APPLYING ANTI-OXIDATION COATING TO THE INSIDE OF ROCKET NOZZLES

ATI
Specialty Alloys & Components

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PROBLEM STATEMENT

- Design, fabricate and test an apparatus that applies a uniform silicide coating to the inside surface of a niobium based alloy rocket nozzle

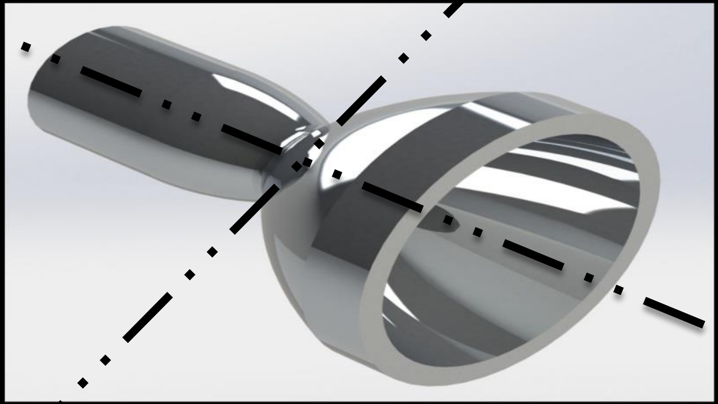
- Apparatus must be able to accommodate a range of nozzle sizes, and address problems that arise from current coating method

ISSUES WITH DIPPING METHOD

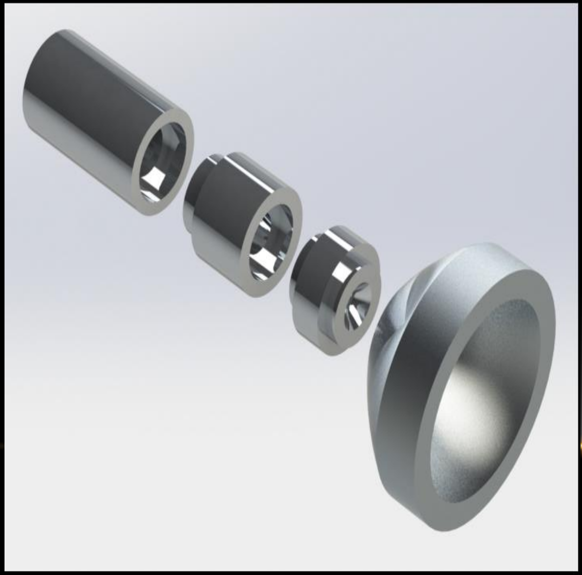
- Currently dipping nozzles into container of slurry with a controlled withdrawal speed
- Problems with dip method
  - Inconsistent coating thickness
  - Causes throat of smallest nozzle to bridge
  - Largest nozzle requires two coats to obtain sufficient thickness – second coat shears

PROPOSED SOLUTION

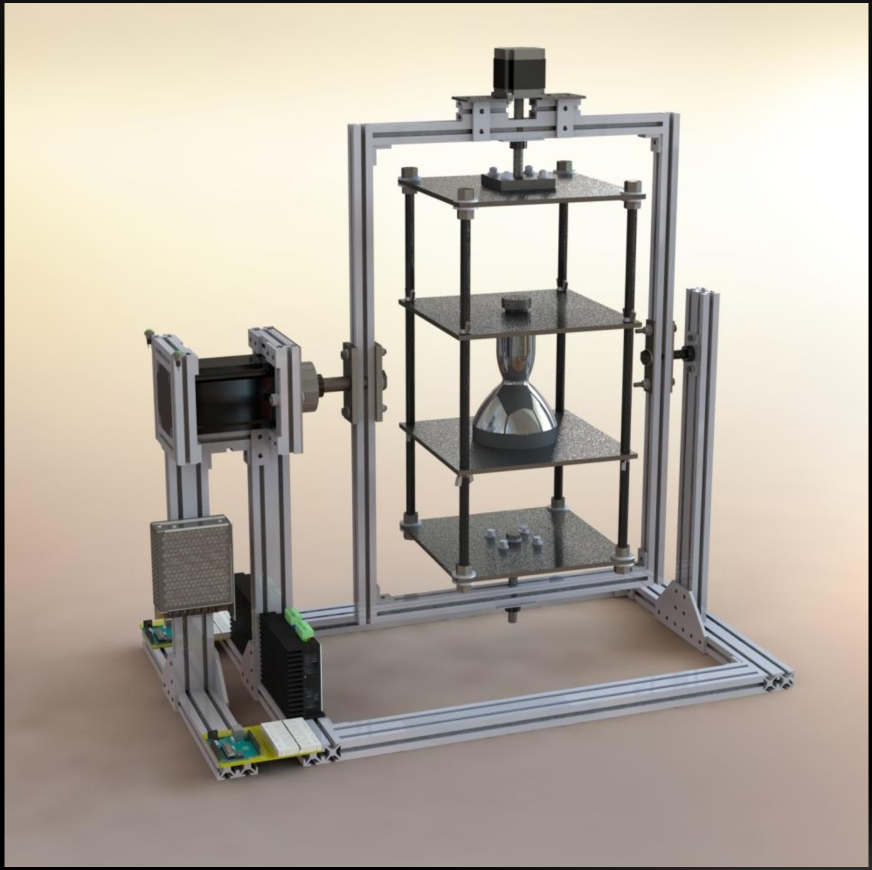
- An apparatus capable of dual axis rotation
- Continuous rotation about the vertical axis causes slurry to move outward, coating entire inner surface
- Flipping over its horizontal axis eliminates shearing due to gravity and counteracts centrifugal force on conical section
- Rotating while drying prevents unevenness

