Title: LS-DYNA Nonlinear Analysis of Plastics, Elastomers and Foams

Keywords: LS-DYNA, projectile, plastic, elastomer, foam, composite, nonlinear analysis, transient, dynamic, element erosion, damage prediction, contact analysis, Femap, Siemens PLM Software, nonlinear FEA analysis, nylon 12

Main Graphic:

Caption: Athletic body armors use a complex array of plastics, elastomers and foams.

Analysis Type: Explicit and Implicit Nonlinear Transient Analysis

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Objective: This case study presents several consulting projects where LS-DYNA was used in the nonlinear analysis of plastics, elastomers and foams.

Nylon 12 Watch Band

In the first project, a Nylon 12 watch band's opening and closing movement was simulated. Due to the time period involved, the simulation was run in implicit mode. Figure 1 shows a partial set of results. At the end of this project results were checked against in-house experimental work with good correlation noted.

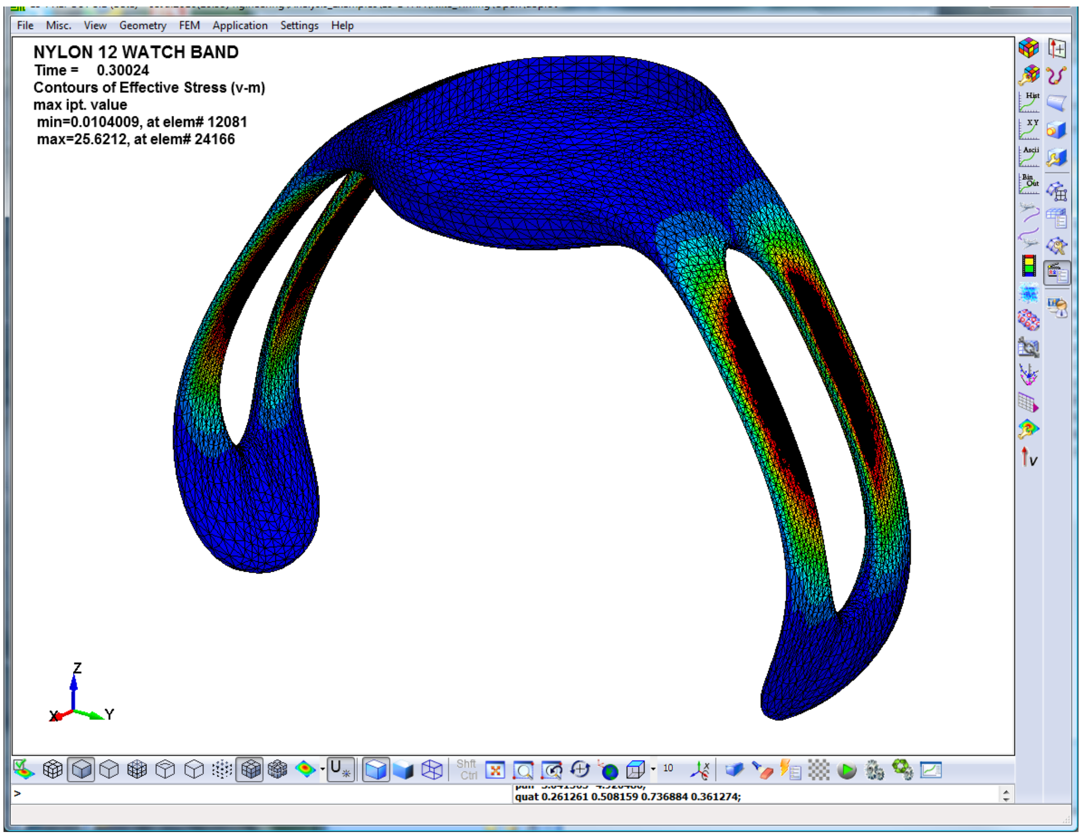


Figure 1: Nylon 12 is an extremely versatile plastic material that is widely used in the consumer products community. The complex flex behavior of the watch band from opening to closing was simulated. Opening force numbers were checked against experiment results and found to be in close agreement.

Drop-Test of Styrene Acrylonitrile (SAN) Plastic Cup

The manufacturer of this drink cup needed to switch to new plastic material and wanted to verify that it could still withstand a four foot drop test. The LS-DYNA model was built using plate elements with the silicon O-ring built using hex elements. The cup was dropped in a manner similar to MIL-STD-810E format. Results indicated that the cup lid would fly open but that the cup would not break! This was later confirmed upon testing of the actual article.

