A report on

R S

Product Failure

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Background Information

Mr. R A contacted us in early January to assist him in resolving the quality related issues with Injection molded parts referred to as Snap. According to him the problem centered on the excessive flexibility found in over half of the 566,000 parts. The molded parts when excessively flexible do not perform the intended function when compared to the normal stiff parts. He also mentioned that he had given the molder specific criteria related to the stiffness requirement for the parts and also provided them with test fixture and instructions on how to use the test fixture to check the parts for minimum acceptable flexibility.

Part Name: Snap

Material: Nylon 66

Grade: DuPont Zytel 101L or equivalent prime grade material

Color: Natural

Mold:

Molder: Modern Silicone

General Information

Polyamides, more commonly known as nylons are strong and tough engineering thermoplastic materials. They are highly resistance to abrasion and to most chemicals. Molded articles retain their shape at elevated temperatures, are strong in thin sections and have low coefficient of friction.

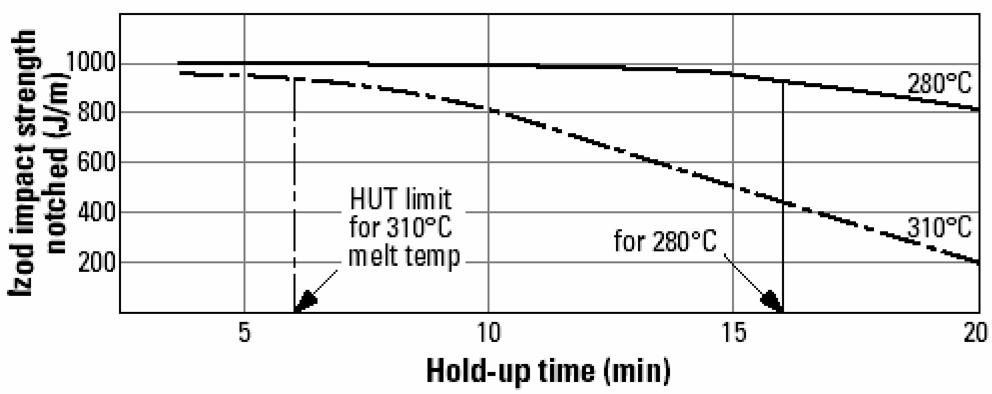
Moisture

Most thermoplastics absorb atmospheric moisture, which under normal processing conditions can cause degradation of the polymer. Nylons are hygroscopic resins and they demand proper pre-drying before molding: these polymers do react with moisture at high (processing) temperatures. When this reaction occurs, polymer chains break, resulting in loss of properties. Excessive moisture can manifest itself in splay, silver streaking, blisters or degradation, which reduce the cosmetic and physical properties of molded components. The removal of moisture is therefore essential to ensure optimal performance of the final part.

Thermal degradation

As with all plastics, nylon resins can be thermally degraded. The thermal degradation can be significant the hold-up time of the material in the barrel is too long, or the melt temperature too high. The hold-up time (or barrel residence time) is the average time taken for a granule to pass from the hopper throat to the moment when it is injected into the mold. Nylons, like any plastic, can be degraded during the molding process. The degradation of the polymer will affect the molecular weight and reduce the properties, as explained above.
Degradation depends both on the melt temperature and hold-up time (i.e. residential time of resin in the injection machine). The higher the melt temperature the shorter the hold-up time that will lead to damaged
material.

Fig. 8 Effect of hold-up time on impact properties of toughened nylons



Prime Resin vs. Wide spec Resin

Plastic materials are sold in two categories. Prime material is the material that meets all the specifications that are listed in material supplier's data sheet. Material supplier at the request of a purchaser will provide certification stating that the material sold meets the specifications. Wide spec materials are the materials that do not meet data sheet specifications. Material is sold as wide spec material because the manufacturing issues the supplier may have encountered. Material is classified wide spec due to wide molecular weight distribution, black specs, yellowness and other issues. Some molding and performance related issues are expected. Material is also supplied by the manufacturer with lot numbers for traceability purposes. Lot to lot variation is not uncommon. The prudent thing for the purchaser of the plastic resin is to purchase no more than two lots of material at one time for the same job.

Generally Accepted Good Molding Practices by Professional Molders.

Molding practices and routines vary from molder to molder throughout the world. However, there are certain very basic and fundamental rules a molder must follow to qualify as a quality and professional molder.

