Electrical Connector Assembly Ease

The design of seals for automobile electrical connectors presents two competing effects: (1) Low interference to ensure minimum assembly forces, and (2) Sufficient compression to maintain sealability over the life of a vehicle.

With the desire to avoid "trial and error", *Framatome Connectors Interlock* requested assistance from WIDL to develop a 14-way electrical connector assembly. A statement of work between the firms was divided into four major phases:

1. Characterizing rubber making the seal, and defining design parameters;

2. Building a mathematical model of a connector assembly case study;

3. Validating numerical predictions (on the case study) with test results, and

4. Optimizing the 14-way connector system

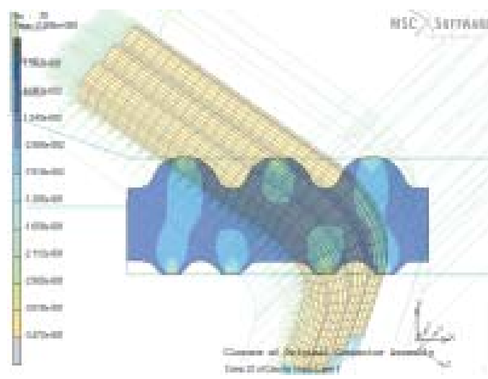
A 10-way connector, in production at *FCI*, encompassing male and female plastics mates, and in-between multi-bead seal was considered for case study.

Testing Silicone Seal for Friction

Electrical Connector by FCI

A self-lubricating rubber by *American Silicones* was suggested for the application. A small batch was compression-molded at WIDL, in buttons, sheets, and ring gaskets. These were stored for 24 hours in an environmental chamber at 23°C and 50% Relative Humidity. Quasi-static tests under uniaxial tension and compression, and planar tension defined shearing. Compressibility derived from curve fitting polynomials to "true" stress-strain data under hydrostatic conditions.

Five samples were tested in each of the modes of deformation to ensure an entire repeatability of the collected data. Besides, friction constants derived from dragging rubber samples along plastics substrates. Reactions were recorded for various speeds, weights, and lubricants. The data allowed definition of Coulomb's friction model in FEA.



Quarter of Original Seal upon Assembly

More testing at WIDL defined a minimum pressure to seal. Rings were air-pressure leak tested to establish the onset of sealing at "time zero". Visco-elastic tests (Compression Stress Relaxation or CSR) allowed the extrapolation of results, "in time".

A blue print, of the production seal and components (male and female connectors), was supplied by *FCI*. The seal was built as a solid, in Pro| Engineer® (cf: http://www.ptc.com). The assembly presented two planes of symmetry; consequently, only a quarter, of the seal and plastics components, was analyzed.

Modeling used contact and restraining boundary conditions. Connectors were considered as rigid, in contact with the deforming rubber, in FEA.

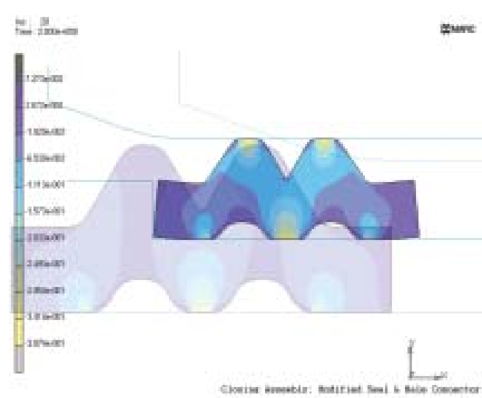
Blue Print of Seal; Three-dimensional Model

Nodes at the symmetry plans were "pinned" perpendicularly to the cuts.

Expansion of the seal on the male connector added restraints along the assembly axis (left free), to eliminate rigid body motion. The male connector was divided into two straight portions and a round, stretching rubber in place. Contact conditions and kinematics were specified through tables in Mentat™ (cf: http://www.marc.com).

Modeling the 10-way connector in Marc™ was within 5% of testing assemblies. Design of the 14-way connector seal reduced contact between rubber and mates. This increased sealing pressures, and reduced assembly forces.

Assembly of the 14-way connector was further eased with modifications to the female connector, "smoothening" the passage of male connector hosting the seal. The design was optimized over three weeks of materials characterization and FEA. Prototyping was based on analyses, which proved accurate through testing at *FCI*.



Modified Seal and Male Connector