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Autodesk Moldflow Insight 2019

Consolidation of Sink Mark Solutions

This report is to demonstrate that, after the consolidation of formulas used for sink mark calculation, the consistency of sink depth predictions have been improved between Autodesk Moldflow Insight Midplane and 3D solutions.

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Contents

Introduction **3**
Formulas **4**
Case Study .... Error! Bookmark not defined.
Validation **4**
Conclusions **8**
References **8**

Introduction

Sink marks, which refer to small depressions on the surfaces typically opposite to reinforcing ribs, are often encountered in injection molded plastic parts. Sink marks can cause structural weakness and be visually unacceptable. Both Autodesk Moldflow Insight (AMI) and Advisers (AMA) can predict location as well as depth of sink marks. However, different formulas have been used in the past between Midplane and 3D/DD solvers for the calculation of sink depth, which sometimes leads to large differences in the prediction of sink depth. In this release, the formulas for sink depth calculation have been consolidated for “Flow + Sink Mark” analysis sequence across all mesh types, as detailed in Table 1 below. For “Fill + Sink Mark” analysis sequence, available in AMA only, the estimation of sink depth remains unchanged as its formula take pressure and temperature at end of fill instead of volumetric shrinkage as inputs. This report also includes comparison of sink depth predictions before and after the consolidation of formulas.

Table1 Configuration of Sink Mark Solution in AMI and AMA

		Midplane	Dual Domain	3D
AMI	Fill	**“Sink Mark Depth” is not calculated for “Fill” only analysis**		
	Flow	Calculated within Flow solver. Input: Volumetric shrinkage. Consolidated formula	Calculated by sink mark solver Input: Volumetric shrinkage. Consolidated formula	Calculated by sink mark solver Input: Volumetric shrinkage. Consolidated formula
AMA	Fill	**Not applicable. Advisers do not take Midplane models**	Calculated by sink mark solver Input: Pressure & Temperature Existing formula	Calculated by sink mark solver Input: Pressure & Temperature Existing formula
	Flow		Calculated by sink mark solver Input: volumetric shrinkage. Consolidated formula	Calculated by sink mark solver Input: volumetric shrinkage. Consolidated formula

Formulas

Formulas for sink depth calculation are kept confidential. The consolidation work does not involve any changes in workflow for Flow and Sink Mark analysis.

Validation

Limited experimental data for sink mark depth are available in literature [1][2]. A few researchers in academia, Battey and Gupta [3][4] for example, have used a combination of Flow analysis with thermal/structural analysis (ABAQUS) to predict sink mark depth. Agreement between their analyses and experiment data was reasonable.

The same mold geometry and material are utilized in this report to validate sink depth predictions from AMI solutions. The Midplane and 3D mesh models are shown in Figure 1 below. The base thickness is 4 mm and rib thickness varies from 25% to nearly100% of base thickness. The material (ABS, Cycolac KJB, GE Plastics USA) data and processing conditions are identical to those used by Battey and Gupta [3][4]. Packing pressures varied in the experiment with packing time kept the same at 14 seconds. The comparison of sink depth predictions with experimental values are compiled in Figures 2—6. Predictions agreed well with experiment data in general. Most importantly, the predictions between Midplane and 3D solutions have become more consistent after the consolidation of the formula used for sink depth calculation.

