Bleed Hole Location, Sizing, and Configuration for Use in Hypersonic Inlets

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**Project Objective**

**Objective:** Design a bleed hole configuration for an axisymmetric Busemann inlet to start at a freestream Mach of 3.5 (2600 mph). The inlet is to include a geometric contraction ratio of 5.8 and a bleed plenum incorporated into the internal structure.

**Testing:** Bleed perforation configuration will be validated via Computational Fluid Dynamics (CFD) and wind tunnel experiments.

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**Importance of Bleed**

- Hypersonic airbreathing vehicles are the future for cruise missiles, reconnaissance and space access
- Some limiting technology holding field back → unstarted inlets
- Bleed perforations are inexpensive and lightest solution to inlet starting (passive starting solution) in comparison to variable geometry and retractable doors

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**Research**

- High contraction ratios at high speeds make inlet starting difficult; but are desired for optimal performance
- As flight Mach number increases maximum started contraction ratio will increase
- Introducing bleed holes effectively lowers the contraction ratio, allowing operation at lower Mach ranges

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**Design and Computational Results**

Cart3D was used to produce all CFD results for this project. Cart3D is a high-fidelity inviscid tool developed by NASA Ames for automated CFD.

**Preliminary Design**

Preliminary design included holes sized by the Mölder Theory. Holes were spaced evenly along the length of the inlet. The bleed holes all had a diameter of 0.25”. The Mach contour shows a normal shock at the beginning of the plenum.

**Next Step:** Isolate inlet to determine cause for normal shock

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**Conclusions and Future Work**

Conclusions:
- Mölder Theory with Kantrowitz spacing proved most efficient
- Offset and smaller diameter holes produced more uniform flow
- Angled holes were less efficient due to small thickness of wall

Future Work – Wind Tunnel Testing
- Test at Mach 3.5 in GoHypersonic Inc. (Dayton, OH) wind tunnel
- Total designed hole area ≈ 1% larger than theoretically determined hole size
- Excess holes will be plugged with dental paste to determine minim required hole area