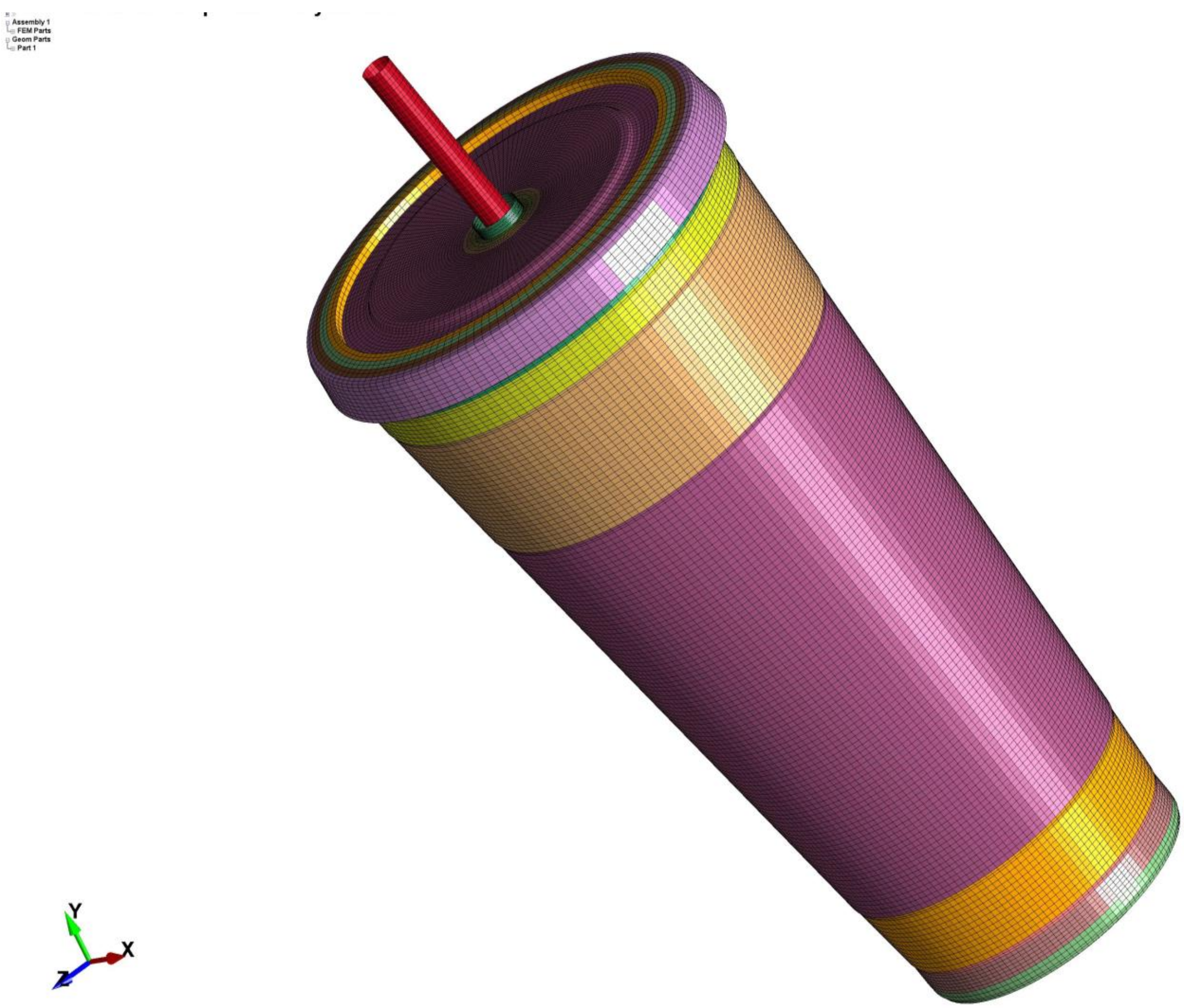


Figure 1: Plastic drink cup subjected to drop test from four feet.

NCAA Baseball Bat and Elastomeric Ball

This project was all about the calibration of the “ball”. The development of the single-walled aluminum bat was simple and direct while the ball had to be carefully calibrated against experimental work. The ball’s material model was an elastomeric rubber material using LS-DYNA’s MAT-181 simple rubber material model.

