Autodesk® Moldflow 2021

Sink-mark Prediction Enhancements for 3D Injection Molding Processes

Executive summary

This report is about the enhancements for sink-marks prediction for 3D injection molding processes in both Autodesk Moldflow Insight 2021 and Autodesk Moldflow Adviser 2021 including some example cases. The enhancement allows the identification of sinks marks in any region of the geometry where thickness variations exist.

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Introduction

In Autodesk Moldflow Insight 2021 and Autodesk Moldflow Adviser 2021, the prediction of sink-marks for 3D cases have been improved in terms of the magnitude and the location predictions. The prediction is now able to predict sink marks in any location where thickness variations exists, not only in rib locations as had previously been the case.

Example Cases

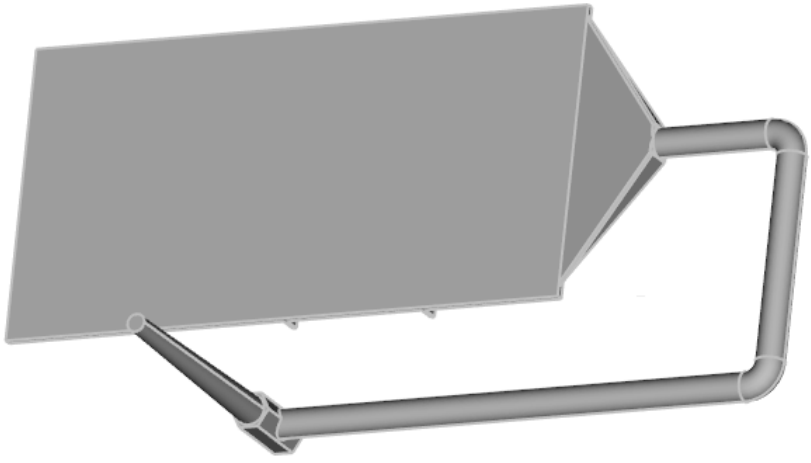
In section 1, some examples will be shown where the sink-mark depth predictions are improved. In section 2, some examples will be shown where the locations of the sink-marks are improved.

1. Sink-mark value improvements

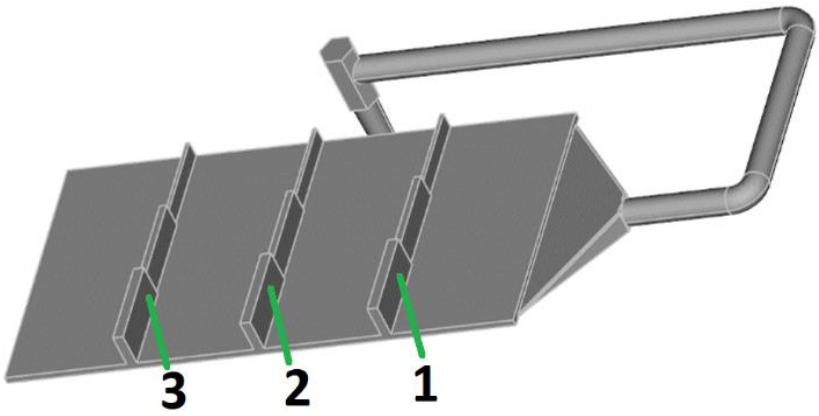
In this section, some examples will be shown where the prediction of the sink-mark values is improved in the Moldflow 2021 release over the Moldflow 2019 release.

In the study, moldings were performed and measurements were taken at Autodesk Moldflow Plastics Lab. An Arburg 520A Electric Molding Machine was used to produce the moldings.

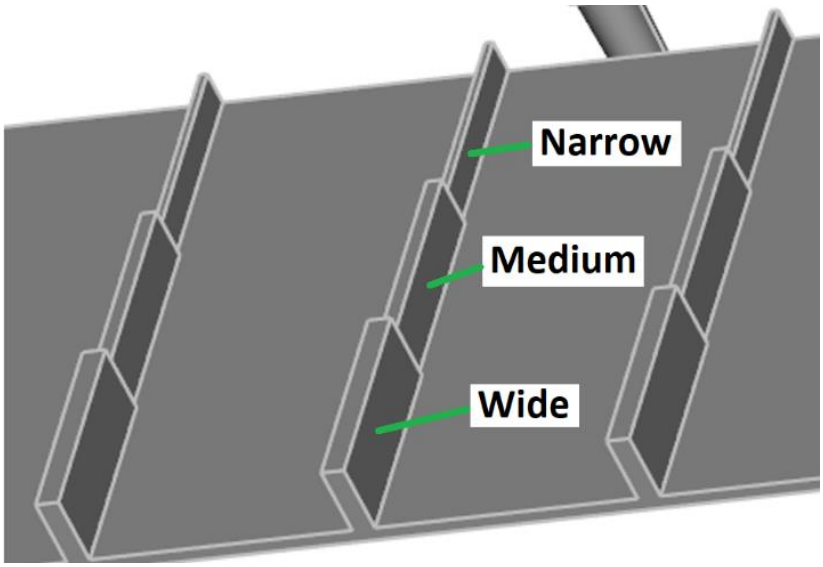
The schematic of the part and the runner system used in the molding is shown in Figure 1. As can be seen, the cavity is a rectangular plaque with a fanned gate. The rectangular cavity is 150 mm long, 75 mm wide and 2 mm thick. It has ribs at 3 locations as shown in Figure 1(b). The rib closest to the gate will be labeled as #1, and the one furthest #3. Also, each rib has 3 regions with different heights and widths. The region with smallest height and width (1 mm width) will be called the “narrow” region, the one with medium height and width (2 mm width) will be called the “medium” region, and the region which has the largest height and width (3 mm width) will be called the “wide” region (Fig. 1(c)).



(a)



(b)

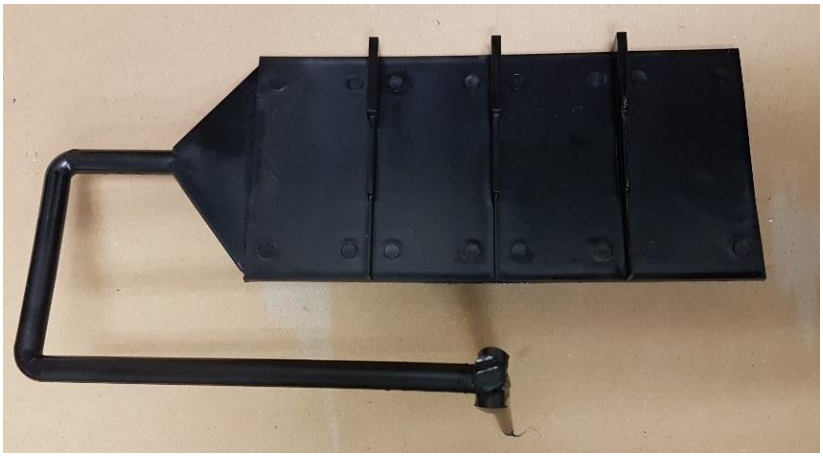


(c)

Figure 1: The geometry of the part and runner systems used in the molding trials: (a) opposite side of the ribs, (b) rib side (the rib numbers 1, 2 and 3 are indicated in the figure), and (c) expanded view of the ribs (the region with “narrow”, “medium” and “wide” regions are marked).

