Non Destructive Examination of Plastics Failures

Introduction

Common plastics are used in many consumer products, including water delivery, filtering, storage and waste removal. Within the typical residence or commercial property, the failure of an inexpensive part can lead to property damage, which can vary from slight to significant losses. While large losses are commonly pursued, smaller damage claims may not be, due to the costs involved to investigate. A recent rise in plastic failures has led us to develop new, non-destructive methods and cost-effective techniques for identifying the reasons for these failures.

Using Computed Axial Tomography (CAT) Scanning has provided us with a means of "looking inside" a part. Oftentimes we have found considerable material voids that contribute to stress risers and decreased structural integrity. CAT scans can provide a quick and relatively inexpensive method to determine whether or not to pursue lengthy subrogation claims that often include expensive and destructive group inspections.

Typical Failure – Why, Where, and How

A recently completed water loss claim had a water canister which suffered a fracture, causing significant damage to a local business. Our findings were that the subject fracture occurred along one of the threads used to secure and mount the canister to the bonnet. This is a typical failure location in threaded components as it is this thread root that carries the highest stresses in the part. Stresses are concentrated in this region because of sharp geometry changes, known as stress risers, and a reduced cross-sectional thickness (the area is not as thick as that of a thread crest).

Figure 1 is a finite element model reflecting the highest stress region along the thread root:

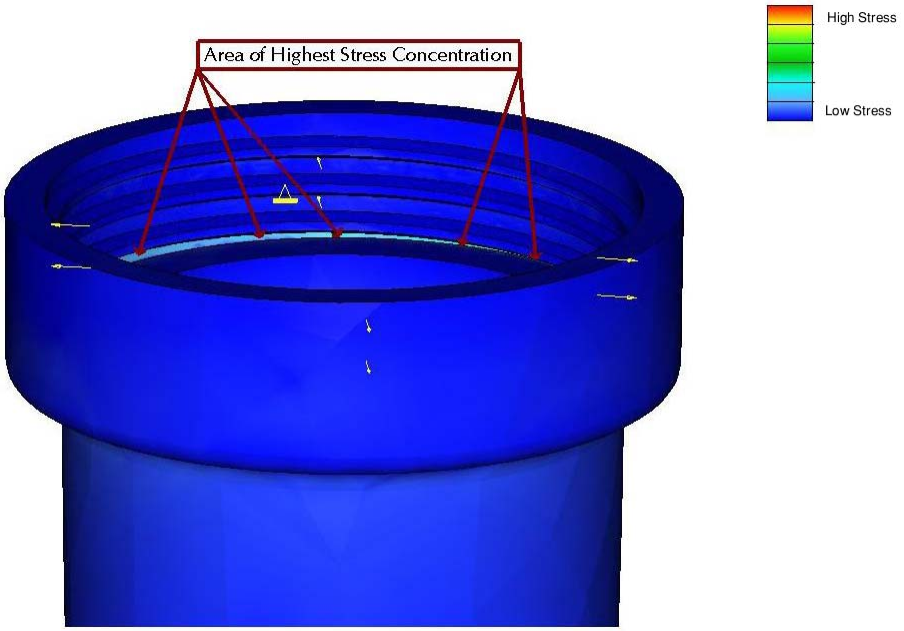

Figure 1

The fracture was consistent with creep rupture, a typical failure mode in loaded plastic components. Over time, the stresses below the yield strength of the material relax the polymer chains, reducing the ultimate strength of the canister. When the ultimate strength of the part is reduced to that of the applied stresses, the part fails.

In this instance, the failure did not travel about the entire circumference of the part. As the canister began to crack, stresses were relieved elsewhere in the part, resulting in the incomplete fracture observed.

The subject canister had been in use for three years. Our experience suggests that canisters of this type which fail within five years are likely to have manufacturing defects, such as internal voids.

Figure 2 shows a cross section of a canister containing material voids as a result of poor manufacturing:

Figure 2

Utilization of CAT Scans

The image on the left side of Figure 3 is an X-ray profile view of a reverse osmosis canister. The set of red, dashed lines indicates the region scanned. Looking closely at this image it can be seen that the canister fracture is located just to the right of the red dashed line.

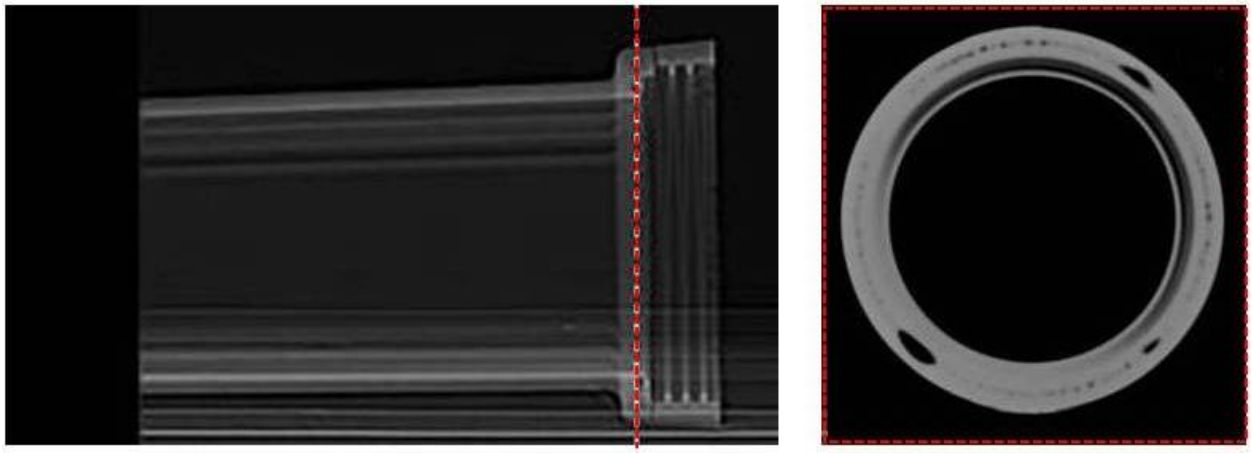

Figure 3

The image on the right side of Figure 3 shows an example image slice from the CAT scan data. The image slice shown corresponds to the red dashed line visible on the X-ray profile image. The CAT scan data showed the part is solid through its cross-section but contains areas of significant material voids.