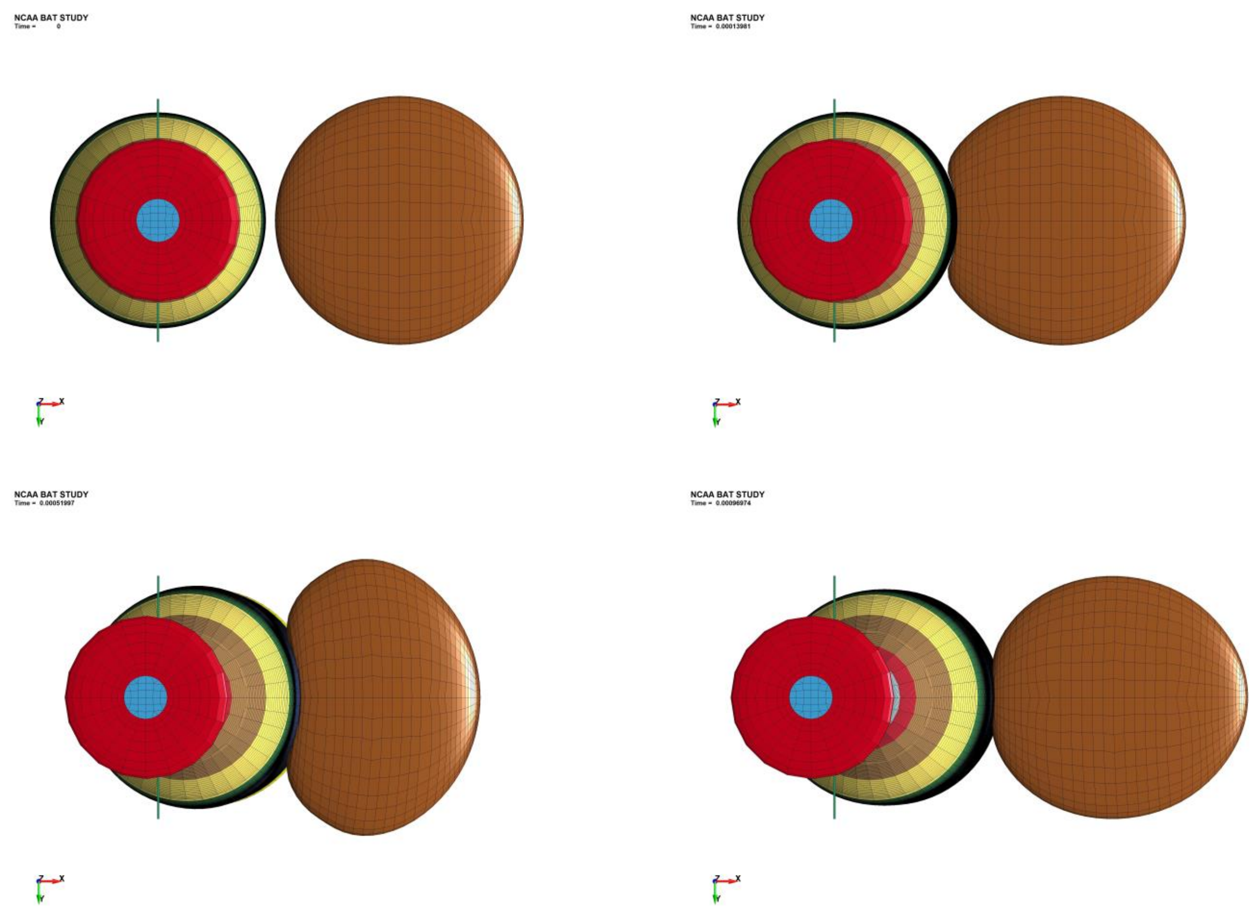


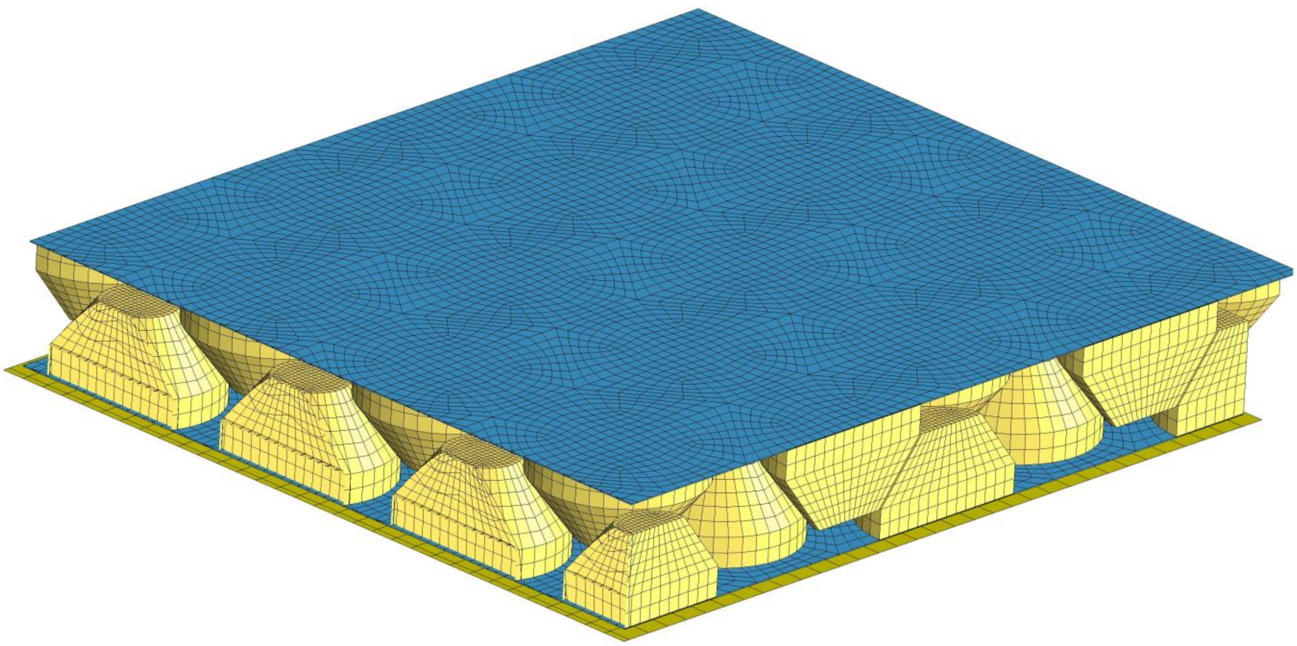
Figure 3: A NCAA single-walled aluminum baseball bat was simulated. The ball was modeled as an elastomeric material.

Foam Based Body Armor

As basketball athletes have gotten bigger and more powerful, continual sport contact leads to severe bruising during league play. One technique to reduce the magnitude of these contacts is to use under garment soft armor. These armors are created through an interwoven combination of fabrics and various foam densities.

A LS-DYNA was studied to determine the impact energy absorption capabilities of foam materials. The first step of this analysis work was to create the material model from experimental data. Upon calibration of the MAT_83 Fu Chang Foam model, the impact test results correlated within 5%.

Analysis work was used to drive the design process toward more effective foam combinations.



