Title: connector deformation from crimping

DOC00134476

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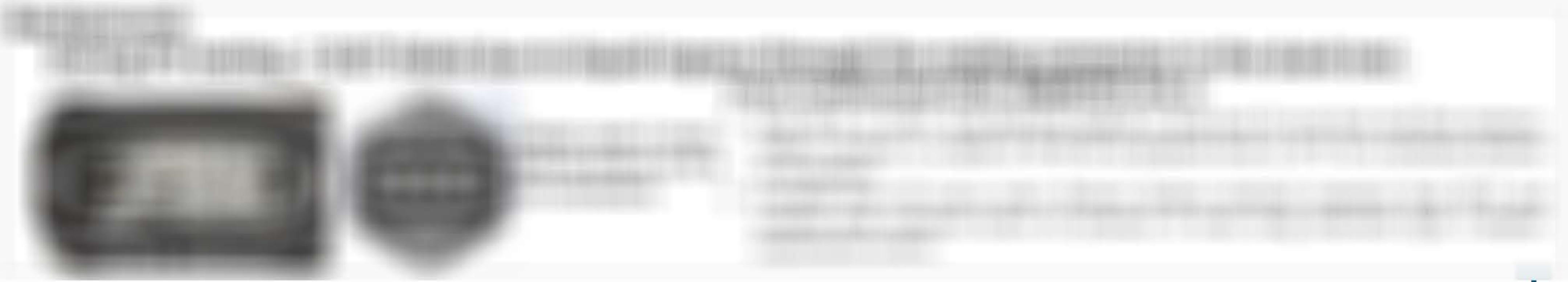
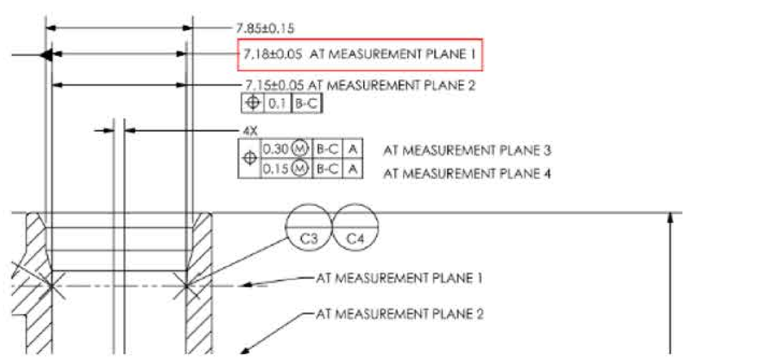
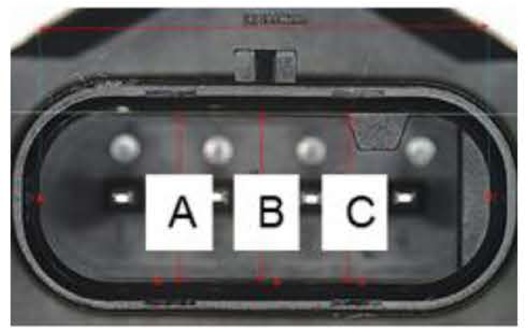
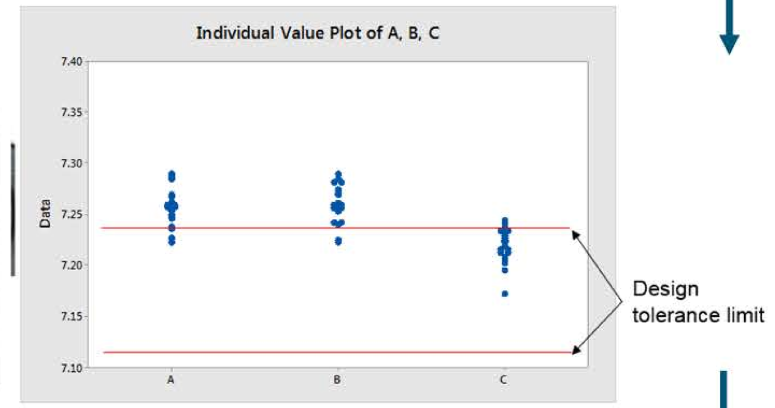
Sensata Technologies



