



Labyrinth Seal Test Rig

Sponsored by Danfoss –Turbocor
Spring 2009 2nd Project Update
Presentation



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Overview

- Work that has been completed
- Design “Changes” that occurred after initial machining
- Revamped flow calculations (using new information)
- Pressure measurement possibilities
- Work that still needs to be completed



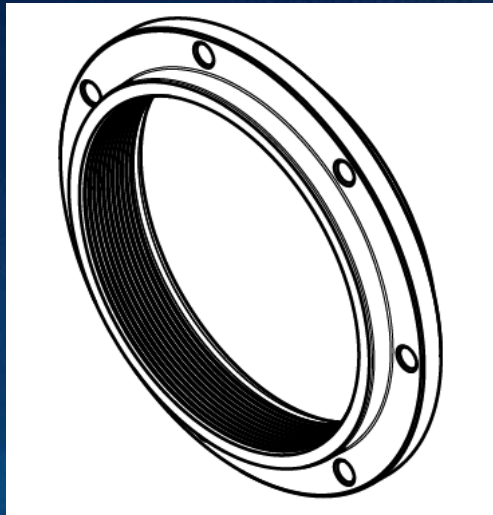
Progress to Date

- January:
 - Cut down raw materials into more manageable sizes
 - Met with DTC head machinist to discuss machining options
 - Performed new flow rate predictions using new pressure data and seal sizes
- February:
 - Finished preliminary machine work
 - Delivered materials to DTC for professional machining
 - Built Orifice and Venturi flow meter prototypes
 - Minor design alterations to save money

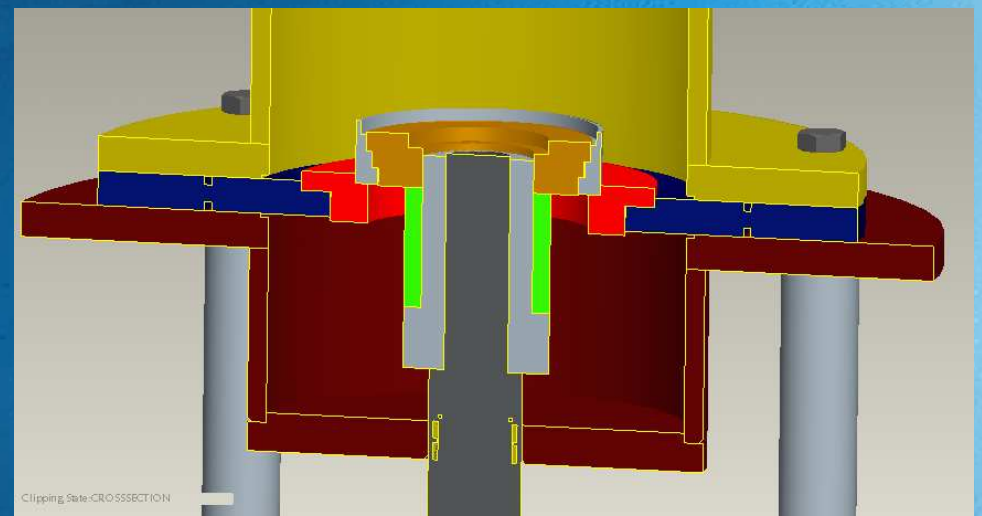
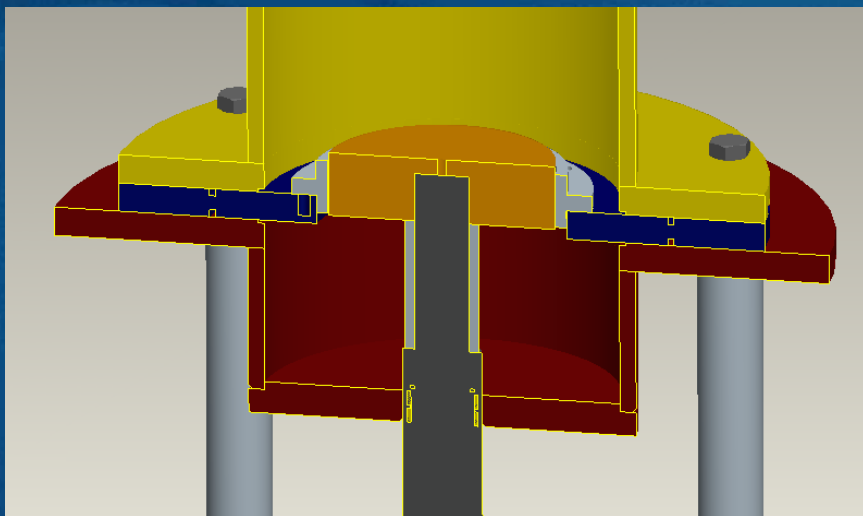
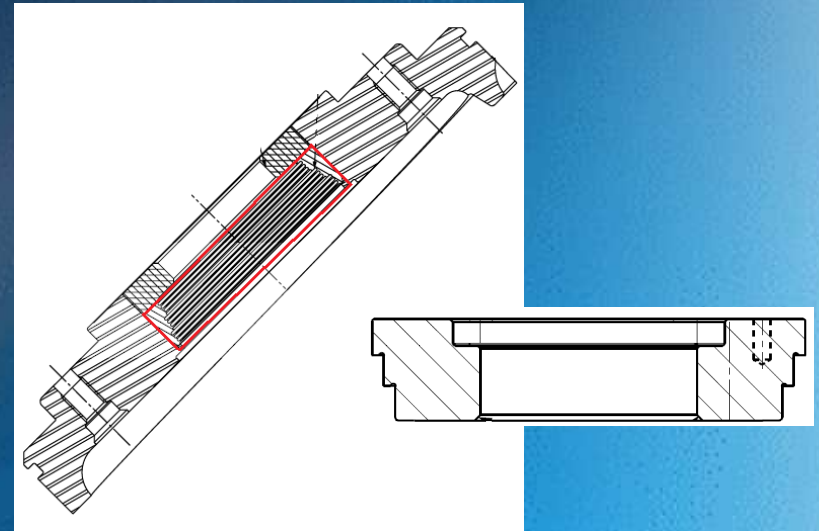