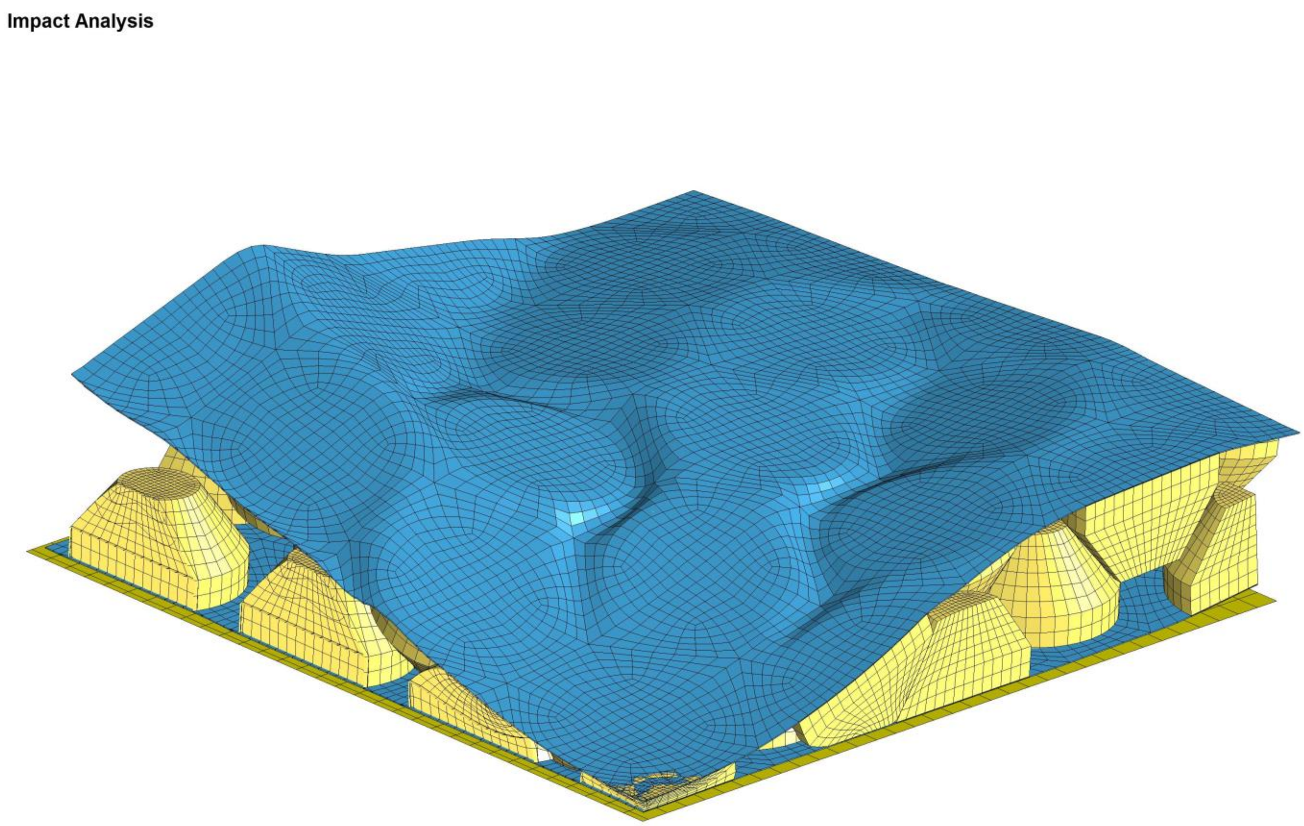


Figure 4: LS-DYNA Impact of nested foam blocks.

Advanced All-Plastic Medical Device

This analysis work was done to develop a proof-of-concept for an all-plastic snap-fit medical device. By movement of the handle, a snap-fit mechanism would be activated allowing the medical technician to easily put the device into use. The all plastic device used several grades of materials such as: copolyester, polypropylene and Zytel.