Problem Description: Connector sealing dimension found to be too big



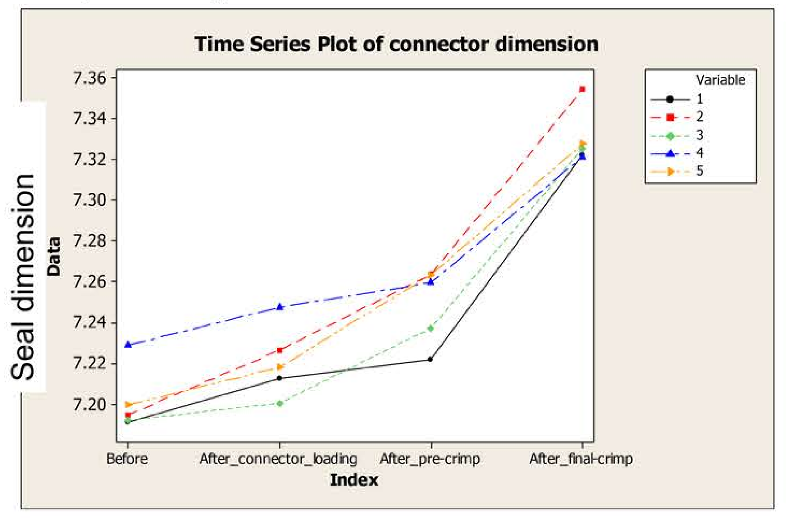




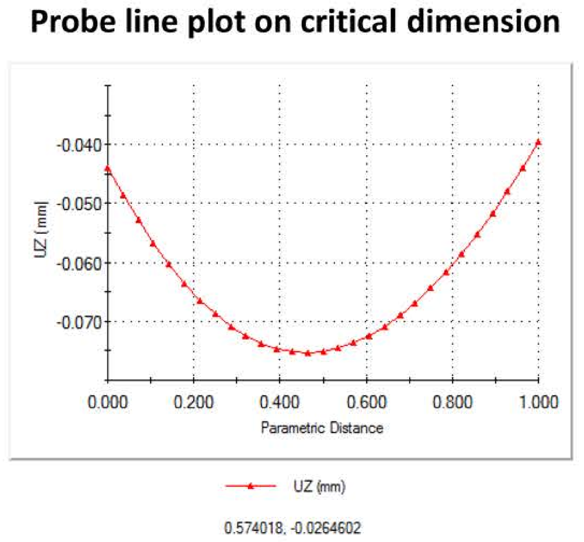
Analysis:

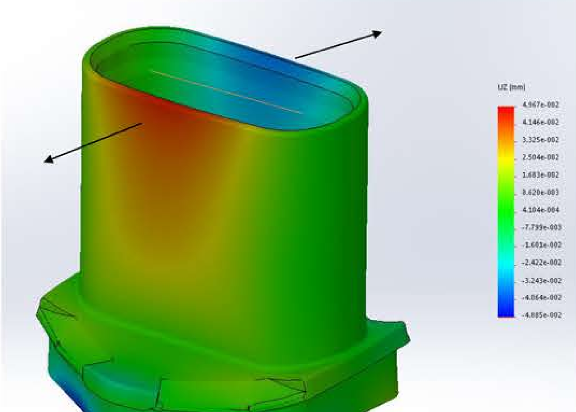
Crimping of connector found to be the cause. Component design makes it impossible to have good crimp without changing the connector dimension

Step 1: Audit process for gap expansion, identified as the crimp process specifically



