Datapoint

Reporting on developments in material properties for engineering design

STRUCTURAL ANALYSIS

New *TestPaks* for MF/Stress allow FEA of injection-molded components

A major challenge faced while doing finite element analysis (FEA) of injection-molded components is the transfer of actual geometries of the molded part from the mold analysis program into the FEA simulation. Moldflow's MF/Stress, combined with new *TestPaks* from DatapointLabs, now present an elegant solution for such analyses.

Following a filling analysis, MF/Stress can read in a .PR0 file, which contains the geometry of the molded part. If the material is isotropic, non-linear FEA can be performed to determine the performance under static conditions of the component. The input material properties are generated using the MF/Stress Isotropic Materials *TestPak*. This *TestPak* contains all the properties needed to run the analysis. The *TestPak* can be requested at non-ambient temperatures to permit simulations at the desired high or low temperature.

For the structural analysis of fiber filled materials, the procedure is similar; however the input material properties are different and the MF/Stress Anisotropic Materials *TestPak* is needed. Here, properties are generated in the two major principal directions. As before, simulations can be performed above or below room temperature with the appropriate test data. (Materials are assumed to be symmetric in tension and compression.)

For the analysis of creep, isotropic stress-strain curves are input into the program using the MF/Stress Creep *TestPak*. With this data, simulations of long term performance can be made.

All of the above *TestPaks* are available exclusively from DatapointLabs.

FOCUS:
Injection Molding CAE

Injection molding simulation has evolved greatly since its inception 25 years ago. As the tools become more powerful and accurate, their reliance on precision input material properties increases. It becomes a challenge to provide such inputs while keeping costs under control.

In this issue, we discuss the no-flow temperature, its importance and improvements based on current technologies.

Also highlighted are new *TestPaks* for CADMOULD, PlasView, BlowView, FormView and TXS - CAE programs from three new members of DatapointLabs' *TestPaks* Alliance Program.

Finally, our address has changed slightly. Please note our new address on page 3.

DatapointLabs launches expansion into new facility

Mechanical, rheological, and thermal analysis laboratories in the new facility (clockwise from top)

ITHACA, NY: Aug. 27, 2001- DatapointLabs launched an expansion into a new facility to accommodate its growing line of test instruments. The new facility is composed of four laboratories. The mechanical test lab is a new, climate controlled area housing the universal testing machine, impact testing machines, fatigue and creep machines. A new rheological test laboratory contains the DMA and capillary rheometers as well as the thermal conductivity and HDT testers. The separate thermal analysis laboratory houses a complete Perkin Elmer suite of differential scanning calorimeter, dynamic mechanical analyzer, thermo-mechanical analyzer, thermo-gravimetric analyzer, along with the Karl Fischer moisture analysis equipment. There is a new machining facility for preparation of test specimens. The PVT test laboratory remains unchanged and separate from the other labs.

"Our new facility is 50% larger than our previous space, giving us room for expansion. And the new labs are attractive, well-organized, and efficient," says Twylene Bethard, Lab Manager.

MOLD ANALYSIS

No-Flow Temperature in Mold Analysis

The no-flow temperature was first proposed by Moldflow as a means to define the temperature where plastic stops flowing in the mold. This is an important criterion in mold analysis that defines the location in a mold where the material is solid and unable to flow. Its proper definition is crucial to determination of flow fronts, pressure predictions and shear rates. In subsequent implementations of mold analysis codes, the use of the no-flow temperature was extended still further as a means to determine whether residual stresses would accumulate or dissipate at a particular node, the precursor calculation to the estimation of shrinkage and warpage.

Analysis

The no-flow temperature is based on a simple measure: molten plastic is cooled at a relatively slow cooling rate in a capillary rheometer under a constant load. The temperature at which flow ceases is the no-flow temperature. The technique yields comparable results to differential scanning calorimetry (DSC) for semi-crystalline materials (eg. PE, PP, PPS) which undergo a kinetic 'crystallization' transition, provided that the DSC tests are performed at slow cooling rates. At the high cooling rates typical to those seen in injection molding, the transitions observed by DSC occur at significantly lower temperatures because of super-cooling effects.

In the case of amorphous materials such as PS and PC, the no-flow temperature is always higher than the typical DSC transition, the glass transition temperature. Further, it has been observed for amorphous materials that the 'solidified' material can start flowing once again if the load is increased. Amorphous transitions do not depend on cooling rate because the glass transition is not kinetic but thermodynamic in nature.

