



# Performance Evaluation of Pump Volute Geometries Optimized for Additive Manufacturing

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1<sup>st</sup> of April 2026

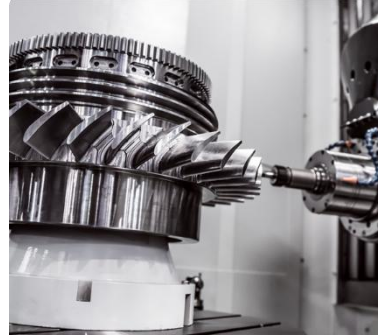
# Agenda

Concepts NREC

Volutes and manufacturing methods

Comparative Study

Conclusions



# Concepts NREC

## Our core business units:

Software (CAE and CAM)

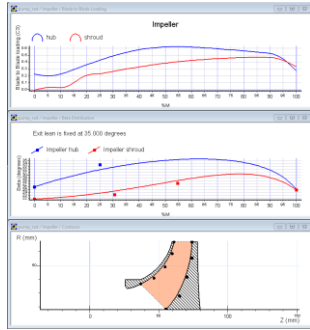
Engineering

Manufacturing, Assembly and Test

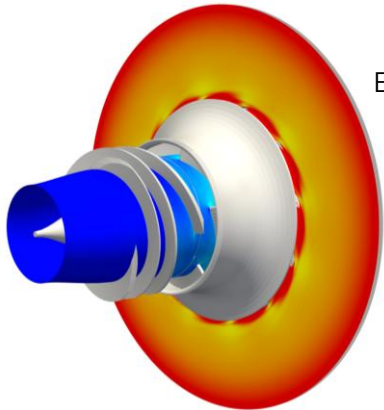
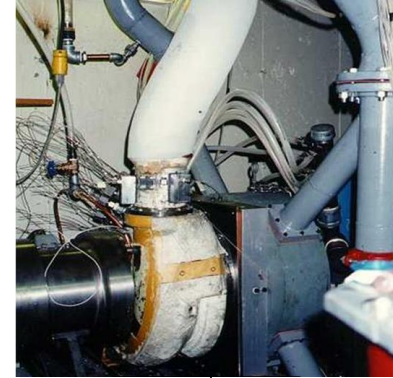
Engineering Courses



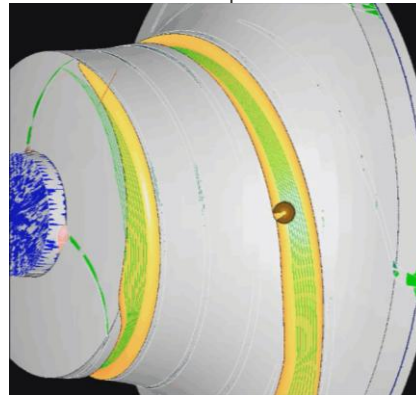
# Solutions for Turbomachinery



Computer Aided Manufacturing (CAM)

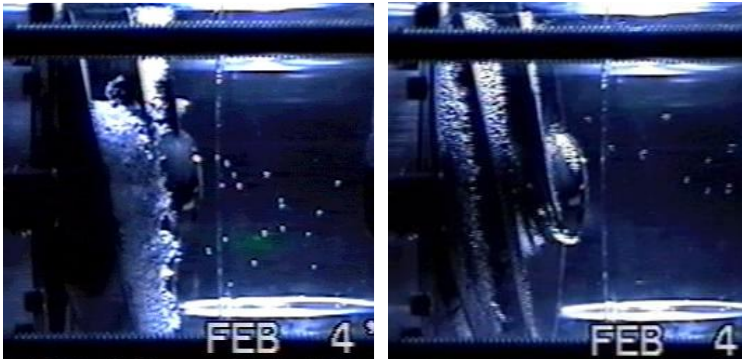
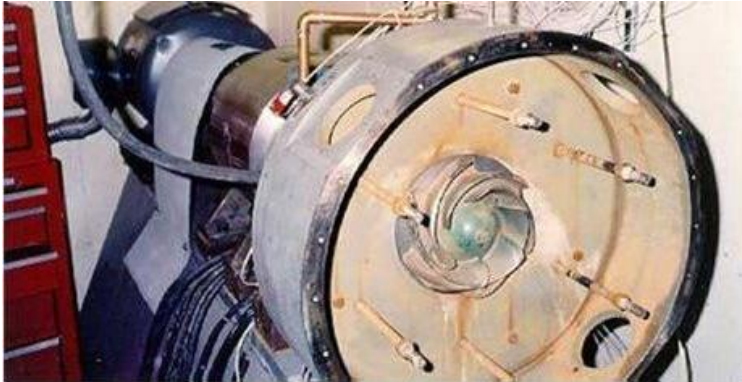


Computer Aided Engineering (CAE)



Engineering Services, Prototyping and Assembly

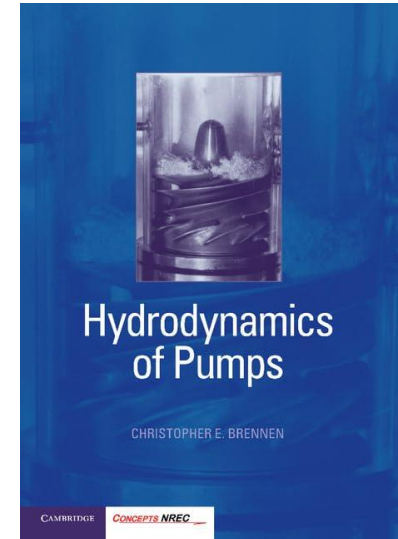
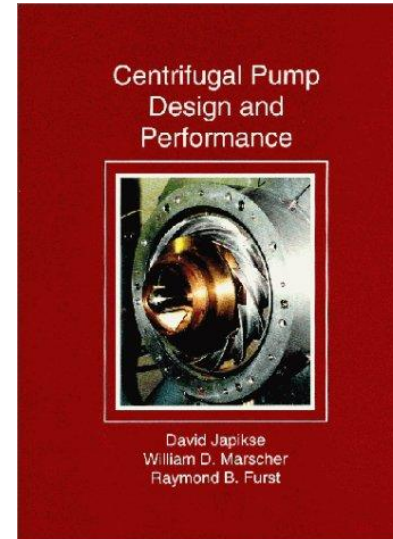


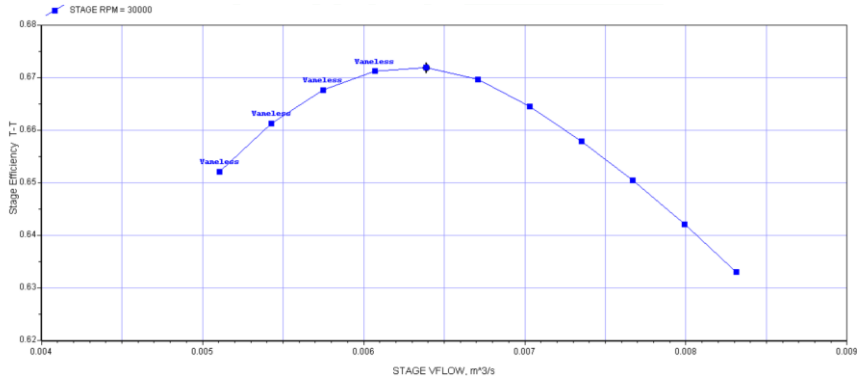
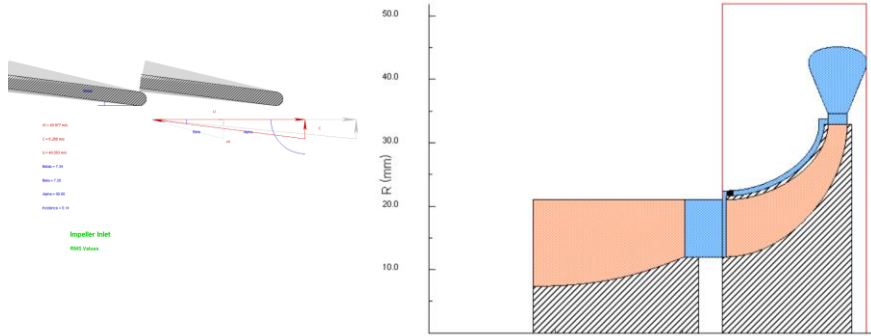


- Enhanced Pump Design (**Industrial Client**)
- Seal Test (**Industrial Client**)
- Impeller Lateral and Axial Force versus Tip Clearance (**AFRL**)
- Volute Design to Minimize Axial Force (**NASA**)
- SSME First Stage Test (including inlet pipe) (**NASA**)
- High Head Turbopump Development (**AFRL**)
- Inducer Cavitation Performance (**NASA, NSF**)
- Lateral Impeller Forces (**Volute Consortium**)
- Backface Pump-Out Vane Design & Clearance (**Thrust Consortium**)
- Ultra-high Suction Performance Inducers (**AFRL**)
- Rotordynamic Coefficients – SSME LOX Inducer (**NASA**)
- Pump Hydrodynamic and Cavitation (**NG and AEROJET USET**)
- Extracting POGO Transfer Function - SSME LOX inducer (**NASA**)
- Cavitation Testing and POGO (**NASA**)

## References

- ▶ [1] C. E. Brennen, **Hydrodynamics of Pumps**, 1st ed. Cambridge University Press, 2011. doi: 10.1017/CBO9780511976728.
- ▶ [2] Japikse, D., Marscher, W. D., and Furst, R. B., **Centrifugal Pump Design and Performance**, Concepts ETI, Inc., 1997.
- ▶ [3] D. D. Japikse, D. N. Baines, M. J. Platt, and C. Eti, “**DESIGN STUDY OF A LOW-COST LOX TURBOPUMP**”.
- ▶ [4] K. N. Oliphant, E. M. Krivitzky, T. Miller, and P. Sweeny, “**DESIGN FOR CNC MANUFACTURING OF AN INTEGRALLY SHROUDED LH2 PUMP IMPELLER**”.
- ▶ [5] M. J. Platt, D. M. M. Yu, and M. Marsh, “**MULTIDISCIPLINARY OPTIMIZATION OF A LH2 TURBOPUMP DESIGN IN AN AGILE ENGINEERING ENVIRONMENT**”

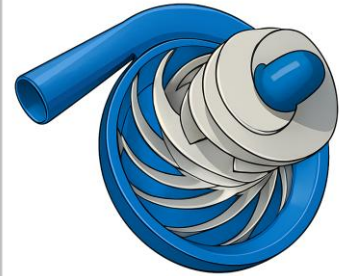


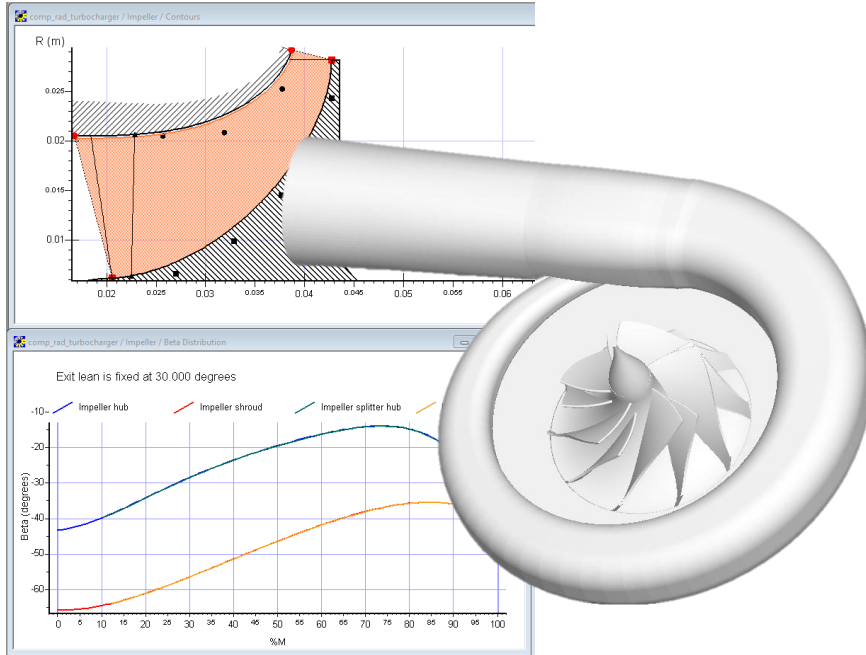


Suitable for new designs from scratch or analysis of existing machines ;

**Dedicated Concepts NREC Cavitation Model developed and validated in house**

Quick and accurate trade-off evaluations of design parameters;

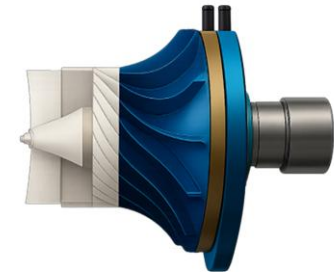




Easily handles the most complex rotating and stationary blade geometry

**Design of impellers, diffusers, return channels, features to design volutes and others;**

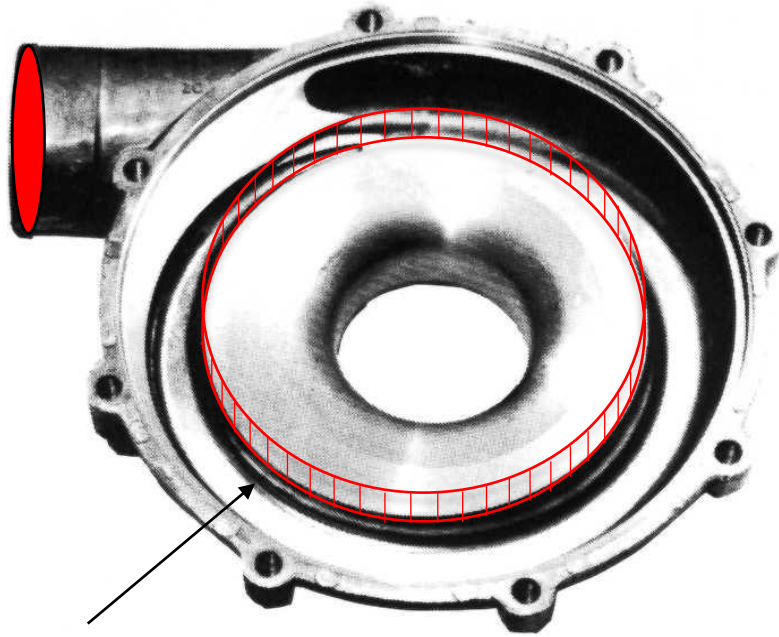
Fully integrated with preliminary design tools, CFD, FEA and others;



