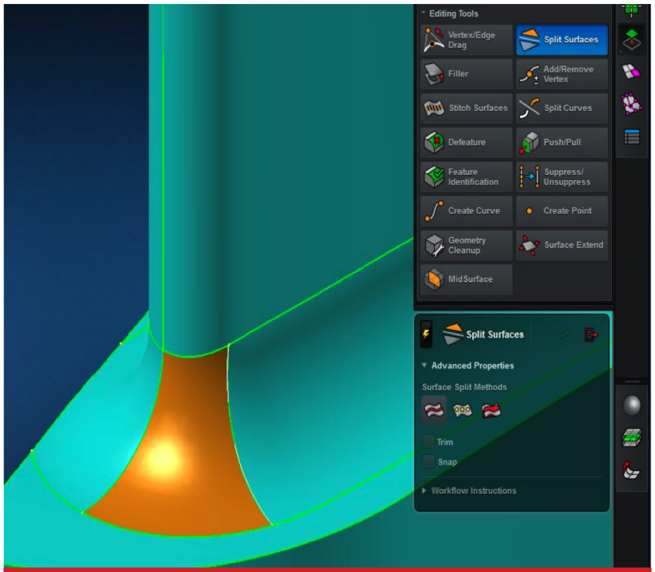
Case Study: **Dynetics Technical Services Inc.**

MSC Apex Used to Reduce Geometry Cleanup of Fuel Pump Components from Two Days to One Hour

Overview

The National Aeronautics and Space Administration's (NASA's) Space Launch System (SLS) will be the most powerful rocket in history, launching crews of up to four astronauts in the Orion spacecraft to explore multiple, deep space destinations. The SLS is designed around an evolvable architecture that will support versions ranging from 77-metric-ton (77 ton) to 130 metric ton (143 tons) lift capability. The SLS core stage, more than 200 feet tall with a diameter of 27.6 feet, will store cryogenic liquid hydrogen and oxygen that will feed four RS-25 engines. The RS-25 served as the Space Shuttle main engines and operated with 100% mission success during 135 missions. The RS-25 is being modified to serve on the SLS by increasing its power from 491,000 to 512,000 pounds of vacuum thrust among many other improvements.



Taylor used the advanced geometry modification utilities in MSC Apex Modeler to greatly simplify the process of repurposing the CAD Geometry

“The technology innovation represented in MSC Apex’s capability suite and ease of use was head and shoulders above any other stand-alone CAD healer or integrated CAD-CAE meshing software I have used.”

W. Scott Taylor, Senior Mechanical Engineer, Dynetics Technical Services, Inc.

Challenge

Engineers who have been modifying the design of numerous Fuel Pump Components used on the RS-25 and many rocket engine systems up to and including the SLS, have based their analysis efforts on preexisting CAD design models. These models have been received either by direct third party translators or open standards like STEP. Both avenues of data sharing have historically been fraught with geometric pathologies and over-specifications that were passed on in translating from proprietary geometry kernel forms to industry standard forms. The problem is systemic and has as much to do with NUBS vs NURBS implementations as topological boundary incompatibilities.

This has led to technology development in specialized software that is focused on the translation process that utilizes sophisticated algorithms to clean up geometry and make re-purposing of CAD data suitable to the demands of field based meshing software. While significant process improvements have resulted in reduced analysis modeling times, recent technology innovations represent a significant enhancement to the “state-of-the-art” and were tested recently at the NASA Marshall Space Flight Center (MSFC).

As a case in point, a recent demo is based on CAD geometry from a third party parametric solid modeling program that was altered to be generic and generally representative of the kind of complex airfoil geometries such as engine and fuel pump turbine blades. But the geometry produced by the third party program required considerable cleanup work before it could be meshed for structural analysis. “The blade profile surface wrapped around the leading and trailing edges of the blade without having a seam at either to facilitate a finer mesh discretization at these key areas,” said W. Scott Taylor, Senior Mechanical Engineer, Dynetics Technical Services, Inc., who is working on contract at MSFC.

Another problem was that the control point net for the NURBS surfaces used to define the blade profile was also very dense. The underlying formulation for the surface prevented clean subdivisions deemed necessary for mesh discretization. This was not realized until the translated geometry was read into a separate structural meshing pre-processor. The inability to disassociate the underlying NURBS data prevented B-Rep “stitching” into a Solid in the structural analysis preprocessor. That necessitated a second pass and alternate methods were applied, but to no avail. Finally, the geometry in question had to be redefined and the parent geometry deleted. The resultant “patches” created to facilitate a structural discretization appeared correct on visual inspection but contained new distortions that again frustrated creation of a solid model on translation to the structural pre-processor. These problems are representative of common artifacts of CAD-to-CAE data transfer at present and are time consuming to correct. This makes meeting estimated milestone objectives on time problematic and at times upsets critical path itineraries.

