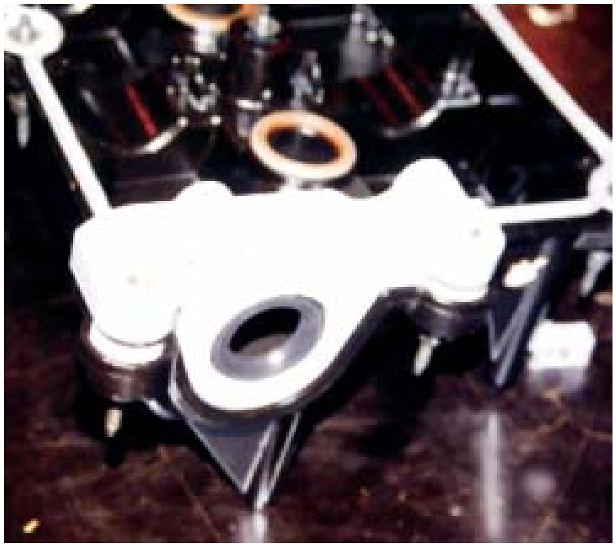
Rear Retainer Manufacturing Tolerances Guidance

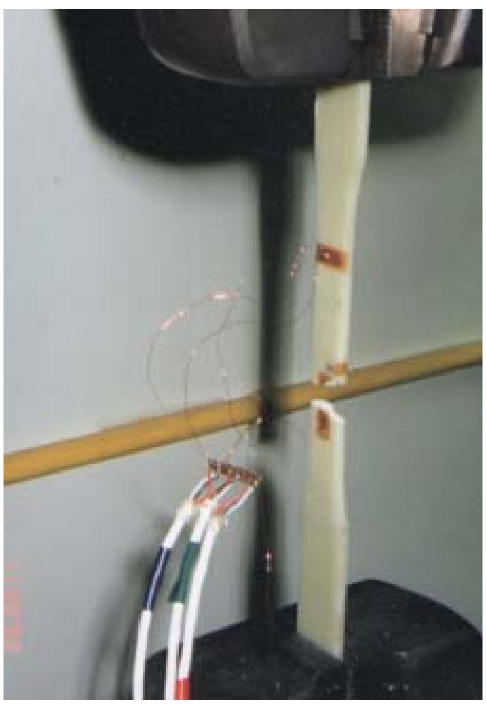
Ford Motor Company selected WIDL to assess the feasibility of converting a heavily machined aluminum rear-retainer, to epoxy vinyl ester composite. Initial prototypes failed as molding tolerances led to disagreements between plastics and rubber parts suppliers.



Rear-retainer on Valve Cover; Dynamic and PIP Seals

WIDL set a program of tests and analyses to help resolve the issue. Prototypes dimensional checks established capabilities of plastics molder.

Characterization at WIDL included testing Viton™ (used in the dynamic seal for the rear-retainer), for strain energy density models. More tests on rubber explored friction, minimum pressure to seal, shearing the bound holding rubber to steel plates, and tensile strength. Characterization also extracted properties of epoxy-vinyl ester (Young's modulus, Poisson's ratio, and tensile stress along and across the fibers). Tests at WIDL were conducted at typical underhood temperatures (from -40 to +150°C).



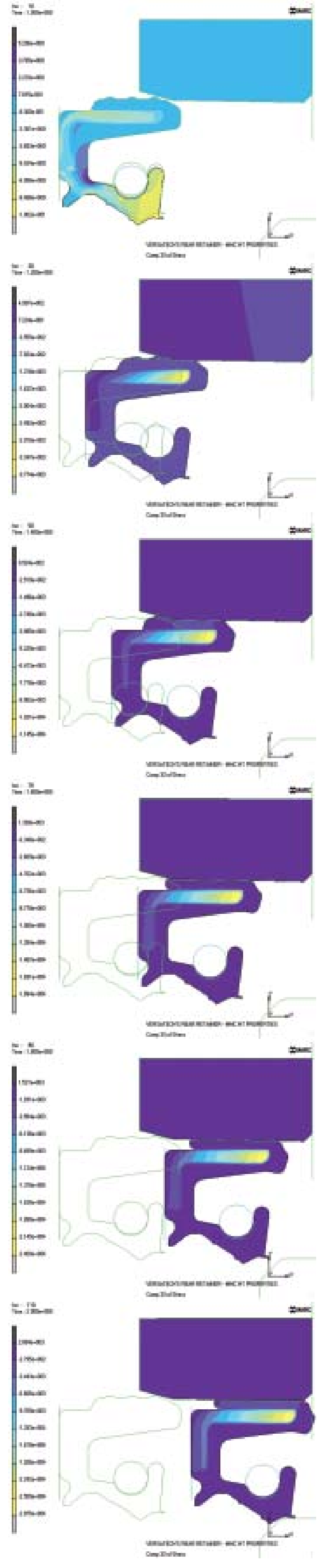
Plastics Tension Testing to Failure

Fully non-linear finite element models of the rear-retainer assembly used Marc™ (cf: http://www.mscsoftware.com). Modeling included contact between deforming bodies, seal to bore of retainer, and the seal and various rigid bodies (circular spring, insertion and retention plates, and shaft).

Deformations of the seal entering the bore of rear-retainer were monitored at WIDL. Internal stresses and contact pressures were particularly plotted. Reaction of the bore of the rear-retainer to insertion of the seal at the housing supplier, compared to within 5% of numerical predictions.

Analyses under least and maximum material conditions (LMC and MMC) allowed the establishment of sealing and strength. The LMC ensured sufficient contact not to leak, while holding the seal from spinning with the rotating shaft. The MMC allowed assessment of strength of bond between rubber and steel insert, and that of the weakest section of rear-retainer. Analyses accounted for parts changes in dimensions (thermal expansion/contraction); they also altered materials properties with temperature. True stress-strain data across the fibers defined the physical behavior of the thermoset plastics, based on flow analyses.

Leak testing ring gaskets at -40°C and FEA allowed the establishment of a LMC to hold in molding the rear-retainer. A MMC was also established, so that the weakest section of plastics housing withstands radial expansion at elevated temperatures. Modeling helped troubleshoot the application and avoid "trial and error" in tooling, prototyping, and the testing of many prototypes, quite an extensive and costly approach. Still, the opportunity window closed, as 1/ the seal supplier was not motivated to switch to another housing material and supplying source (for a product that has already been validated for aluminum retainer), and 2/ the plastics molder wasted over 10 months in "trial and error" with issues related to such metal-to-plastics conversion.



Inserting Dynamic Seal in Retainer at MMC and HT