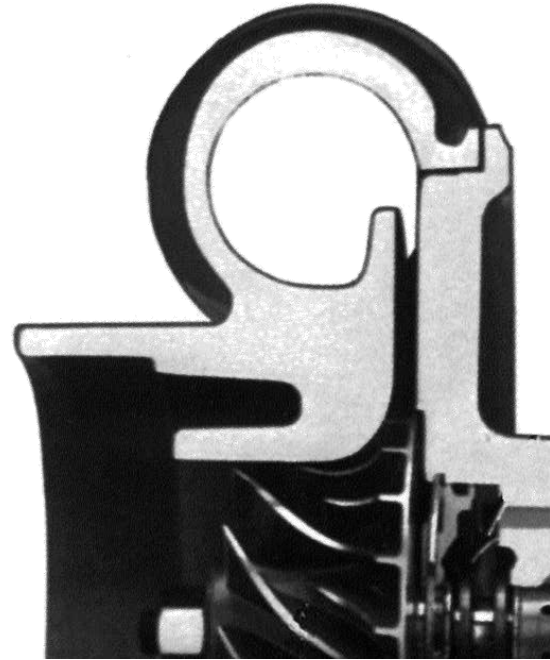
# Volutes and Manufacturing Methods

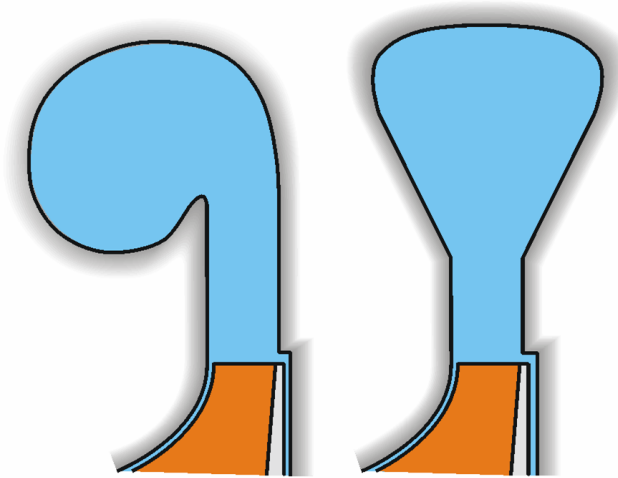
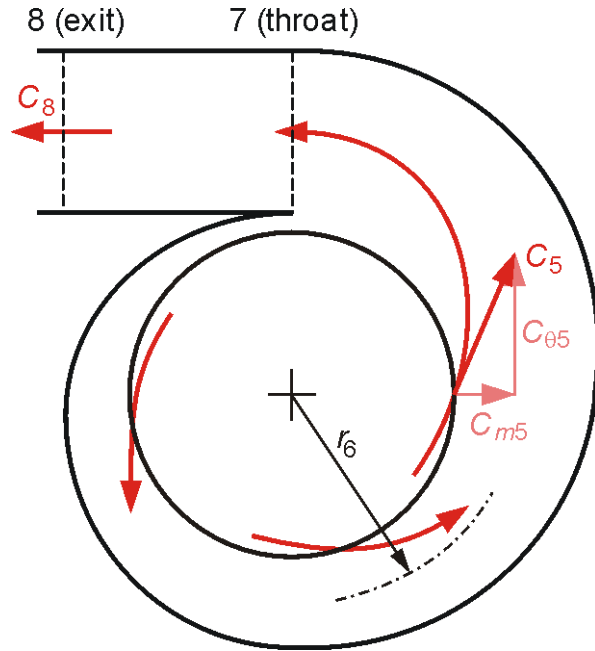
What and how

Exit Area



Inlet Area



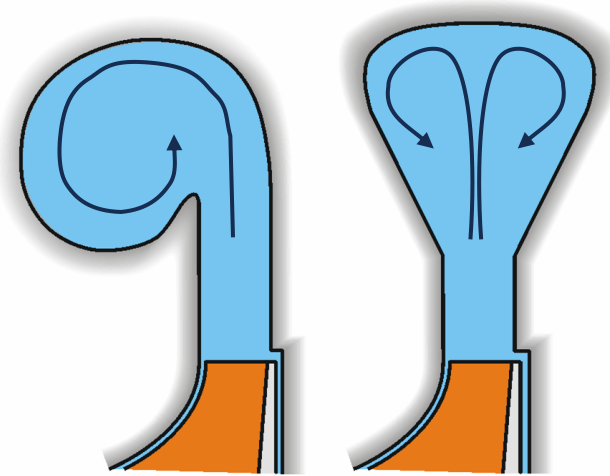
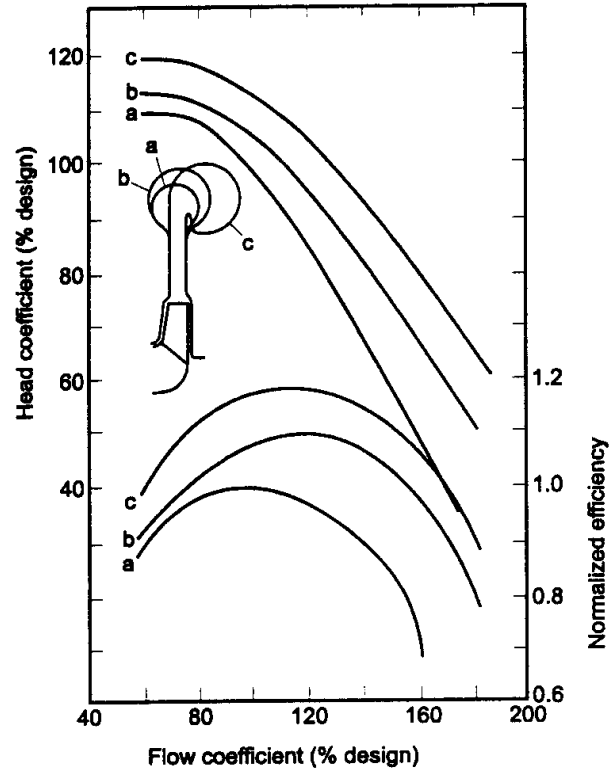


Overhung volute

Symmetric volute

**Overhung volute allows a larger diffuser within the same overall space envelope**

# Pump Volute: Different Cross-Section Geometries

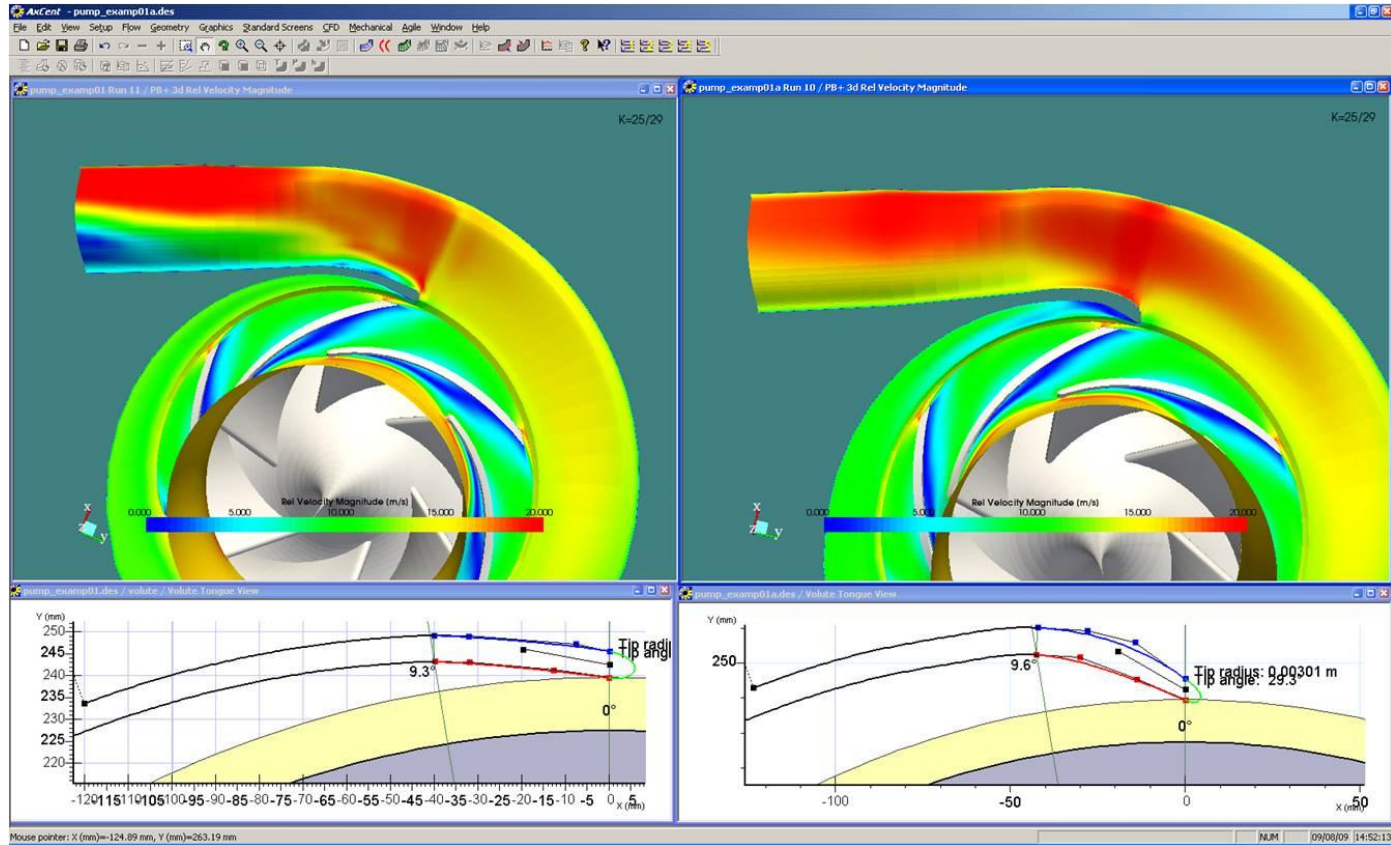


Overhung volute

Symmetric volute

**Overhung volute allows a larger diffuser within the same overall space envelope**

# Volute Tongue



Volutes are crucial for pump performance but often an after thought on the design process

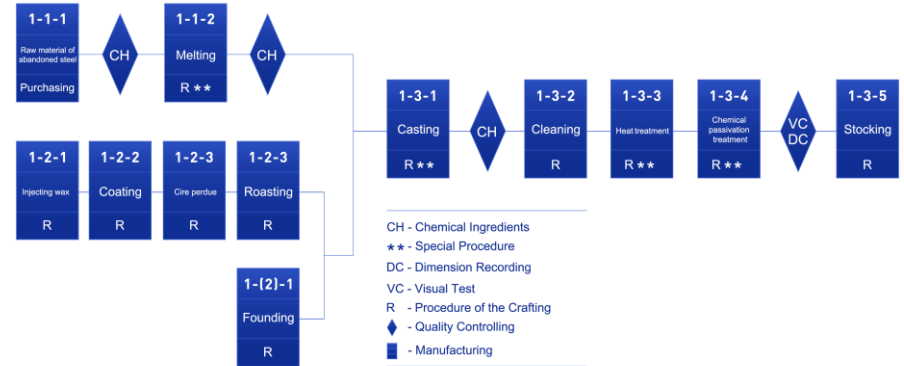
**The main performance point is the area**

