

Mosaic Roto Intro

The effect of pigments and warpage
on HDPE rotomolded parts.

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What is warpage?

- Warpage is distortion in shape of a molded article.
- The cause is internal stresses that are great enough to exceed the mechanical strengths of the article.
- Shrinkage, especially non uniform shrinkage, can be an indicator of warp and internal stresses.
- Internal stress can lead to poor impact and other properties.

Variables that effect warpage

1. Part Design
2. Mold Design
3. Cooling Cycle
4. Pigmentation

Variables

1. Cooling time;
Time to wall thickness ratio. (Crystal formation)
2. Mold pressure;
Maintains better cure and more uniform crystals.
3. Wall thickness variation.
4. Uniformity of cooling across whole part.

Initial Test Protocol

1. Roto molded 3 blue colors with 3 different blue pigments. We molded 2 reds with 2 pigments. We also did a standard white. All were compounded using Nova 341 Surpass.
2. Measured the percentage of shrinkage in roto mold.
3. Heated each panel for 24 and 48 hours at 100 degrees c.
4. Measured to view % of size change.

Product #	Length	%	Width	%	Diagonal	%	
Cold Mold	3.977	0	2.963	0	4.732	0	
M6248	3.833	3.6	2.862	3.4	4.584	3.1	610
M6247	3.87	2.7	2.888	2.5	4.626	2.3	370
M6246	3.858	3.0	2.89	2.5	4.558	3.7	705
White	3.905	1.8	2.906	1.9	4.616	2.5	
M4646	3.871	2.7	2.892	2.4	4.607	2.7	LW Red
M6289	3.869	2.7	2.878	2.9	4.557	3.7	
341	3.895	2.6	2.9	1.9	4.646	2.2	
735	3.913	1.4	2.93	1.1	4.651	1.8	
245	3.909	1.7	2.91	1.5	4.63	2.6	

Heat Treatment for ARM

Product	Before Treatment	24 Hours	%	48 Hours	%
White	W - 2.375 L - 3.339	2.365 3.33	-.5% -.3%	2.364 3.33	-.5% -.3%
M4646 (Std. Red)	W - 2.415 L - 3.375	2.418 3.38	+.1% +.15%	2.419 3.376	+.14% +.03%
M6246 (705)	W - 2.467 L - 3.43	2.465 3.432	-.1% +.05%	2.463 3.43	-.16% 0%
M6247 (370)	W - 2.345 L - 3.429	2.342 3.426	-.13% -.01%	2.342 3.422	-.13% -.2%

Heat Treatment for ARM

M6248 (610)	W - 2.395 L - 3.351	2.395 3.35	0% 0%	2.396 3.348	+.04% - .1%
M6289 (Warp Red)	W - 2.444 L - 3.479	2.445 3.477	+.05% - .15%	2.445 3.478	+.05% - .10%

Compounded Nova 341 Surpass

		Flex mod	Tensile	Impact - Brittle
M2776	White	155,000	3450	55 – 0/9

		Flex mod	Tensile	Impact - Brittle
M6246		154,000	3500	55 – 0/9
M6247		163,000	3600	45 – 5/9
M6248		163,000	3250	50 – 0/9

		Flex mod	Tensile	Impact - Brittle
M2777	Red	153,000	3450	50 – 0/9
M6289		162,000	3600	55 – 0/9

Compounded Magnum .947

Melt Flow		4.3		
Flex Modulus		138,000		
Density		.947		
Cold Impact	-40 F	55 ft. / lbs.		