Of course, established engineering calculations and finite analysis can be done in conjunction with CAT scans to determine the estimated life span of a plastic part such a toilet connector or a reverse osmosis filter canister.

In Service – Life Expectancy

Creep life expectancies for some common materials can be seen in Figure 4. The logarithmic graph data contained in Figure 4 was calculated for average room temperatures. This information helps determine, under a certain amount of stress, such as water pressure, how long the part would likely last.

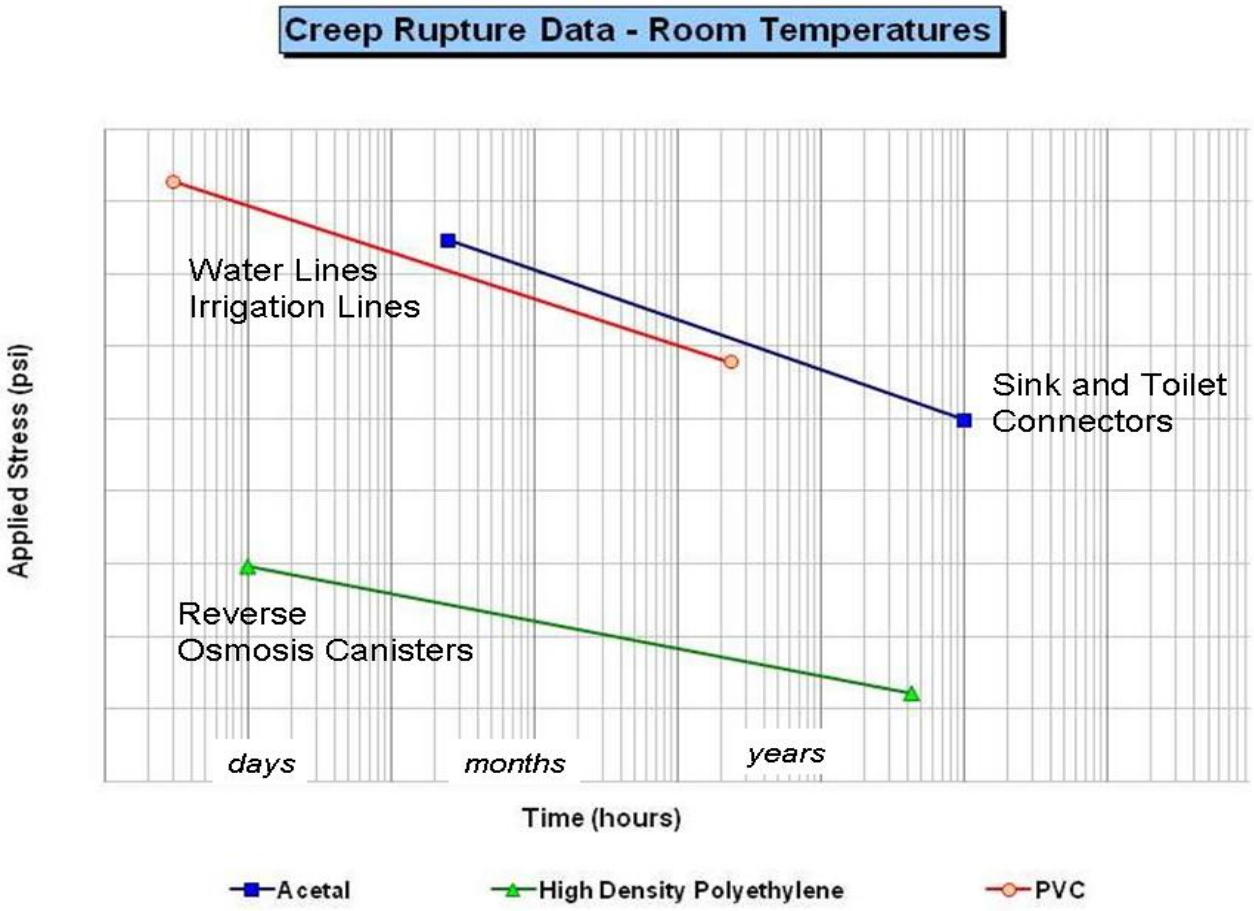

Figure 4

Using CAT scan imagery, a plastic part can be analyzed at a minimal cost and without any destructive or invasive procedures. This allows for more timely and cost-effective analyses to be completed and a determination of whether additional subrogation efforts should be continued.

In summary, a more cost-effective and timely analysis of the probable cause of plastic failures can be conducted using the any and all of the following techniques:

- Examination of the subject part – fractures tend to occur in characteristic locations
- Finite Element Analysis – to verify regions of highest stress
- Material analysis – comparison of the applied stresses and time to the material in use
- CAT Scans – non-destructive examination of the subject component interior