Gallery of goofs

This is the third in a continuing series that reports on errors of judgment made in the design and engineering of actual plastic parts and products.

This case history reviews an all-too-frequent oversight in the design of plastic parts with tapered pipe threads, and describes how the resulting product failure was corrected with a simple design modification. The author is Glenn L. Beall, president of Glenn Beall Plastics and former design editor of Plastics Design Forum *magazine.*

The product was a small, replaceable-cartridge-type water-filtering unit typical of those being used increasingly in homes and small commercial establishments to improve the quality of consumable water. It was intended to be installed in the central plumbing system by homeowners as well as by experienced plumbers.

The vast majority of plumbing systems used in the United States prior to 1960 were metal with tapered threaded fittings. This filtering unit was designed to be inserted into a water inlet pipe between the water meter and the water heater. It was anticipated that a section of the inlet pipe would be removed and that the filter would be inserted, utilizing the standard tapered pipe fittings and one union. While many other uses were expected, this was a primary one.

The filter body that accepted the threaded tapered pipe fittings was injection molded in a medium-impact ABS plastic. The single-cavity production mold was top-center-sprue-gated (Figure 1).

The product was designed to withstand a water pressure of 150 psi, which is the maximum residential-use pressure. Allowances were made for cyclic loading, water pound, and road-vibration effects. Extensive preintroduction testing indicated that the tapered pipe fittings were satisfactory and, in fact, were overdesigned.

Reports of product failures were received shortly after the product was introduced. Two incidents were especially noteworthy. One unit installed on a drinking-water cooler on the fifth floor of an office building developed a leak on a weekend while the building was unattended. Water ran across the floor and down a nearby elevator shaft, causing extensive damage on each successive floor.

Another unit was given to the owner of a large chain of plumbing-supply houses as a promotional sample for his personal use. The unit failed, and the plumbing-supply tycoon's basement was flooded—while he was away on vacation. Many other units failed, but—it is hoped—under less distressing circumstances.

Examination of defective units that were returned revealed that all of the failures were the result of stress cracks in the inside tapered pipe threads used for attaching the unit to the central plumbing system. In all cases, the failures were located below the thread as shown in Figure 2. None of the returned units were of the type adapted to be used with soldered-copper solvent-bonded plastic pipe.

Considering the location of the gate and the flow of the melt (Figure 1), it is obvious that the filter bodies contained weld lines in the inside thread in the area of the failures. Careful examination of returned units also indicated that all of the defects had at least started in the weld line below the thread. Inspection of unsold filter bodies molded at the same time, as well as observations made on the failed units, indicated that the parts had been properly molded. The weld lines were completely closed and well-knitted.

It is a known fact that weld lines always weaken a structure. However, in this case, weakness at the weld lines had not been a problem during the extensive preproduction testing program. Inquiries revealed that the technician who conducted the tests was aware of and had observed stress cracking in the area below the thread. This problem had been eliminated by taking care not to overtighten the threaded fitting.

It was concluded that the stress cracks were due to

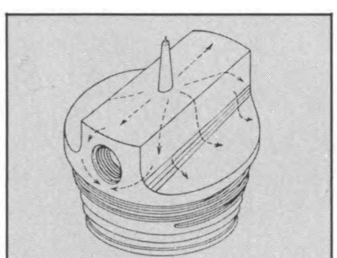

Figure 1.

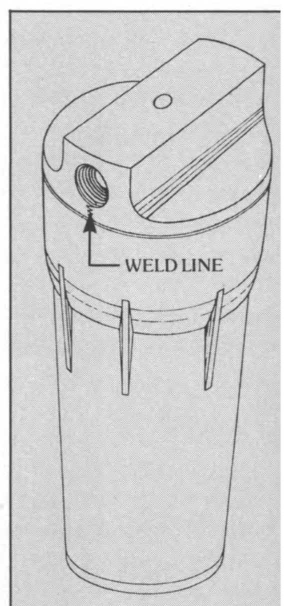

Figure 2.

overzealous tightening of the tapered pipe thread fittings. In retrospect, overtightening was an anticipatable misuse prompted by a desire to avoid leakage at the fitting. It was also speculated that overtightening was encouraged by the fact that during assembly the inside and outside threads gradually became tight with no positive indication of when a seal had been made. Metal fittings of this type abruptly become too tight to turn further. Thermoplastic parts with inside tapered threads are capable of expanding as the outside tapered thread is driven deeper into the inside tapered thread. Figure 3a illustrates this condition.

The threaded core pins in the filter-body mold subsequently were modified to provide a stop at the bottom of the thread as shown in Figure 3b. It was anticipated that this stop would provide an abrupt increase in torque that would indicate to the assembler that the fitting was tight enough.

This relatively simple modification of the product eliminated the failures that were being caused by overtightening of the fitting.

Thermoplastic materials have been used successfully for many years in applications requiring tapered pipe threads. It must be recognized, however, that driving the two tapered fittings together stretches the outside thread and imposes a high loop stress on the material surrounding the inside thread. Plastic materials with a high elongation can accommodate a high percentage of this type of loading. Given time, the creep of the plastic material will also relieve some of this hoop stress. Outside tapered threads are subjected to the same forces; however, in that case, the plastic part is loaded in compression and plastics are able to perform much better under that type of loading.

Inside tapered threads are a troublesome design detail

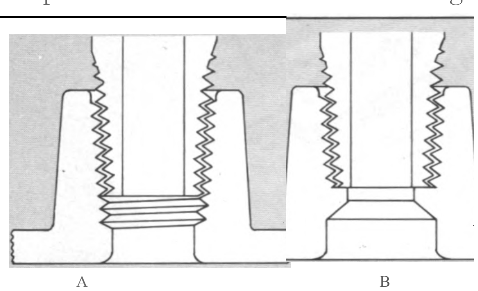

Figure 3.

that cannot always be avoided. Many types of products rely on tapered threads for a positive seal—hydraulic, pneumatic, and plumbing applications are examples. But the designer should always watch for opportunities to replace tapered threaded fittings with other lower-stress-type fittings—nontapered threads, for example.

When contemplating the design of tapered inside threads, the designer must allow for the possibility of high hoop stress generated by overtightening of the fitting. The thread stop described above will be useful in some cases. The designer must also exercise care in providing an adequate thickness of material around the outside of inside tapered threads. Careful attention to sharp edges in and around the fitting that could act as stress concentrators should also be given careful attention. Inside threads almost always contain weld lines, and their inherent weakening effect on the part must not be overlooked.

The thread stop described above eliminated the water filtering unit failures that were the result of overtightening of the fitting.