Step 2: Set-up model in Solidworks and simulate crimp expansion

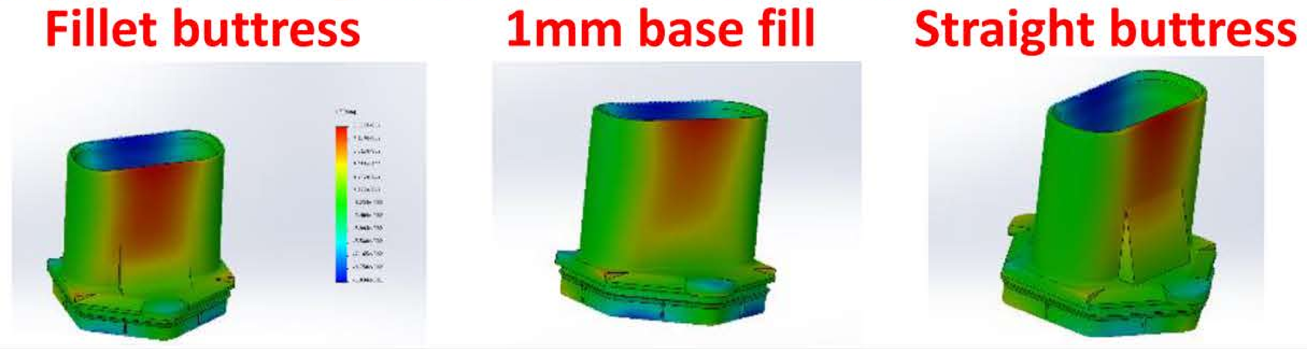




Contour colors indicate deformation in the axis indicated by the arrows based on loading conditions.

Step 3: Virtually iterate connector design to prevent distortion from occuring in connector, validate with FEA

No significant benefit to deformation direction or magnitude added by stiffening with added material

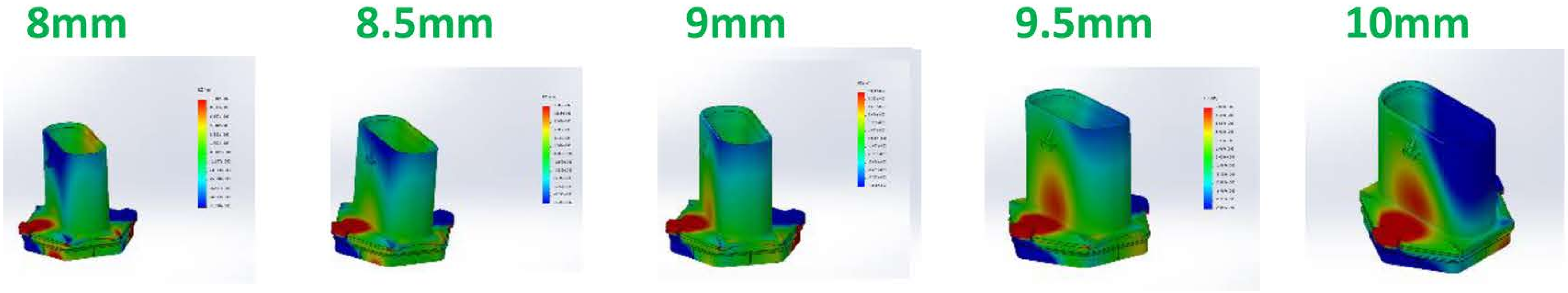


	Probe line deformation (mm)
Production Connector	0.08
Fillet Buttress	0.11
1mm base fill	0.07
Straight Buttress	0.13

Removing material to balance 3D stress resulted in improvement.

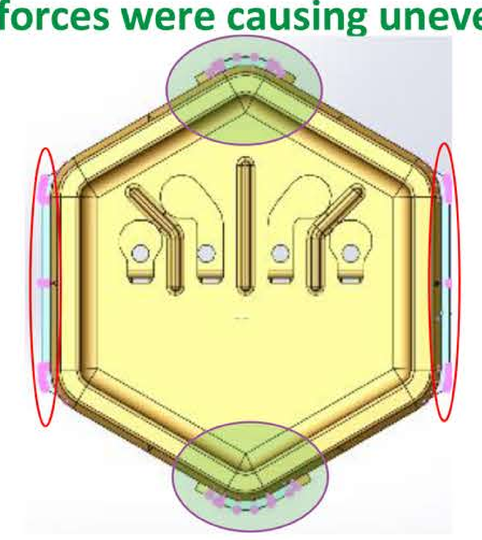
	Probe line deformation (mm)
Production Connector	0.08
Notched Edge	0.04
Larger Notched Edge	0.02
Under X-Trench	0.05