**Cross Section Shape is secondary but still important**

**The interaction with the tongue is also important**

**How to build and assembly a volute also pays a big role in the design**

# Manufacturing methods – Casting

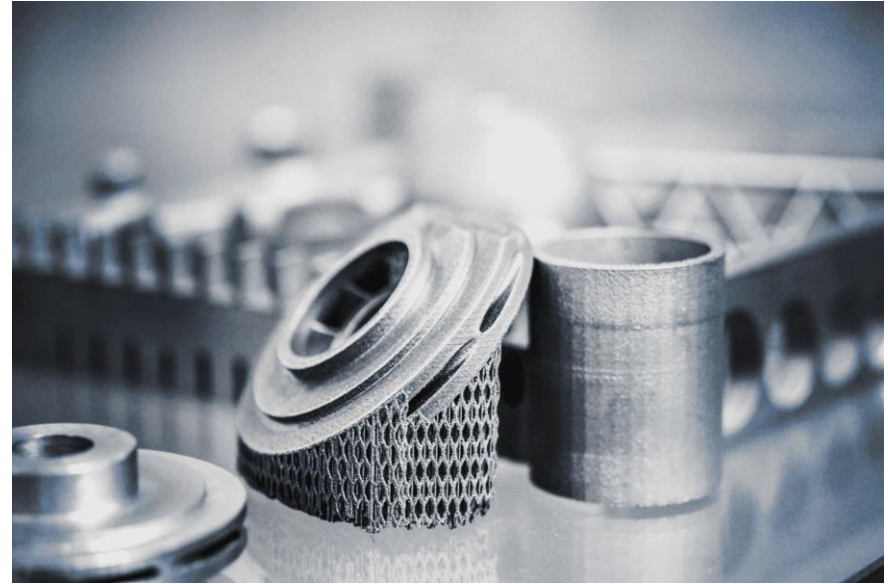
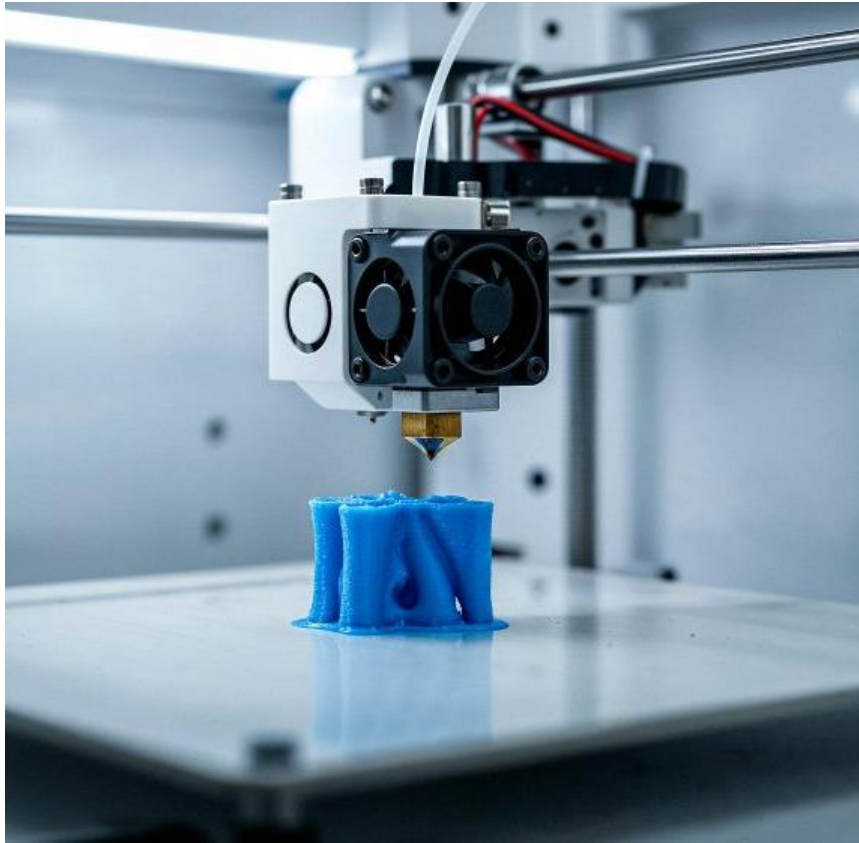


Source: Stainless Steel Casting,  
Feilang Pump Valve Co.

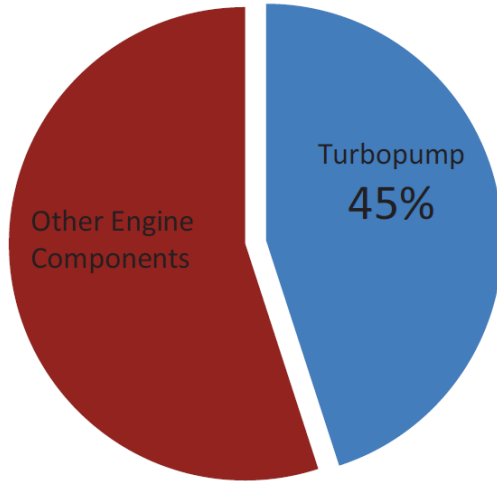
<https://www.feilangcasting.com/stainless-steel-casting/>

# Manufacturing methods – Machining





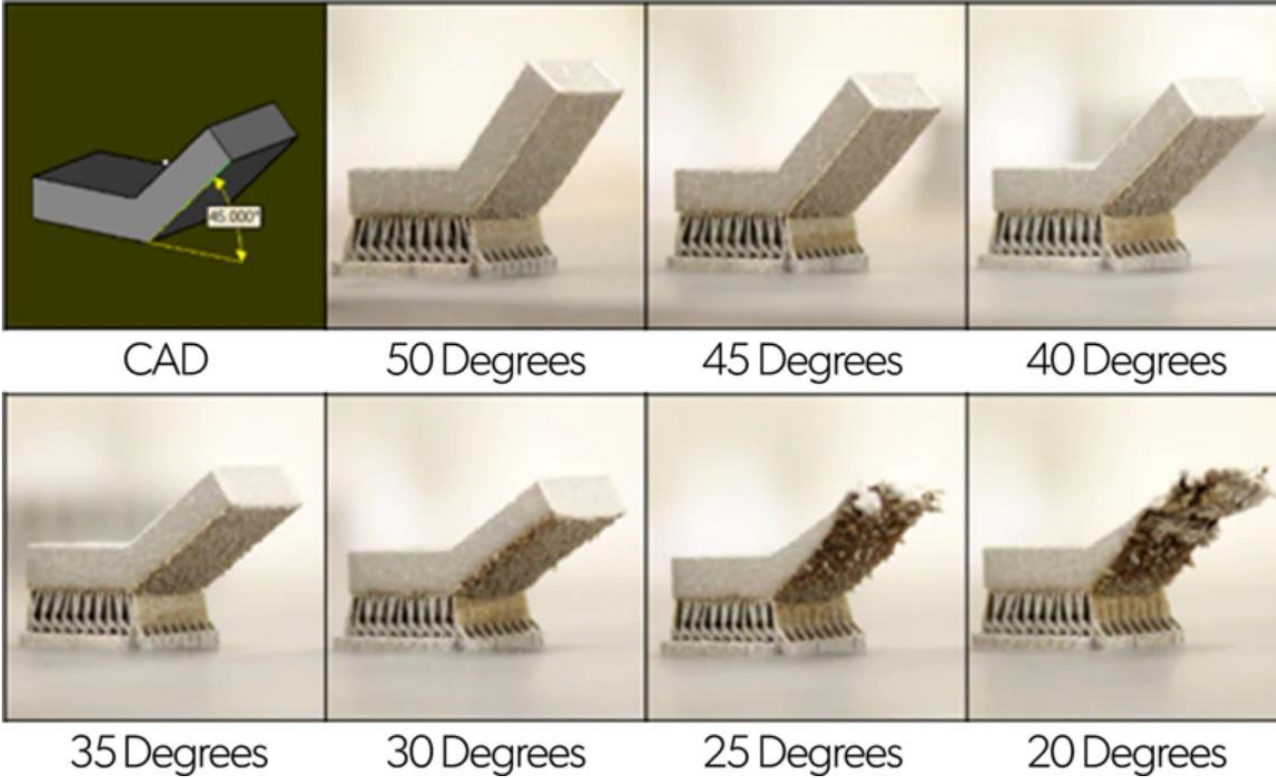
## Fastrac Development Engine Manufacturing Cost



Can we use **Additive Manufacturing** techniques to:

- Reduce manufacturing cost and lead time?
- Get hardware into test early enough to anchor models and provide a more robust design?

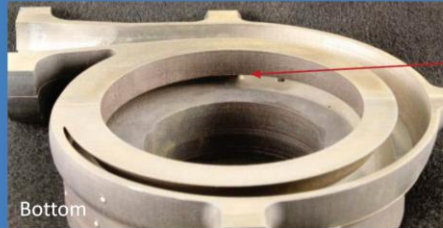
**Source:** Evaluation of Additively Manufactured Demonstration Hardware for a Turbopump Application; O'Neal, Derek (NASA Marshall Space Flight Center Huntsville, AL, United States); Report Number: M15-4466



## Pump Volute

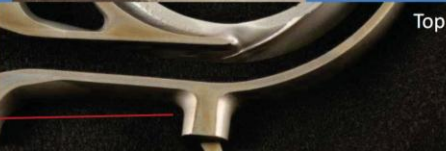
### Vendor A

Surface Finish:  
Ext: Bead Blast  
Int: Extrude Hone



### Vendor B

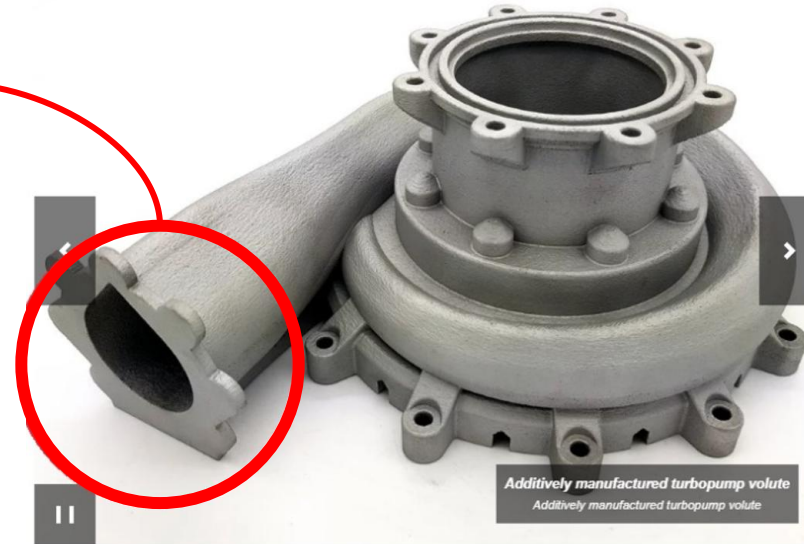
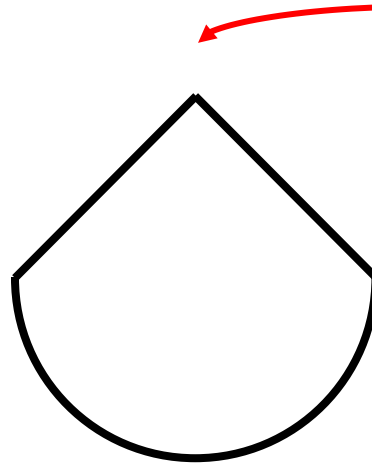
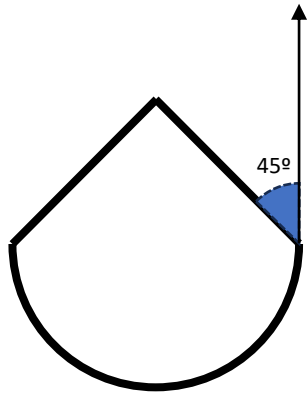
Surface Finish:  
Ext: Bead Blast  
Int: Extrude Hone



Approved for public release; distribution is unlimited.

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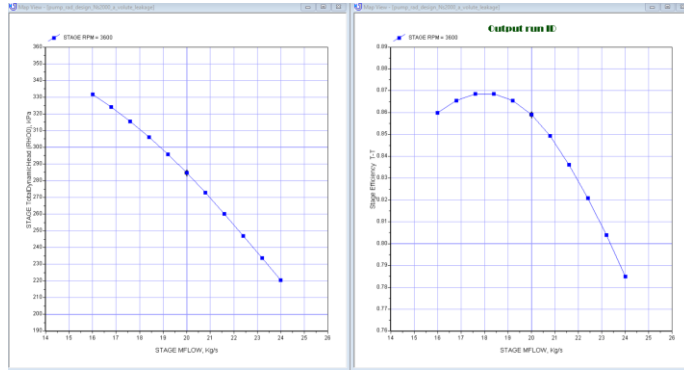
**Source:** Evaluation of Additively Manufactured Demonstration Hardware for a Turbopump Application; O'Neal, Derek (NASA Marshall Space Flight Center Huntsville, AL, United States); Report Number: M15-4466



# Comparative Study on Pump Volutes

An Evaluation of Pump Performance for Additive Manufacturing Parts and its impact on performance