An example of an actual sample obtained from the molding trial is shown in Figure 2. As can be seen in Figure 2(a), sink-marks are visible on the opposite side of the ribs.

(a)



(b)

Figure 2: Samples obtained from molding trials: (a) Opposite to rib side which shows the sink-marks and (b) the rib side.

Sink-mark depth values were measured using a 3D laser scanner (Romer 7525 SI) on the opposite side of the rib. Using the 3D point cloud data from the scan, the local sink mark depth values were calculated at each rib (1, 2, and 3) and each rib region (narrow, medium and wide). The average sink mark depth values in each rib region were determined.

The actual mesh used in the simulation is shown in Figure 3.

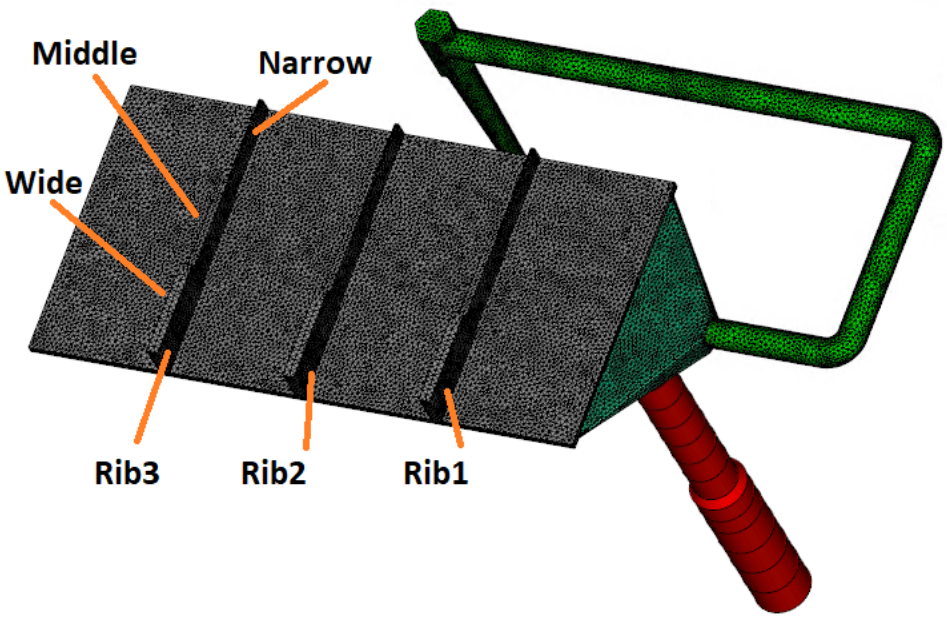


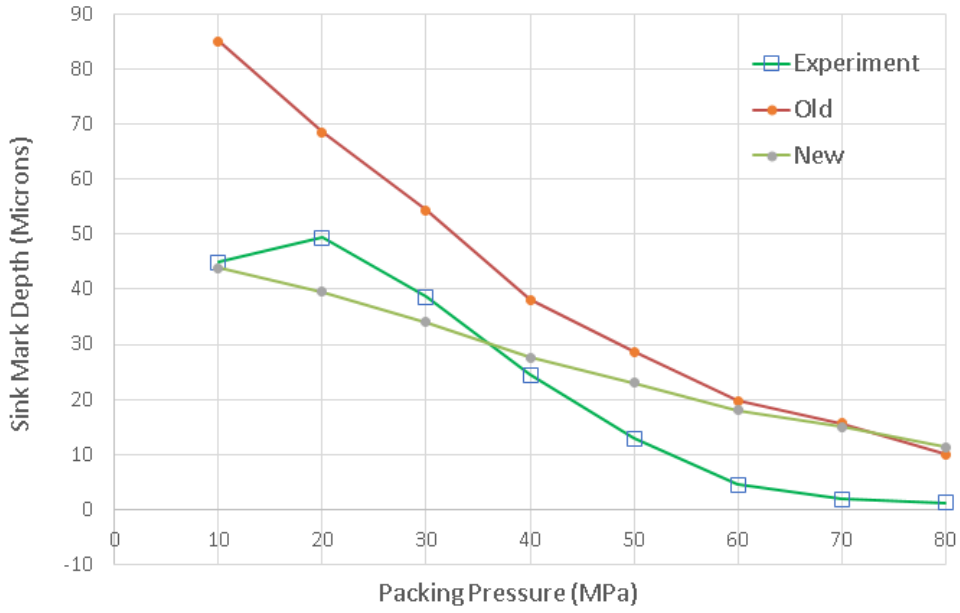
Figure 3: Mesh used in the case study of regular reactive microcellular injection molding.

Three different molding materials were used in the molding trials. Results for each molding material will be described in the sections below (1.1, 1.2 and 1.3).

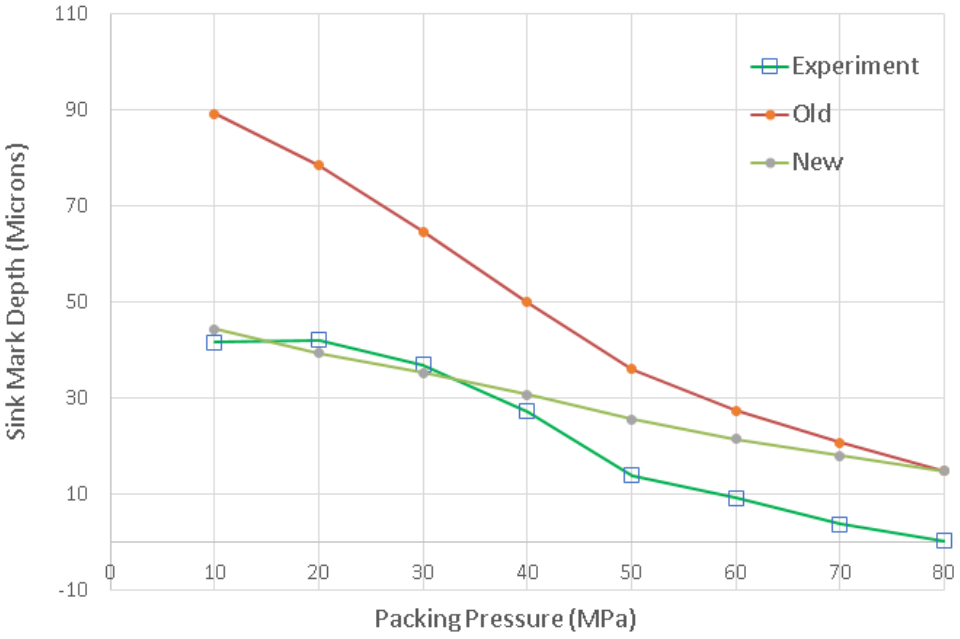
1.1 Molding with ASA material

The first material used in the molding study was an Acrylonitrile Styrene Acrylate (ASA), with the material grade of CSW860UV from Cepla Co. The mold temperature was 60^{o}C, the initial melt temperature was 220^{o}C, and the fill time was approximately 1 sec with flow rate of 40 cm^{3}/sec. The packing time was 8 sec, and the cooling time was 15 sec. Packing pressures were varied from 10 MPa to 80 MPa to examine the effects of the packing pressure on sink-marks.

