NASA Small Engine Components Compressor Test Facility: High Efficiency Centrifugal Compressor Vaneless Diffuser and Transition Duct Configurations

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Boston, MA USA
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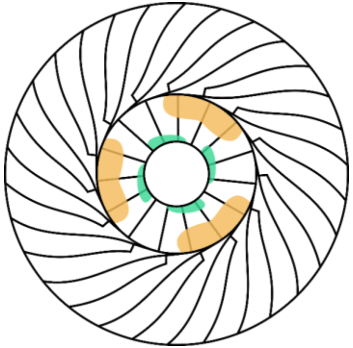
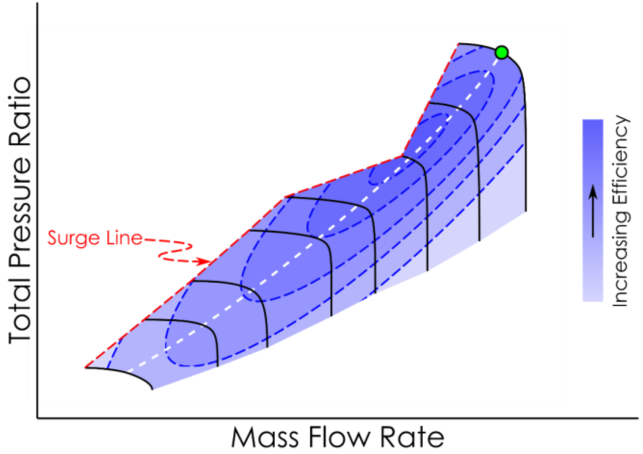
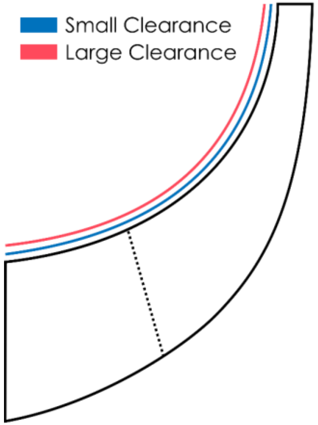
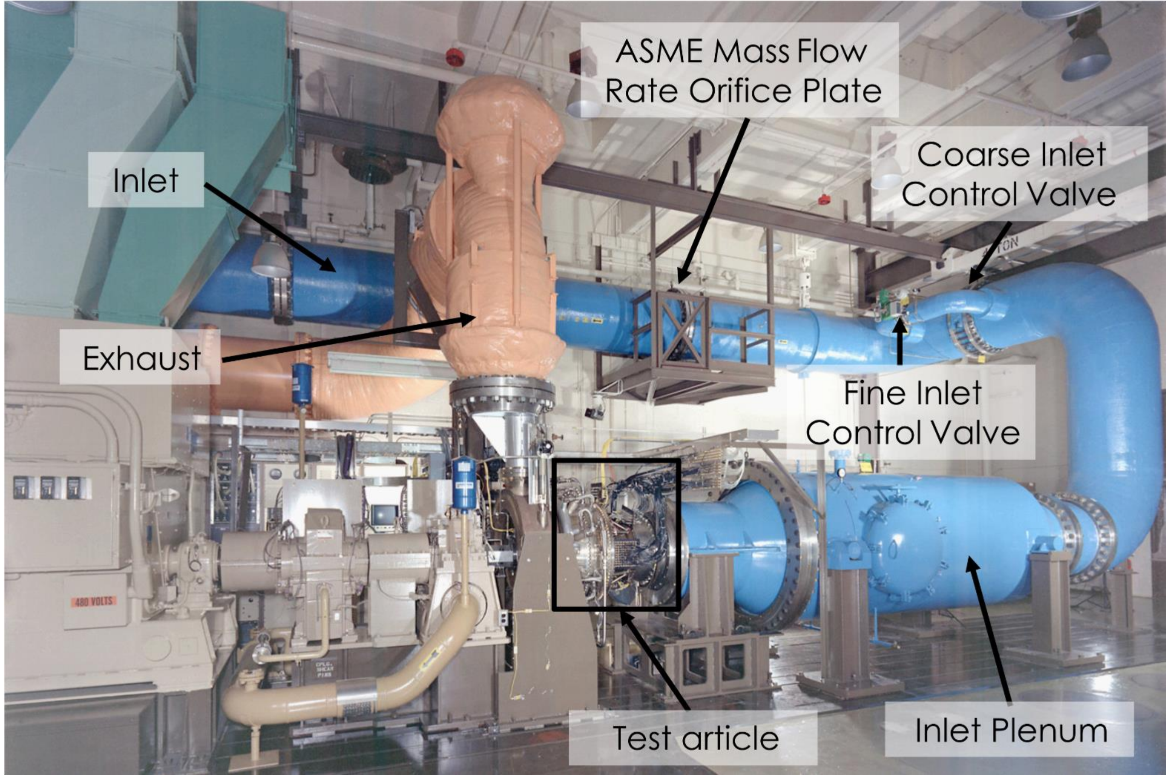
Very few well-documented open turbomachinery cases are available in the open literature