Failure to account for these anomalies has resulted in significant doubt being cast upon the no-flow temperature and the technique has been the subject of widespread criticism as being subjective and, at best, suited for comparative purposes only. While it is true that there could be better ways to measure this transition, importance of measuring a solidification transition correctly cannot be understated. Good simulations require a precise solidification transition.

Several means have been proposed to replace the no-flow temperature. C-MOLD's transition temperature is based solely on DSC, assigning the transition using measures taken from ASTM standards. While it is easy to measure and presents advantages, the DSC transition temperature suffers from a few drawbacks. Chief among these is the assumption that the thermal transition observed by the DSC correlates to the rheological change that results in the cessation of flow in the mold. It can be seen from Figure 1 that this assumption holds well for semi-crystalline materials where the transition is rapid once crystallization commences. In the above experiment, we performed rheological measurements using a parallel plate rheometer, observing the varia-

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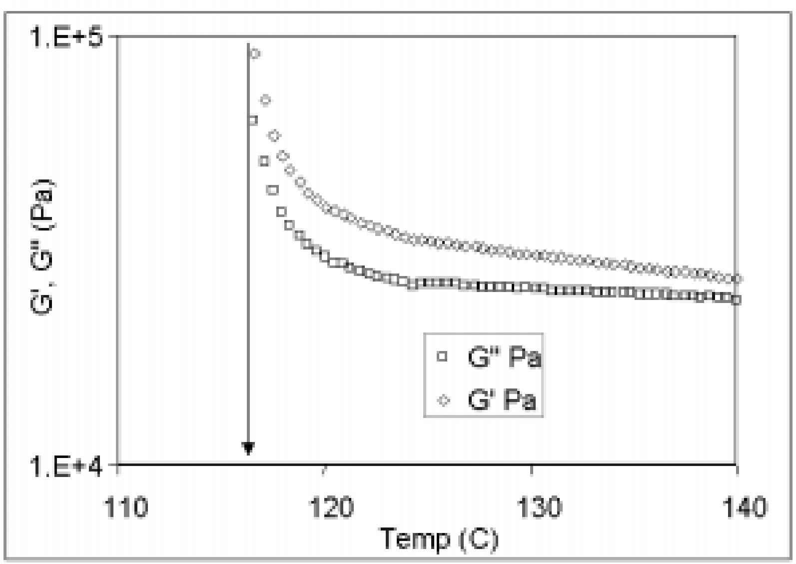

Figure 1. Parallel plate rheology data for semi-crystalline polypropylene

TAP EXPANSION

SIMCON joins TAP

DatapointLabs announces the participation of SIMCON in its *TestPaks* Alliance Program (TAP). CADMOULD is an injection molding simulation program produced by SIMCON, a German software company with an international client base in Europe, USA and Asia. *TestPaks* for CADMOULD are now available at www.datapointlabs.com. CADMOULD users can now obtain material characterizations for basic filling and post filling simulations. DatapointLabs will provide support for warpage simulations on a case-by-case basis.

National Research Council, Canada CAE codes to be supported

Following an agreement with the NRC, the National Research Council of Canada, DatapointLabs is developing *TestPaks* for users of PlasView, BlowView and FormView.

TestPaks for PlasView will permit users to obtain input material properties for filling, post-filling and warpage injection molding simulations using PlasView. BlowView and FormView, blow molding and thermoforming simulation codes, require visco-elastic material models. *TestPaks* for these programs will provide the necessary material characterizations to permit the simulation of these processes.

Simulation for twin screw extrusion supported

TestPaks are now available for TXS, a simulation program for fully intermeshing co-rotating twin screw extruders. According to software vendor Polytec, TXS can simulate a range of compounding operations, and supports a variety of screw elements.

Two *Testpaks* have been developed by DatapointLabs. One, recommended for amorphous polymers which are rubbery at ambient temperature, contains all the properties required for simulations using the 'Melt Only' option. The General *TestPak* is able to handle the simulations for most other materials.

Additional details for these *Testpaks*, including specific tests performed, are available at www.datapointlabs.com.

