Injection Molding Process Development Of Widgets

<u>ABC Corporation</u>

Report prepared by:

Vishu Shah
Consultek
2/27/03

Project

The project requires molding of D and P portions of the leads.

From the quick review of the process, it became very apparent that this is a very unique endevor, not a typical or conventional molding process. This is development project and assistance from material suppliers cannot be expected. Although urethane elastomers are sucessfully insert molded around variety of thermoplastics and metals, molding of leads presents a challenge due to the extermely small and intricate geometry, close tolerences, long cycle times, small cross sectional areas, challenge in maintaining small part positions under high injection speeds and pressures. **It is extremely unlikely that there is anything remotely similar to this product being molded in the plastics industry**.
The following problems were encounterd during the early stage of the development cycle.

a. Bubbles in molded parts, foamy appearance in sprue and runners.
b. Poor bonding between tube and molded part.
c. Inconsistent filling of the molded part.
d. Cold slug (varying degree) from the machine nozzle.
e. Premature cooling of machine nozzle.
f. Unbalance part fill (one side filling faster than other resulting in uneven distribution of components in molded part the leads to push to one side).

In order to develop a successful solution the scientific approach was used to solve one variable at a time in order of priority. This included examination of material selection, drying equipment, drying techniques, the injection molding machine, processing parameters, mold temperature settings, part design, and tooling design.

Material

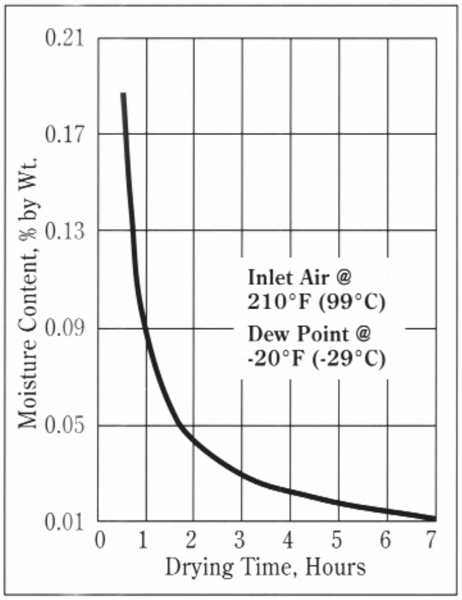
Polyurethane (Dow Pellathane 2363 series, Polyether based elastomer) is the material of choice in terms of application, performance and processing.

Drying

Polyurethane elastomers are extremely hygroscopic, that is the material readily absorbs moisture from the air. This can results in a degradation of physical properties of the material in addition to causes processing issues such as voids and bubbles. Cognizant of this fact Advanced Bionics invested in one of the best dryers available on the market. In order to validate proper drying of the material, a sophisticated moisture analyzer was also purchased.   Figure 1 shows a typical drying curve for pellethane elastomers. As can be seen in Figure 1 ideally a moisture level of 0.02 weight percent be maintained prior to molding.

Testing conducted on material samples taken from the dryer storage hopper measured well below 0.02 weight percent. However there were still bubbles present in the parts molded with this “dry” material. It was determined that the problem was caused by the material transport mechanism. Air in the section of the mold between the drying hopper and molding machine had a high moisture content (specific number would be useful). In order to overcome this problem small quantities of material are hand loaded into the machine hopper. This has resulted in the disapperance of all bubbles.

Figure 1 – Typical Drying Curve for PELLETHANE Elastomers



Process parameters

There were two sets of conflicting conditions in trying to attempt molding of leads. The procees dictated that the leads be hand loaded into the mold . This process of hand loading requires at least 160 seconds of mold open time. In order to avoid excessive residence of the material and subsequent degradation during part loading various temperture combinations were tried. First the temperature in the rear zone was turned off and the temperature in the two front zones was raised. The results were unfavorable due to an unbalanced and non-uniform melt. This was corrected by reverting to standard (rear and two fronts) temperature settings and lowering of all temperatures. This solved the resident time issue and also solved the problem of poor bonding between the tube and molded part, resulting in excellent fusion at this interface.

Cold Slug issue

The tooling design for the part requires the use of an extended shut off nozzle. This extended nozzle creates a clod slug (cold piece of material) in front of the nozzle due to its contact with relatively colder mold surface. The cold slug varies in length from shot to shot resulting in inconsistant filling of the mold. This problem was solved by adding a heater band to the extended nozzle.

Unbalanced part filling

After the fundamental machine issues were addressed, we were able to concentrate on the major issue of unbalanced filling of the mold. In the case of both the proximal and distal molds one side of the runner and gates were filling faster than the other. This caused unequal cavity pressure which resulted in pushing of the components to one side of the mold leading to an unacceptable final part. Critical mold dimensions (runner diameters, depth, distances etc.) were measured multiple times and were equal. This problem was solved using a step-wise method to address the issues. First, venting was increased to improve the evacuation of gases from the material to determine if one side was venting better than the other. There was no appreciable improvement in filling. Next, the steel temperature of various parts of the mold was measured using a surface probe and pyrometer. The measured difference between the sides of the mold was negligible and the mold was heating up evenly. Cold slug wells ware located at the end of the runners and catch cold material so that only uniformly melted material will enter the gates to the part. The cold slug wells were enlarged in order to catch more of the cooler melt, however no appreciable improvement was observed. Next, the diameter of the primary, secondary and tertiary runners were increased to help fill the parts with greater ease and thereby reduce cavity pressure, improvement was noted. Since none of the conventional techniques and logical steps yielded satisfactory results, we decided to incrementally increase the diameters of the primary and secondary runners on the side that was filling last. This resulted in a balanced mold and accepatable parts.

Future steps

Astudy is required to determine the cause of the imbalanced fill. This willl ensure that future mold cavities are fabricated with a certain degree of assurance. The following suggestions and recommendations are made in order to deteremine the cause:

1) Analysis using Moldflow, a commercially available computer simulation software. This softward is useful for identifying and solving critical manufacturability and quality issues in the early stages of part and mold design, and can eliminate potential manufacturing problems downstream.

   With **Moldflow Part Advisor** module Designers get rapid feedback on how modifications to wall thickness, gate locations and other changes can affect the production of their part design. Moldflow Part Adviser software also provides precise information on the location of weld lines and air traps, as well as the filling pattern, and pressure/temperature distributions in the part cavity. The **Moldflow Mold Adviser** module allows mold designers to layout and optimize the gate and runner systems for single-cavity, multi-cavity and family molds, as well as to predict clamp tonnage, shot size and cycle time requirements, all before the part geometry is finalized.

   Mold designers and tool builders can create and optimize the mold design during the first stages of the part design process.

2) The dryer manufacturer should be able to address issue of mixing moist air during material conveyance to the hopper of the molding machine. This will allow automatic loading of the predried material. According to John the dryer manufacturer has resolved this issue.

3) A means to measure the actual melt temperature should be employed since melt temperature has a pronounced effect on the quality of the bond between various components.

The entire process, when fine-tuned should run totally automatic without operator intervention. A Boy machine is capable of reproducing shot after shot and is well equipped with a variety of statistical analysis and process monitoring tools. Some limited amount of work still needs to be done to achieve/establish optimum molding cycle whereby the results are predictable and outcome is very reliable.

Summary

It is the opinion of the author that the current personnel roster at ABC Corporation is capable of developing and maintaining the integrity of the project with minimum outside consulting from the plastics expert.