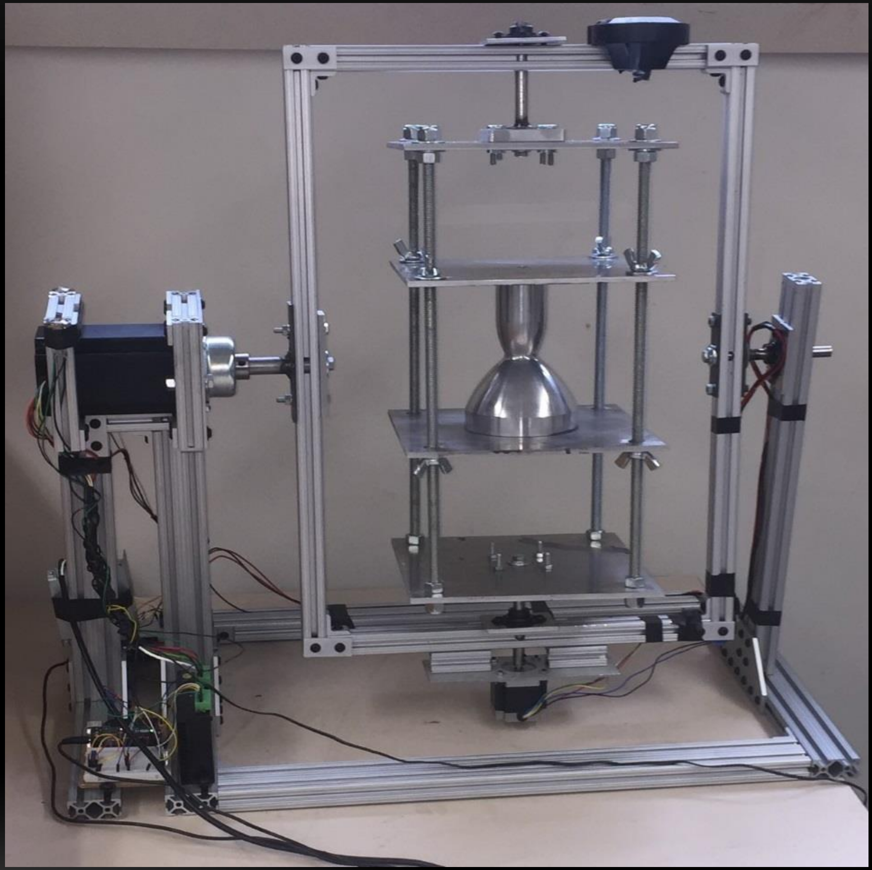


MACHINING OF THE NOZZLES



APPARATUS DESIGN





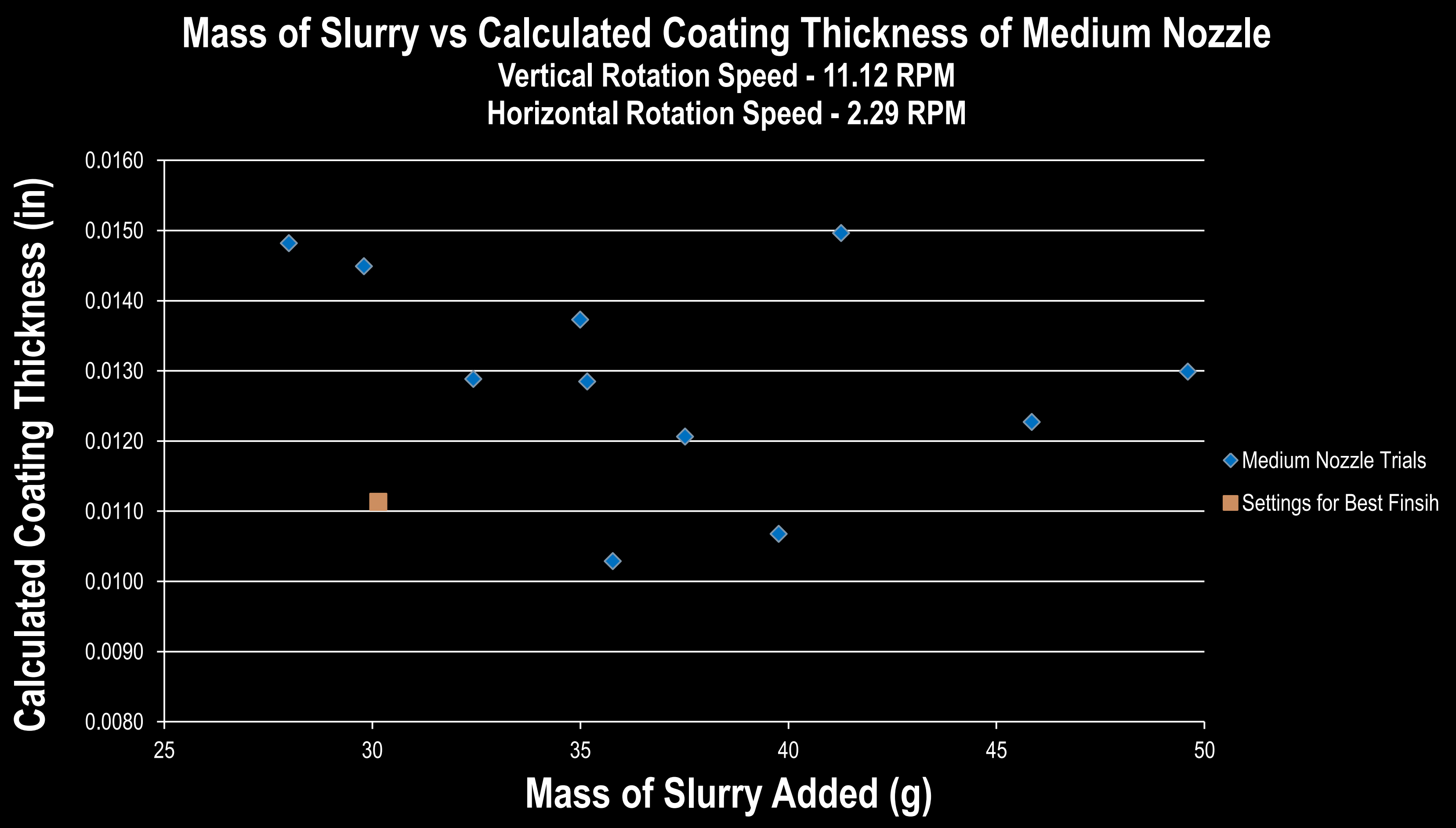
TRIAL STRUCTURE

- Viscosity tested before each trial
- Testing progression
    - Experimented with variety of methods to determine best practice technique
- Medium Nozzle
    - Speeds remained constant during testing
    - Varied initial slurry volume to determine optimal volume range
    - Experimented with drying cycles to determine sufficient drying time

TRIAL STRUCTURE

- Small Nozzle
    - Experimented with different rotation limits, speeds and testing techniques eliminate bridging at the throat
    - Modified fill method from medium nozzle

RESULTS


Mass of Slurry vs Calculated Coating Thickness of Medium Nozzle
Vertical Rotation Speed - 11.12 RPM
Horizontal Rotation Speed - 2.29 RPM
Calculated Coating Thickness (in)
0.0160
0.0150
0.0140
0.0130
0.0120
0.0110
0.0100
0.0090
0.0080
25
30
35
40
45
50
Mass of Slurry Added (g)
Medium Nozzle Trials