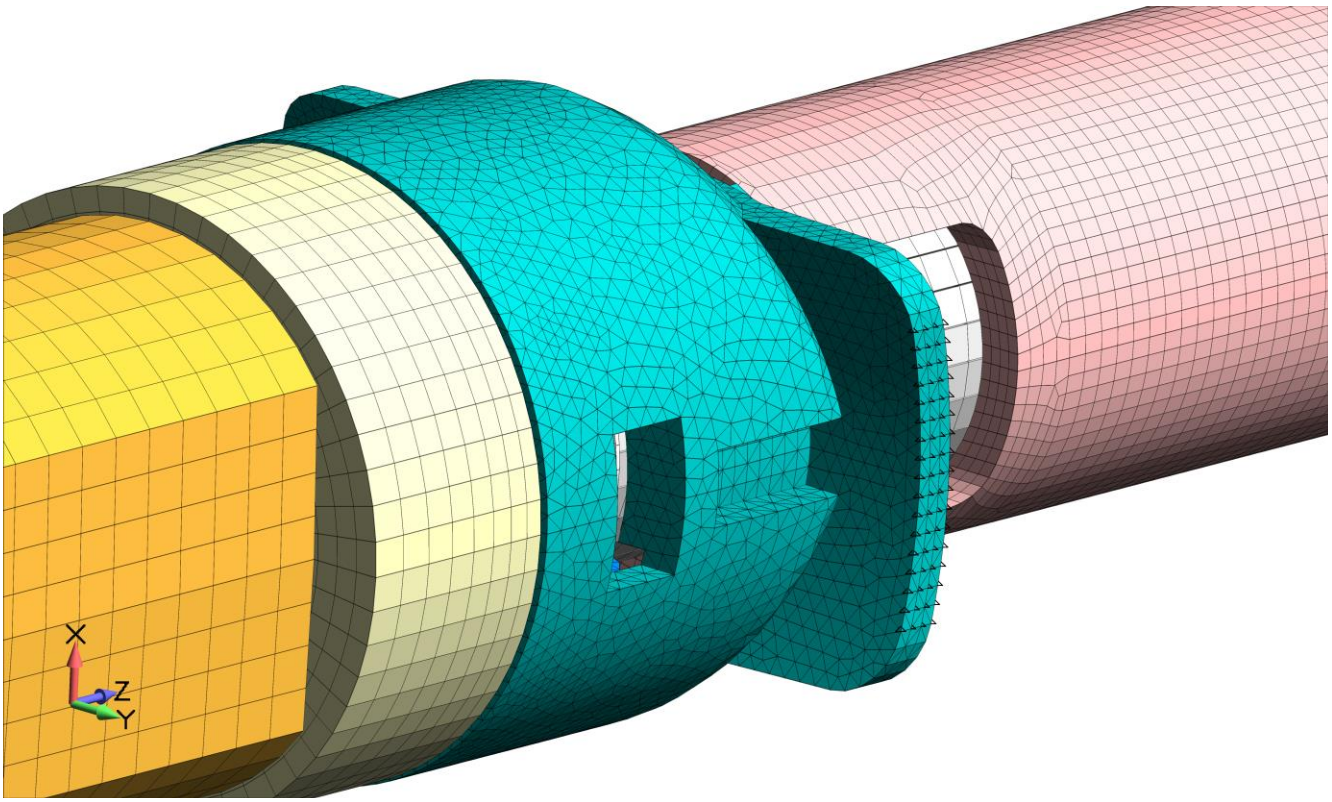


Figure 5: The mesh was a mix of structured brick elements and tetrahedral elements

The work focused on the mechanism design and required a frictional snap-fit analysis of the device. Results showed functionality and proof-of-concept