MOLD ANALYSIS

No-Flow Temperature in Mold Analysis

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tion of the two components of the modulus (G' and G") with temperature as the sample cooled. In the melt processing region, viscous effects predominate and the G" is higher than the elastic component G'. As we lower the temperature, elastic effects become more important and the melt becomes visco-elastic. Here the elastic component G' is higher than the viscous component G", though both moduli are low enough that flow is possible. Upon solidification, both moduli increase dramatically, indicating that further flow is not possible. This dramatic increase in modulus represents the solidification transition. While the transitions agree for both techniques, the rheological data is better in that it pinpoints the degree of crystallinity at which solidification occurs, rather than assuming that it occurs at onset of the transition.

With amorphous materials, the transition is more gradual (Figure 2) and the no-flow and DSC transition temperature do not match. Curiously, a G'-G" crossover is observed to occur at a higher temperature than Tg, apparently correlating with the no-flow temperature.

Other known problems with the determination of the solidification transition exist, particularly in the case of immiscible blends. DSC analysis shows every transition that occurs but has no means of telling us which transition is significant. For example, a PC-PBT blend may show DSC transitions at 220°C for PBT and 140°C for PC. However, blends with small quantities of PBT continue to flow below 220°C, albeit at a higher viscosity. Hence, the DSC based transition temperature has no means to tell us whether we should choose 220°C or 140°C. A no-flow temperature, on the other hand, would be able to distinguish the relevant transition.

Solutions

The parallel plate rheometer presents the means to accurately quantify the solidification transition for all materials. It yields the temperature sensitivity of viscosity at low temperatures, which increases model accuracy. For amorphous materials, if the current no-flow temperature is indeed of importance for simulation, the G'-G" crossover, measured by the parallel plate rheometer, provides a quantified measure of the solidification transition and sets a better stage for the correct accumulation of residual stresses in the part, as the plastic moves from the melt to the solid state. Further, the melt is in a state of oscillatory deformation rather than the quiescent state seen in the capillary rheometer. For blends, the parallel plate rheometer will determine the significant transition. Further, it will yield valuable information about the change in viscosity with temperature across the transitions. The DSC can be used for semi-crystalline materials. It remains a valuable tool for shifting transitions, to account for effects of high cooling rate.

Conclusion

A solidification transition is vital to good simulations. It governs the change over from melt to solid state. Techniques exist today to provide robust measurements of the no-flow temperature. Proper implementation of these techniques will enhance the accuracy of molding simulations.

-Hubert Lobo, DatapointLabs

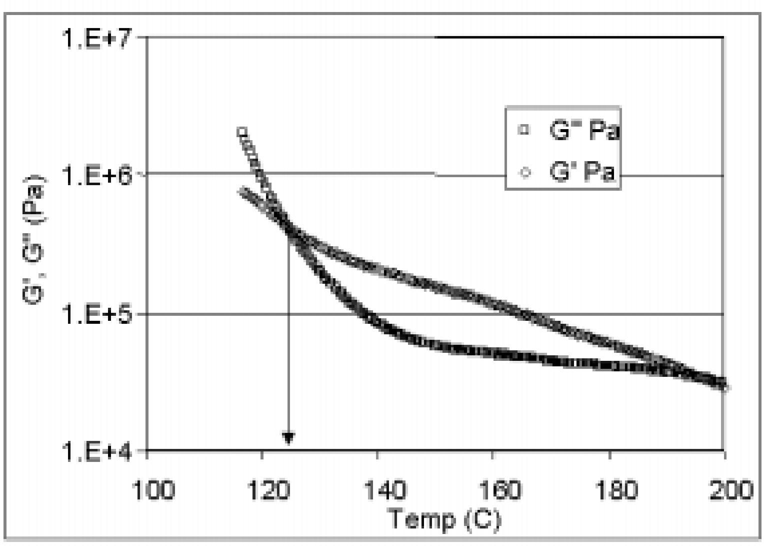

Figure 2. Parallel plate rheology data for amorphous polystyrene

CALENDAR

DatapointLabs a sponsor at Moldflow meet

DatapointLabs is a Silver Level sponsor at the Moldflow International User Group Meeting to be held September 17-19 2001. Meet Hubert Lobo and S. Scott Kumpf at the Sponsor Event. CANCELLED

Upcoming events

ISO TC61 Meeting. September 9-15, Berlin, Germany

Moldflow 2001 International User Group Meeting. September 17-19, Boston, MA CANCELLED

SPE Topical Conference 2001- A Plastics Odyssey, September 24-25, Rochester, NY CANCELLED

We've moved!

Please note our new address:

DatapointLabs
95 Brown Road #102
Ithaca, NY 14850

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If you do not yet have full access to our website, please contact us for activation. A user name and password are required to place orders on line.