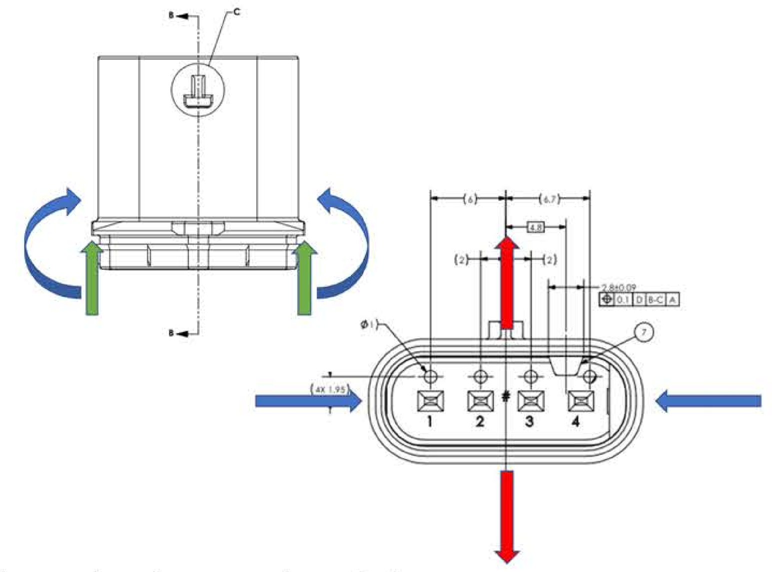
Enhanced reduction in deformation via notch optimization (significant asymmetrical deformation variance)



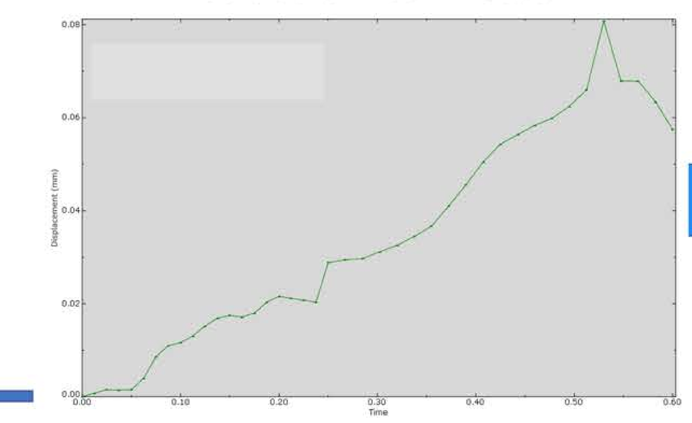
Corrective action and implementation:

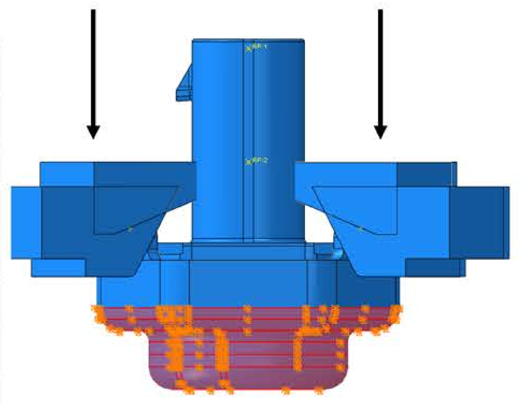
Through FEA analysis of current product design, the team reached the conclusion that unbalanced interfacial reaction forces were causing uneven deformation on the connector.

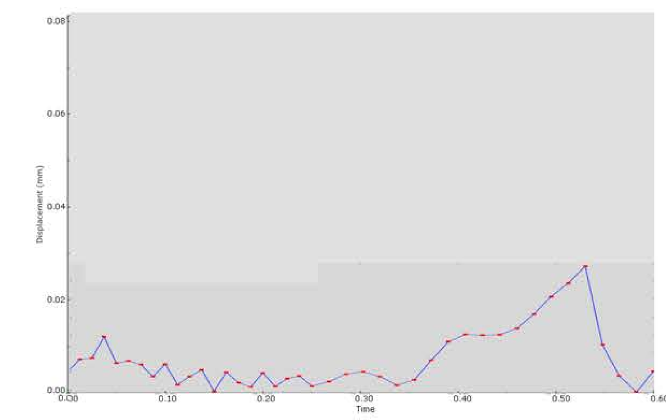




To confirm accuracy of Solidworks simulation, Simulation COE used Abaqus with production die solid models and component assemblies.