Figure 1 Midplane (top) and 3D (bottom) mesh models

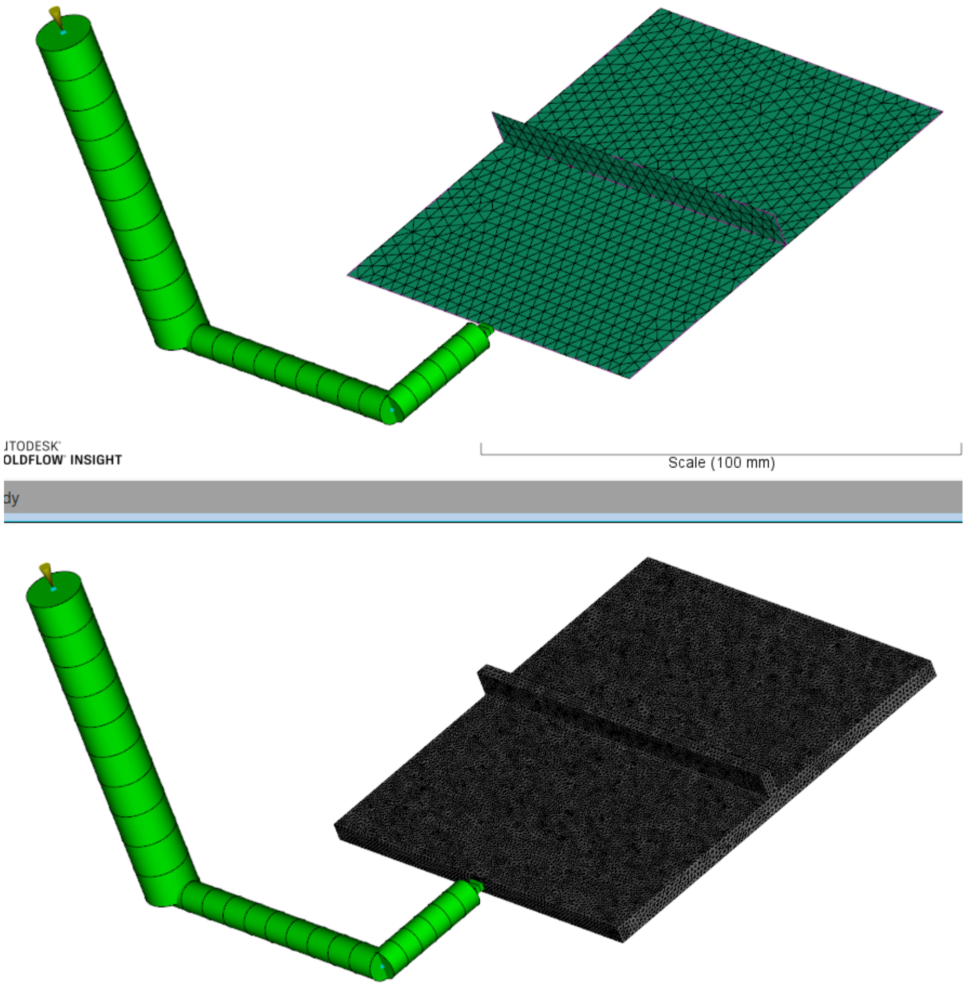


Figure 2 Comparison of sink depth values for 1.00 mm rib

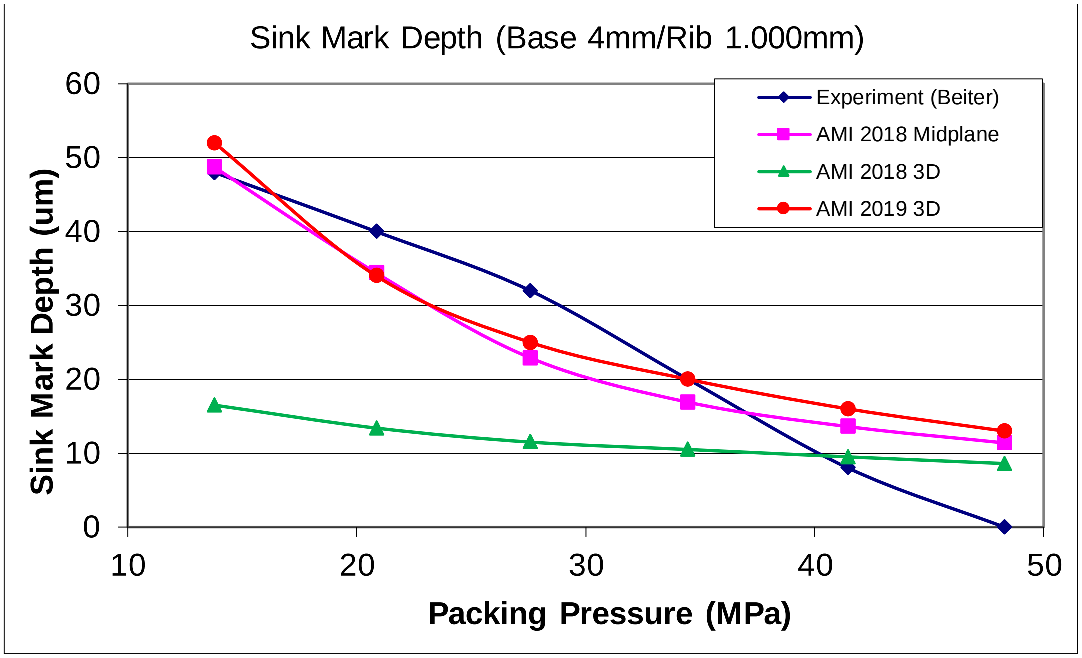


Figure 3 Comparison of sink depth values for 1.524 mm rib

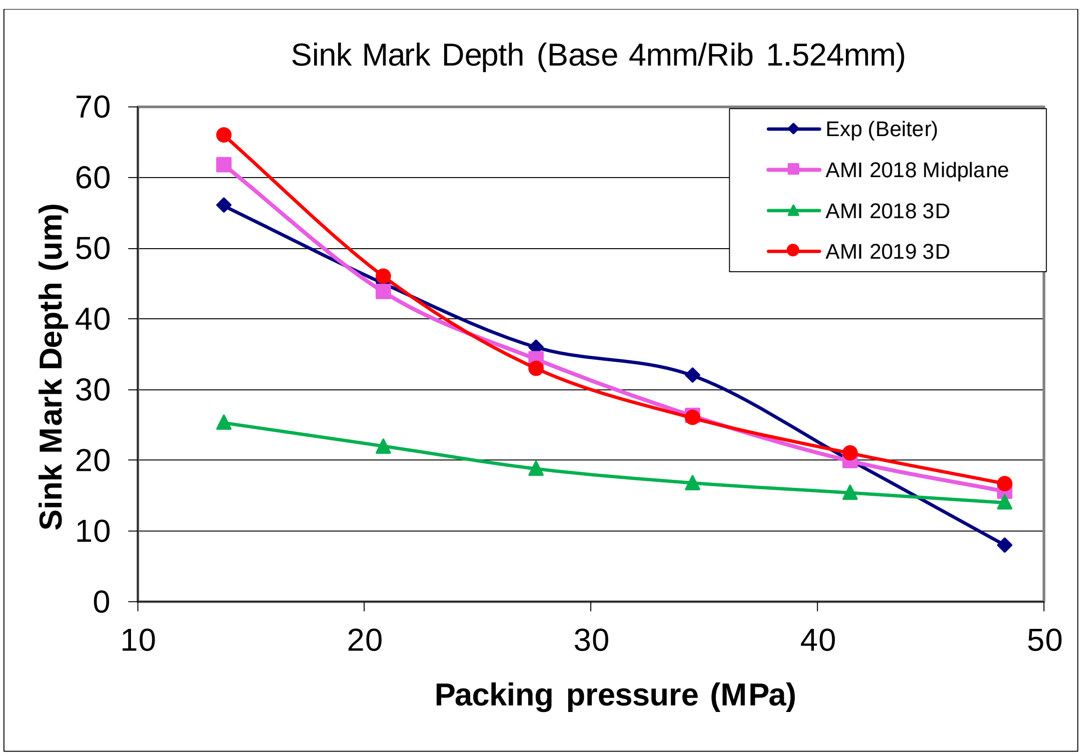


Figure 4 Comparison of sink depth values for 2.286 mm rib

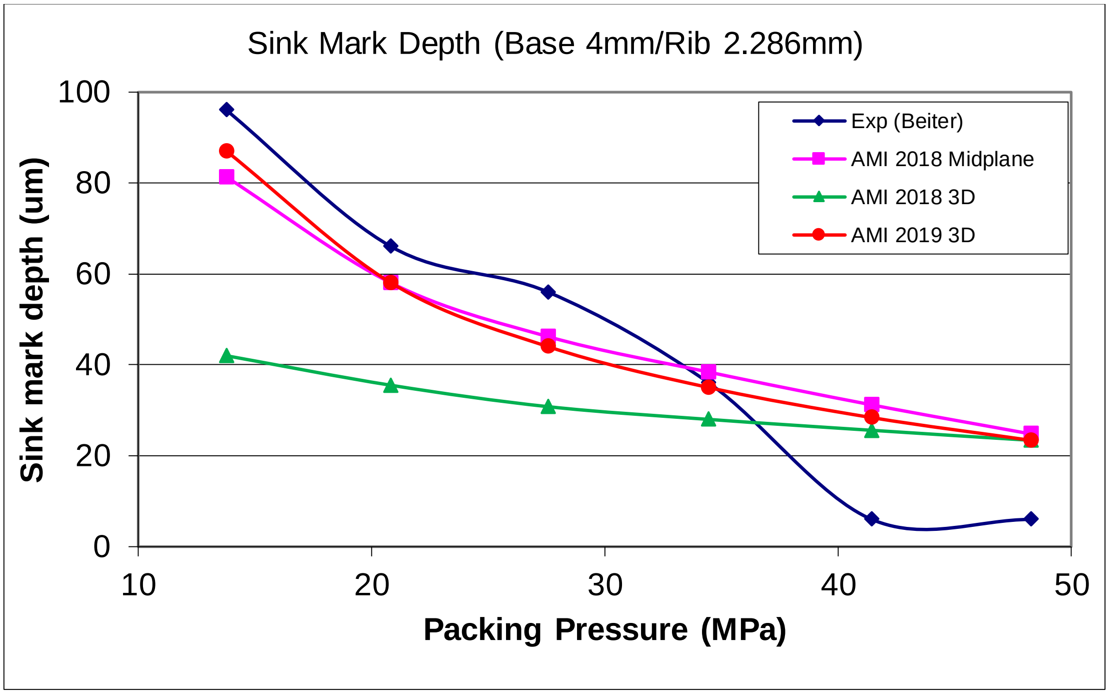


Figure 5 Comparison of sink depth values for 2.946 mm rib