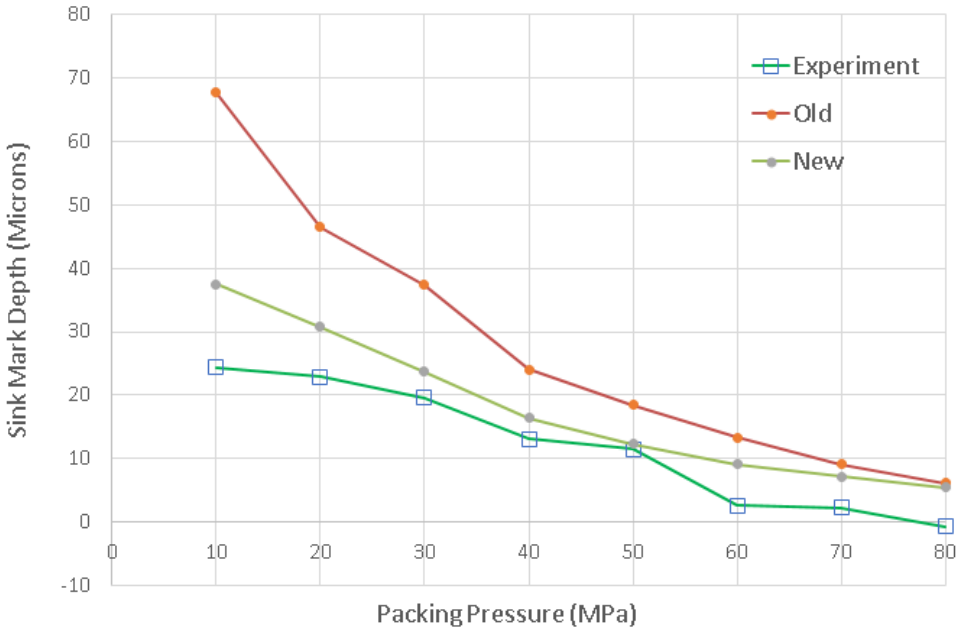
The Sink-mark values measured from moldings (“Experiment”), and predicted by Moldflow 2019 (“Old”) and Moldflow 2021 (“New”) are compared in Figure 4 (at various rib locations). As can be seen, the results from Moldflow 2021 are closer to the experimental results than those from Molding 2019 in most cases.


Experiment
Old
New
Sink Mark Depth (Microns)
Packing Pressure (MPa)
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80

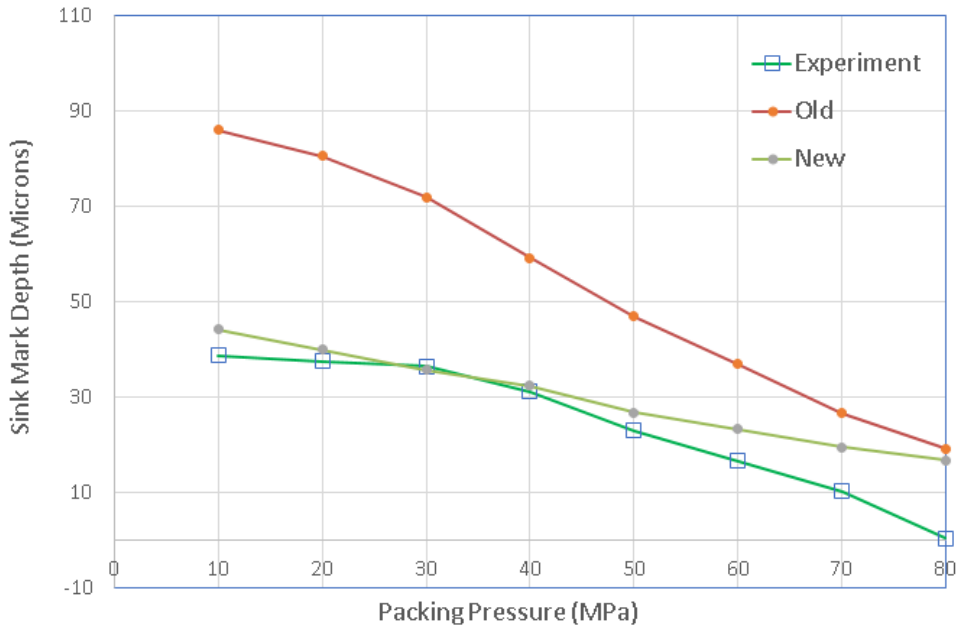
(a)


Experiment
Old
New
Sink Mark Depth (Microns)
Packing Pressure (MPa)
110
90
70
50
30
10
-10
0
10
20
30
40
50
60
70
80

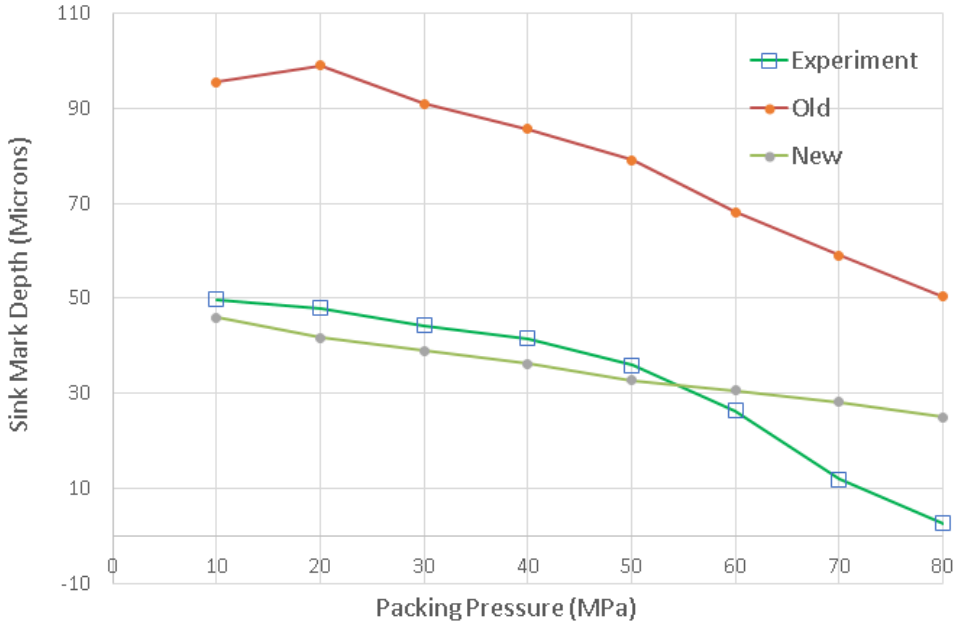
(b)


Experiment
Old
New
Sink Mark Depth (Microns)
Packing Pressure (MPa)
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
60
70
80

(c)


Experiment
Old
New
Sink Mark Depth (Microns)
Packing Pressure (MPa)
110
90
70
50
30
10
-10
0
10
20
30
40
50
60
70
80

(d)