# Pump Case



Fluid: Water

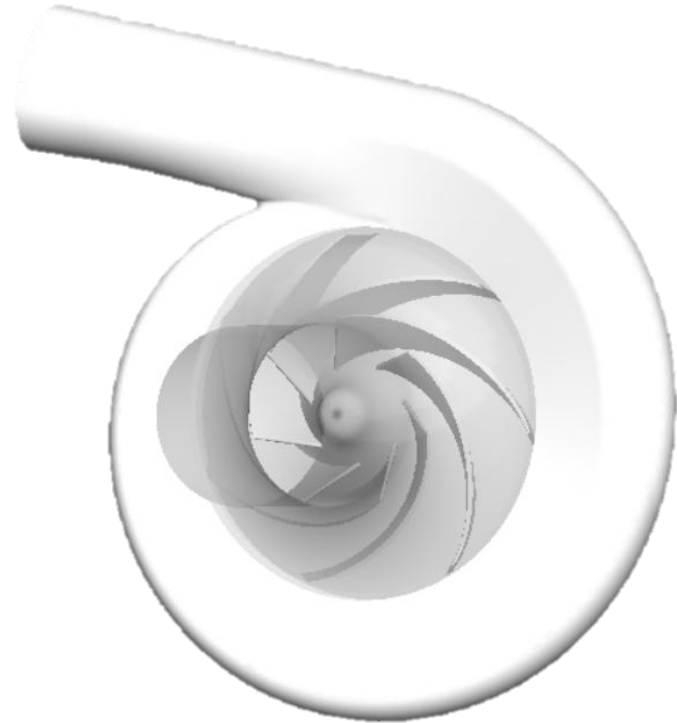
Inlet T0 = 20 C

Inlet P0 = 100 kPa

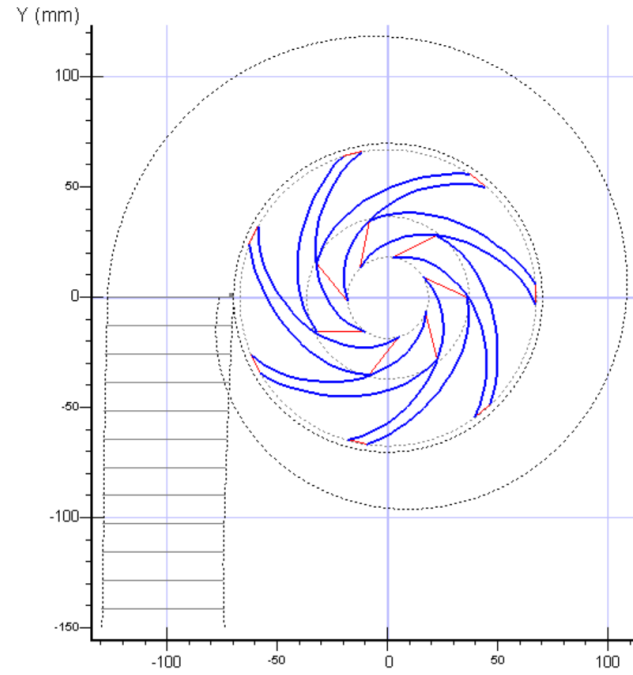
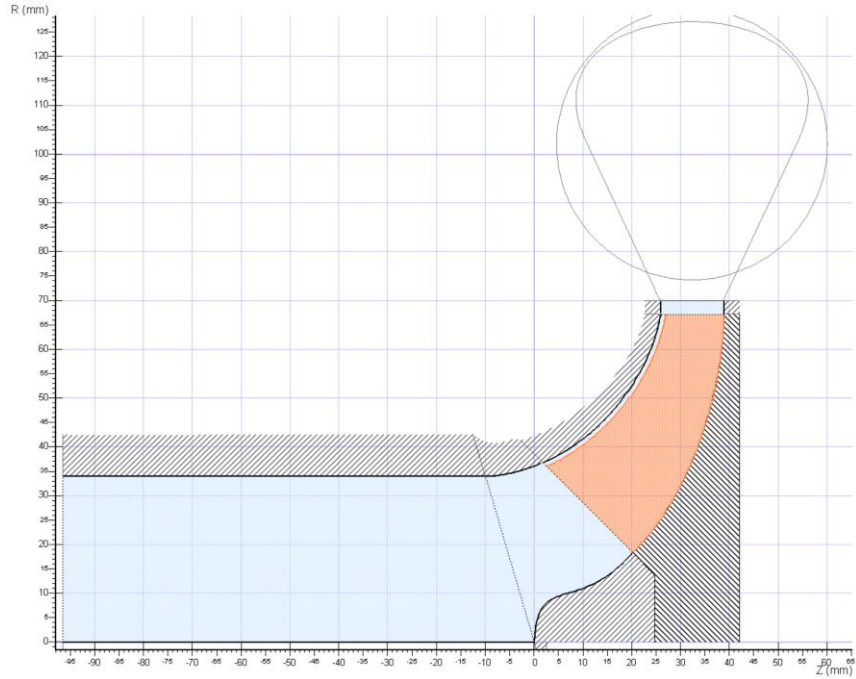
M = 20 kg/s

H = 29.0 m (285 kPa)

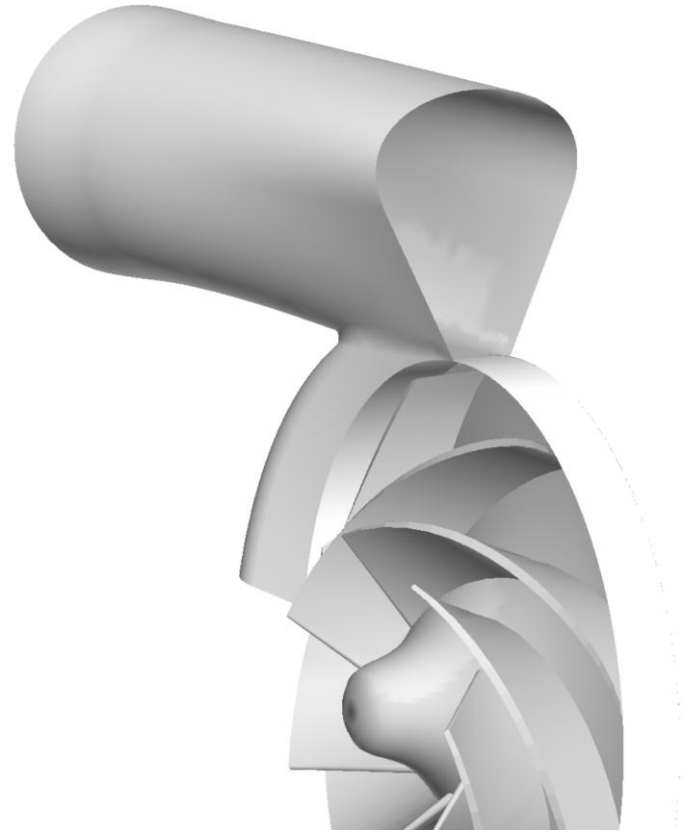
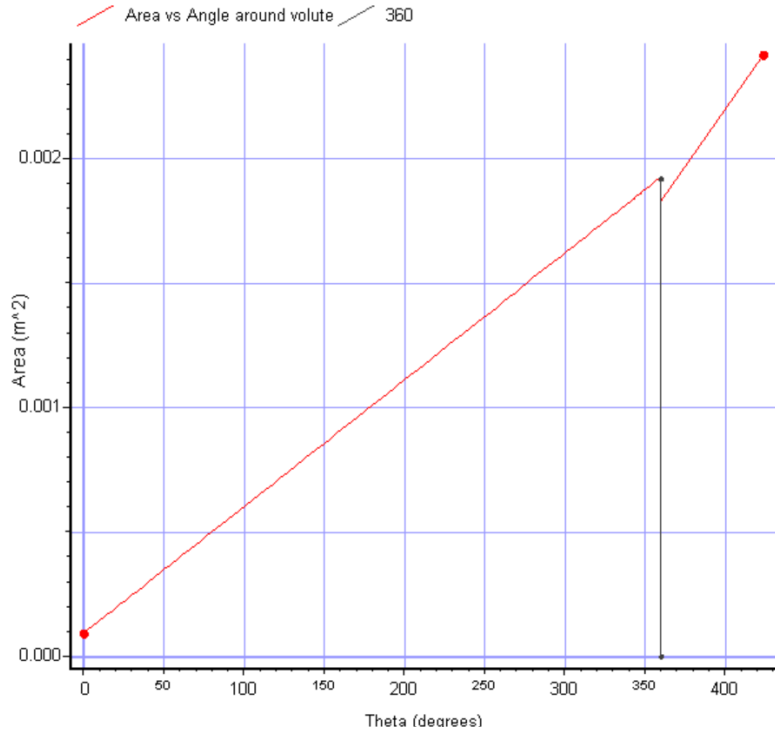
R = 3600 RPM



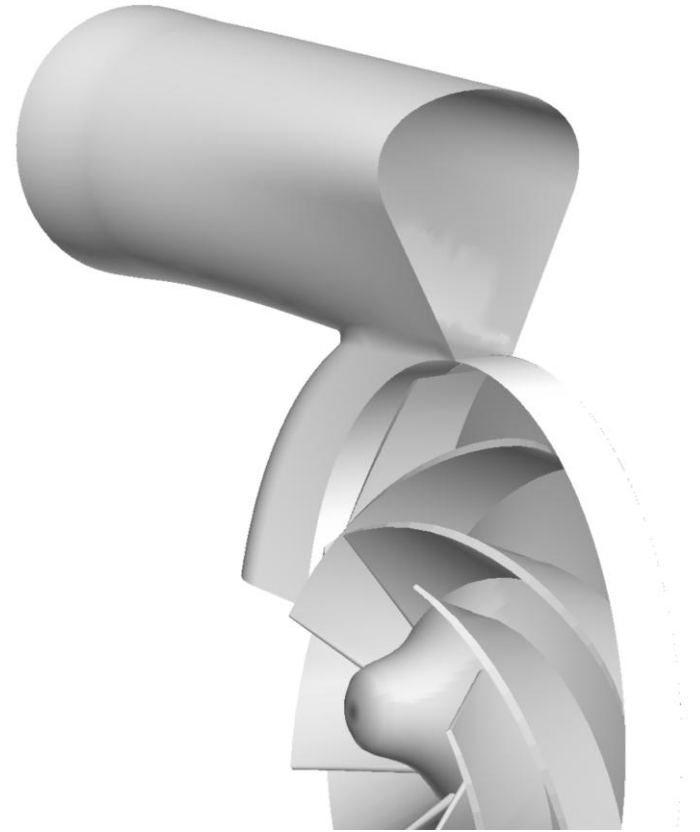
# Volute Geometry



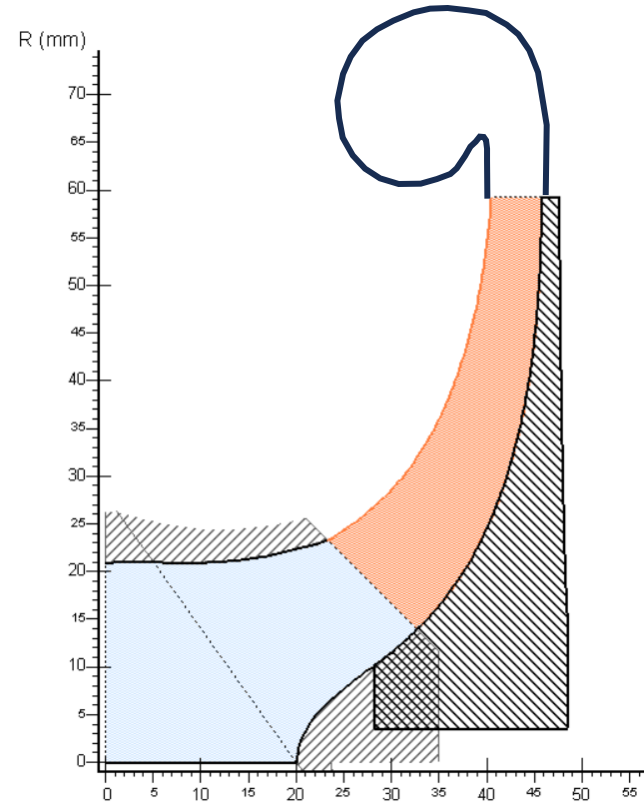
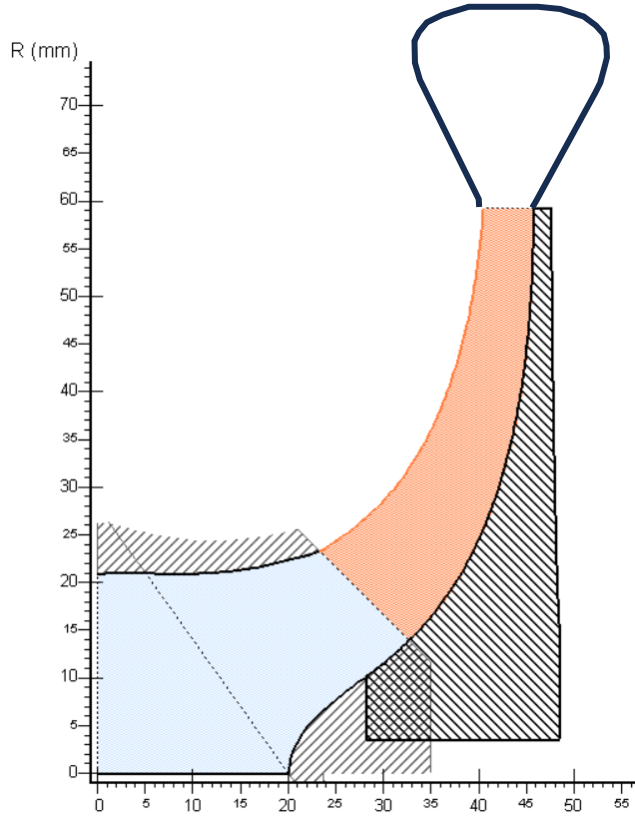
# Volute Geometry