Mold Shrinkage

	W	L	D
Cold Mold	2.963	3.977	4.732
M2776	2.860	3.830	4.540
% Shrink	3.5	3.7	4.1
M2773	2.856	3.823	4.534
% Shrink	3.7	4.0	4.4
M5974	2.862	3.828	4.532
% Shrink	3.5	3.9	4.4
M2778	2.873	3.853	4.570
% Shrink	3.1	3.2	3.5
M2862	2.865	3.836	4.553
% Shrink	3.4	3.7	3.9

Mold Shrinkage

M6259	2.860	3.860	4.540
% Shrink	3.6	3.0	4.2
M5968	2.850	3.830	4.530
% Shrink	4.0	3.8	4.5
M3005	2.863	3.835	4.550
% Shrink	3.5	3.7	4.0
M6527	2.873	3.854	4.553
% Shrink	3.1	3.2	3.9
M2775	2.856	3.834	4.553
% Shrink	3.7	3.7	3.9
M5992	2.878	3.857	4.578
% Shrink	3.0	3.1	3.4

Mold Shrinkage

M6376	2.871	3.846	4.561
% Shrink	3.2	3.4	3.7
M5991	2.890	3.893	4.629
% Shrink	2.5	2.2	2.2
M5967	2.892	3.878	4.562
% Shrink	2.5	2.6	3.7
M2770	2.900	3.827	4.546
% Shrink	2.2	3.9	4.1
M2802	2.871	3.849	4.511
% Shrink	3.2	3.3	4.9
M2774	2.879	3.861	4.577
% Shrink	2.9	3.0	3.4

Mold Shrinkage

3004	2.855	3.826	4.520
% Shrink	3.8	3.9	4.7
4505	2.856	3.831	4.535
% Shrink	3.7	3.8	4.3
5969	2.830	3.850	4.540
% Shrink	4.7	3.3	4.2
3723	2.880	3.880	4.550
% Shrink	2.9	2.5	4.0

Shrinkage Data

Product				24 Hours			48 Hours		
	W	L	D	W	L	D	W	L	D
M2802	2.362	3.200	3.967	2.360	3.198	3.961	2.368	3.203	3.953
% Change				-0.1	-0.1	-0.2	+0.2	+0.1	0.4
M2774	2.298	3.232	3.964	2.305	3.238	3.946	2.299	3.239	3.948
% Change				0.3	0.2	-0.5	0.0	0.2	-0.4
M3004	2.269	3.144	3.879	2.288	3.145	3.847	2.290	3.140	3.867
% Change				0.8	0.0	-0.8	0.9	-0.1	-0.3
M4505	2.176	3.101	3.782	2.178	3.102	3.782	2.182	3.100	3.761
% Change				0.1	0.0	0.0	0.3	0.0	-0.6
M5969	2.330	3.230	3.960	2.313	3.225	3.949	2.317	3.222	3.940
% Change				-0.7	-0.2	-0.3	-0.6	-0.2	-0.5
M3723	2.216	3.201	3.883	2.209	3.210	3.881	2.207	3.202	3.881
% Change				-0.3	0.3	-0.3	-0.4	0.0	-0.1

Shrinkage Data

Product				24 Hours			48 Hours		
	W	L	D	W	L	D	W	L	D
M6259	2.279	3.168	3.879	2.278	3.171	3.898	2.280	3.167	3.901
% Change				0.0	0.1	0.5	0.0	0.0	0.6
M5968	2.265	3.166	3.866	2.274	3.169	3.851	2.272	3.170	3.850
% Change				0.4	0.1	-0.4	0.3	0.1	-0.4
M3005	2.413	3.319	4.073	2.425	3.314	4.050	2.414	3.311	4.062
% Change				0.5	-0.2	-0.6	0.0	-0.2	-0.3
M6527	2.326	3.236	3.981	2.323	3.232	3.969	2.325	3.238	3.969
% Change				-0.1	-0.1	-0.3	0.0	0.1	-0.3
M2775	2.332	3.206	3.950	2.329	3.206	3.946	2.331	3.208	3.211
% Change				-0.1	0.0	-0.1	0.0	0.1	-0.1
M5992	2.433	3.135	3.962	2.441	3.141	3.950	2.439	3.141	3.953
% Change				0.3	0.2	-0.3	0.2	0.2	-0.2

