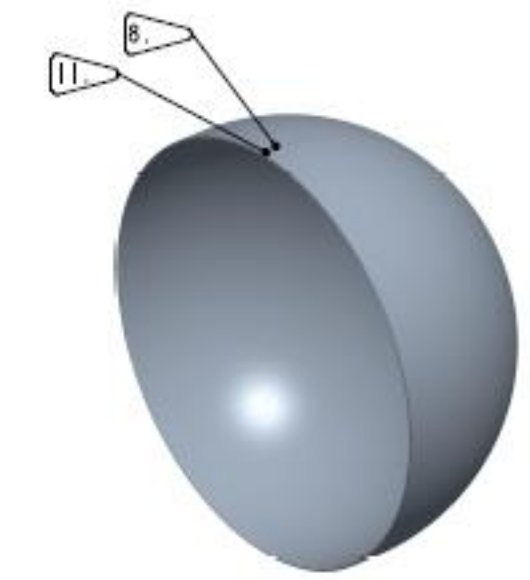
Design and Manufacturing of Hemispherical Part



Project Collaboration with Los Alamos National Lab

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Abstract

Project collaboration between UT Rio Grande Valley and Los Alamos National Lab with the goal of preparing engineering students with the necessary skills to contribute to LANL's national security efforts.

Figure 1 UTRGV leaders and elected officials

This project aims to find innovative manufacturing methods for producing a hemispherical part in accordance with engineering specifications provided by LANL. Furthermore, tackling real-world manufacturing constraints such as:

- Tooling, machine parameters, software, material waste, design, functionality, and reliability.

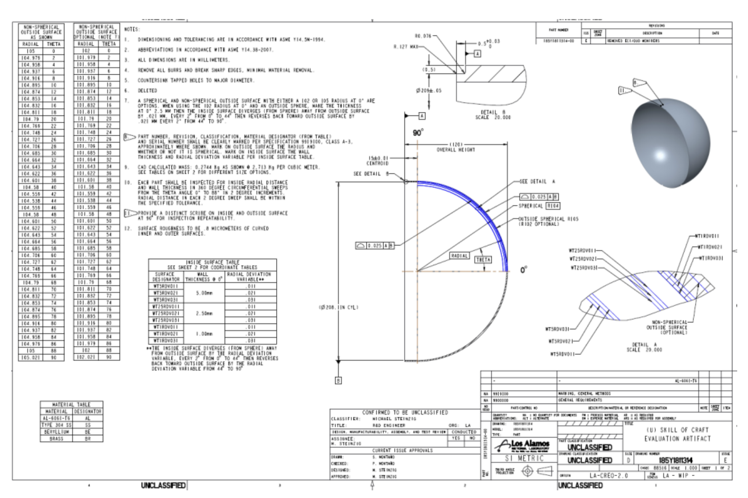


Figure 2 Skill of Craft Evaluation Artifact (Hemi)

Elevator Speech

Defining Our Problem

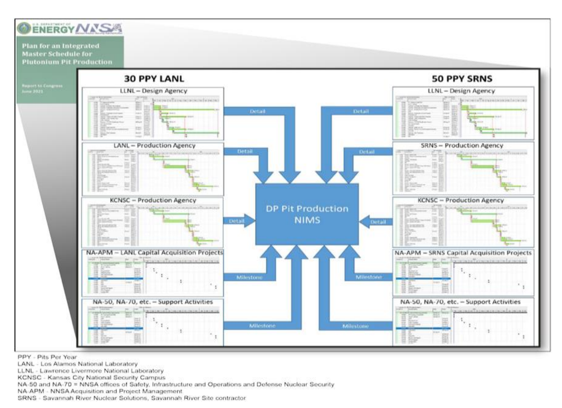
1. **Part Size**: The "Hemi" is considerably big, having a diameter of 8.25 inches and length of 4.72 inches, posing a challenge from the manufacturability standpoint.
2. **Tolerances**: bilateral, unilateral, profile, and surface finish tolerances, as well as spherical and non-spherical inside and outside surfaces.
3. **Equipment Availability**: Unlike LANL, our university doesn't have machinery tailored for this part, therefore the challenge is to manufacture it with the current available equipment.

Our Approach and Competitive Advantage

- Conducted a literature review an found DMLS (3D metal printing), Metal Spinning, Stamping, CNC Machining. The process/approach selected was CNC machining – turning, that is due to equipment availability, part size, and part geometry, CNC turning machining was logical choice.
- Our competitive advantage is still not fully defined, since we are in the research and experimentation stage. Current efforts are directed to find optimal machining parameters (feeds & speeds), part fixturing and optimal tooling.
- CNC Turning offers machining operations such as boring, grooving, profiling that are more than enough to transform our raw material to the final part.