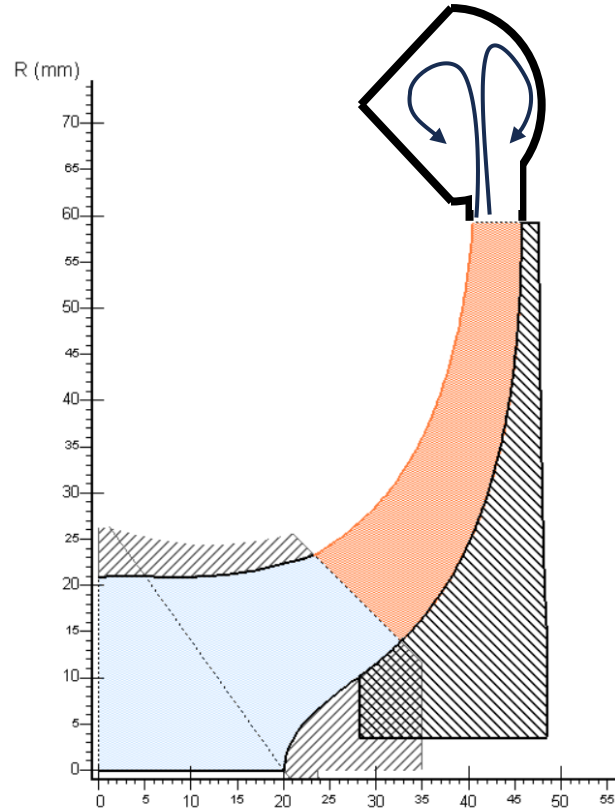
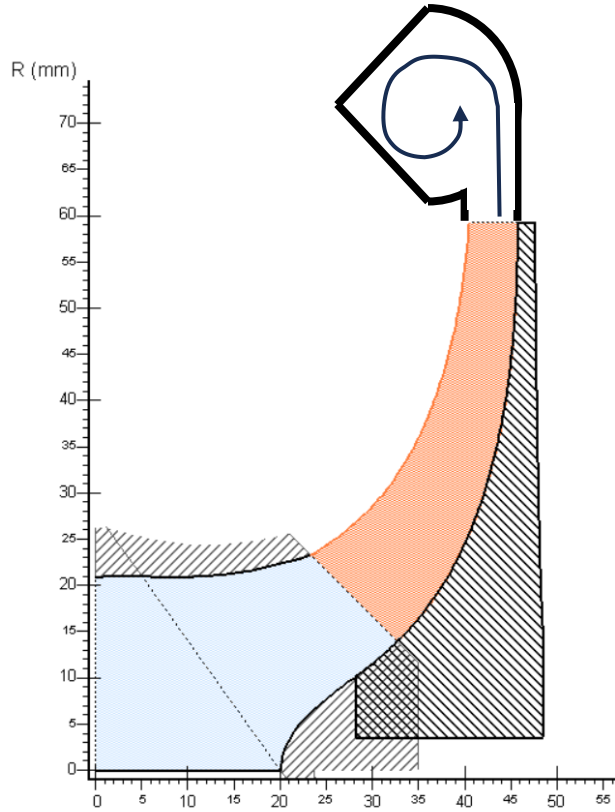
Area vs Angle around volute	
Theta (degrees)	Area (m <sup>2</sup> )
0°	9.14E-05
360° (Before the thong)	0.00191898
360° (After the thong) - Throat	0.0018276
Exit Pipe - Outlet	0.002417



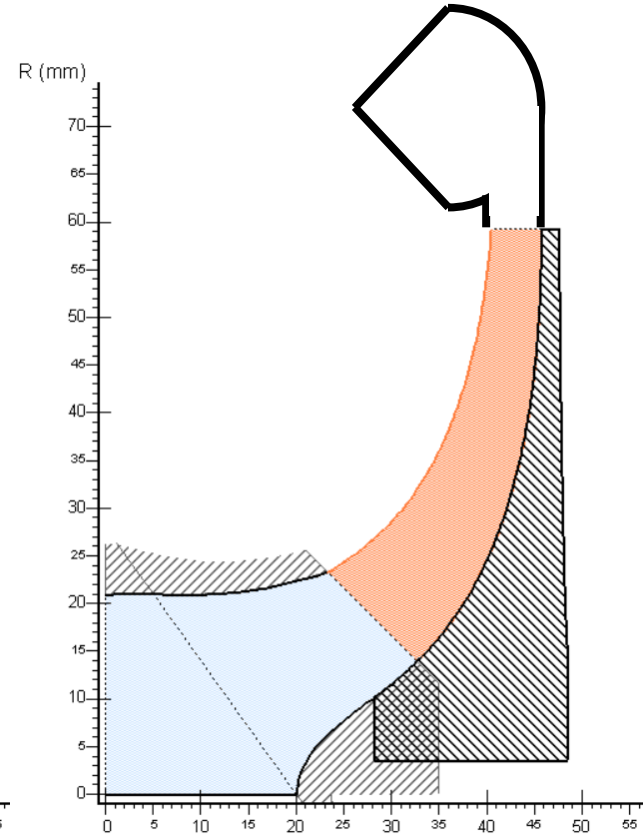
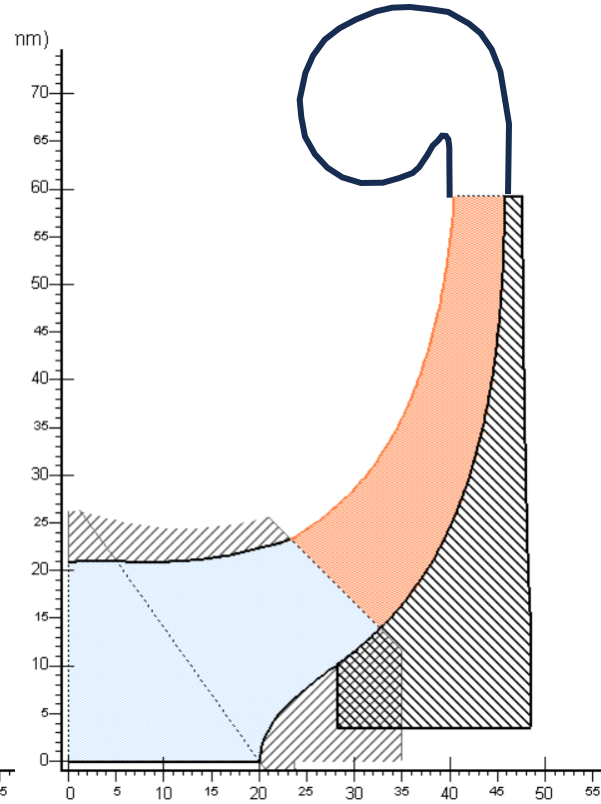
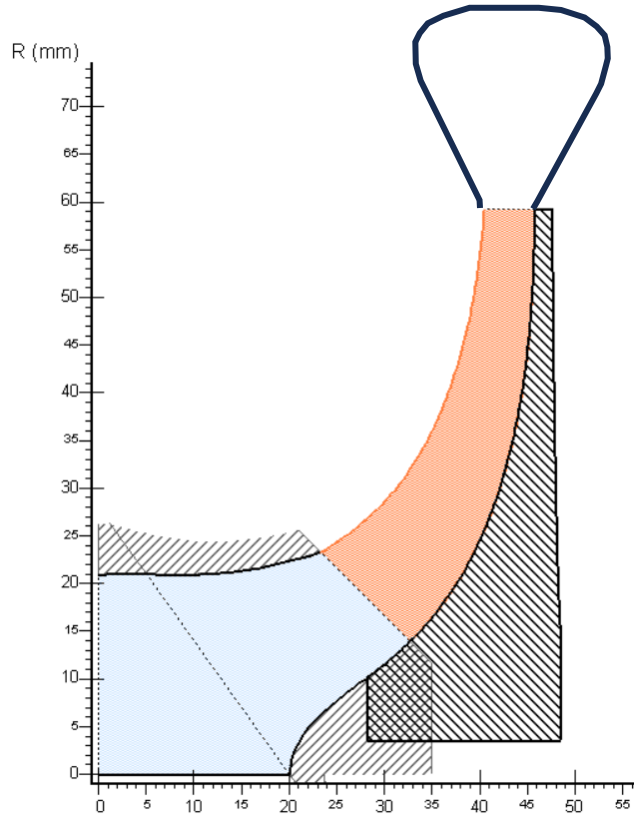
# Volute Geometry Variants



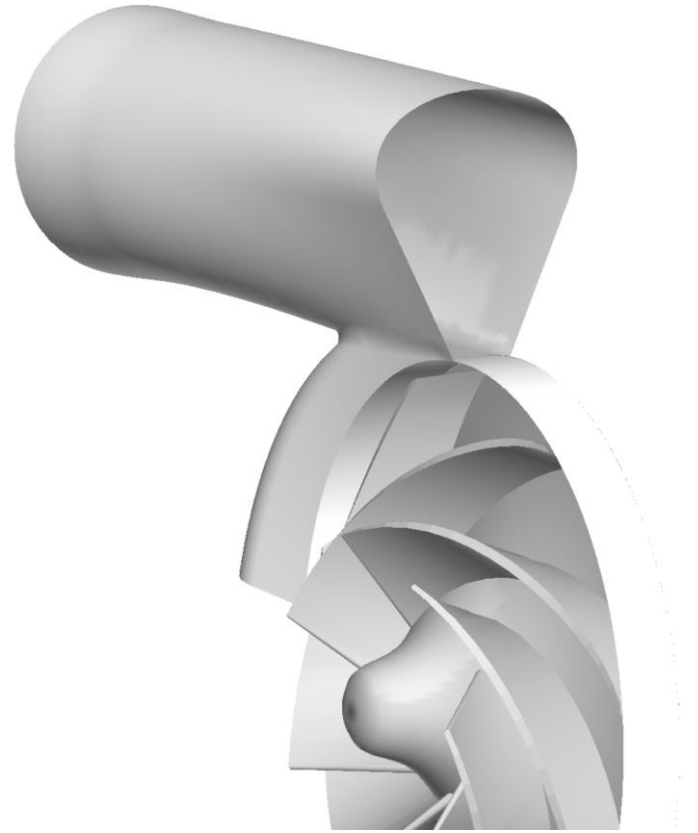
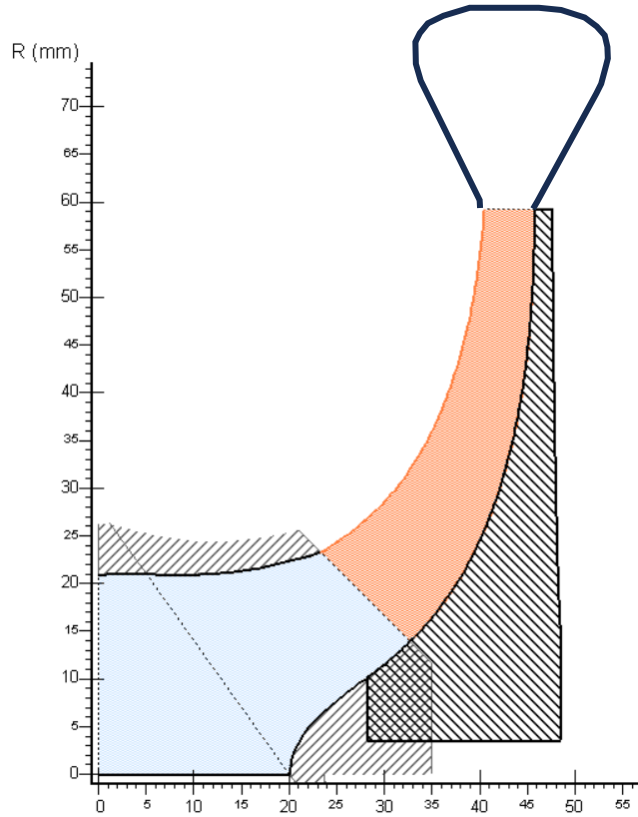
# Volute Teardrop Variants