Shrinkage Data



Product				24 Hours			48 Hours		
	W	L	D	W	L	D	W	L	D
M6376	2.353	3.212	3.983	2.359	3.215	3.967	2.358	3.220	3.996
% Change				0.3	0.1	-0.4	0.2	0.2	0.3
M5991	2.417	3.246	4.021	2.415	3.245	4.013	2.420	3.245	4.012
% Change				-0.1	0.0	-0.2	0.1	0.0	-0.2
M5967	2.227	3.149	3.865	2.224	3.144	3.857	2.225	3.143	3.862
% Change				-0.1	-0.2	-0.2	-0.1	-0.2	-0.1
M2770	2.205	3.252	3.911	2.205	3.240	3.883	2.205	3.249	3.888
% Change				0.0	-0.4	-0.7	0.0	-0.1	-0.6
M2776	2.302	3.160	3.901	2.296	3.152	3.890	2.298	3.151	3.889
% Change				-0.3	-0.3	-0.3	-0.2	-0.3	-0.3
M2773	2.342	3.147	3.894	2.329	3.136	3.884	2.330	3.135	3.882
% Change				-0.6	-0.4	-0.3	-0.5	-0.4	-0.3

Shrinkage Data

Product				24 Hours			48 Hours		
	W	L	D	W	L	D	W	L	D
M5974	2.298	3.241	3.959	2.301	3.230	3.934	2.299	3.235	3.939
% Change				0.1	-0.3	-0.6	0.0	-0.2	-0.5
M2778	2.268	3.179	3.871	2.260	3.169	3.870	2.259	3.171	3.859
% Change				-0.4	-0.3	0.0	-0.4	-0.3	-0.3
M2862	2.386	3.146	3.929	2.380	3.145	3.921	2.383	3.149	3.921
% Change				-0.3	0.0	-0.2	-0.1	0.1	-0.2

Earth Tones

		Flex Modulus	Impact Ft / Lbs	Tensile Strength PSI	Brittles
M2774	Gray	132,000	55	3400	0/12
M2775	Brown	133,000	55	3450	0/12
M2776	White	131,000	60	3400	0/12
M4505	Virgin Black	132,000	55	3350	0/12
M5967	Steel Gray	133,000	55	3450	0/12
M6376	Tan	131,000	55	3400	0/12

Red / Yellow

		Flex Modulus	Impact Ft / Lbs	Tensile Strength PSI	Brittles
M2802	Orange	130,000	55	3350	0/12
M3005	Purple	132,000	55	3400	0/12
M3723	Magenta	131,000	60	3450	0/12
M5969	Yellow	132,000	50	3400	0/12
M5974	Traffic Red	132,000	55	3400	0/12

Blue / Green

		Flex Modulus	Impact Ft / Lbs	Tensile Strength PSI	Brittles
M2778	Spruce	132,000	55	3450	0/12
M2862	Blue	132,000	60	3400	0/12
M3004	Turquoise	131,000	55	3400	0/12
M5968	Aqua	136,000	50	3350	0/12
M5992	Seafoam	131,000	55	3350	0/12
M5991	Bright Green	133,000	55	3450	0/12
M6259	Grass Green	132,000	55	3450	0/12



DRY COLOR VS COMPOUND

Product	Impact	Brittle	Flex	Tensile
6721 Natural Magnum	60	0	145,000	3350
Nova 735 PE	50	0	100,000	2650
6721 White	30	5/11	139,000	3450
735 White	45	0/11	90,000	2450
6721 Blue	35	4/11	140,000	3400
735 Blue	50	0/11	98,000	2500
6721 Purple	40	2/11	138,000	3350
735 Purple	45	0/11	95,000	2500

Conclusions

- 1. Still much work to do.
- 2. Density is a driver, especially in dry color, but pigments affect the results.
- 3. Impact studies on the samples at various PIAT is important to develop a true process parameter.
- 4. Color form matters and is a big contributor to warp, shrink, impact, etc.