Market Size & Competitive Products.

- The NNSA established plans with ability to produce 80 plutonium pits/year the central core of nuclear weapons. At Los Alamos National Lab the plan is to produce 30 pits/year, at Savannah River Site the plan is to produce 50 pits/year.
- Establishing pit production represents NNSA's largest investment ($5 billion over the past two decades and additional 3.6 billion 2005-2020) in weapons production infrastructure up to date.



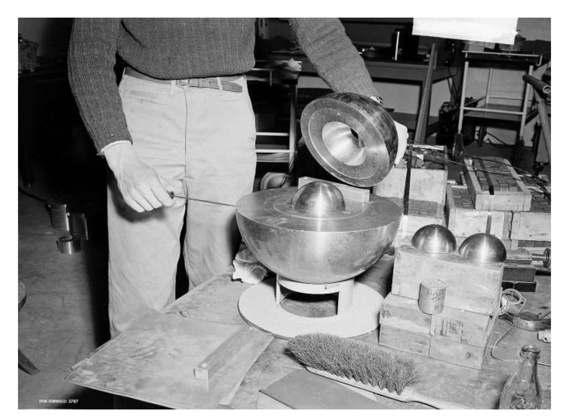


Figure 3 (Left) Excerpt of NNSA's Submittal to Congress of a Plan for a Pit Production Capability Integrated Master Schedule.

Figure 4: (Right) A plutonium pit design from the 1940s Source by LANL

The product being manufactured is intended solely for testing purposes at LANL, unlike their actual product, which is integrated into a functional plutonium weapon. The main differences between both products are dimensions and material.

- **LANL Product**
  - Overall Length = 4.72 in
  - Overall Diameter = 8.27 in
  - Part Material = Plutonium (Pu)
- **Team 5 SD I & II Product**
  - Overall Length = 2.36 in
  - Overall Diameter = 4.13 in
  - Material = Al 6061-T6

Proposed Solution

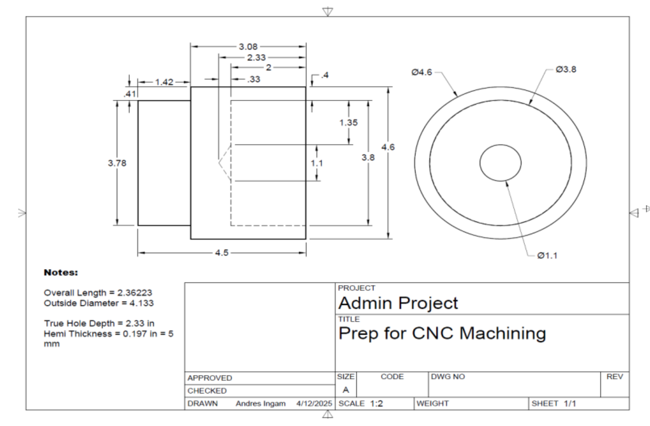


Figure 6 Prep RW machining design

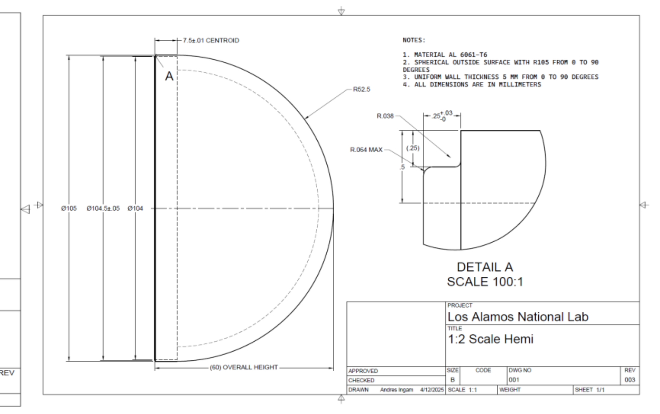
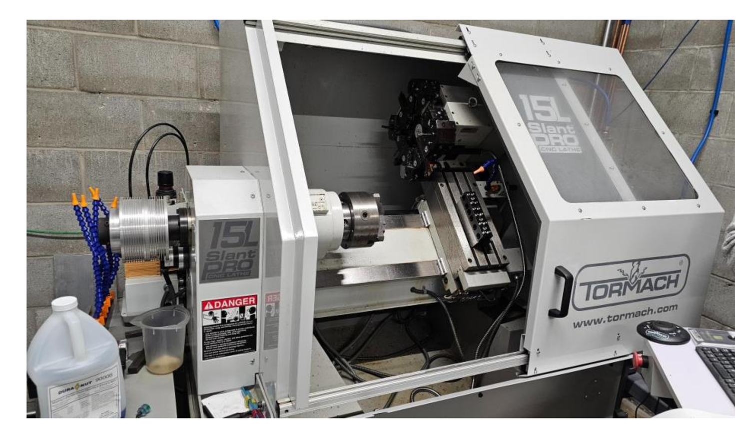