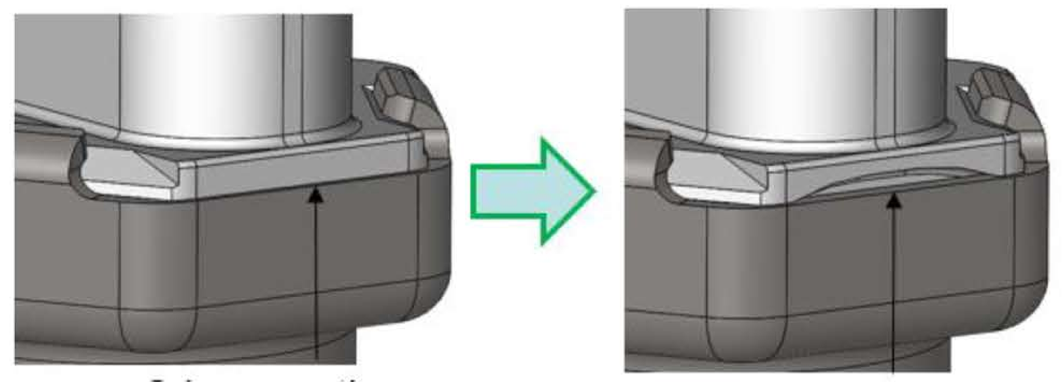
Peak displacement reduced from 0.080mm to 0.030mm, final displacement reduced from 0.060mm to ~0.00mm according to Abaqus simulation.

Analytical justification:

The reaction force, exerted on the base ede of the connector acts as a moment buckling a "column" resulting in medial expansion, deflection. The buckling behavior explains why the 3-pin connector does not deform under the same loading parameters, as the *critical* or *unsupported length* of the "column", *L*, is exponentially inverse to the amount of force required for a column to bow or buckle.

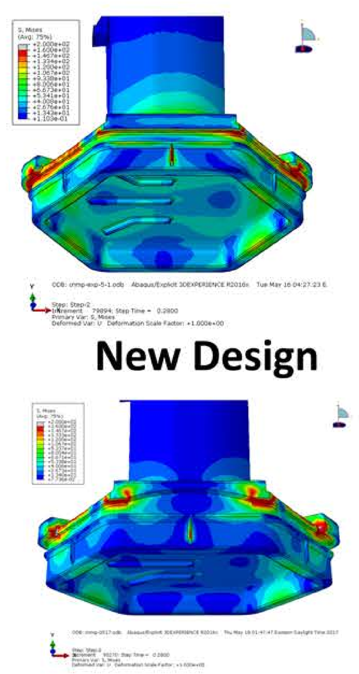
$$P_{cr} = \frac{\pi^2 EI}{(KL)^2}$$

P_{cr} = Euler's critical load (longitudinal compression load on column),
E = modulus of elasticity of column material,
I = minimum area moment of inertia of the cross section of the column,
L = unsupported length of column,
K = column effective length factor

