Application Note
LR-69

Mixer tests on MIM feedstock and blends with reground sprue to determine the optimum mixture for the injection moulding process

Bernd Jakob, Thermo Fisher Scientific, Material Characterization, Karlsruhe, Germany

Abstract

In the MIM process especially for small parts the amount of sprue is significant high. To minimize waste the sprue is reground and blended with virgin feedstock. This is only possible to a certain amount because with higher sprue content the demoulding of the green parts is not possible anymore without damage to the parts.
Using a torque rheometer with a small batch mixer is an approach to distinguish between virgin feedstock and reground sprue. In a next step different blends of virgin feedstock with reground sprue are tested to determine the maximum amount of waste for the blends.
The rheograms (mixer curves) of virgin feedstock and reground sprue are significant different. Rheograms of blends of virgin feedstock and reground sprue shift with increasing amount of reground sprue from the curve of the virgin feedstock to the curve of pure reground sprue. The mixer test performed at process temperature is a useful method to determine the optimum blend to avoid defective green parts.

Powder / binder ratio

An important factor regarding feedstock characteristics this ratio is the most important. There are three categories that one may fall into concerning this ratio:

1. Excess binder – Too much binder will separate out during debinding and cause slumping and other inhomogeneity in the final component.
2. Excess powder – Too much powder results in a material with trapped air pockets and a very high viscosity. The high viscosity hinders processing and prevents proper mold fill. The air pockets cause cracking in the product during debinding.
3. Critical solids loading – This occurs when all the powder particles are packed as tightly as possible with binder occupying all voids. Most companies use a powder: binder ratio slightly less than the critical solids loading to ease molding while maintaining product quality.

Fig. 1: PolyLab OS with mixer

To easily find the critical solids loading, one should use a lab-scale batch mixer attached to a torque rheometer (Fig. 1).

The binder mixture should be added to the mixer first. After the torque stabilization, the initial solids loading should begin, keeping a constant mixing speed for the rest of the test. Enough of the metal or ceramic powder is added so that the mixture is still easily processable, and close to, but

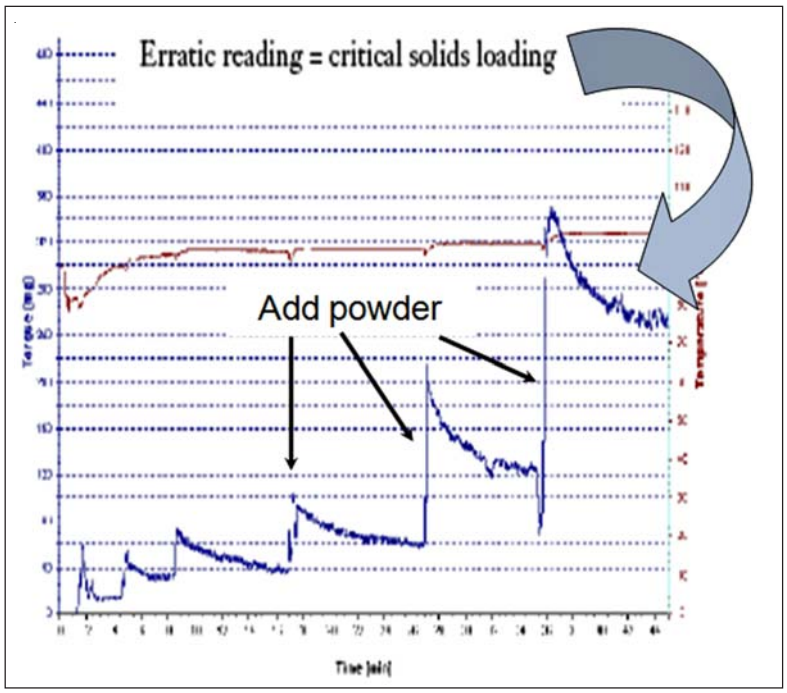

Fig. 2: Critical load of powder

under the critical solids loading (feedstock are usually between 45-75% solids, so if there is no idea of where the critical point is, bring the solids to the maximum load). The torque reading is allowed to stabilize once again. After this, powder additions are made in small steps.
After each step, watch to see if the torque reading reaches a stable value. If the reading becomes stable, the next step is added. If the torque reading becomes very erratic, the critical solids' loading has been reached. A typical graph of such a test is shown in Fig. 2.

Fresh and regrind feedstock sample

In the MIM process especially for small parts the amount of sprue is significant high. To minimize waste the sprue is reground and blended with virgin feedstock. This is only possible to a certain amount because with higher sprue content the demoulding of the green parts is not possible anymore without damage to the parts.
Mixer test have been conducted with fresh and reground feedstock at the process temperature of 185 °C of the injection moulding process. For the test roller rotors were used. The speed was for all tests 40 rpm. In Fig. 3 a rheogram of a reground feedstock sample is shown. The mixer test was performed twice each with new material of the same batch. Displayed is the torque and temperature curve. The repeatability is excellent.
In a next step two fresh feedstock samples of different batches have been tested under the same conditions see Fig. 4.
The two samples are different but as longer the test runs the they come to the same level – they have the same viscosity.
When now the fresh and reground samples are compared in Fig. 5 it is obvious that the reground sample is significant lower in torque / viscosity.

Conclusion

A simple mixer test is suitable to distinguish the feedstock. Further tests have to be carried out to determine how much reground material can be blended to fresh feedstock and still give good green parts.