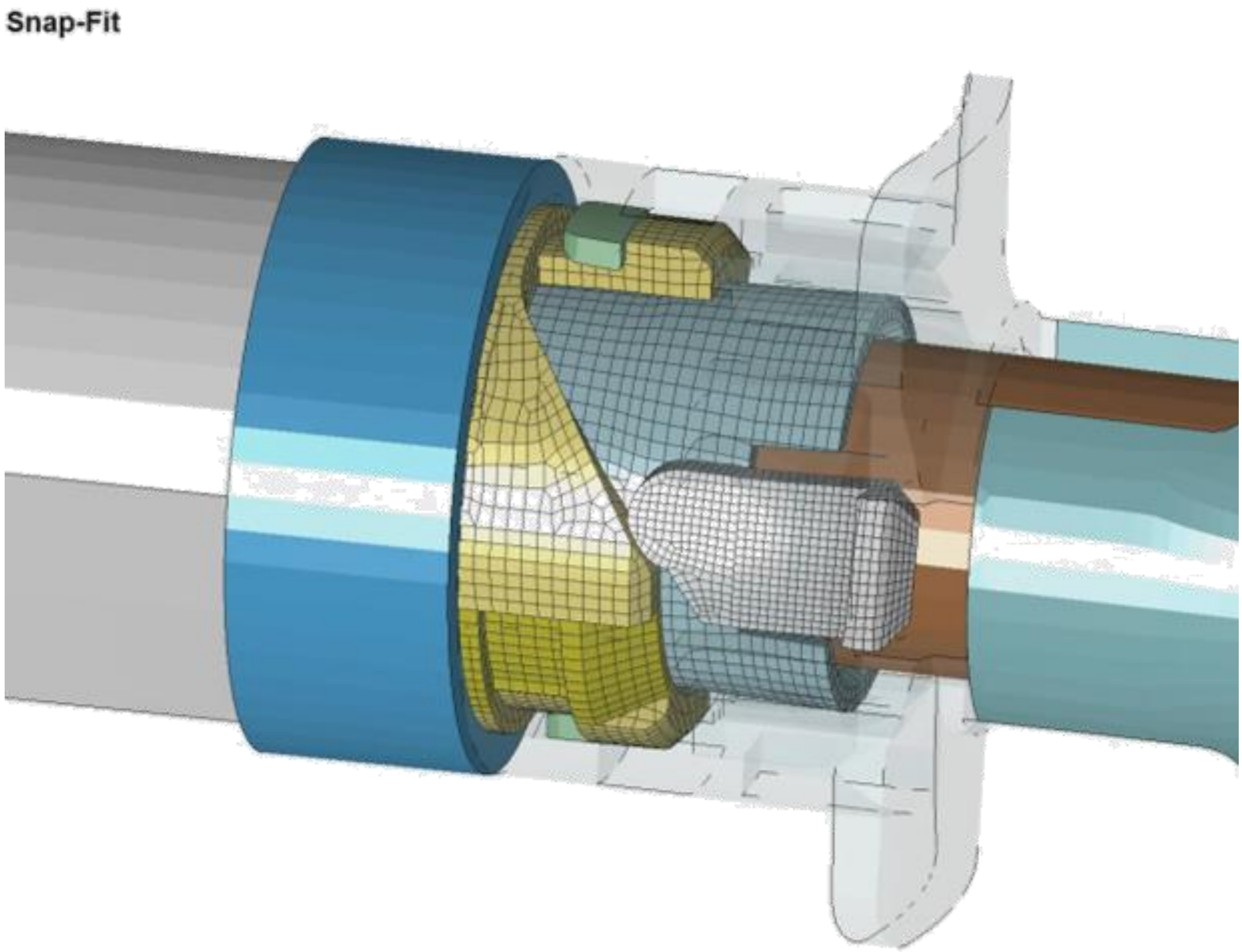


Figure 6: LS-DYNA dynamic analysis of all plastic medical device

Given the medical environment, abuse loading of the device was investigated through multiple load cases. Peak loads and "what-if" scenarios alowed the design process to move confidently forward knowing that the device would be robust againt in-advertant harsh loading.

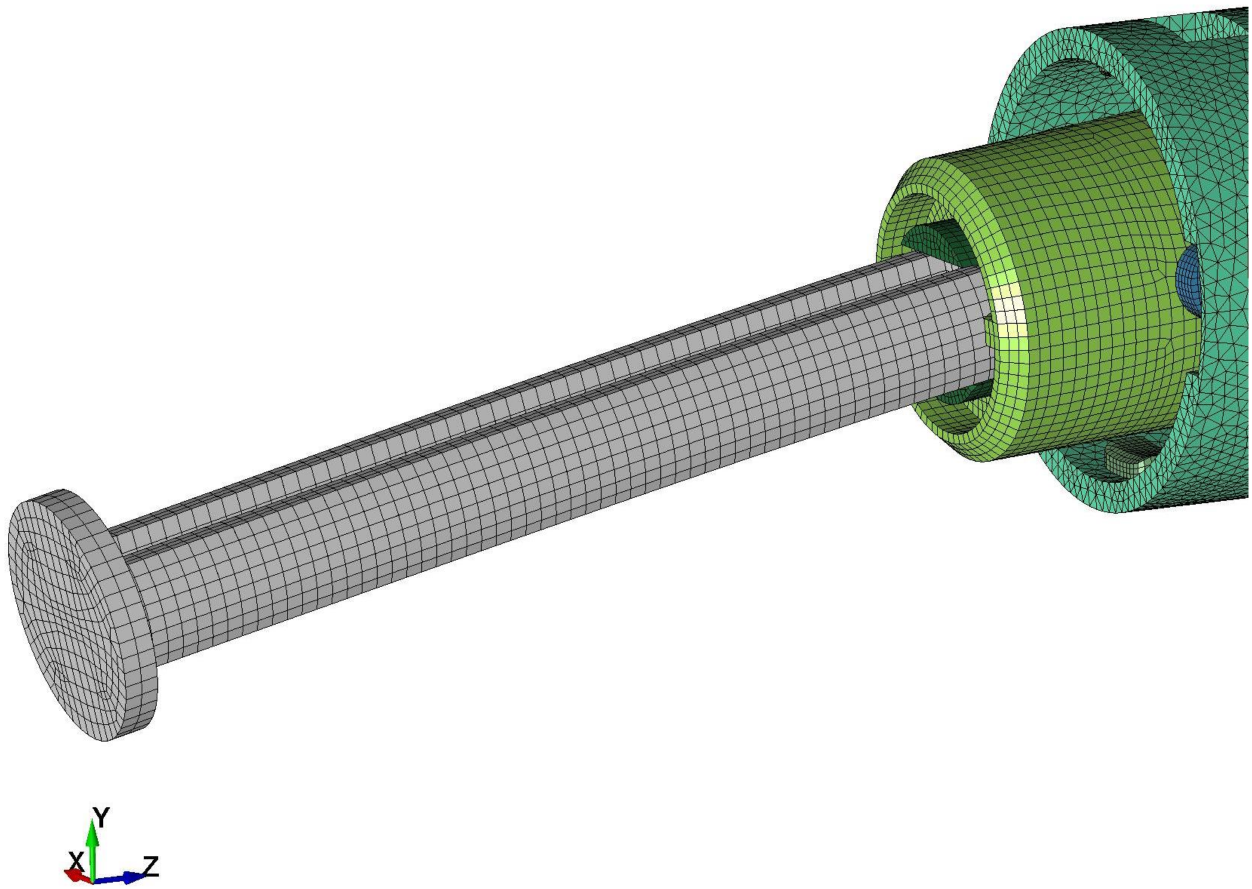


Figure 7: The analysis work also included abuse loading of the device

Elastomeric seal design is something well suited to be analyzed by LS-DYNA. In the axisymmetric model shown below, an inner cup presses down past a snap-fit lip and then pushes up against a silicone seal. Once seated, seal pressures can be interrogated to determine the sealing effectiveness of the seal. Seal geometry changes can quickly be made along with variations in hyperelastic material properties to determine optimized configurations. A key advantage of this approach is that it allows the ability to investigate low-cost materials without the necessity of making molds and conducting tests.