Solution/Validation

Taylor used the advanced geometry modification utilities in MSC Apex Modeler to greatly simplify the process of repurposing the CAD geometry. The “suppress edges” function in MSC Apex was used to identify and remove all undesirable boundary edges in a single step. Taylor removed many arbitrary lines and

Key Highlights:

Product: MSC Apex

Industry: Aerospace

Benefits:

- Identify and remove all undesirable boundary edges in a single step
- Create new surface boundaries by sketching lines in place
- Create a global solid element mesh while maintaining curvature based refinement and topological congruency

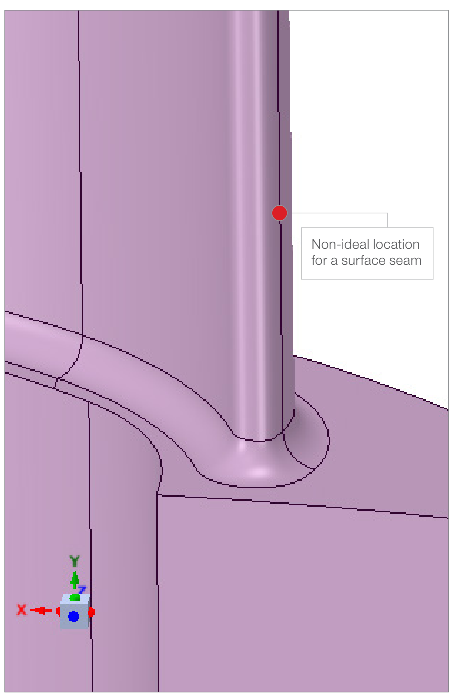


Figure 1: Seams should be located at leading and trailing edges

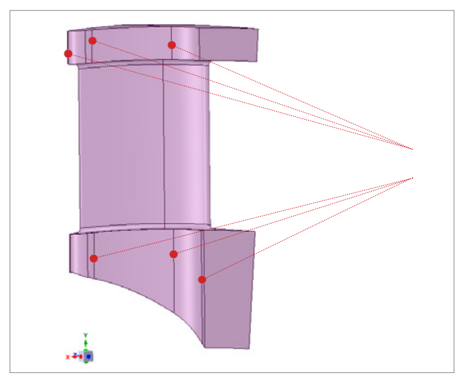


Figure 2: Arbitrary lines used to define NURBS surfaces need to be removed in order to avoid poor element quality

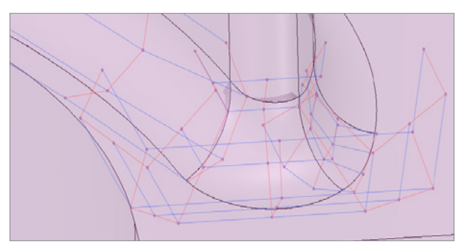
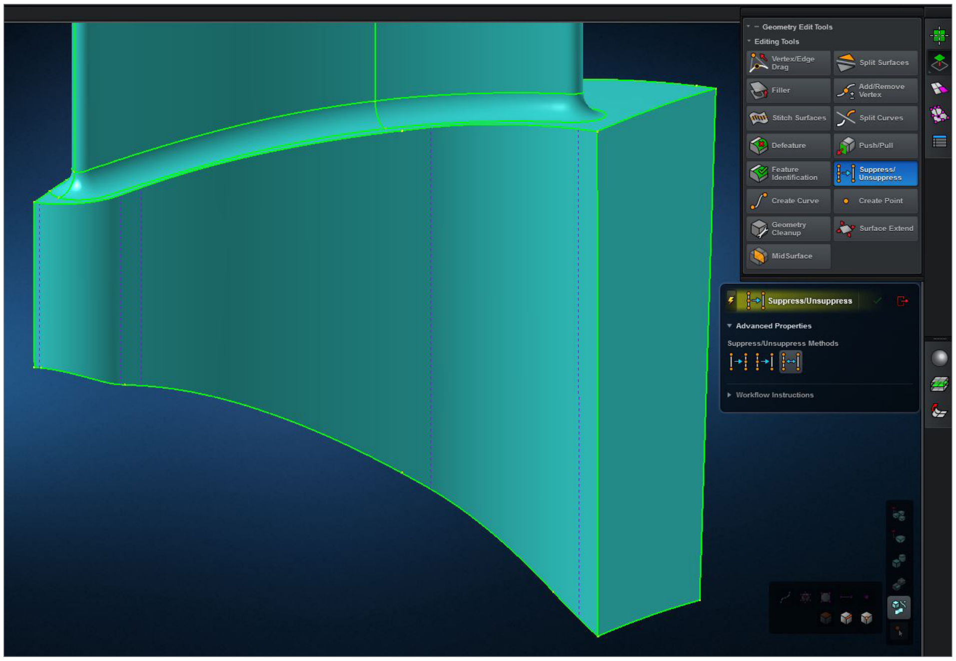
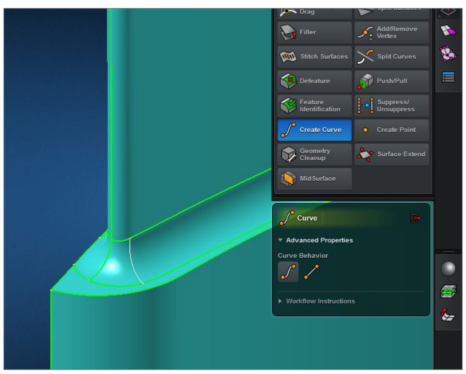