Seal Specifics

Seal Set A



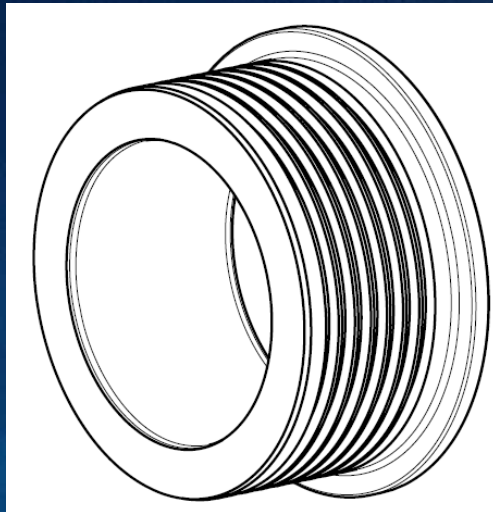
Seal Set B



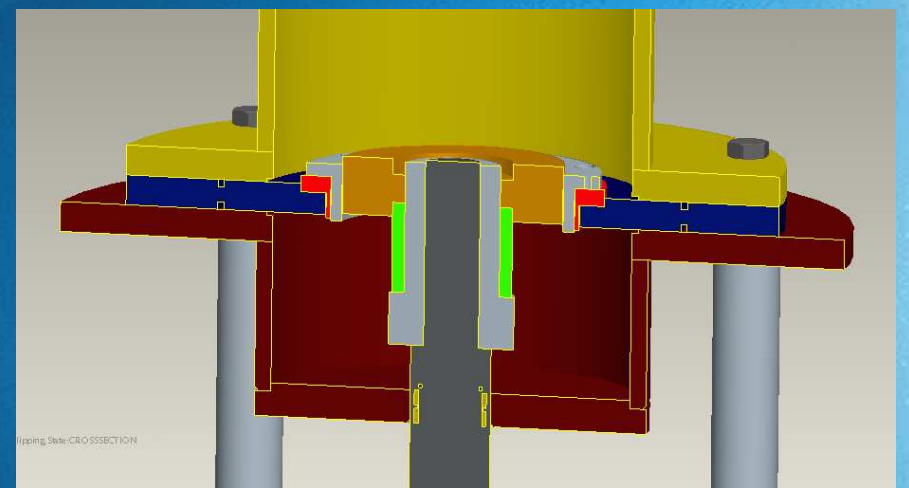
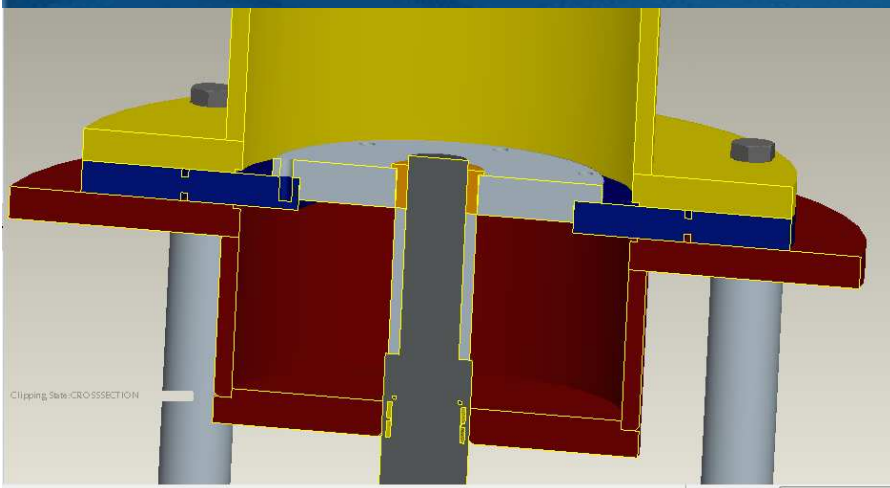
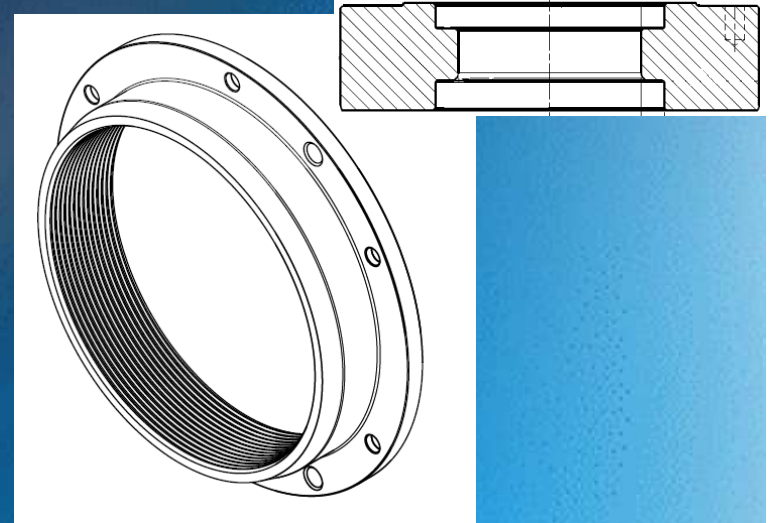


Seal Specifics

Seal Set C



Seal Set D





Predicted Flow Rates

Seal	Seal Diameter (mm)	Number of Teeth	Mass Flow Rate (kg/s)	Vol Flow Rate (L/min)
1st Stage Shrouded Impeller	93.076	9	0.06	743.486
Impeller S1.70	89.65	12	0.048	596.391
Interstage W15.48	33.6	6	0.021	262.234
Touchdown Bearing 1st step	75.215	3	0.01	128.121
Touchdown Bearing 2nd step	71.215	3	0.009	121.307
Touchdown Bearing 3rd step	67.215	3	0.009	114.494