Goal of HECC research is to provide high quality, open access data for centrifugal compressors



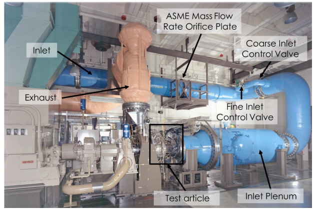




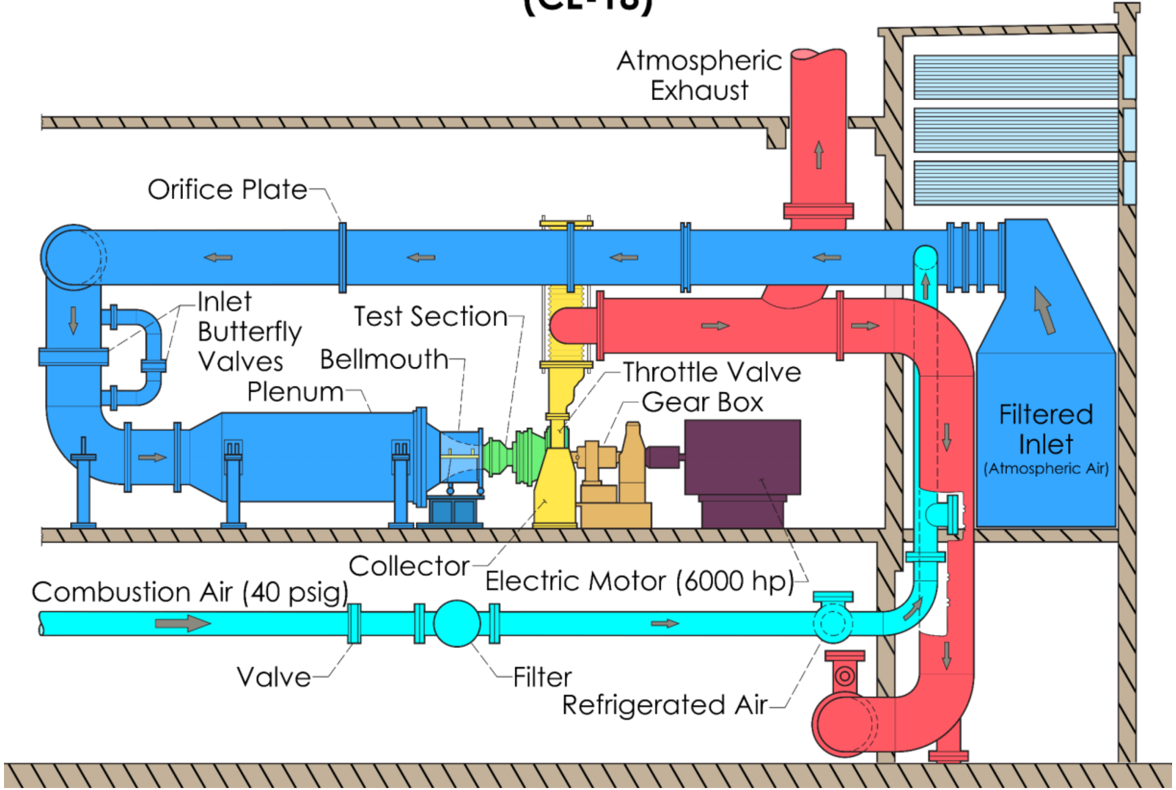


Small Engine Components Compressor Test Facility (CE-18)

