends depending on the size of the production order and the blender capacity.

- Off line blending is where the materials are mixed independently in a suitable mixer away from the extruder. Once the blend has been mixed it is dropped into a bowl or other container which is then taken to be loaded into the extruder hopper. An advantage of this method is that you can make a few batches and then extrude later in the day or shift. A disadvantage is that if you leave the blend to stand for too long sometimes the heavier materials within the blend can start to sift down through the blend leading to an inconsistent mix.
- On line blending is where the mixer is placed above the extruder. The blending takes place in 'real time'. An advantage would be that it is a fresh mix with no time for settlement and a disadvantage would be that you have to keep up with the extruder and timing is essential.

We have named a few disadvantages and advantages, and there are more, however each manufacturer has their own preferences.

Mixing/blending techniques

Typical of the industry, for compound we recommend that you:

- Add all of the resin.
- Add a binding agent (usually a food grade mineral oil) close mixing and mix for around 2 minutes if using a high-speed mixer or around 20 minutes if using a tumble or ribbon blender.
- Add the pigments, additives and dispersing aids (some additives may need to be added nearer the end (see note below) close mixer and re-spin for 3 to 5 minutes if high speed or 20 minutes if tumble or Ribbon blending.

Note; Some additives like Antistatic or Slip additives have a low melting point of 30 to 60°C and high-speed mixing can generate temperatures in excess of this, and if this happens the blend can become very lumpy and difficult to feed, so care must be taken to avoid this problem. Normally these types of additives are added later than the rest of the components and the speed of the high-speed blender is lowered to avoid generating so much heat. This problem does not occur in tumble or ribbon blenders as the blend speeds are much lower.

- Compounds unless heavily filled are normally processed on a single screw extruder because less shear is required and single screw extruders are much easier to clean and are far less expensive than twin screw extruders.

Typical of the industry, for masterbatch we recommend that you:

- Use a high-speed mixer rather than Tumble or Ribbon though these can be used if there are pigments or additives that can be damaged by too much high-speed mixing.
- Use powdered polymer and a small amount of Pellet feed normally around 5 to 10% of the total weight.
- Add the around 50% of powder polymer to the blend then add all of the pigments, additives and dispersing aids, then add the rest of the powdered polymer and pellet feed.
- Close the mixer and spin on high speed typically for 3 to 5 minutes. (the speed and time of the high-speed mixers can be pre-set once a successful blend technique has been determined)
- Examine the blend if the colour looks consistent and there are no large lumps of undispersed pigment then the blend is fit to go to the extruder, if there are signs of lumps or inconsistency respin for a further 2 or 3 minutes until these inconsistencies disappear. Though it should be noted too much mixing can damage certain pigments and adversely affect the dispersion of the blend.
- Most masterbatch formulations need high intensity mixing that can only be achieved on a Twin Screw extruder, Continour Mixer or Banbury mixer. Without this high intensity mixing the pigments within the formula might not develop to their full potential.

Testing of the blends

When these blends are due to run on the extruder, they can be pre-tested within the laboratory or ran directly onto the production line. These can be 'test, or 'no test 'mixes.

If pre-tested in the laboratory, the laboratory extruders must have good correlation with the actual production extrusion lines; otherwise, the colours can develop differently. Accurately pretesting blends within the laboratory allow all the blends to run without delay straight onto the extruder lines, this is considered to be the most efficient method if done correctly.

To assess the quality in the case of Compounds the mixed blend is often tested in the lab straight into an injection moulder or two roll mill and the colour, is checked for accuracy either visually or using a spectrophotometer.

For masterbatch formulations the blend is first run through a small twin screw extruder prior to testing on the injection moulder at the specified addition rate. If the colour is okay it is passed, if not the formulation has a modification, is re-blended and tested until the correct result is achieved.

Sensitive formulations that have historical processing problems always undergo a test at the blend stage.

Advantage - You are not holding up an extruder for long periods of time.

Disadvantage - If it is online mixing or off line, and production are waiting to process the material, there can be some downtime in production and on occasions the pre-test does not give the same expected shade as the plant extruded material, meaning a rerun and correction of the blend will be necessary.

If the material is going to be run directly onto the extruder it's not unusual as a procedure for a small sample to be first dropped out of the blender to be run through the production extruder line as a pre-check; only if the colour is right does the rest of the blend get extruded. If the colour needs adjusting then the blend is re-spun with a correction and the process is repeated until the colour is judged to be acceptable.

Once a good reliably consistent formulation has been established most companies take a view that pre-testing the material out of the blender using the production line is too time consuming and skip this pre-test. This blend consistency can only be achieved if the blend conditions remain exactly the same as well as the consistency of the pigments and that the weighing of the correct components going into the blend is always done accurately.

Another point to mention here is that from the previous article when formulating compounds, what works in the laboratory does not always work first time in production. Hence there are always a lot of tweaking and hand holding done by the laboratory and process engineering. More and more new mixers are coming onto the market from small batch operator – friendly, to completely automated systems. In addition, mixers are easier to clean down so there is less downtime.

When multiple blends are involved it's sometimes necessary to homogenise the total quality to better improve the colour consistency after the extrusion process. This is usually done if the colour variation is considered to be too extreme within the batch to satisfy the end customers 'needs. The homogenisation is usually done in Tumble or Ribbon blenders though high-speed mixers can also be used.

It's also worth pointing out that sometimes the manufacturing company prefers to add the components used within the formula directly on line either through separate side feeders as is often the case with large percentages of fillers and pigments like titanium dioxide, or by using gravimetric or volumetric feeders positioned directly above the throat of the extruder for smaller quantities. Some extruder lines have up to 8 feeders which can add quantities of less than 1% or up to as much as 80% depending on the size and type of the feeder equipment or side feeders being used.

This method of manufacture is less labour intensive and for large production runs is often preferred though the calibration and maintenance of the feeders as to be maintained at the highest level in order to ensure the right quantities of each component are being added.

Customers normally choose to go the masterbatch route because they save money and have better control of their feed stock.

Purchasing 20 tonnes of a coloured Compound means customers have to pay the manufacture for each tonne processed which tends to vary from anything between £400 per tonne to £1200 a tonne which is quite an expense. If however customers can use a 1% masterbatch then they will only be paying for 200kg of masterbatch production costs the rest of the 19,800kg will be their own natural base polymer.

Another advantage of using masterbatch is lower stock holding leading to less risk of high volumes of redundant compound colours being accumulated.

The only disadvantage of going the masterbatch route is usually in the colour accuracy or possible streaks in the mouldings where the masterbatch has failed to disperse correctly. Sometimes on older injection moulding machines, the masterbatch cannot be incorporated as uniformly as it should be and, in these cases, it might be necessary to go the Compound route.

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