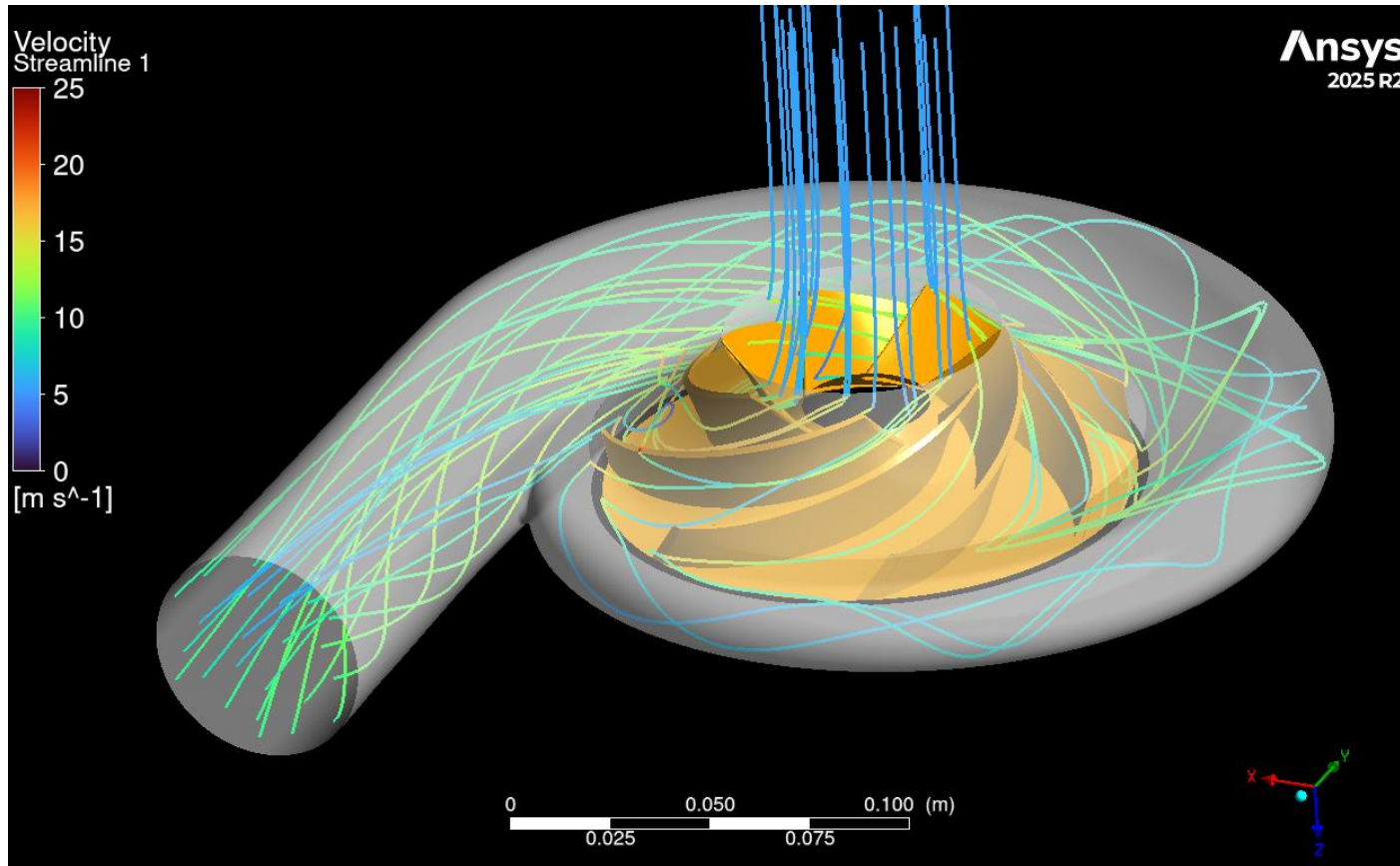
# Volute Geometry Variants



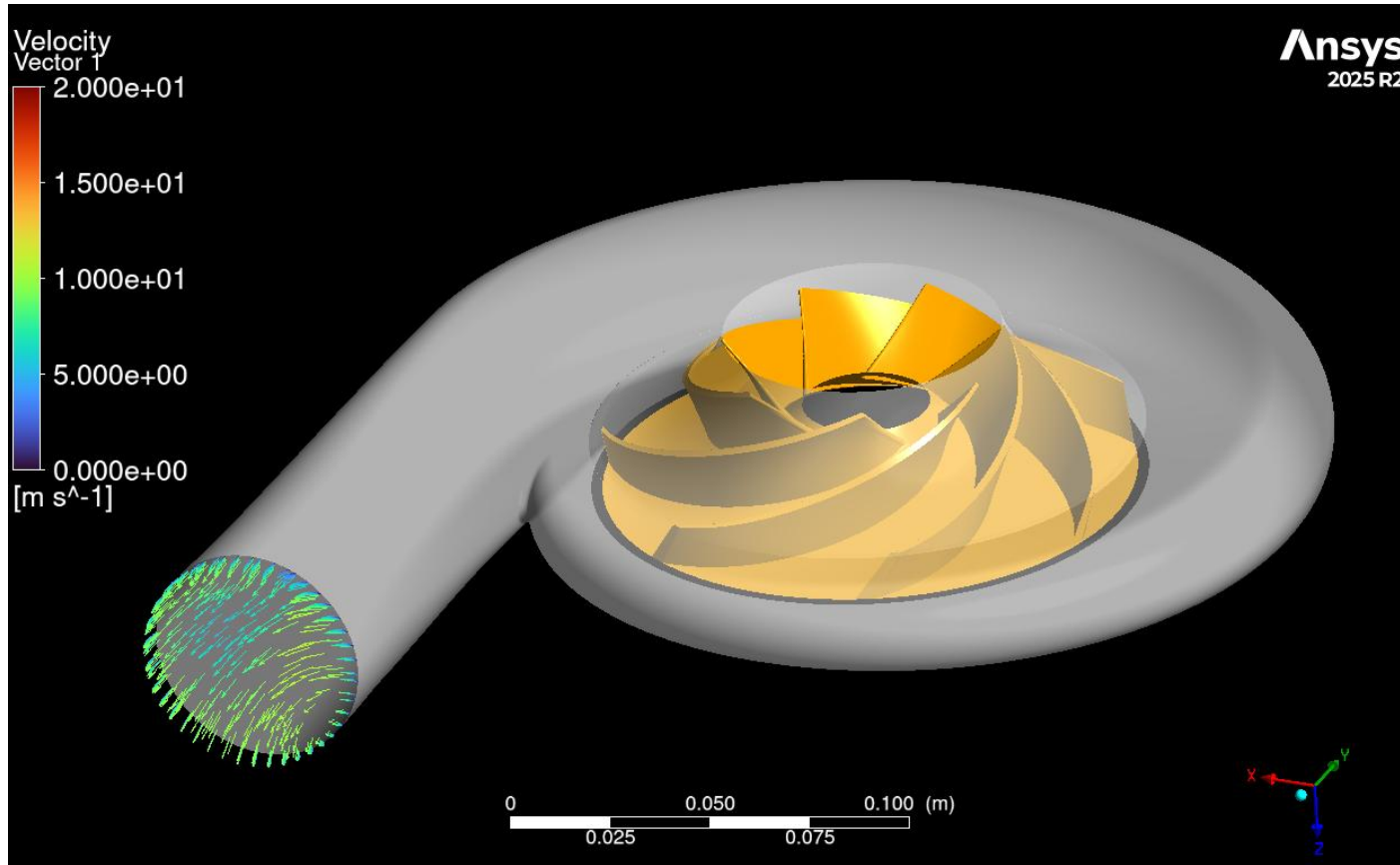
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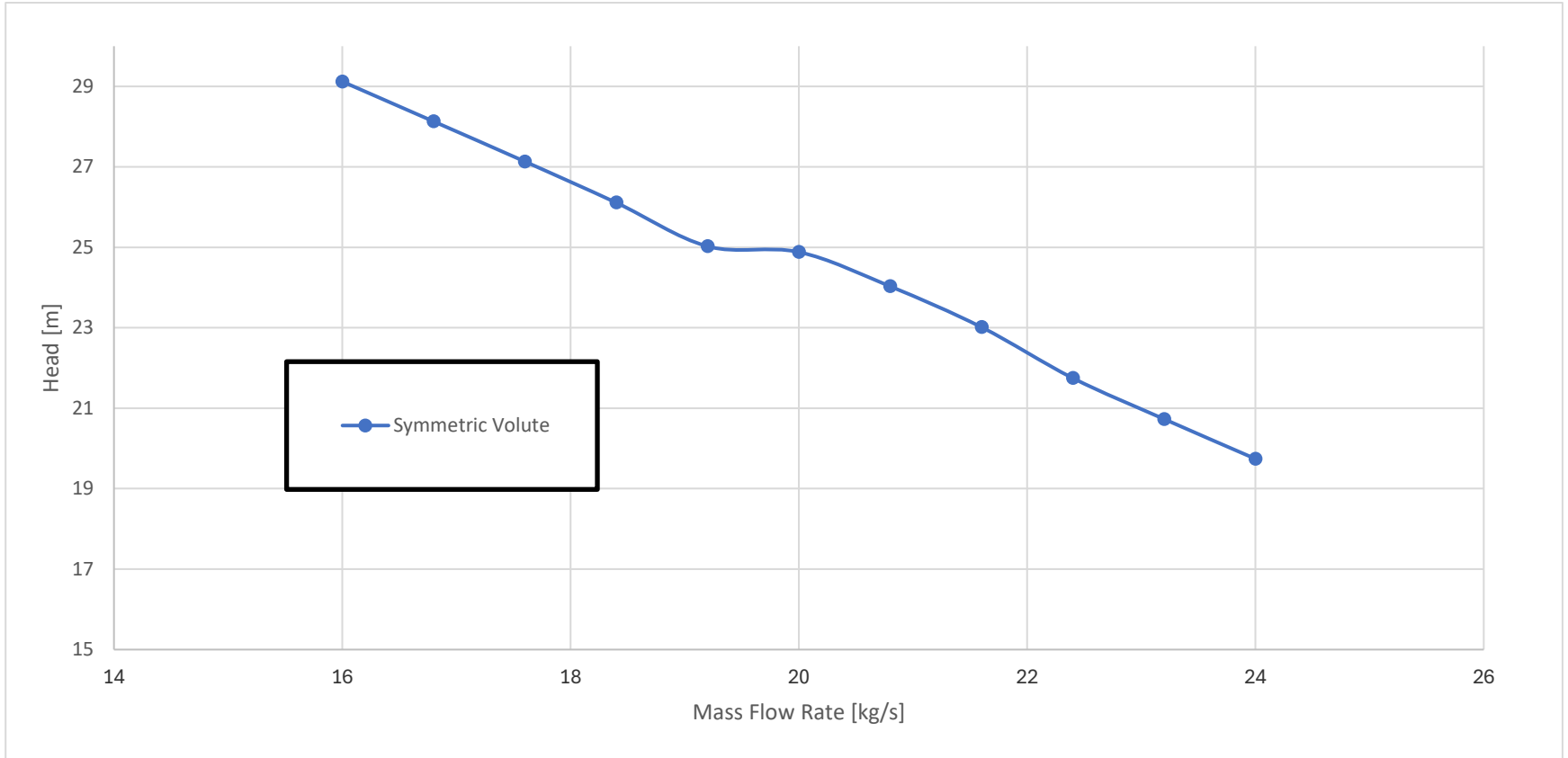
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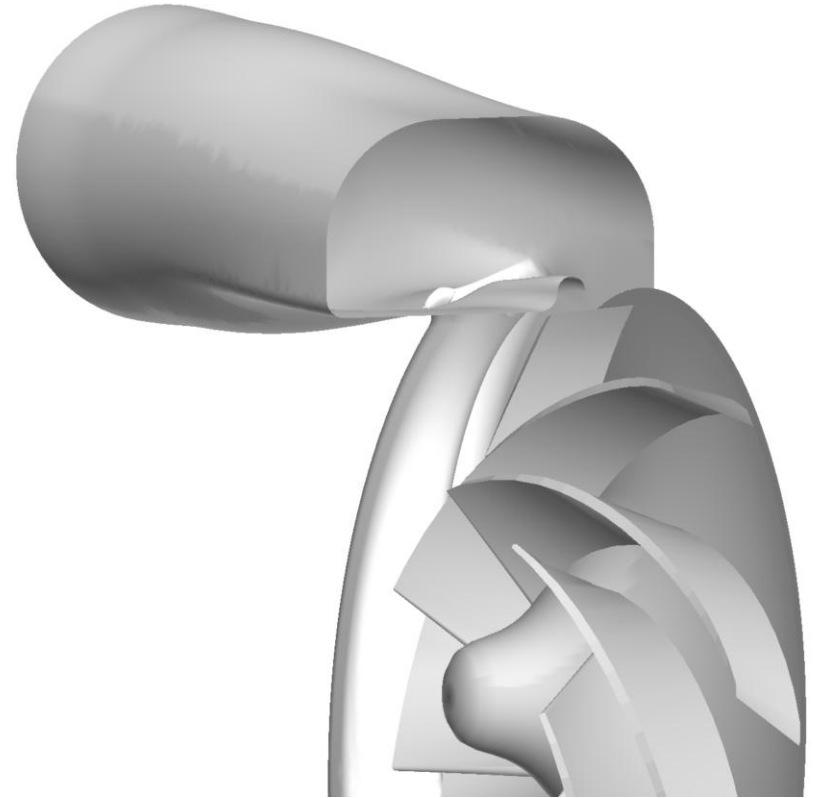
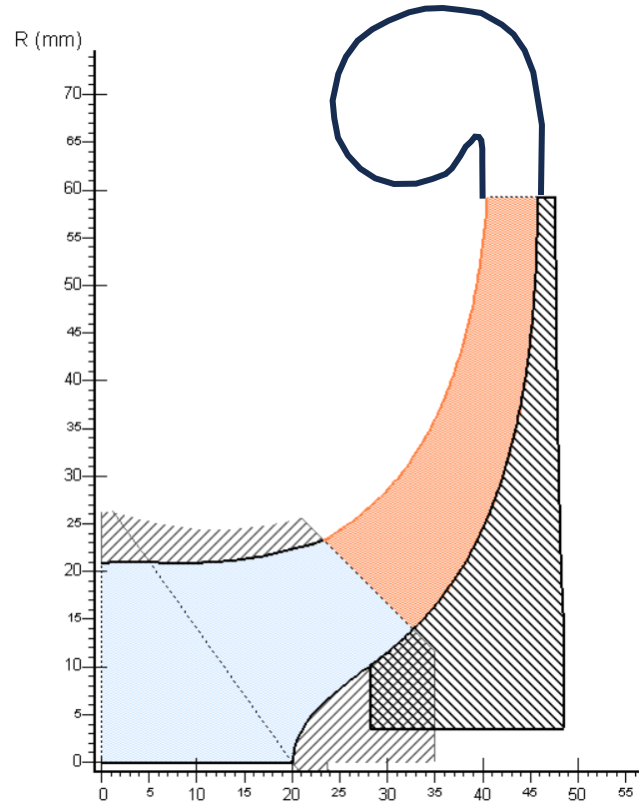
# Symmetric Volute