The CE-18 test cell facilitates high fidelity centrifugal compressor research

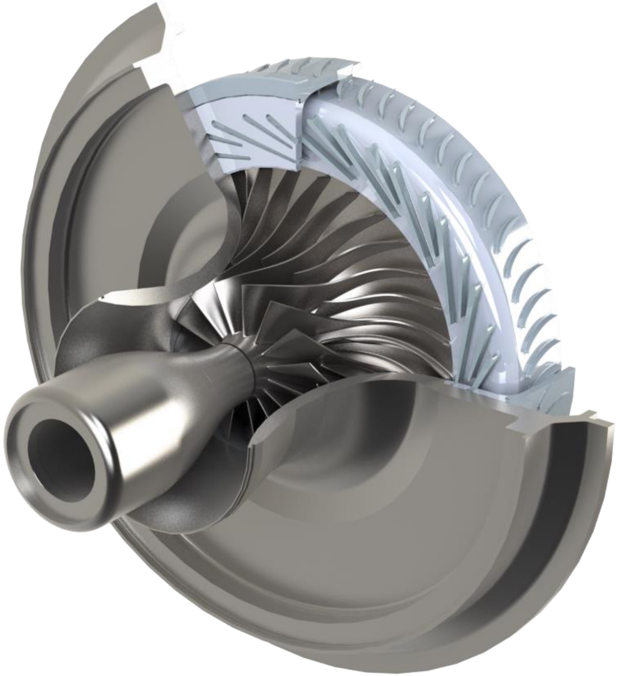


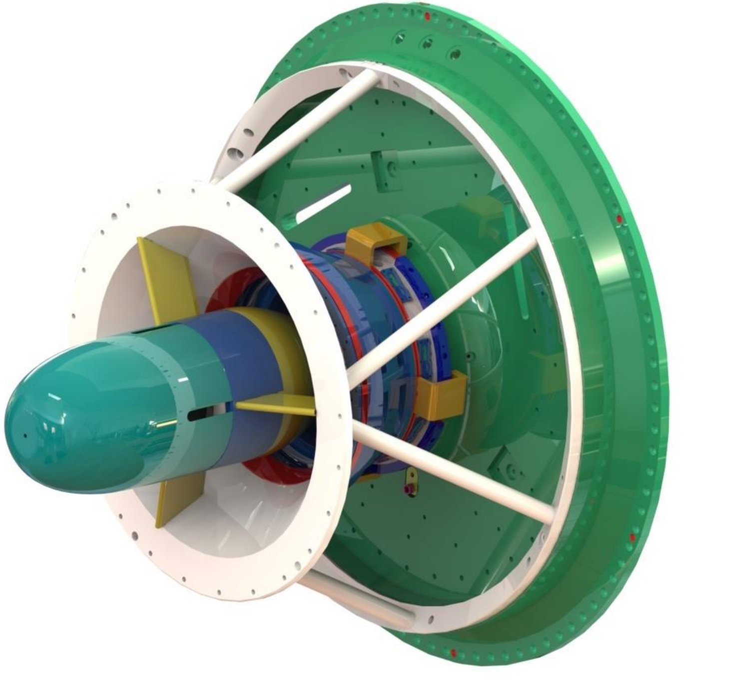
SMALL ENGINE COMPONENTS COMPRESSOR TEST FACILITY
(CE-18)



HECC Test Article

HECC configurations: vaned and vaneless diffusers; baseline and transition duct inlets





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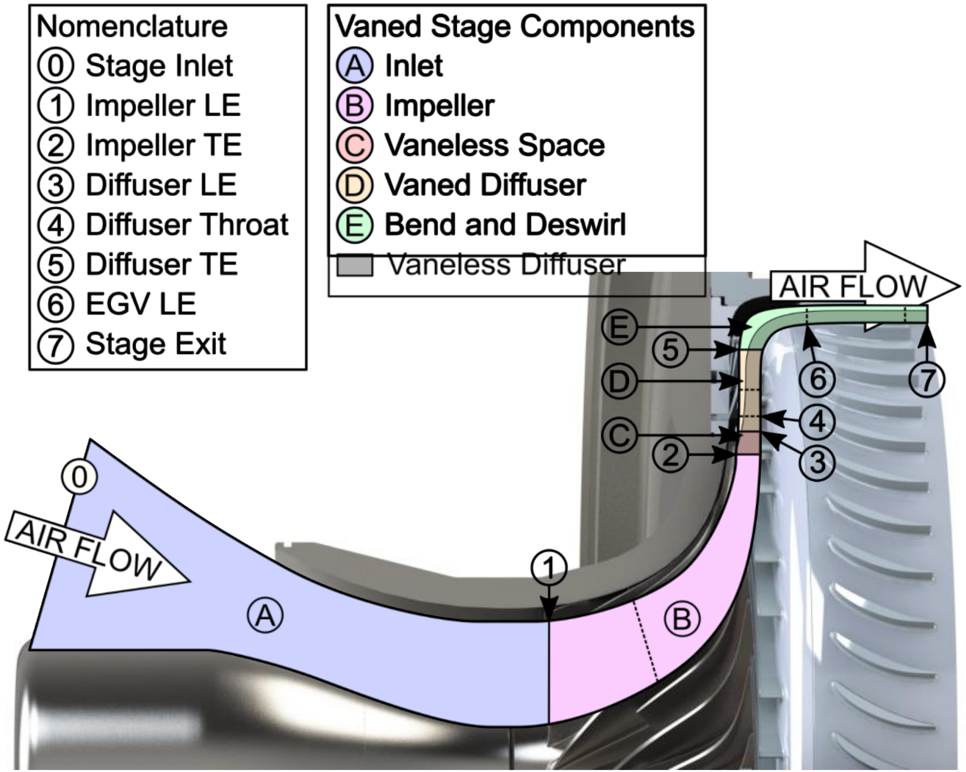