Figure 5 Final Part Design

Figure 7 Machined Part



Test Data (Collection & Analysis)

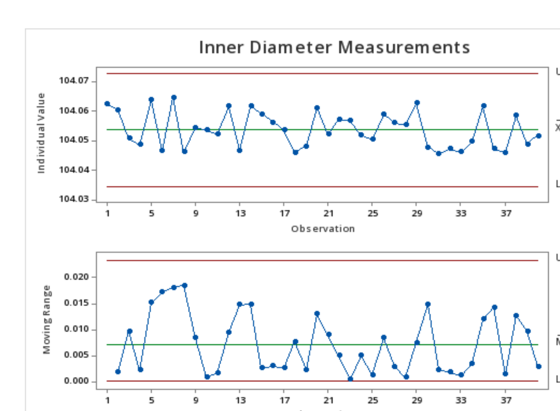


Figure 7: I-MR Chart

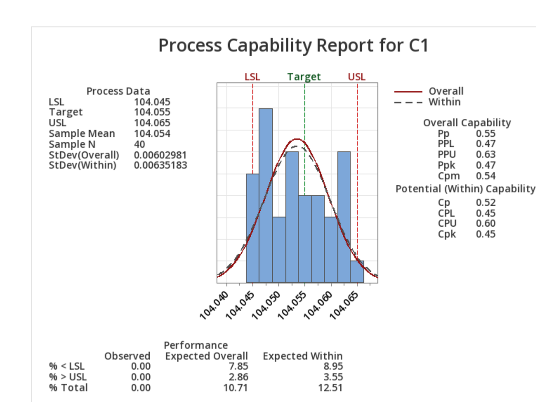


Figure 8: Process Capability Chart

Performance Analysis

Expected results were

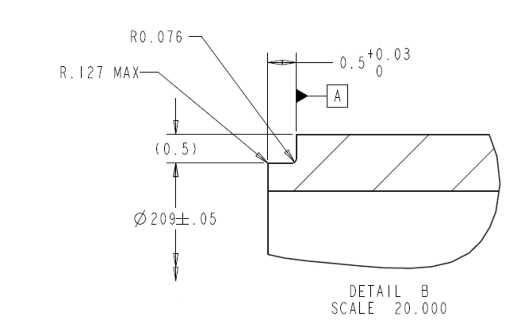
- Fully machine a 1:1 scale "Hemi" as per drawing specifications.
- Accomplish the tolerances specified by LANL drawing specifications

Predicted results were

- Fully machine a 1:2 scale "Hemi"
- Accomplish some tolerances specified by LANL drawing specifications

Why are the results different?

1. The CNC lathe machines in campus didn't have the capabilities to work with a 1:1 scale "Hemi" as per the drawing
2. Datum A features had smaller dimensions than our tooling nose radiuses
3. Tool holders and insert geometry played a big part when considering both the 1:1 scale and 1:2 scale "Hemi", it was necessary to reconsider the tooling strategy (tool holders and inserts)



Conclusions and/or Future Work

Future students of SDII will continue working on the hemi, with the hopes of improving the work done by our team. As of right now the team focused on the design for manufacturing (DFM) of the hemi, but there's still need to be an integration of a metrology process, for quality assurance purposes. The collaboration between these two institutions is 2 years, therefore the efforts will continue for a few years.

References (Some)

[1] Gao-23-104661, nuclear weapons: NNSA does not ... (n.d.). https://www.gao.gov/assets/gao-23-104661.pdf

[2] Whitney Spivey. (2025, March 20). "we have commenced war-reserve pit production": LANL. https://www.lanl.gov/media/publications/national-security-science/1224-we-have-commenced-war-reserve-pit-production

[3] [3] Energy. (n.d.-a). https://www.energy.gov/sites/default/files/2024-04/Day2%200805%20LANL%20LAP4%20Lessons%20Learned%20FINAL%2003%2026%2024.pdf