POLYMER PROCESSING-WARPAGE DURING INJECTION MOLDING

Problem description:

HDPE Warpage is a common problem which is encountered during injection moulding. Warpage is defined as the differential or anisotropic shrinkage of an injection molded part along the three different axes. Warpage leads to a part distortion, which can result in the reduction of mechanical properties as well as issues with fitting with other parts such as stackable boxes or crates and lids. Warpage is influenced by the polymer characteristics, the geometry of the molded article, the molding and cooling conditions, and additives such as pigments. There are several reasons which can be attributed to this problem

Mechanical Reasons:

1) Processing parameters

- High Injection Rate
- Low Injection Rate
- Low Melt Temperature
- Short Cooling Time
- Short Hold Time

2) Mould Issue

- Ejector design flaws
- Gate Too Small
- Poor Mold Making
- Uneven Cooling
- Wrong Gate Location

3) Part Design Issue

- Lack of strengthening Ribs
- Part Shape
- Part Too Thin
- Sudden or Large Differences in Wall Thickness

Choice of Polymer

1. Other than above mentioned mechanical, process parameters, there could be problems with Polymer itself and various additives, masterbatch components, pigments, nucleating agents, which are used during moulding.
2. In terms of Polymer itself the extent of warpage will very much depend on factors like molecular mass, degree of polymerization, amount of branching, and molecular weight distribution.
3. Higher molecular weight polymers tend to be less prone to warpage than lower molecular weight ones.
4. Branched polymers tend to warp less versus un-branched polymers.

Chemical Reasons

Problem with choice of nucleating agents

Nucleating agents are often used in polypropylene-based compositions; however, due to the fast crystallization rate, typically nucleating agents are not as effective when used with HDPE.

In theory, if the positive effects of a nucleating agent can outperform the nucleating effect caused by the various pigments, the negative nucleation effects will disappear and all coloured articles will behave in the same way.

Warpage and stress cracking will be eliminated and moulding conditions will not need to be altered for each colour. Pigment levelling is the term commonly used to describe this effect.

There are many commercially promoted nucleating agents. They create heterogeneous nucleation sites in the polymer melt so crystallization is initiated at higher temperatures. Some, like Micronised Sodium Benzoate, Talc, Silica, and PTFE remain solid at processing temperatures. For maximum efficiency these should be present in nano form to generate the highest density of nucleation sites.

Micronised Sodium Benzoate, which has been used for a very long time, deserves some respect as a pigment levelling nucleant. Micronised Sodium Benzoate is a Traditional and fast ("hyper") nucleators enhance physical properties and productivity and reduce warpage.

Fillers used in the formulation will also lead to warpage.

Fillers are responsible for the alignment of the polymer chains in the injection molding direction. The orientation of the polymer chains influences the orientation of the crystalline areas and is responsible for the difference in shrinkage along and perpendicular to the flow direction. However there are recent developments to offer Micronised (Nanosized) Fillers which can also act as Nucleating agents in addition to being used as fillers.

Problems with Organic Pigments

Dimensional stability issues are more prevalent in semi-crystalline polymers such as HDPE. Formulation of organic pigments into HDPE affects the nucleation rates and can lead to further shrinkage and warpage.Organic pigments play a critical role in the nucleation process of semi-crystalline polymers especially in polyolefins and contribute to dimensional instability of the injection molded parts. Organic pigments is that they themselves can act as nucleating however since these pigments are not surface treated nucleation is not even leading to issues of Warpage.

Typical Shrinkage Values

Polymer	**% Shrinkage**	**Polymer**	**% Shrinkage**
PS	0.4-0.7	ABS	0.30-0.8
PA 6	0.5-1.5	PC	0.5-0.7
PP	0.8-2.5	PA 66	0.8-1.5
HDPE	1.5-4.0	Acetal	2.0-2.5

No and Low warping Pigments

C.I.	**Chemistry**	**Warping**
P.R. 177	Anthraquinone	None
P.B. 15:1 with additive	Cu-phthalocyanine	None
P.Y. 128	Disazo condensation	None
P.Y. 93	Disazo condensation	None
P.Y. 95	Disazo condensation	None
P.R. 220	Disazo condensation	None
P.R. 254 with additive	DPP	None
P.R. 264	DPP	None
P.Y. 220	Monoazo	None
P.Y. 168	Monoazo salt	None
P.Y. 191:1	Monoazo salt	None
P.O. 79	Azo salt	Low
P.Y. 180	Benzimidazolone	Low
P.O. 64	Benzimidazolone	Low
P.R. 48:2	Bona (Ca)	Low
P.R. 57:1	Bona (Ca)	Low
P.R. 57:1	Bona (Ca)	Low
P.R. 48:3	BONA (Sr)	Low
P.B. 15:4 with additive	Cu-phthalocyanine	Low
P.G. 7	Cu-phthalocyanine	Low
P.V. 37	Dioxazine	Low
P.V. 23	Dioxazine	Low
P.Y. 155	Disazo condensation	Low
P.O. 71	DPP	Low
P.R. 272	DPP	Low
P.Y. 139	Isoindoline	Low
P.Y. 110 with additive	Isoindoline	Low
P.Y. 62	Monoazo salt	Low
P.Y. 183	Monoazo salt	Low
P.Y. 215	Pteridine	Low
P.R. 122	Quinacridone	Low
P.R. 202	Quinacridone	Low

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