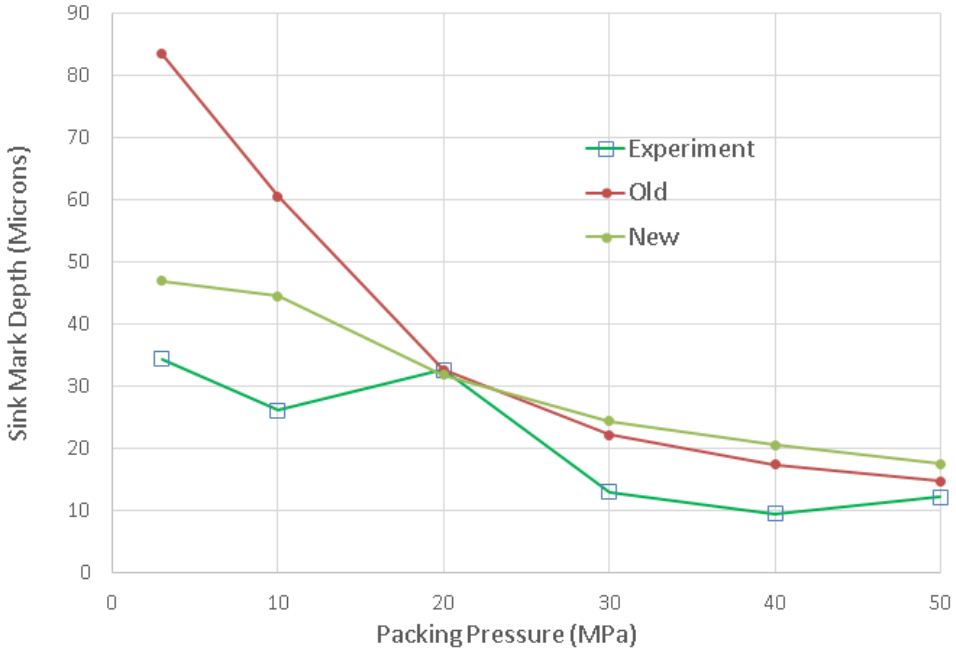
(e)

Figure 4: Sink-mark values measured from moldings (“Experiment”), and predicted by Moldflow 2019 (“Old”) and Moldflow 2021 (“New”): (a) rib 1, medium, (b) rib 2, medium, (c) rib 3, narrow, (d) rib 3, medium and (e) rib 3, wide.

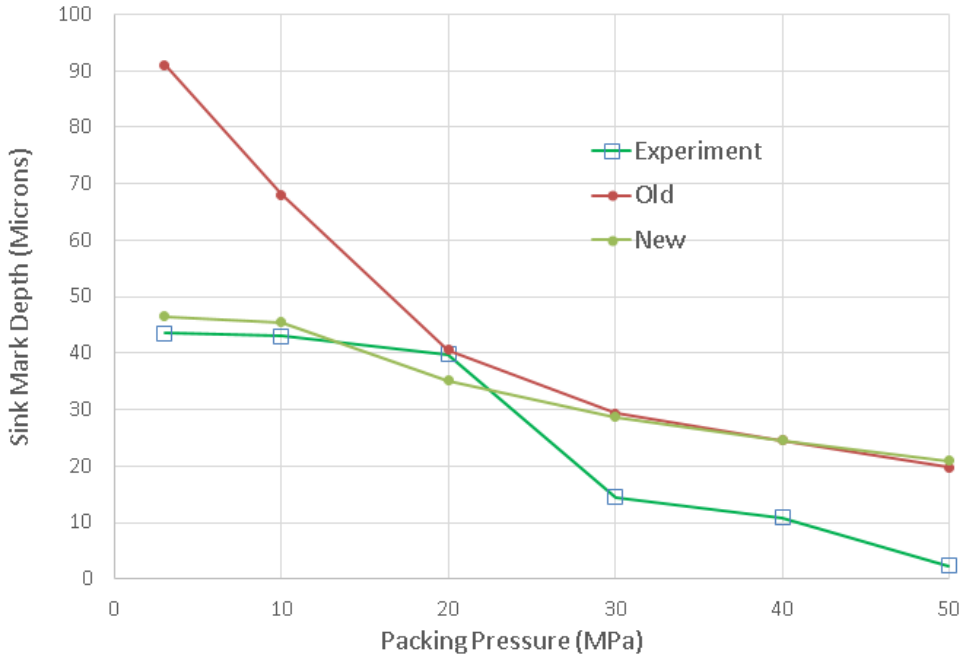
1.2 Molding with COC material

The second material used in the molding study was COC (APEL 5016SL). The mold temperature was 80^{o}C, the initial melt temperature was 280^{o}C, and the fill time was approximately 1 sec with flow rate of 40 cm^{3}/sec. The packing time was 8 sec, and the cooling time was 15 sec. Packing pressures were varied from 3 MPa to 50 MPa to examine the effects of the packing pressure on sink-marks.

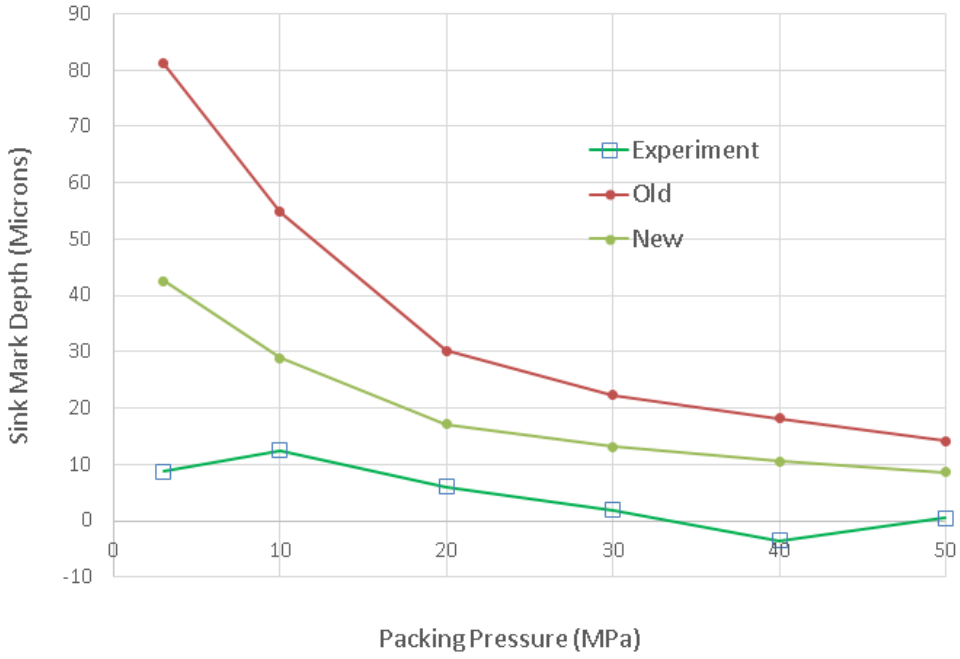
The Sink-mark values measured from moldings (“Experiment”), and predicted by Moldflow 2019 (“Old”) and Moldflow 2021 (“New”) are shown in Figure 5. As can be seen, the results from Moldflow 2021 are closer to the experimental results than those from Moldflow 2019 in most cases.