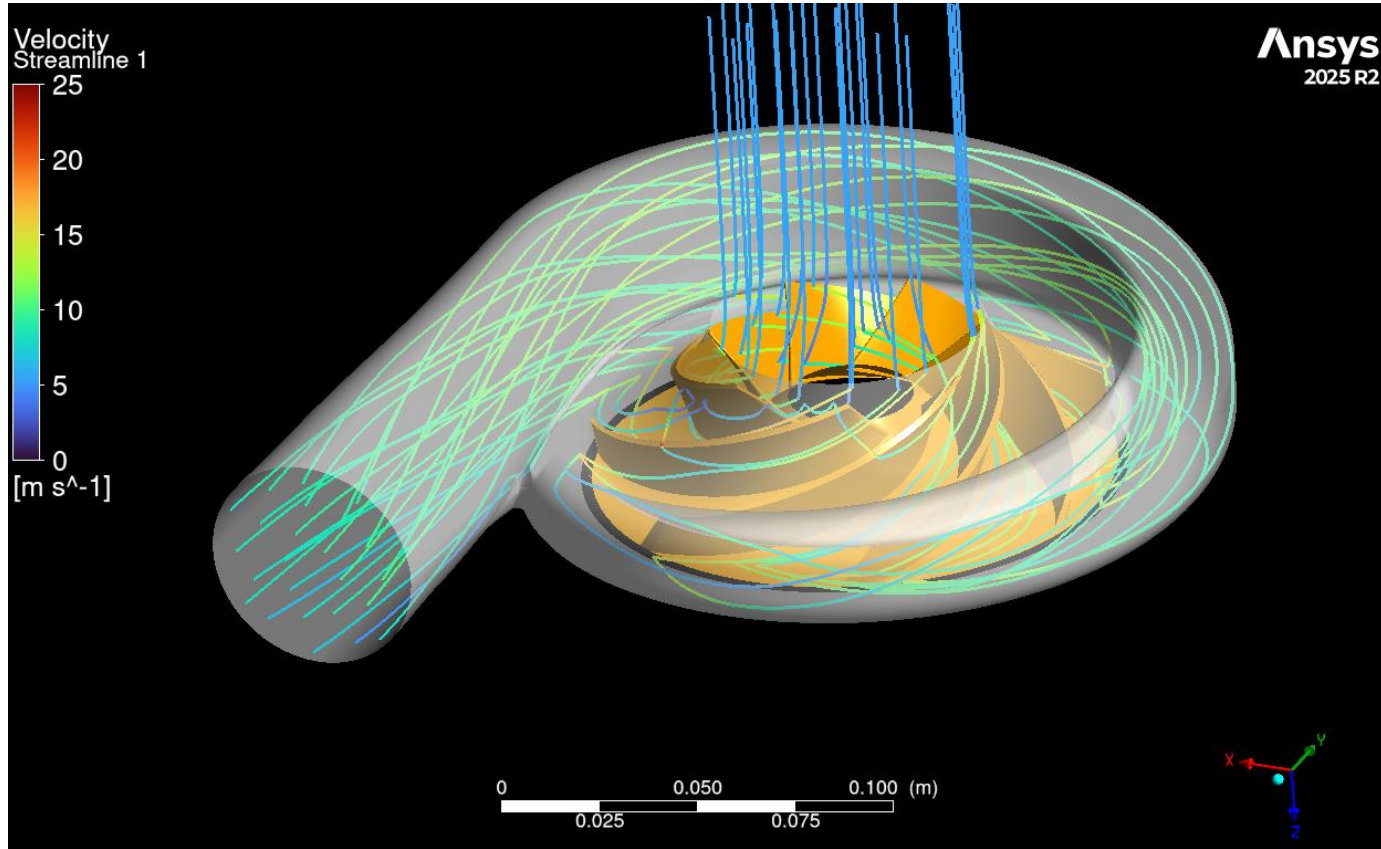
# Volute Performance



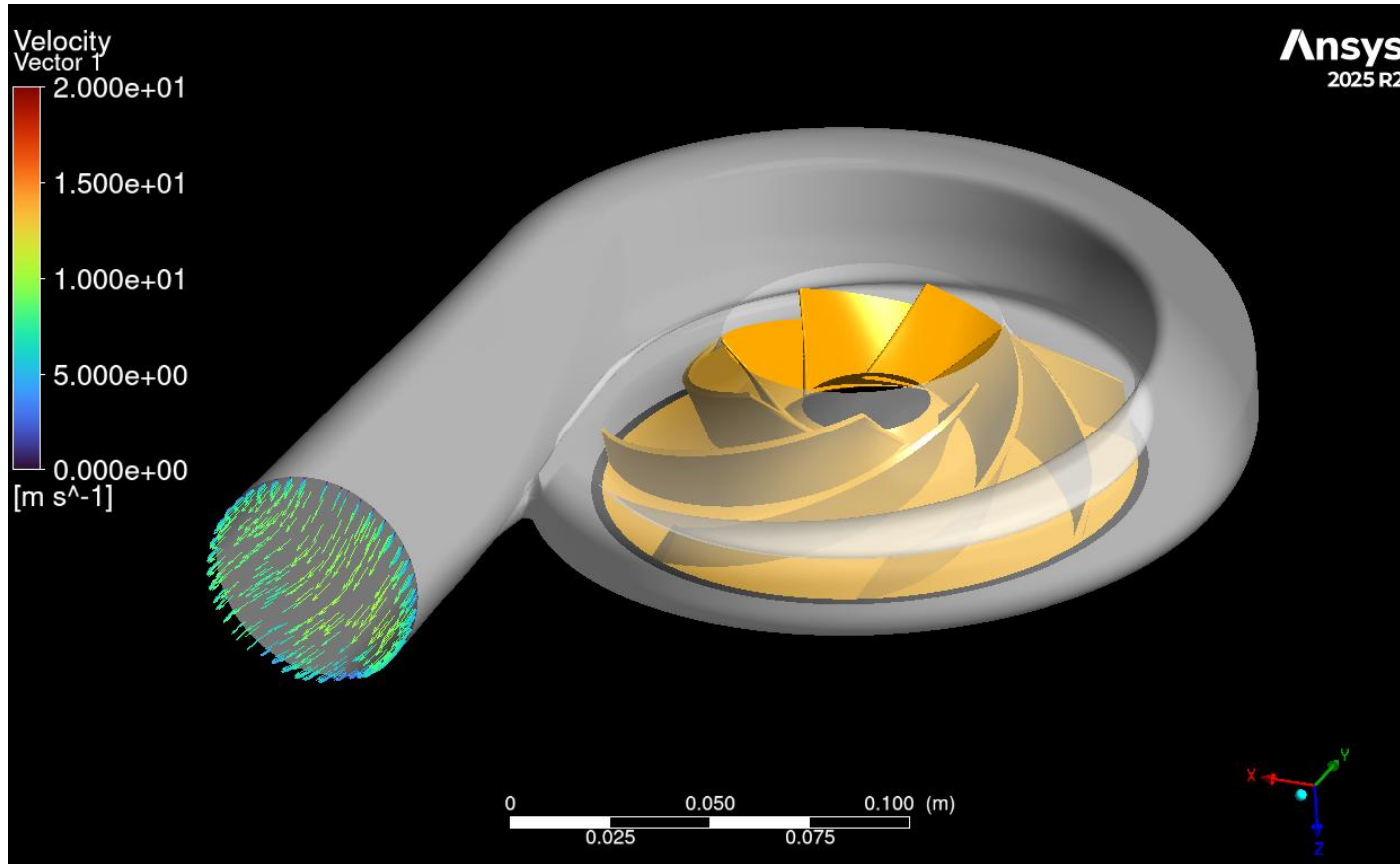
# Overhung Volute



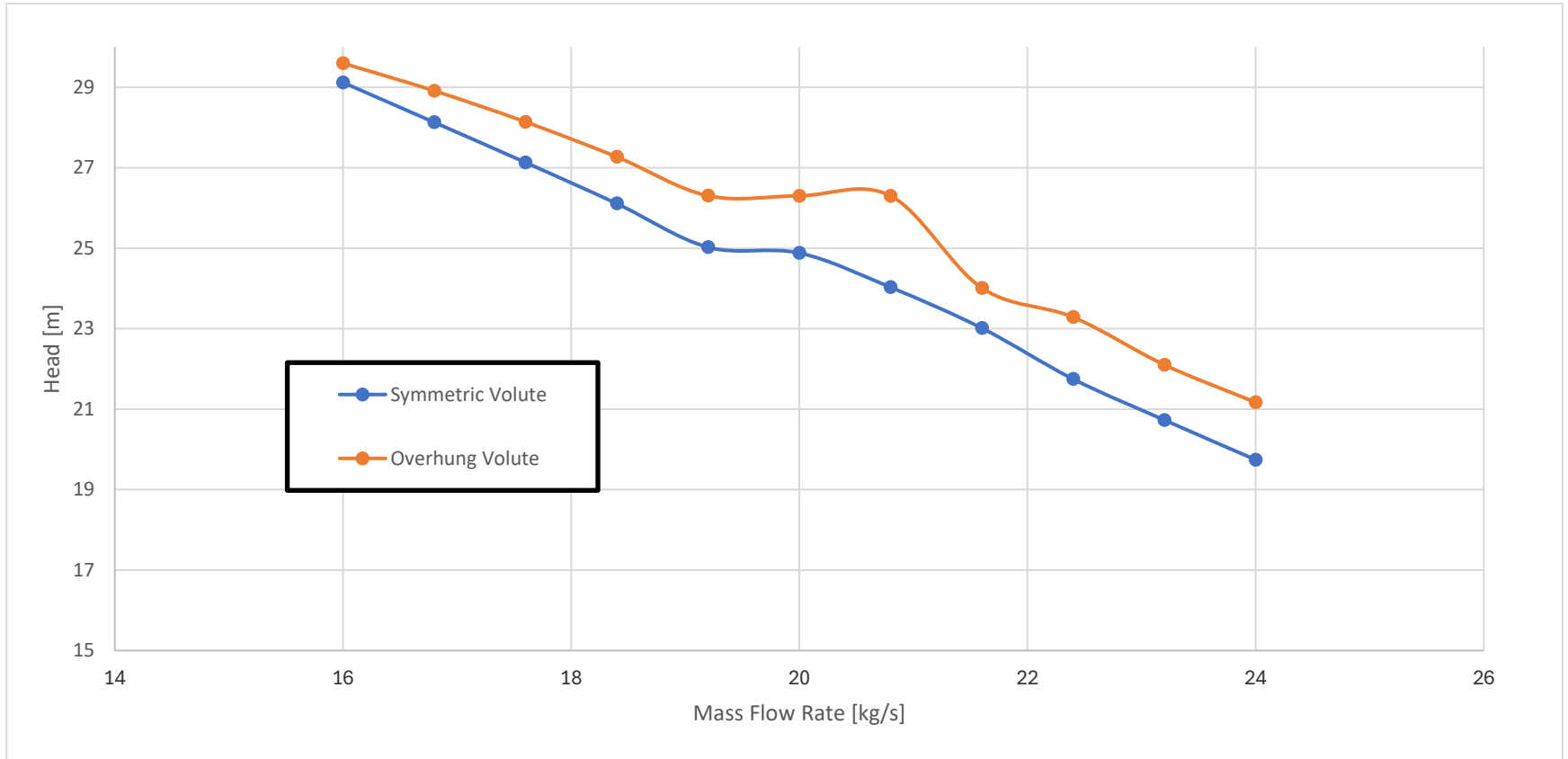
# Overhung Volute



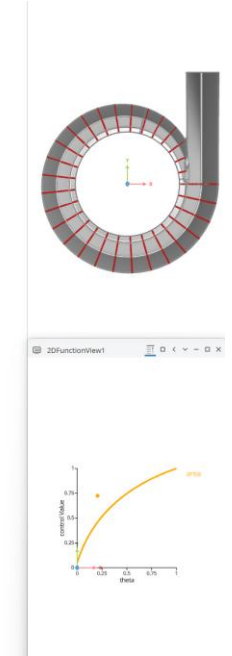
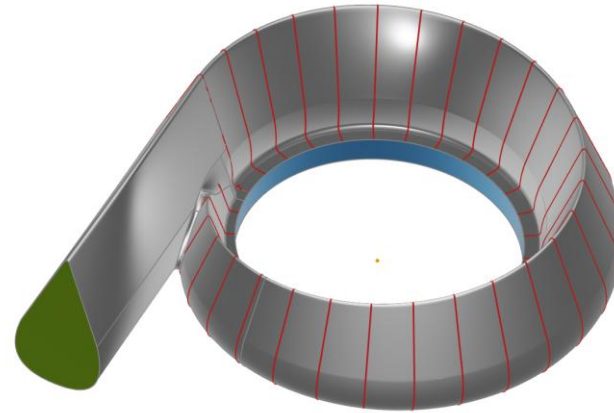
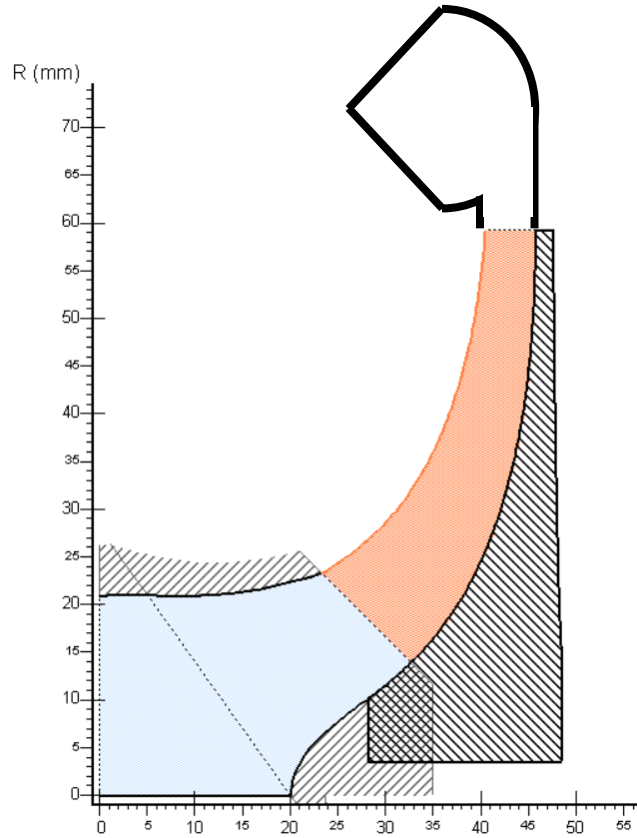
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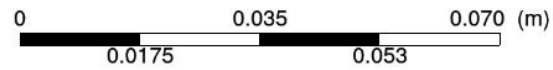
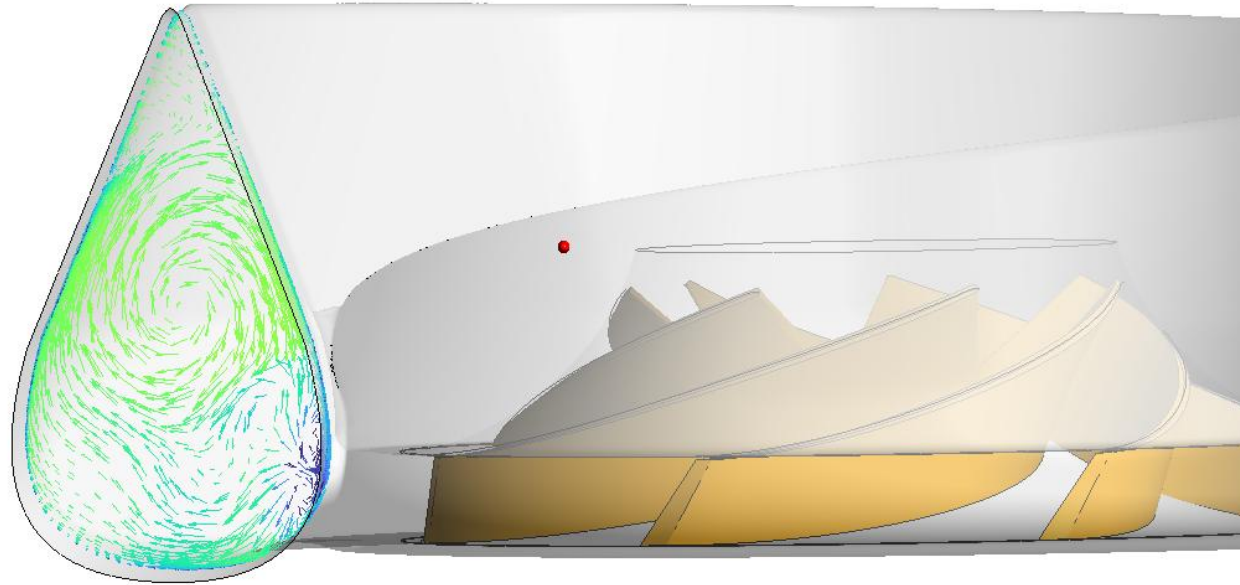