Settings for Best Finsih

RESULTS

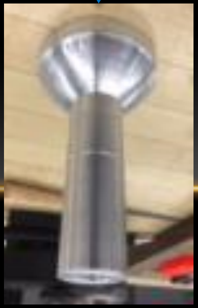
- Successful Medium Nozzle Coating

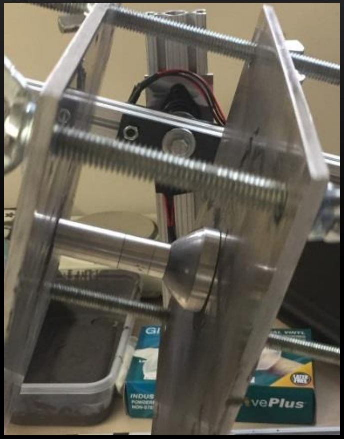
RESULTS

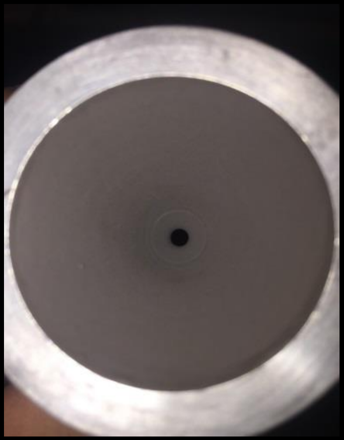
- Small Nozzle
  - Determined bridging only occurs when the conical section is facing down
    - Limited horizontal rotation to roughly 0-100 degrees
    - Determined sufficient drying cycle
    - Successful unbridged nozzle

Bridging occurs

Does not occur







CONCLUSION

- Outcomes
  - Medium coating
    - Known parameters for success
  - Small coating without bridging
    - Discovery of bridging at certain orientation
    - Best practice coating procedure
  - Coating apparatus
    - Variable speed dual axis rotation
    - Accommodates large range of nozzle sizes

FUTURE RESEARCH

- Continued testing with large nozzle to ensure shearing will not occur
- Refine parameters to optimize coating for each nozzle
- Further development of apparatus for consistency and ease of use