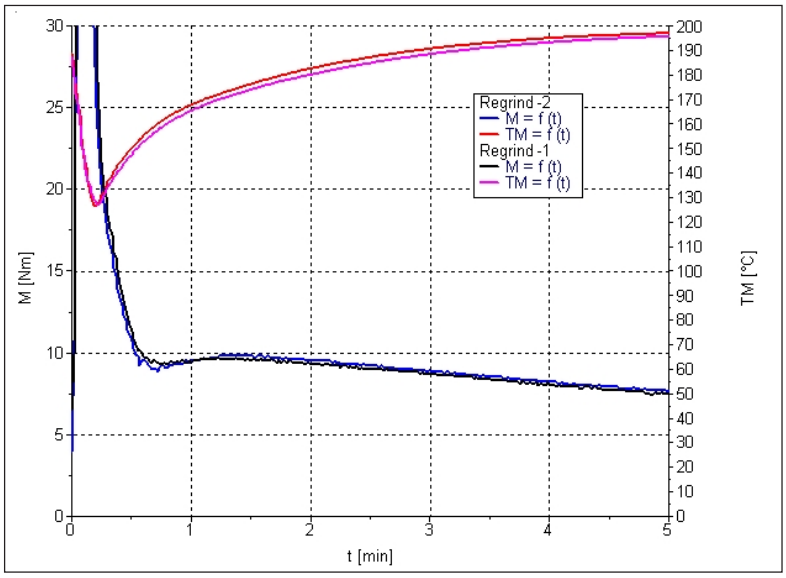

Fig. 3: Repeatability of reground feedstock

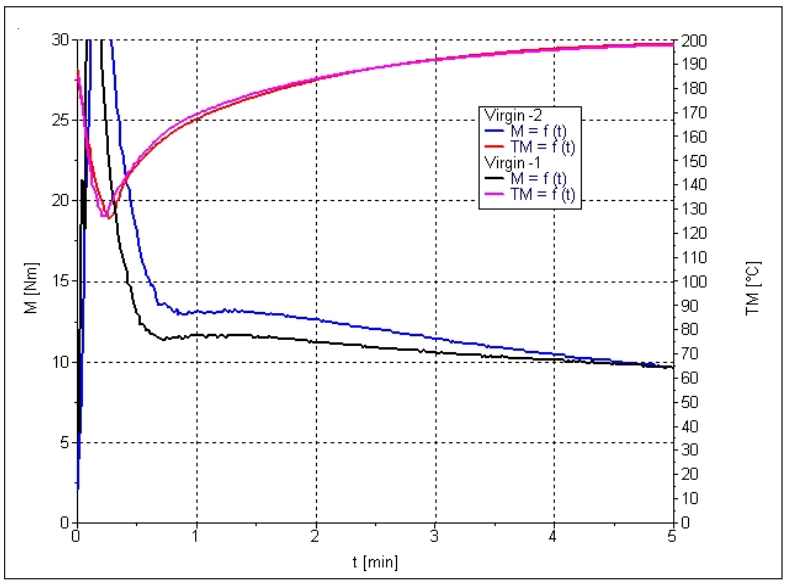

Fig. 4: Two different batches of fresh feedstock

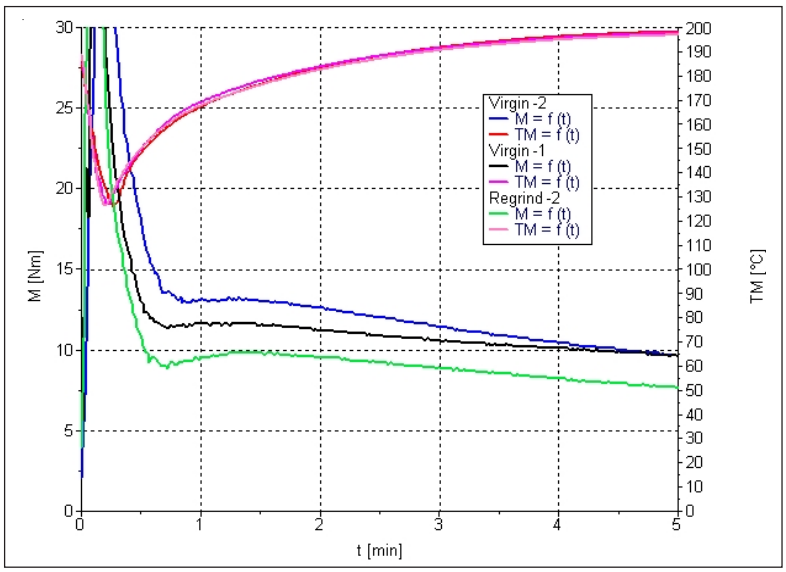

Fig. 5: Two fresh and one reground feedstock sample

Material Characterization

International/Germany
Dieselstr. 4,
76227 Karlsruhe
Tel. +49(0)721 40 94-444
info.mc.de@thermofisher.com

Benelux
Tel. +31 (0) 76 5 87 98 88
info.mc.nl@thermofisher.com

China
Tel. +86 (21) 68 65 45 88
info.mc.china@thermofisher.com

France
Tel. +33 (0) 1 60 92 48 00
info.mc.fr@thermofisher.com

India
Tel. +91 (20) 66 26 7000
info.mc.in@thermofisher.com

Japan
Tel. +81 45 453 9167
info.mc.jp@thermofisher.com

United Kingdom
Tel. +44 (0) 1606 54 81 00
info.mc.uk@thermofisher.com

USA
Tel. 603 436 9444
info.mc.us@thermofisher.com

www.thermoscientific.com/mc

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