# Volute Performance

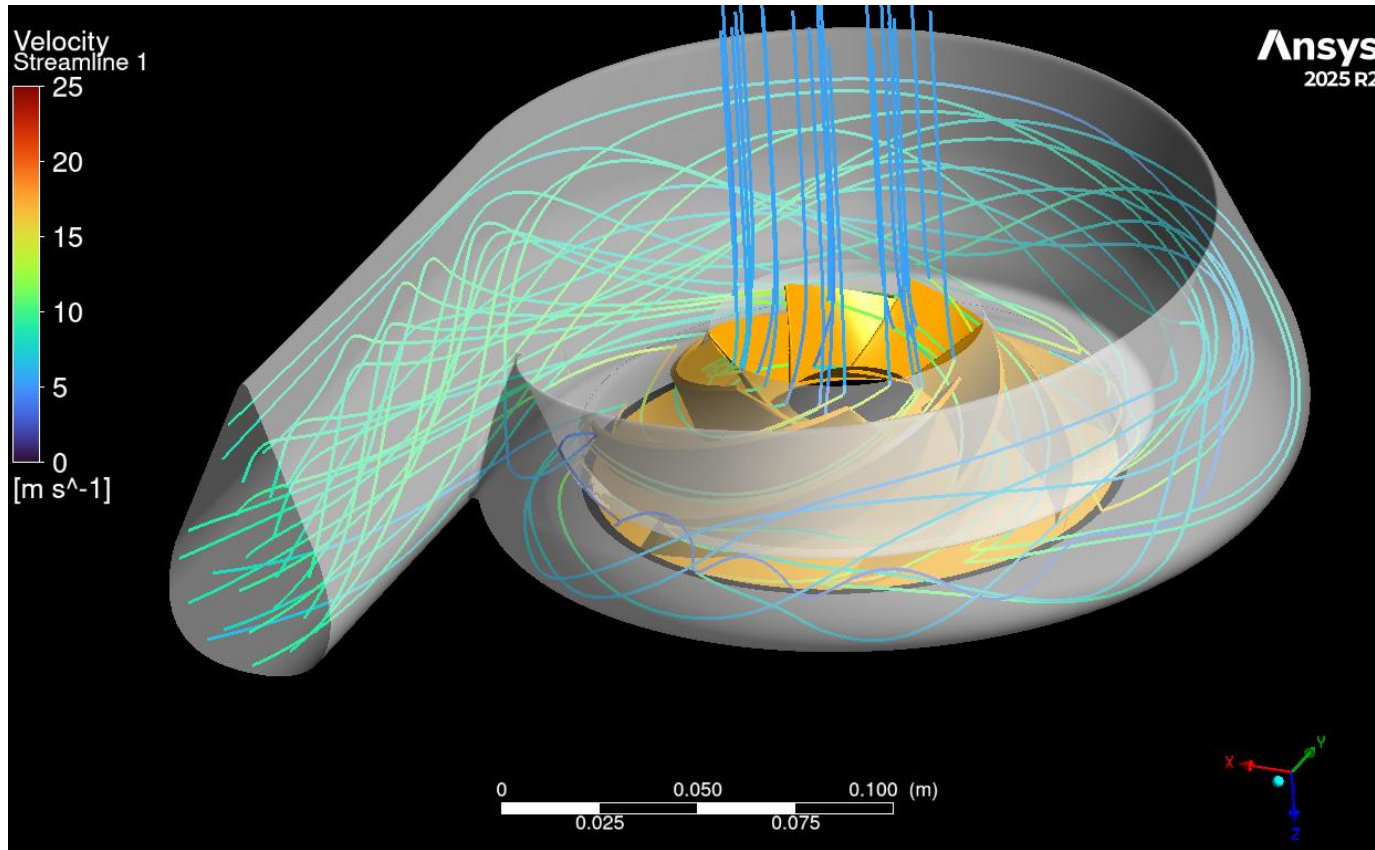


# Teardrop Volute

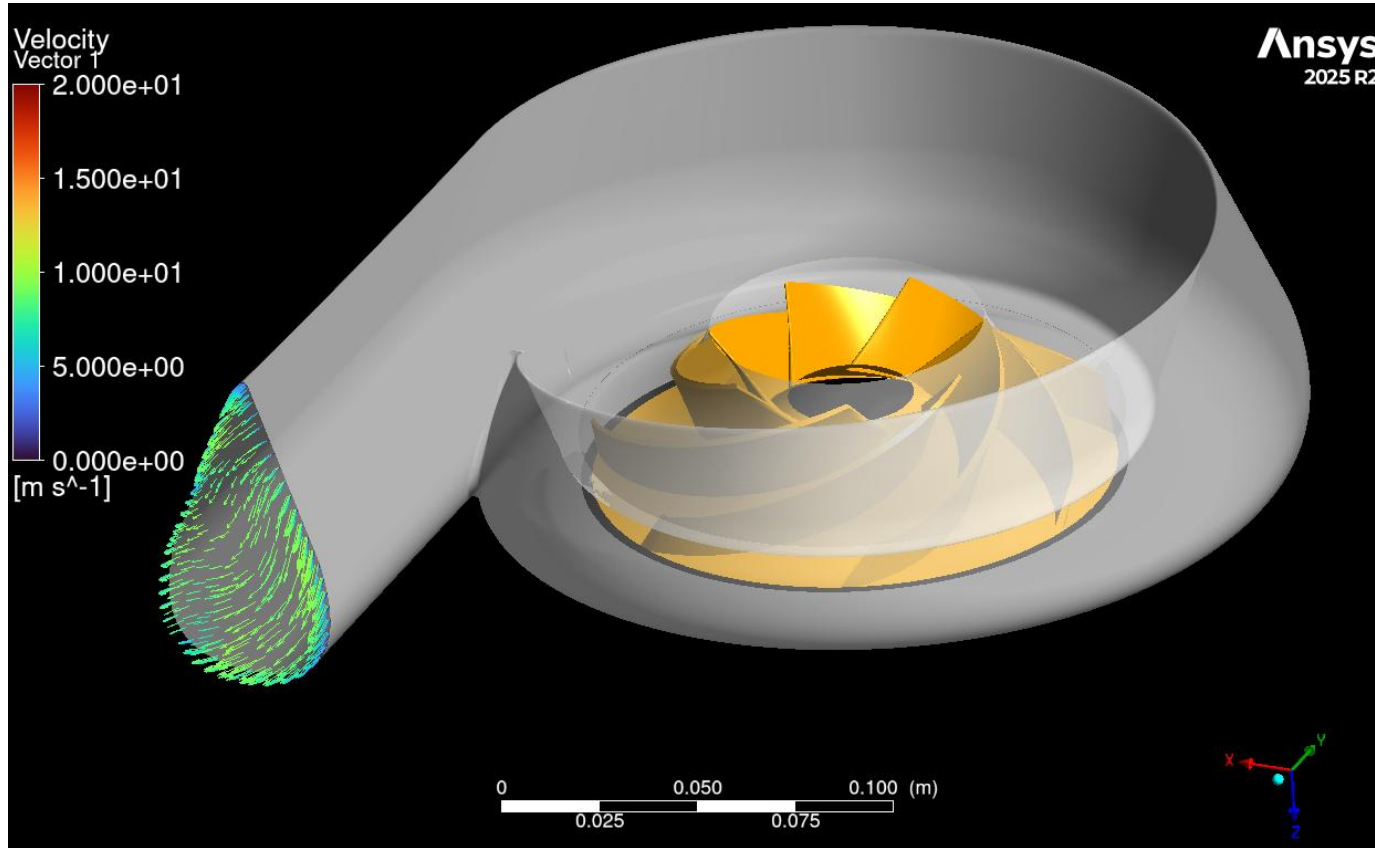




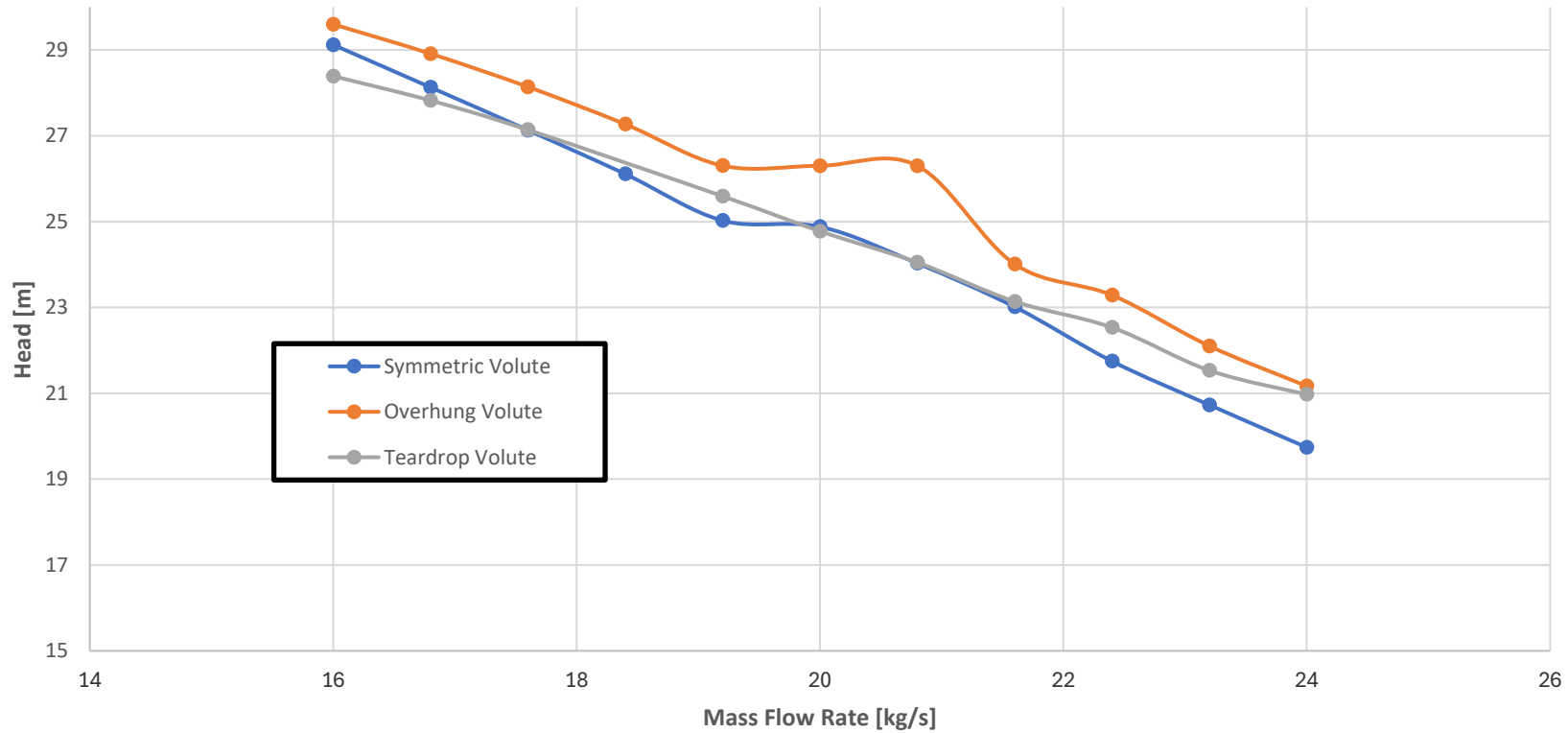
# Overhung Volute



# Overhung Volute



# Volute Performance





# Performance Evaluation of Pump Volute Geometries Optimized for Additive Manufacturing

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1<sup>st</sup> of April 2026