ENGINEERING POLYMERS: THE 'TOP TEN' INJECTION MOULDING PROBLEMS

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Part 7: Poor mould surface finish

1. Moisture in the granules
2. Feed system too small
3. Wrong gate position
4. Hold time too short
5. Wrong melt temperature
6. Wrong tool temperature
7. Poor surface finish
8. Problems with hot runners
9. Warpage
10. Mould deposit

Partially crystalline engineering thermoplastics such as POM (acetal), PA (nylon), PBT and PET (polyesters) are used primarily because of their outstanding mechanical, thermal and electrical properties. Further advantages over amorphous materials include their excellent chemical resistance and low tendency towards stress cracking. In many kinds of applications a high quality surface finish is an additional requirement. This article is intended to help eliminate possible surface defects.

Localisation and definition of surface defects

To solve the problem of surface defects one must first examine the precise location of the defect, and when it actually became evident. Here it is advisable to observe the surface during the actual injection moulding process. The points that need clarification are listed below.

- Does the defect occur with every shot or irregularly?
- Does the defect always occur in the same cavity?
- Does the defect always occur at the same place in the moulding?
- Can the defect be predicted already during a mould filling study?
- Is the defect already evident on the sprue?
- How does the defect react when a new batch of moulding compound is used?
- Does the defect occur with only one machine or with others as well?

Analysis of possible causes of surface defects

Surface defects may be caused by many different factors such as:

- Compounding: drying, compound quality, presence of contaminants (foreign bodies)
- Injection moulding conditions: melt temperature, injection speed and change-over point
- Condition of the injection unit, e.g. wear and dead spots
- Design of the hot runner system (runners, material stoppage etc.)
- Mould design, position of gate and gate cross-section, cold slug interceptor, venting etc.
- Additives such as pigments
- The polymer contained in the moulding compound.

Conclusions to be drawn from surface defects

1. Regular local defects

If surface defects regularly occur in the same place this indicates that there is a problem in the injection nozzle or the hot runner nozzle. The shape and design of the runner, gate or the moulded part itself may be responsible, e.g. sharp edges, sudden changes in wall thickness etc. Another cause may be moulding conditions such as the injection profile or the change-over point.

2. Irregular local defects

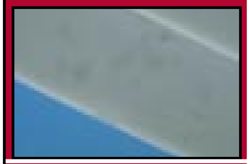
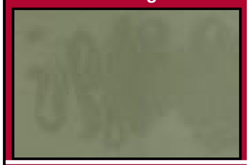
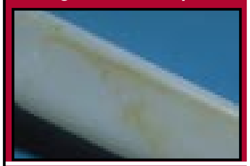
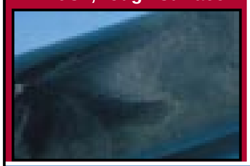
Where surface defects occur irregularly in different places, one should look at compounding (compound quality, presence of dust). Factors such as low melt temperature, back pressure, screw speed and screw retraction can also play an important part.

3. Surface defects covering large areas

This kind of defect usually extends over the entire moulding and is often visible already on the sprue. Here one should check whether melt decomposition has occurred. This is done by forcing a shot of melt into the open and observing whether, for example, it contains bubbles. In the case of hot runner systems, this method can be used with only limited success. Melt decomposition may be due to polymer degradation or decomposition of additives, caused by overheating or excessively long residence times. In the case of hygroscopic polymers, an important part is also played by hydrolytic degradation if the moulding compound has not been dried sufficiently.

General recommendations

Parts made from partially crystalline engineering polymers should preferably not be made by hot runner injection moulding if a perfect surface finish is essential. It is advisable to make use of a subsidiary runner, which thermally isolates the nozzle from the moulded part, thereby reducing the risk of surface defects.
The cold slug coming from the injection or hot runner nozzle should be intercepted by a special device opposite the sprue so that it cannot get into the moulded part.
The following table lists various surface defects and ways and means of eliminating them. In practice however, different surface defects appear simultaneously, which makes any investigation as to their origin – and their elimination – much more difficult.

Symptom	Grades	Where and when	Possible cause	Possible elimination
Streaks in direction of flow 	all	• with every shot across large areas	• damp compound (PA) • thermal degradation	• check moisture content of compound • check drying • check melt temperature
Marbling 	mineral reinforced grades	• with every shot • behind sharp edges • near the gate	• too high shear • slip-stick effect (outer skin migration)	• reduce injection speed (possibly profile) • round off sharp edges • increase gate cross-section
Cold slug 	all, especially reinforced grades	• usually occurs in only one place • goes through the entire wall thickness	• cold slug or inhomogeneous melt from the injection or hot runner nozzle has got into the moulded part	• intercept cold slug • possibly raise nozzle temperature
Sink mark 	all, especially unreinforced grades	• opposite ribs • near melt accumulations	• greater shrinkage near melt accumulations since the holding pressure here is not effective long enough	• improve design, e.g. make ribs thinner and provide uniform wall thickness • move gate elsewhere
Charred surface 	all	• always at the same place (near weld lines and at the end of flow paths)	• oxidation through compressed air which cannot escape (Diesel effect)	• provide or improve venting • inject more slowly
Unmelted particles 	all grades, especially unreinforced ones	• sporadically in different places	• compound has not melted and is not properly homogenised	• check melt temperature (perhaps too low) • increase back pressure • check screw speed • possibly use bigger cylinder (longer residence time)
Jetting 	all	• with every shot • usually starting from the gate	• jet of melt issues from the gate into the moulded part • no flow resistance to support laminar flow	• inject more slowly (possibly profile) to obtain laminar flow • provide flow restrictor behind the gate • possibly move gate elsewhere
Irregular brown spots 	all	• 5-15 shots are correct, then defect occurs during the next 1-2 shots, to be followed by another 5-15 good shots etc.	• dead spot in nozzle or hot runner (e.g. ante-chamber). Only when the compound has degraded is it forced into the melt stream. Dead spot is then filled with fresh melt etc.	• remove dead spot • improve bypass
Whitish, rough surface 	reinforced grades	• near the end of the flow path • behind edges and bypasses • near ribs	• melt front stops for short time during filling • polymer crystallises before it is forced against the wall • glass fibres near the surface	• increase injection speed • check melt temperature, which may be too low • check change-over point and mode (do not fill with holding pressure)

Typical surface defects and their elimination

Source: DuPont

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