Sink Mark Depth (Microns)
Packing Pressure (MPa)
Experiment
Old
New
0
10
20
30
40
50
60
70
80
90

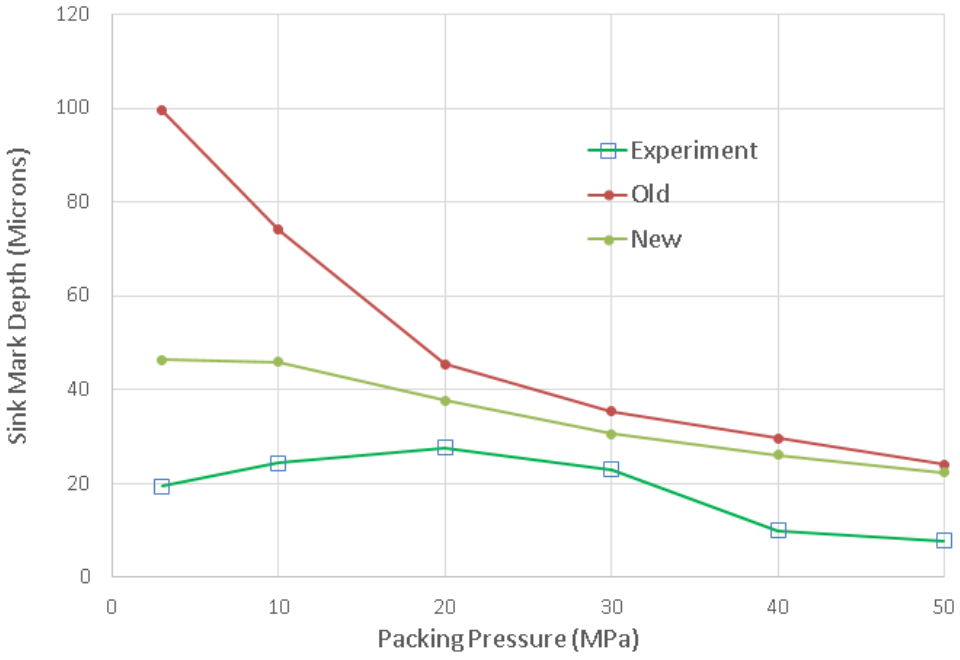
(a)


Sink Mark Depth (Microns)
Packing Pressure (MPa)
Experiment
Old
New
0
10
20
30
40
50
60
70
80
90
100

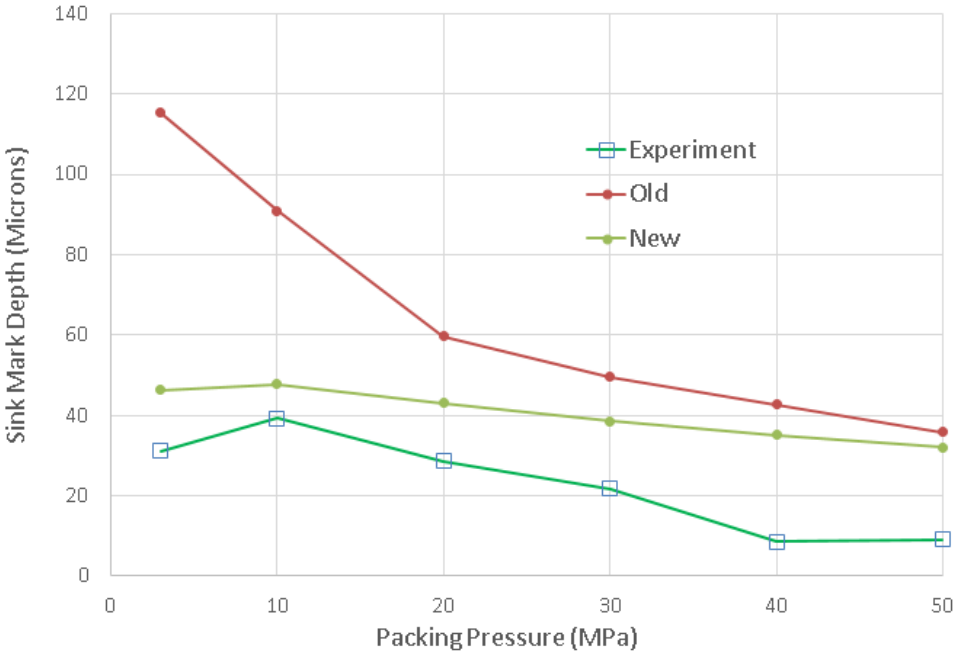
(b)


Sink Mark Depth (Microns)
90
80
70
60
50
40
30
20
10
0
-10
0
10
20
30
40
50
Experiment
Old
New
Packing Pressure (MPa)

(c)


Sink Mark Depth (Microns)
120
100
80
60
40
20
0
0
10
20
30
40
50
Experiment
Old
New
Packing Pressure (MPa)

(d)



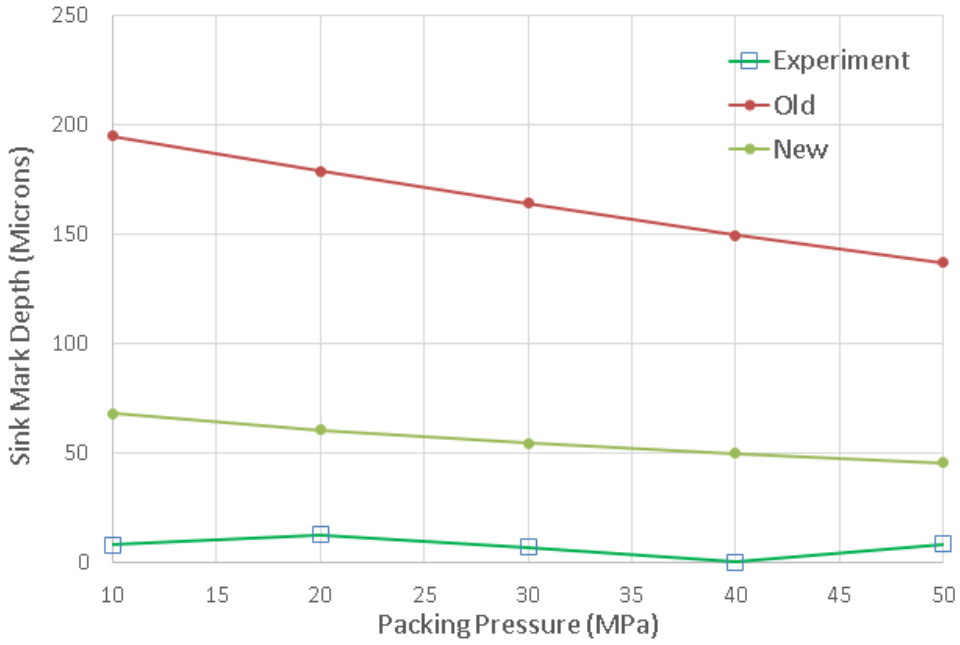
(e)

Figure 5: Sink-mark values measured from moldings ("Experiment"), and predicted by Moldflow 2019 ("Old") and Moldflow 2021 ("New") for COC material: (a) rib 1, medium, (b) rib 2, medium, (c) rib 3, narrow, (d) rib 3, medium and (e) rib 3, wide.