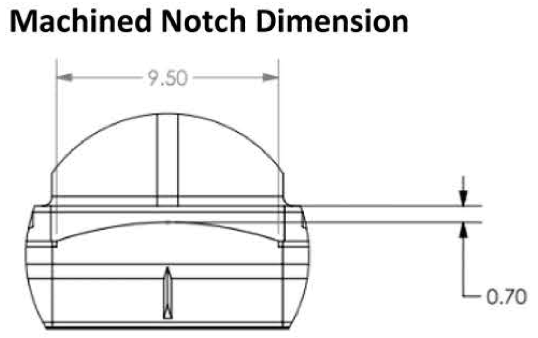


Unbalanced crimp reaction force → Notched to balance crimp reaction force

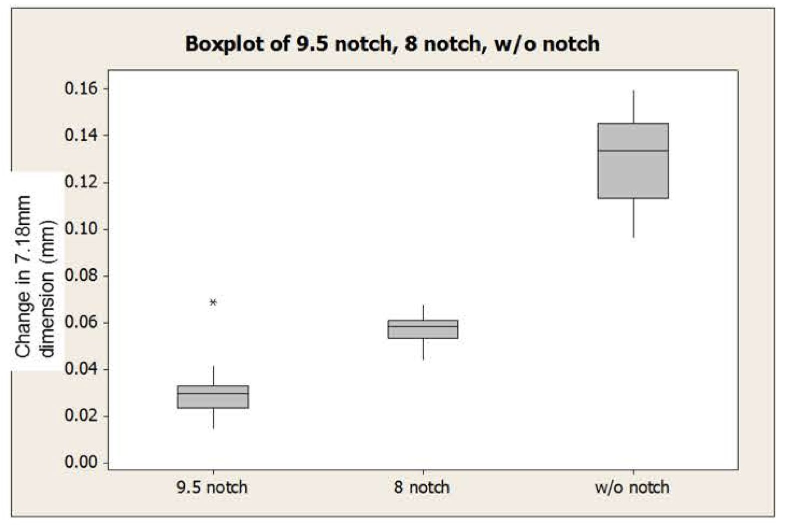
The Abaqus simulation also indicated that there was significant change in localized stress concentration – Von Mises stress spikes near unloaded joints. To ensure solution did not damage connectors, validation testing was conducted. Visual inspection, leak check and ID measurements were performed before and after validation. Validation consisted of crimped parts that were Thermal Shocked, Water Immersion Frozen, and HALT.



Effectiveness/Result:



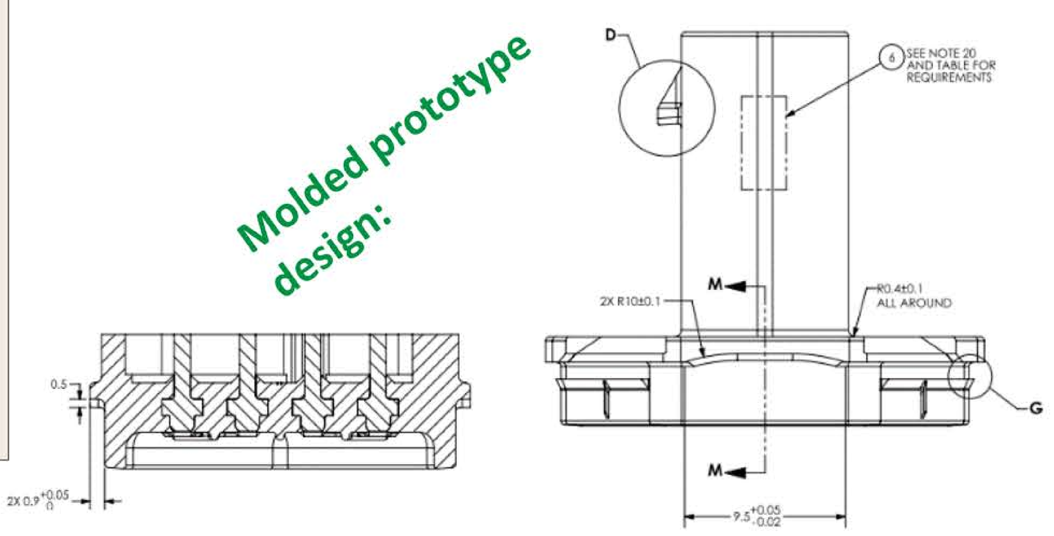
The solution was first verified empirically by machining connectors to varying notch dimensions and measured pre- and post-crimp. Significant reduction in connector growth was found:



Status:

August – Single Cavity Tool Kicked Off

November – Received first off samples, and trialed on crimp equipment. Improvement from original design, requires further tool grooming to bring parts into spec. Taller notch may be pursued.



Applicability (How can lessons learn from this issue apply to anything else?):

- **Always perform FEA on crimp attaches as the large forces (2kN to 30kN+) can result in significant unexpected bulk deformations**
- **Radially asymmetric crimps are especially risky as they are prone to uneven loading**
- **Ensure sensor FAI is performed per the envelope drawing AND to any specification documentation called out on the envelope**
- **Attempt first pass Solidworks simulation to prove design, always verify with non-linear FEA with Simulation COE and/or Empirically**