A molder must:

- Purchase and use only the material specified by the customer
- Use prime Resin and limit the use of regrind as specified
- Use correct size machine in terms of clamp tonnage and shot size
- Keep equipment in reasonably good condition
- Perform calibration on regular basis
- Purchase material in one large lot to minimize variations
- Perform quality checks and test molded products as specified
- Maintain technically competent work force
- Keep customer abreast of current and anticipated problems

Results of the Laboratory report and discussion

R S received approximately 566,000 pieces of the product from the molder in January. Preliminary flexibility tests were conducted by R S to verify the integrity of the product. First 320,000 pieces were found acceptable (Based on acceptable rigidity level) while the rest of the lot of 246,000 pieces were found extremely flexible and were deemed unusable for the application.

Material Analysis:

In order to investigate the possible cause for the discrepancy between the stiffness of two sets of parts supposedly molded form the same grade of Entec N1000 EL natural

Nylon 66, the following tests were proposed and carried out by the independent testing laboratory.

FTIR:

FTIR is one of the most powerful identification techniques available today for positive identification of polymeric materials. The test is conducted simply by passing and infrared beam through a small sample, whereby some of the infrared radiation is absorbed or transmitted. The spectrum resulting from this test acts like a fingerprint unique to a particular polymer. Since no two unique molecular structures produce the same infrared spectrum, the resulting spectra can be compared with known material spectra and material is positively identified.

DSC:

Differential Scanning Calorimetry can differentiate between different materials within the same family of a polymer. For example, DSC can differentiate between Nylon 66 and Nylon 6. Failed parts are often analyzed for reduced level of crystallinity resulting from poor processing practices using this technique.

Brookfield Viscosity Test:

Viscosity is the property of resistance to flow exhibited within the body of a material at a given shear rate. Flow behavior is an indirect measure of product consistency and quality where materials must be consistent from batch to batch. Also, molded parts can be compared to original resin to determine the extent of degradation from the molding process since degraded material would be lower in viscosity as a result of reduced molecular weight. This is a sensitive method for material characterization because flow behavior is responsive to molecular weight and molecular weight distribution.

Results and Conclusion

Test results from the Plastics Technology Laboratory are attached in Appendix. Results are as follows:

1. FTIR test indicated that the material used in both batch of parts were made out of Nylon and no other contaminants present.

2. DSC test results were equally encouraging indicating that there was not a substantial difference between the two samples.

3. Brookfield viscosity test results showed that the material sample marked G (Good) was on the low end of the specification as stated on the Entec Product Certification for each lot of material. Standard minimum Relative Viscosity (RV) is 47.0 and standard maximum is 51.0. The test result showed average RV of 47.6 for the samples marked Good. The results for the samples marked P (Poor) indicated ten percent lower average viscosity when compared to the samples marked G.

   The results of Viscosity tests clearly indicate that the samples marked G are significantly different than the ones marked P. This also indicates that the material for the samples marked P is of lower molecular weight with lower tensile and flexural modulus (Stiffness), affirming the finding of the non-scientific tests conducted by R S.

Overall Conclusions and Preliminary opinions

Based on the conversations with R S, conducting detailed examination of molded parts, and having parts analyzed by an independent certified test laboratory, we have following observations and opinions to offer. Note that the observations are strictly based on conversations and reports; actual visit to the molder to personally observe molding practices and overall plant operation was not made.

The results from the test laboratory points to the issues stemming from material's lower molecular weight and resulting in loss of properties mainly the stiffness which is critical to the function of the part. There are many reasons why the material's molecular weight would lower than specification. As discussed earlier, in the case of condensation polymers such as nylons if the material is not dried properly prior to molding, remaining moisture can react with molten material in the barrel of a molding machine and break the molecular structure, degrade and lower the properties. Another reason for reduction in molecular weight is overheating of the material during molding process and utilizing excessive amount of regrind. Lot to lot variations in the raw material may also have contributed to the problem concerning lower overall stiffness in various lots of parts.

Mr. R A during initial conversation had indicated that he had specifically instructed the molder to conduct stiffness test routinely and he had provided instrument and procedures for conducting such tests. He also pointed out later on that molder had not conducted any tests during the run of his parts.

In closing, it is our opinion that the molder does not appear to have followed “Generally Accepted Good Molding Practices by Professional Molders” as described in earlier section of the report, nor has he exercised prudent judgment in purchasing raw material (Nylon), as evident by accepting six different lots of resin on a single day from a supplier. Molder has also ignored the simple instructions concerning end product testing which R S had established to mitigate premature product failure.