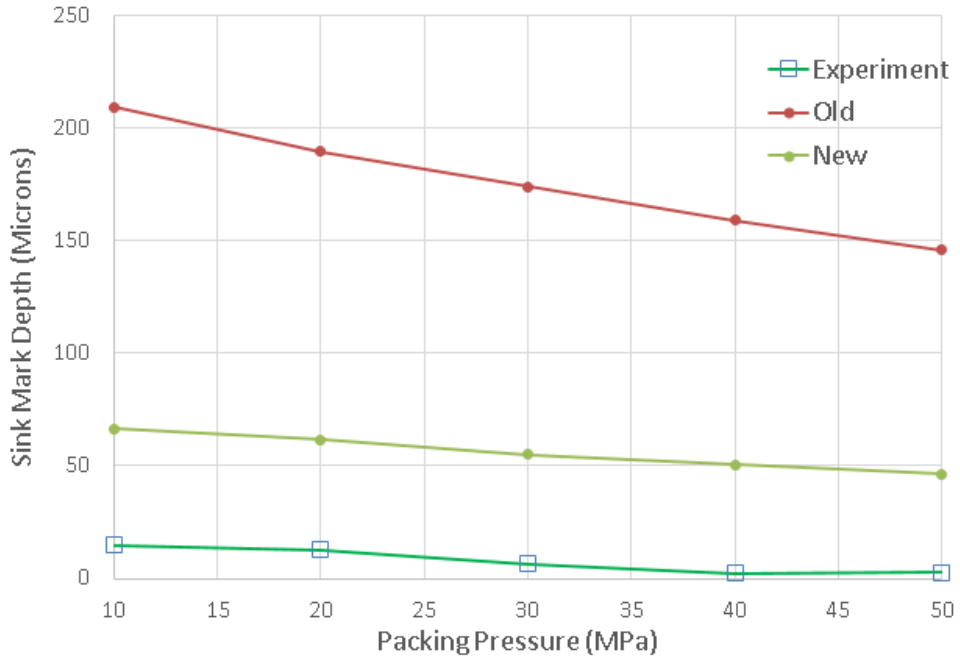
1.3 Molding with PA66 material

The third material used in the molding study was PA66 (FRIANYL A3 V0XI NC 1101/Z). The mold temperature was 80°C, the initial melt temperature was 280°C, and the fill time was approximately 1 sec with flow rate of 40 cm^3/sec. The packing time was 8 sec, and the cooling time was 15 sec. Packing pressures were varied from 10 MPa to 50 MPa to examine the effects of the packing pressure on sink-marks.

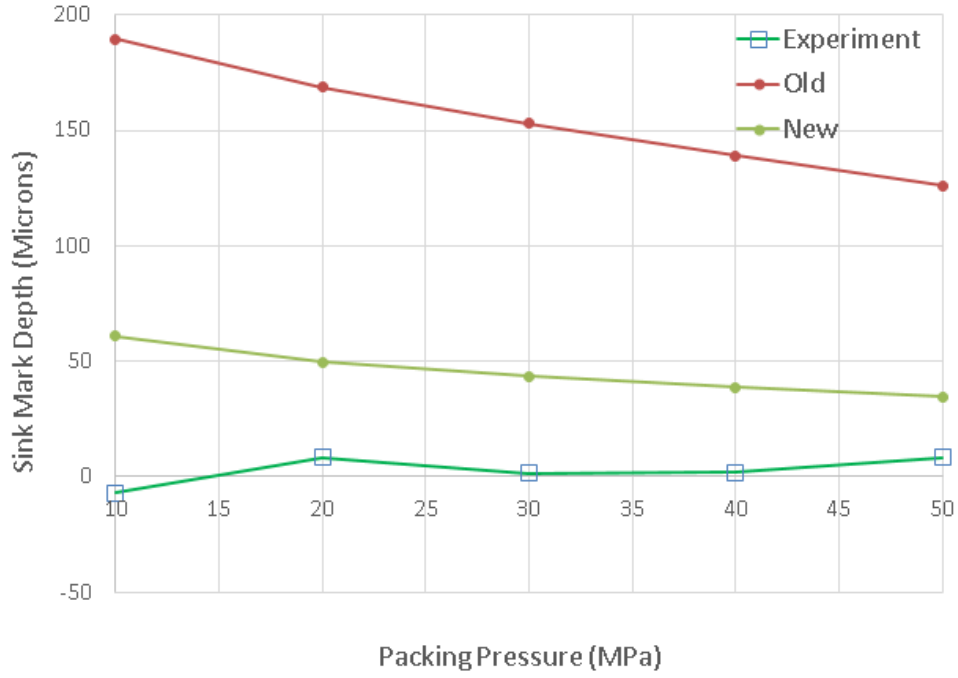
The Sink-mark values measured from moldings ("Experiment"), and predicted by Moldflow 2019 ("Old"), and Moldflow 2021 ("New") are shown in Figure 6. As can be seen, the results from Moldflow 2021 are closer to the experimental results than those from Moldflow 2019 in all cases.


Experiment
Old
New
Sink Mark Depth (Microns)
Packing Pressure (MPa)
250
200
150
100
50
0
10
15
20
25
30
35
40
45
50

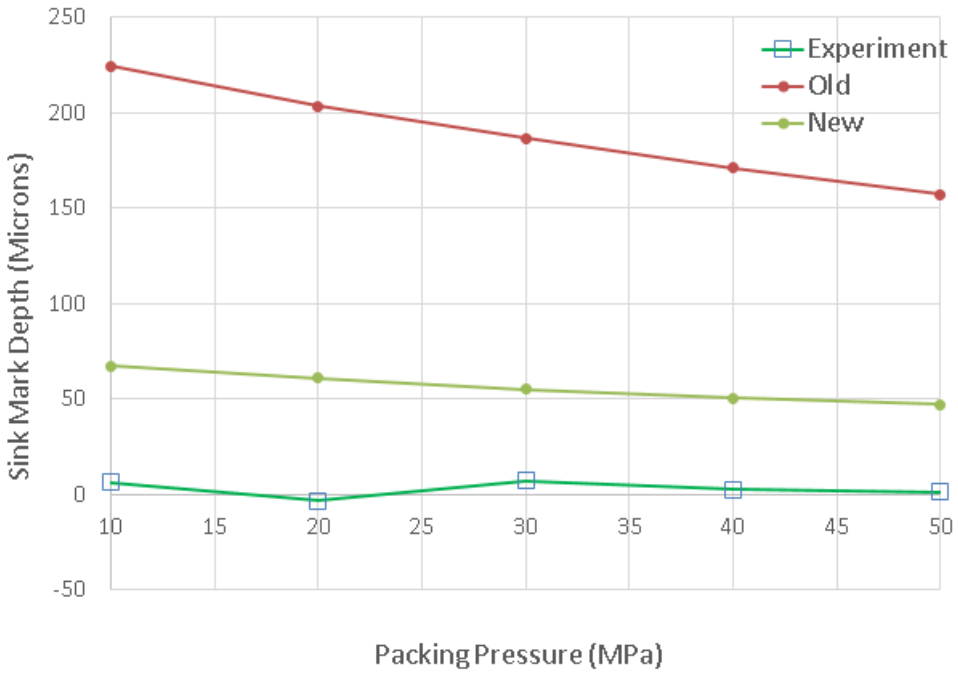
(a)


Experiment
Old
New
Sink Mark Depth (Microns)
Packing Pressure (MPa)
250
200
150
100
50
0
10
15
20
25
30
35
40
45
50

