From the TMG Solutions Archives:

Rain Barrel Analysis

Keywords - Failure, Creep, FEA, Design Evaluation

What Went Wrong?

A plastic rain barrel was cracking at the bottom of a stiffening rib after approximately two weeks in service, which resulted in leakage of water. The rain barrel was injection molded from a high-density polyethylene material.

Evaluation

A visual examination of the failure revealed a smooth fracture surface that initiated at the base of the rib. The fracture surface was characteristic of a brittle fracture mechanism known as creep. Creep is a material response mechanism, commonly experienced by plastics and composites, in which the molecules of the plastic separate under the influence of a constant stress that is below the yield stress of the material.

The design integrity of the rain barrel was evaluated by performing a series of material tests and structural finite element analysis (FEA). The material testing used dynamic mechanical analysis (DMA) to characterize the long-term mechanical properties of the resin while under load. The FEA was used to determine the stress distribution in the rain barrel when the barrel was filled with water. The FEA confirmed the area of high stress coincided with the failure location, and the stress remained below the yield point of the plastic material. Combining the results of the material testing and the FEA allowed for a prediction to be made regarding the amount of time until the rain barrel would fail. With the stress levels predicted in the FEA, the rain barrel was predicted to fail after approximately two weeks of service.

Conclusion

It was the conclusion of the evaluation that the rain barrel failed through a brittle fracture mechanism known as creep. The combination of the rain barrel design and material selected resulted in a stress level that left the rain barrel susceptible to premature failure when filled with water. It was recommended that a either the design of the rain barrel be modified or the plastic should be changed to a more creep resistant material.

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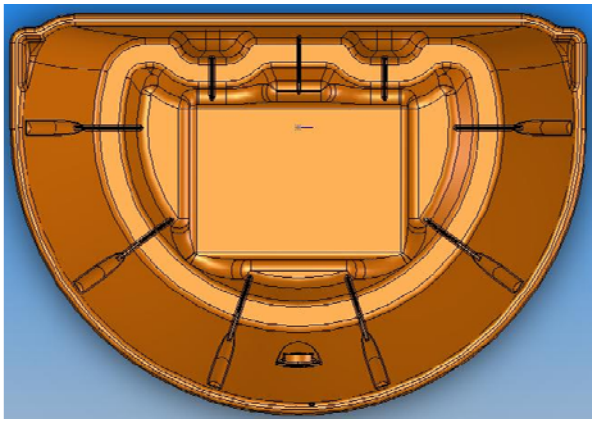
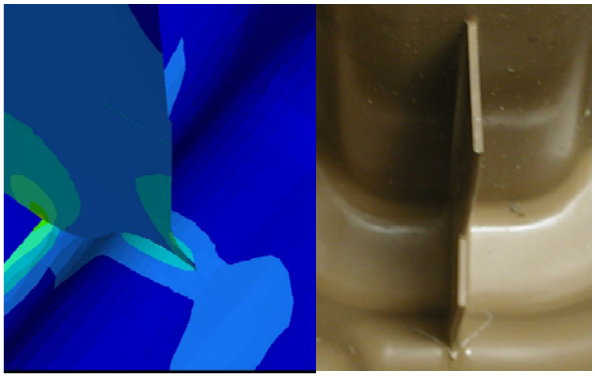
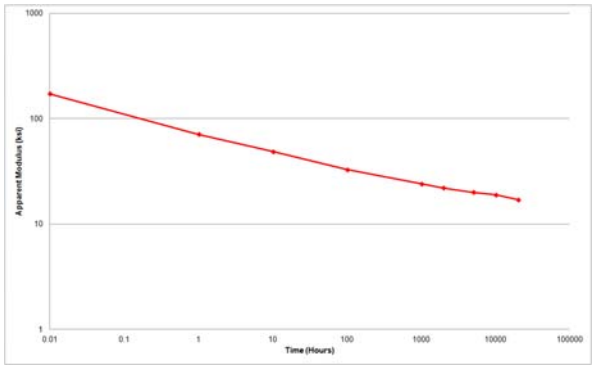


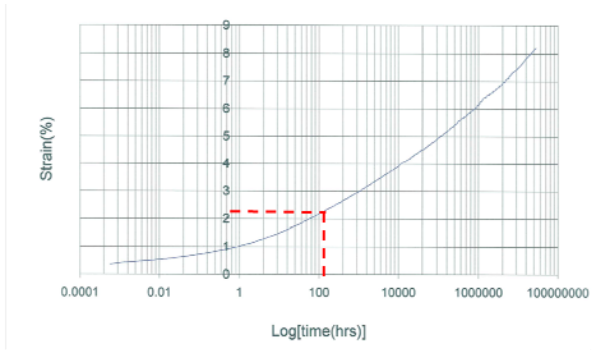
Top view of rain barrel design.



The failure location coincided with high stress area.



Material testing provided a prediction of material response over time.



Failure was predicted to occur after two weeks of service.