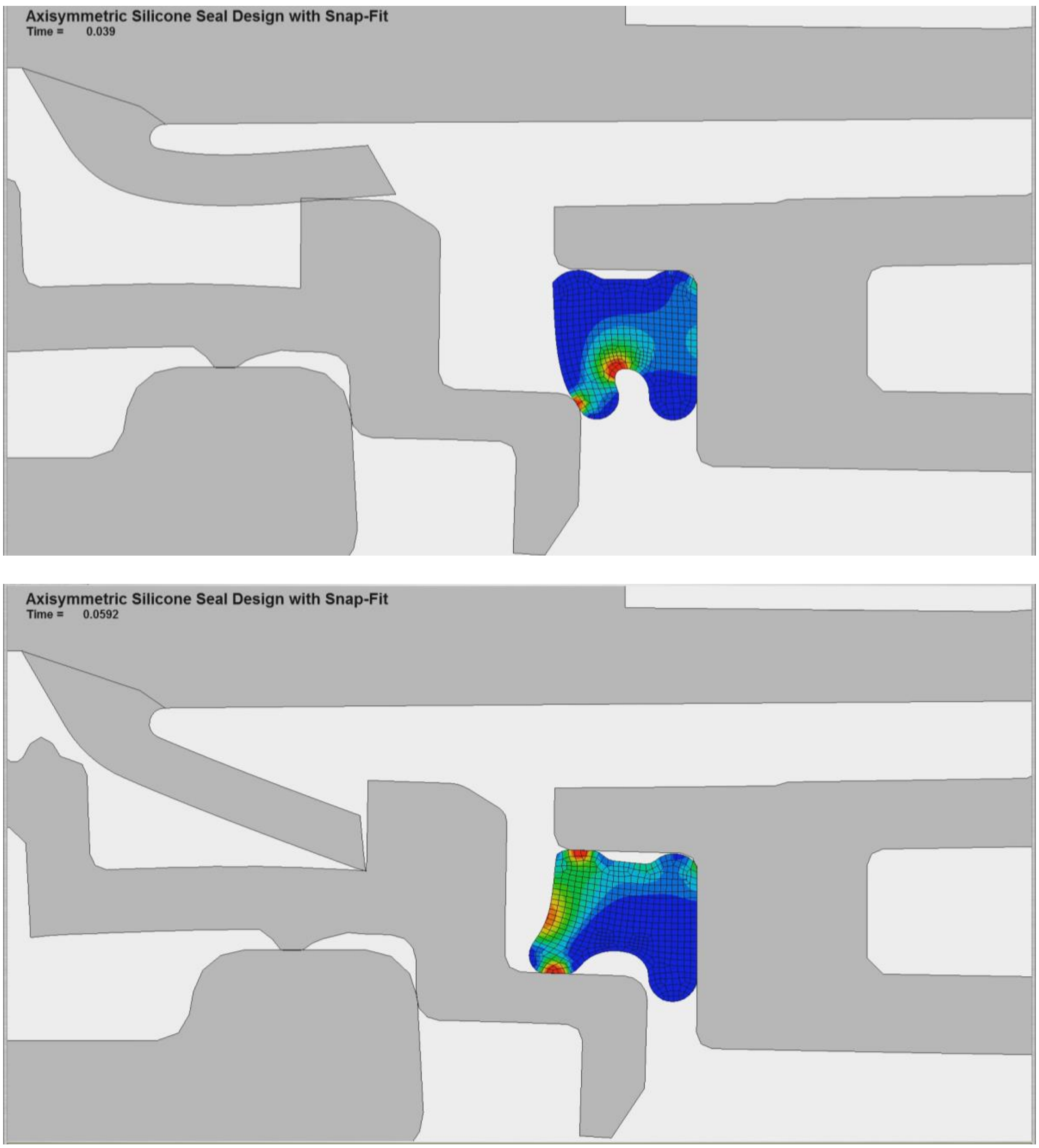


Figure 8: Elastomeric seal design using LS-DYNA analysis with plastic parts