ThP16 Prototyping Activities at AES for ANL-RIA and ATLAS Cavities*

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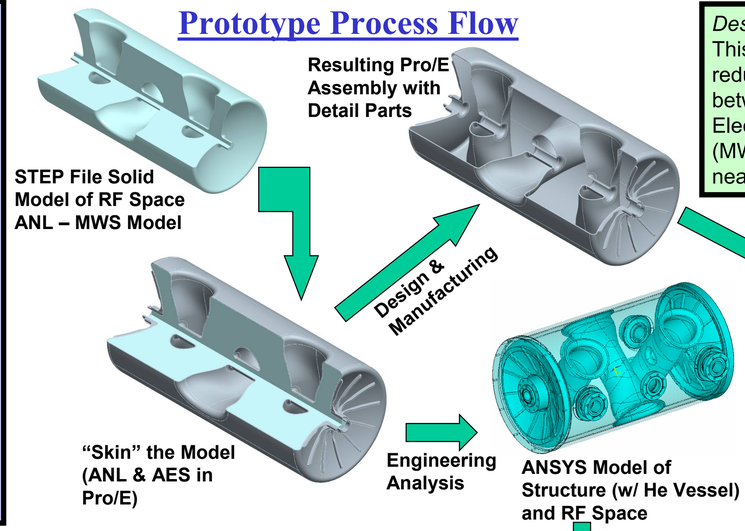
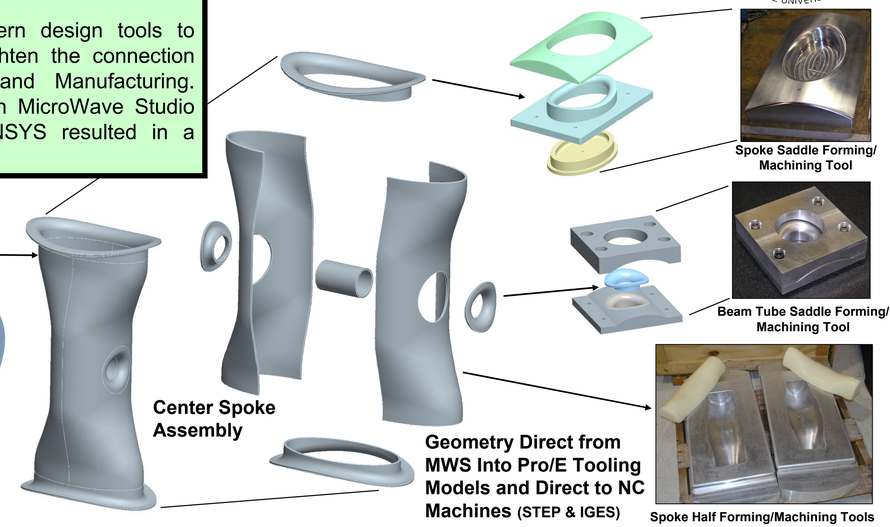
Abstract
Since mid-2001 Advanced Energy Systems (AES) has worked with Argonne National Laboratory (ANL) to produce five prototype cavities for their RIA and ATLAS projects. With ANL leading the effort, AES worked in collaboration in developing design details, performing engineering analysis, and developing manufacturing plans and tooling designs for niobium forming and machining. In manufacturing the cavities AES was responsible for the bulk of the niobium forming and machining while Sciaky Inc. in Chicago performed the electron beam welding under the direction of ANL. Tuning operations prior to the final welds were done at AES while all processing, tuning and testing of the finished cavities was done by ANL. This paper will discuss highlights of the design, analysis and fabrication of these cavities and the concurrent engineering environment that was applied very successfully in this program. We will also discuss the application of modern design and analysis tools to facilitate efficient prototype production.

Prototype Process Flow



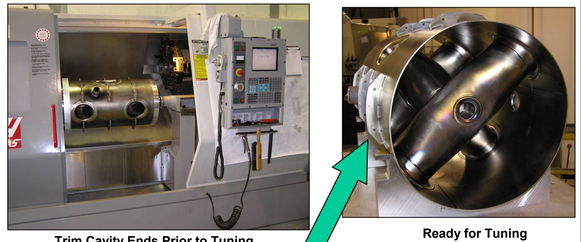
Design and Analysis Tools
This project capitalized on modern design tools to reduce time to prototype and tighten the connection between Physics, Engineering and Manufacturing. Electronic data exchange between MicroWave Studio (MWS), Pro/ENGINEER, and ANSYS resulted in a nearly paperless process.