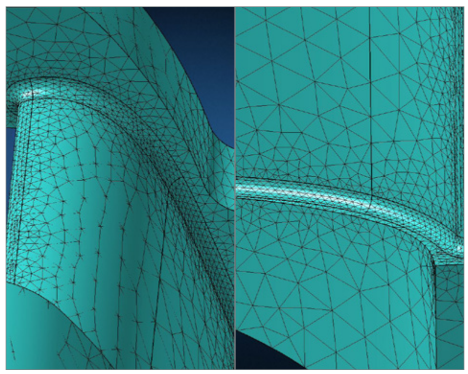
Figure 3: Local shadows caused by round-off inaccuracies



Suppress edges functions used to remove undesirable edges in a single step



Engineers sketched new surface boundaries



Ideal mesh quality is seen on leading (left) and trailing (right) edges

subsections using this tool. Users created new surface boundaries by sketching lines in place. New surface domains were created by selecting the sketched curves. MSC Apex gives the user the option to either create surfaces one at a time or to create all new surface boundaries in one process and then come back and split the surfaces by pointing to the new curves. The desired mesh parameters were chosen and then a global solid element mesh was created while maintaining curvature based refinement and topological congruency.

User-specified surface boundaries helped maintain ideal bias conditions on the leading and trailing edge blade and fillet geometry. “We simply pointed to a position on the leading edge and clicked a button to create a line,” Taylor said. “For example, we touched the top part of the blade to create a seam on the leading edge. We created three more seams on the trailing edge, root and tip of the blade.” A high fidelity mesh was created between the blade and shroud interface. Taylor also closed up remaining gaps and eliminated overlaps by dragging surfaces to close and form congruent surfaces at which point MSC Apex automatically mated up the parts for a congruent surface.

Results

In this demo of MSC Apex on a generic turbine blade geometry that has been encountered and analyzed by engineers for decades, the cleanup of geometric pathologies and arbitrary segment lines was reduced “from two days to one hour,” Taylor said. “These kinds of issues are encountered regularly at MSFC in numerous launch vehicle structural components. The technology innovation represented in MSC Apex’s capability suite and ease of use was head and shoulders above any other stand-alone CAD healer or integrated CAD-CAE meshing software I used. And I’ve been in this business since 1989. I predict the same ratio of time reduction achieved in this demo using MSC Apex can be achieved across a wide range of structural modeling tasks at MSFC.”

About Dynetics Technical Services

Dynetics Technical Services, Inc. stands on the firm foundation Dynetics, Inc. has built over three and a half decades of highly ethical, excellent, and enjoying enrichment. They reach back and build upon those great relationships, performance, integrity, and world renown innovation solving customers’ toughest problems. DTS is committed to continue to collaboratively create this culture, make the world a better place, and focus on these three results-based actions in the global community.

For more information on MSC Apex and for additional Case Studies, please visit **www.mscapex.com**

Corporate
MSC Software Corporation
2 MacArthur Place
Santa Ana, California 92707
Telephone 714.540.8900
www.mscsoftware.com

Europe, Middle East, Africa
MSC Software GmbH
Am Moosfeld 13
81829 Munich, Germany
Telephone 49.89.431.98.70

Asia-Pacific
MSC Software Japan LTD.
Shinjuku First West 8F
23-7 Nishi Shinjuku
1-Chome, Shinjuku-Ku
Tokyo, Japan 160-0023
Telephone 81.3.6911.1200

Asia-Pacific
MSC Software (S) Pte. Ltd.
100 Beach Road
#16-05 Shaw Tower
Singapore 189702
Telephone 65.6272.0082

The MSC Software corporate logo, MSC, and the names of the MSC Software products and services referenced herein are trademarks or registered trademarks of the MSC Software Corporation in the United States and/or other countries. All other trademarks belong to their respective owners. © 2015 MSC Software Corporation. All rights reserved.

DYNETICS*2015FEB*CS