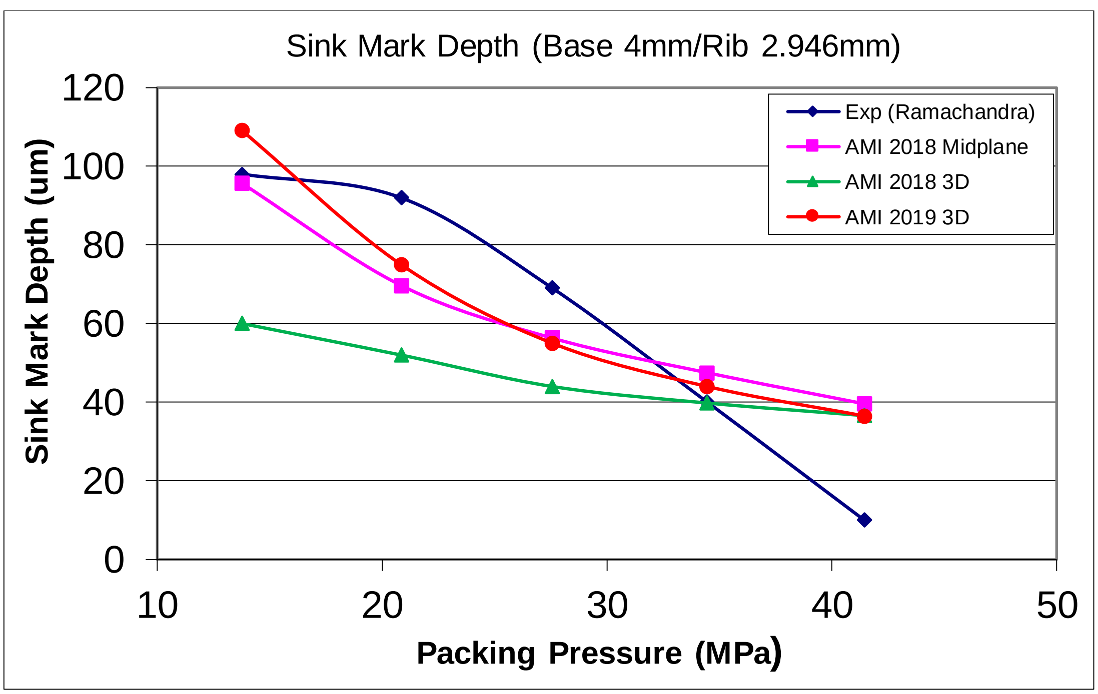
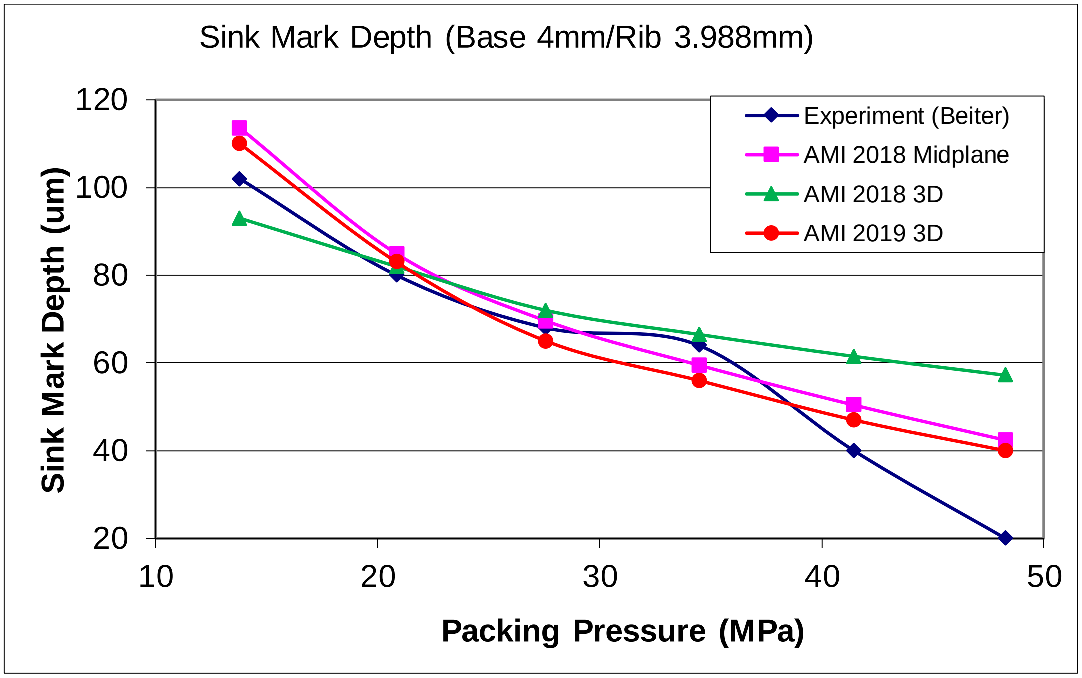


Figure 6 Comparison of sink depth values for 3.988 mm rib



Conclusions

For "Flow + Sink Mark" analysis sequence, AMI and AMA solvers have been enhanced to use the same consolidated formula across all mesh types for sink depth calculation. Predicted sink depth values matched well with experimental values found in literature. More importantly, the predictions between Midplane and 3D solutions have become much more consistent after the formula consolidation.

References

[1] "Study of Sink Marks in Injection Molded Plastic Parts", D. M. Ramachandra, M. S. Thesis, Ohio State University, Columbus (1989).

[2] "Geometry-Based Index for Predicting Sink Mark in Plastic Parts", K. Beiter, M. S. Thesis, Ohio State University, Columbus (1991).

[3] "A Parametric Study of Sink Marks in Injection-Molded Plastics Parts Using the Finite Element Method", D. J. Battey and M. Gupta, *International Polymer Processing Journal*, 12, 288-299 (1998).

[4] "Finite Element Prediction of Sink Marks in Injection-Molded Plastic Parts", D. J. Battey and M. Gupta, ASME MD-Vol 79, *CAE and Intelligent Processing of Polymeric Materials*, Editors: H. P. Wang, L.-S Turng and J.-M. Marchal, 335-350 (1997).