Triple Spoke Fabrication at AES – Spokes & Tank

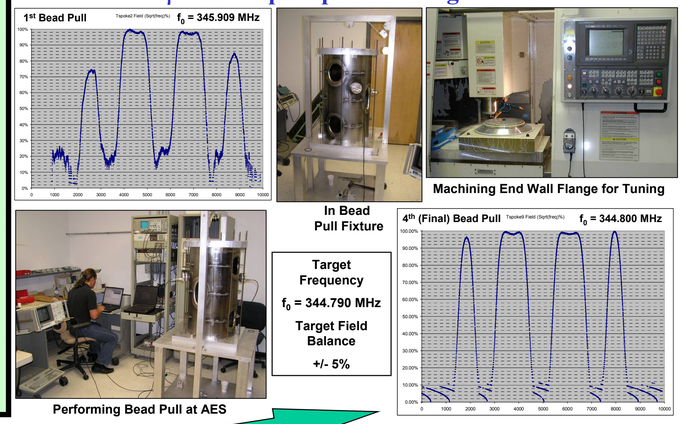
Concurrent Engineering
Analysis conducted during the fabrication continued to refine the design. For example, analysis of the cavity under load from helium pressure resulted in a design for cavity stiffening that allows the cavity to be made virtually immune from frequency changes due to helium pressure variations.

Triple Spoke Fabrication at AES – End Walls & Assembly M/C



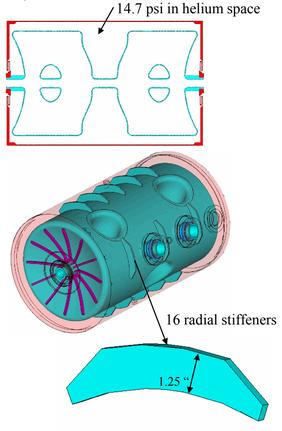
Collaboration
Under the direction of ANL, resources at AES for engineering design, finite element analysis, RF test, and niobium fabrication were used in conjunction with EB welding expertise at Sciaky, Inc. to effect a team that leveraged each participants skills. This experience serves as a blueprint for prototyping efforts in the future

β=.50 Triple Spoke Tuning at AES



Target Frequency
f_0 = 344.790 MHz
Target Field Balance
+/- 5%

Analysis Example - Triple Spoke Model Stiffener Analysis

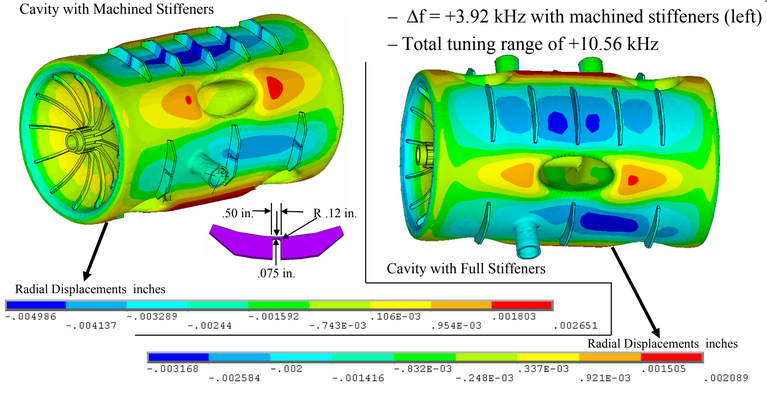


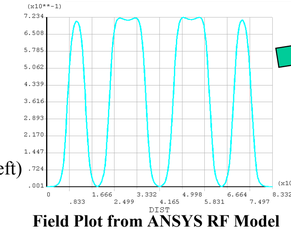
- Spoke resonators exhibit frequency shift due to variations in helium pressure
- Analysis was done under the guidance of K. Shepard to attempt to null out that effect
- In ANSYS, a structural model of the cavity/helium vessel structure and an RF model of the resonator "RF Space" were built. These models share common surfaces at the interface and deformations from the structural analysis are mapped onto the RF model where the Δf is calculated
- A stiffener geometry was developed that reversed the sign of the Δf and allowed fine tuning by machining the stiffeners after fabrication
- A second series of analyses is shown that examines the effect of a fast piezoelectric tuner
- Performance was verified during cavity testing

Stiffener Analysis Result – Tune by Machining

Load = 14.7 psi in helium space
Properties evaluated at RT

- Δf with no stiffeners = +12.04 kHz
- 16 Radial Stiffeners added
  - Δf = -6.64 kHz with full stiffeners (right)
  - Δf = +3.92 kHz with machined stiffeners (left)
  - Total tuning range of +10.56 kHz

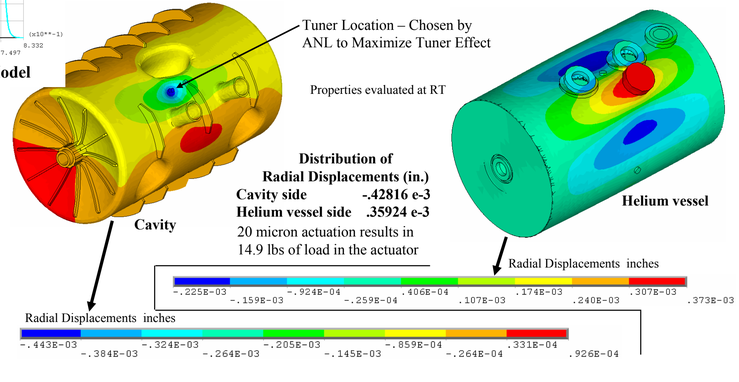




Field Plot from ANSYS RF Model

Fast Tuner Study

- **Analysis Result ➔ Δf = +120 Hz ➔ Verified in Cavity Test**
- Analysis to determine the effect of 20 μm actuation of piezoelectric tuner



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