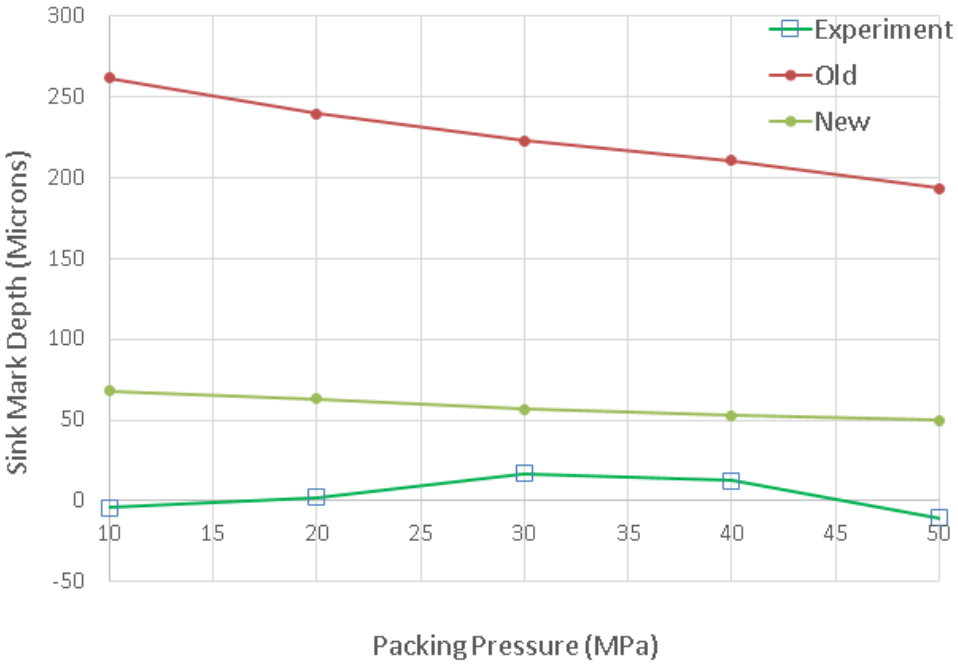
(b)


Experiment
Old
New
Sink Mark Depth (Microns)
200
150
100
50
0
-50
10
15
20
25
30
35
40
45
50
Packing Pressure (MPa)

(c)


Experiment
Old
New
Sink Mark Depth (Microns)
250
200
150
100
50
0
-50
10
15
20
25
30
35
40
45
50
Packing Pressure (MPa)

(d)



(e)

Figure 6: Sink-mark values measured from moldings (“Experiment”), and predicted by Moldflow 2019 (“Old”), and Moldflow 2021 (“New”) for PA66 material: (a) rib 1, medium, (b) rib 2, medium, (c) rib 3, narrow, (d) rib 3, medium and (e) rib 3, wide.

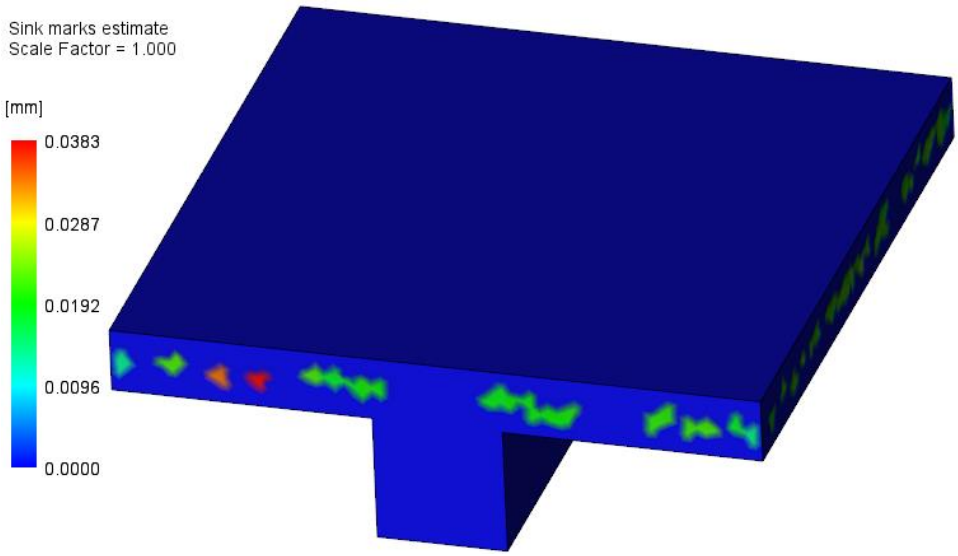
2. Improvements of sink mark locations

In this section, some examples will be shown where the prediction of the sink-mark locations is improved in Moldflow 2021 over Moldflow 2019.

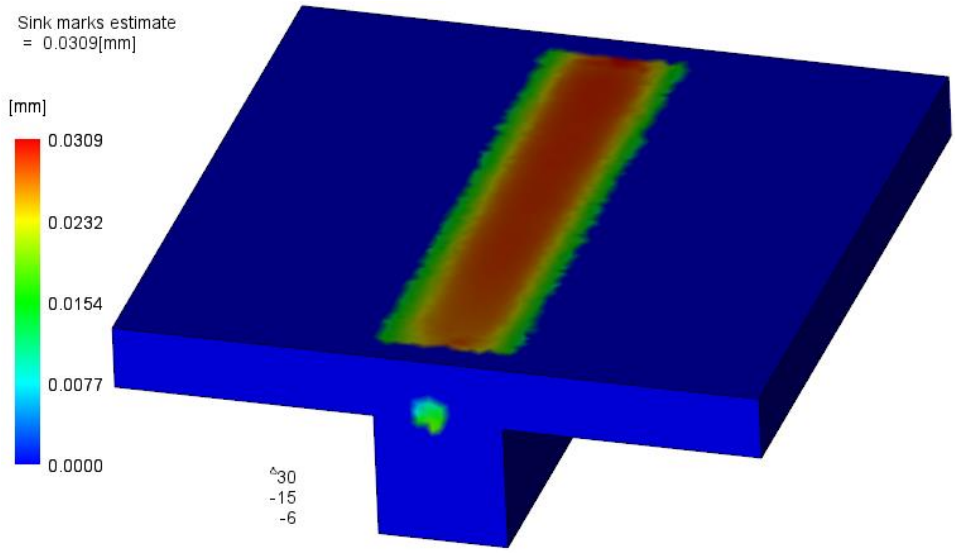
2.1 Thick rib case

For this case study, which includes a thick rib, the material used was PA66 (Grivory GV-5H). The mold temperature was 100ºC, the initial melt temperature was 290ºC, and the fill time was 0.2 sec. The packing time was 10 sec, and the cooling time was 1 sec. Packing pressure was 9 MPa.

The sink-mark simulation results are shown in Figure 7. As can be seen, Moldflow 2019 does not predict the sink-mark location correctly, but Moldflow 2021 correctly predicts the sink-mark locations.