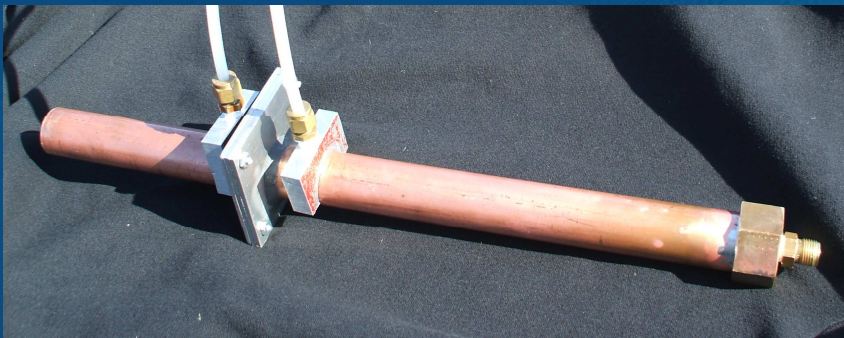
Orifice vs Venturi

Orifice Pro's

- Simple to Build
- Variable orifice sizes
 - Wider pressure range

Orifice Con's

- Lower pressure recovery



Venturi Pro's

- Higher pressure recovery

Venturi Con's

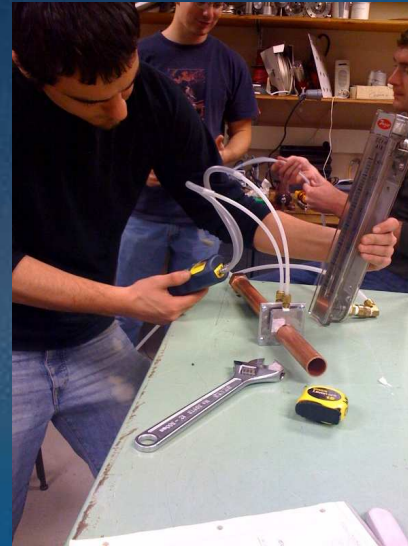
- Longer Build Time





Orifice/Venturi Prototype

- Built both flow meters and tested each using an Ar gas cylinder at varying flow rates
- Venturi:
 - $D=1.03''$
 - $d=0.36''$
 - $\Delta P = 2.7 \text{ kPa}$ (0.4 psi) at 400 SCFH
- Orifice:
 - Pipe $D = 1.1''$
 - Orifice $D= 0.5''$
 - Taps at $1D$ and $\frac{1}{2} D$
 - $\Delta P = 1.57 \text{ kPa}$ at 400 SCFH
 - ΔP was consistently lower than Venturi





Budget Update

- Raw Materials : \$333.24
- Pressure Equipment: \$432.89
- Misc. Parts: \$93.57
- The Joy of Senior Design: *Priceless*

Total: **\$859.70**

Remaining Budget: **\$640.30**

After Consulting with the head DTC machinist, we were able to make several money saving changes to put us back under budget



Timeline

- February:
 - Finalize seal adapter design
- March:
 - March 6th: Receive machined parts from DTC
 - March 7th – 9th: Assemble Test Rig
 - March 10th-20th: Seal Testing
- April / Rest of the Semester:
 - Perform Results analysis
 - Write operations manual
 - Write Final Report
 - Build Presentation board



Conclusion

- Currently waiting to receive finished parts from DTC so that testing can begin
- After receiving specific seal designs and new pressure reading, flow predictions have been redone
- The new calculations are being used to pick a manometer to go along with either an orifice or venturi meter
- There is \$640.00 remaining in the budget
- After receiving the parts, we are on schedule to test the rig and complete the analysis



Thanks to

- **Danfoss – Turbocor Staff:**
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- **FAMU-FSU College of Engineering Faculty**
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 - Dr. Daudi Waryoba
 - Mr. Bill Starch , Shop Supervisor at ASC, NHMFL



References

- **Sources**

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- Childs, Peter R. Mechanical Design Pg 184. Arnold Publishers © 1998
- Classical Concepts and Papers by Egli 1935
- Liptak, Bella G “Flow Measurement”
- Miller, Richard W “Flow Measurement Engineering Handbook 3rd Edt” McGraw-Hill Publishing 1996

- **Vendors:**

- www.Metalsdepot.com
- www.Omega.com



? Questions ?