(a)



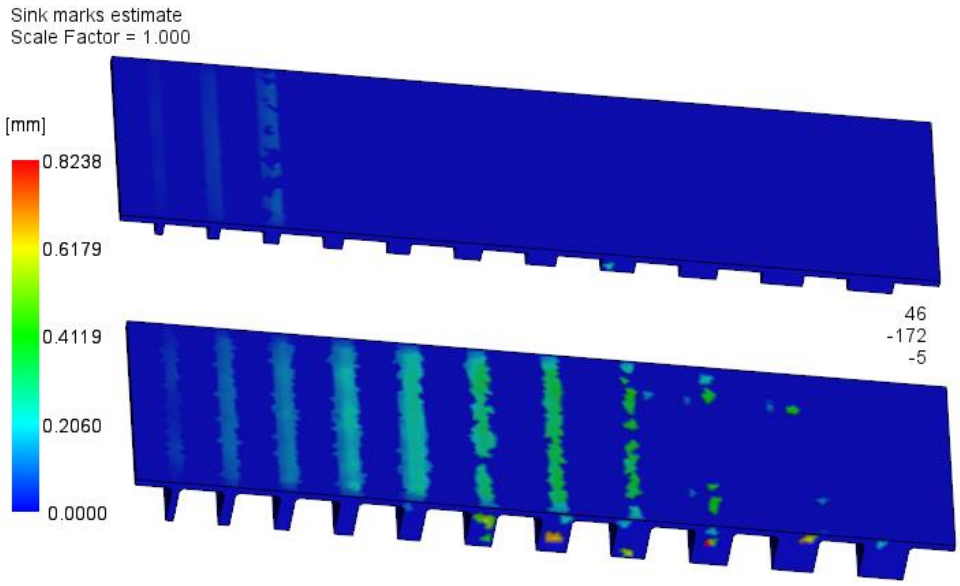
(b)

Figure 7: Sink-marks estimate calculated from (a) Moldflow 2019 and (b) Moldflow 2021.

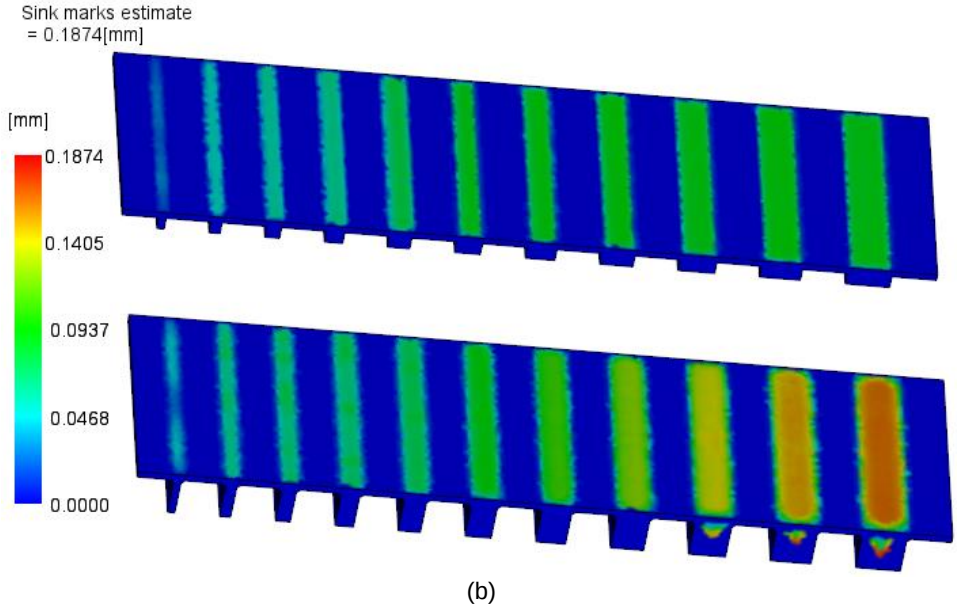
2.2 2-plate case

For this case study, which includes two ribbed plates, having ribs of various thicknesses and widths, the molding material was PP (Generic PP). The mold temperature was 50^{o}C, the initial melt temperature was 220^{o}C, and the fill time was about 3.7 sec. The packing time was 10 sec, and the cooling time was 20 sec. Packing pressure was about 40 MPa.

The simulation results are shown in Figure 8. As can be seen, Moldflow 2019 misses many sink-mark locations, whereas Moldflow 2021 correctly predicts the sink-mark locations.



(a)



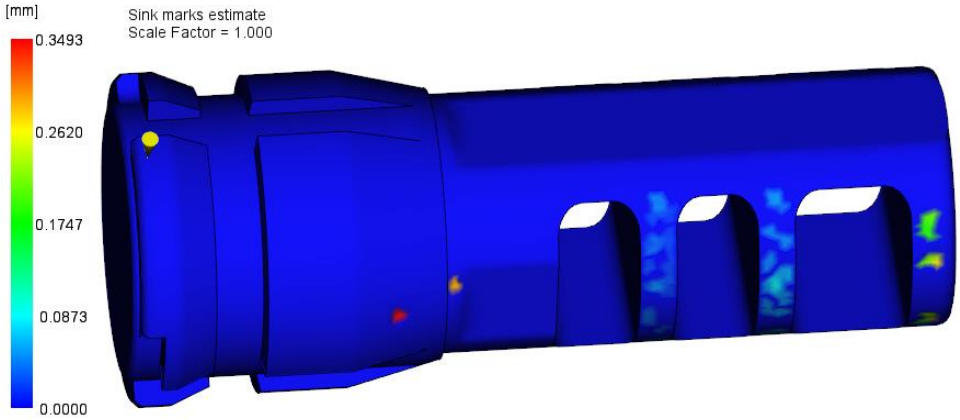
(b)

Figure 8: Sink-marks estimate calculated from (a) Moldflow 2019 and (b) Moldflow 2021.

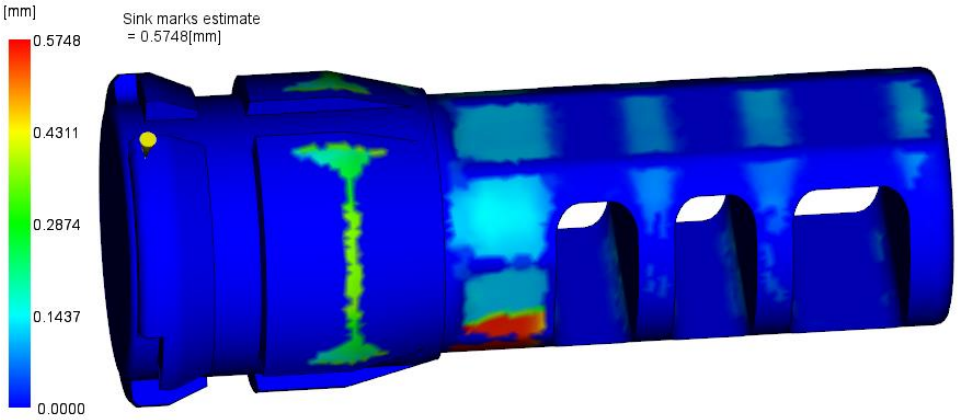
2.3 Hearing aid case

For this case study, which includes strong variations in thickness, the molding material was PP (Generic PP). The mold temperature was 50ºC, the initial melt temperature was 220ºC, and the fill time was about 0.6 sec. The packing time was 10 sec, and the cooling time was 20 sec. Packing pressure was about 4.63 MPa.

The simulation results are shown in Figure 9. As can be seen, Moldflow 2019 misses many sink-mark locations, whereas Moldflow 2021 predicts many sink-marks at locations with variations in thickness.



(a)



(b)

Figure 9: Sink-marks estimate calculated from (a) Moldflow 2019 and (b) Moldflow 2021.

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