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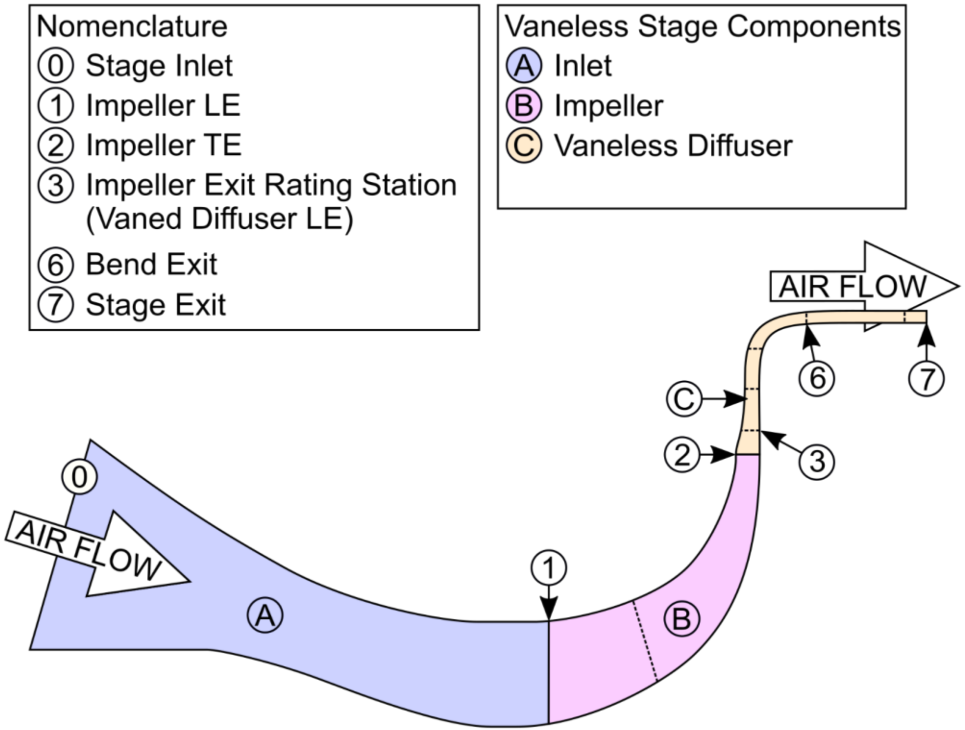
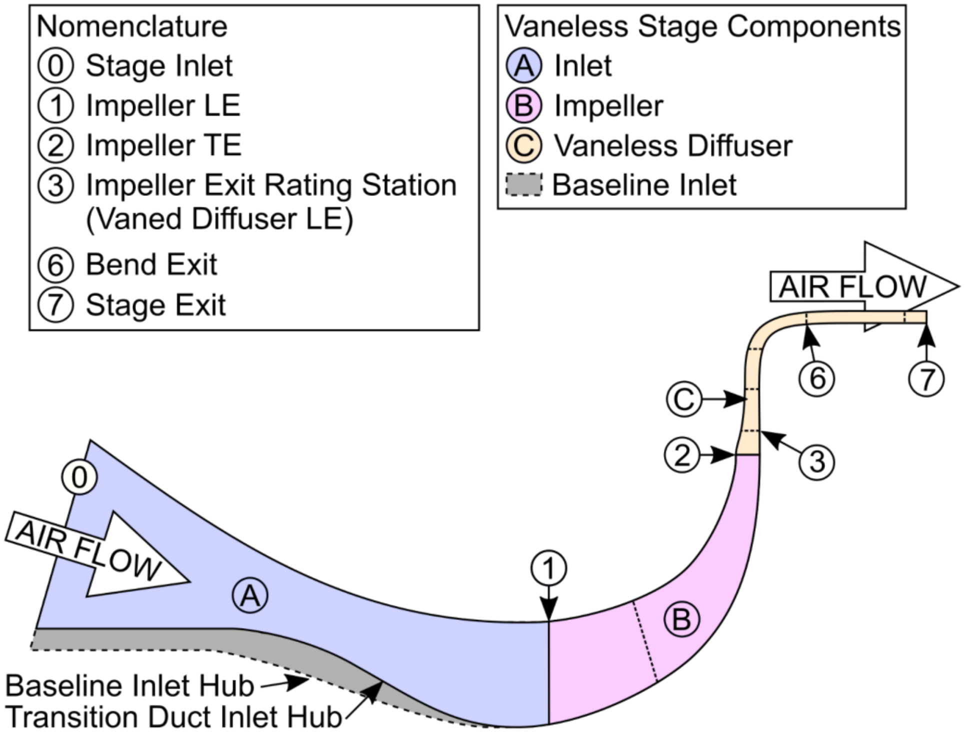
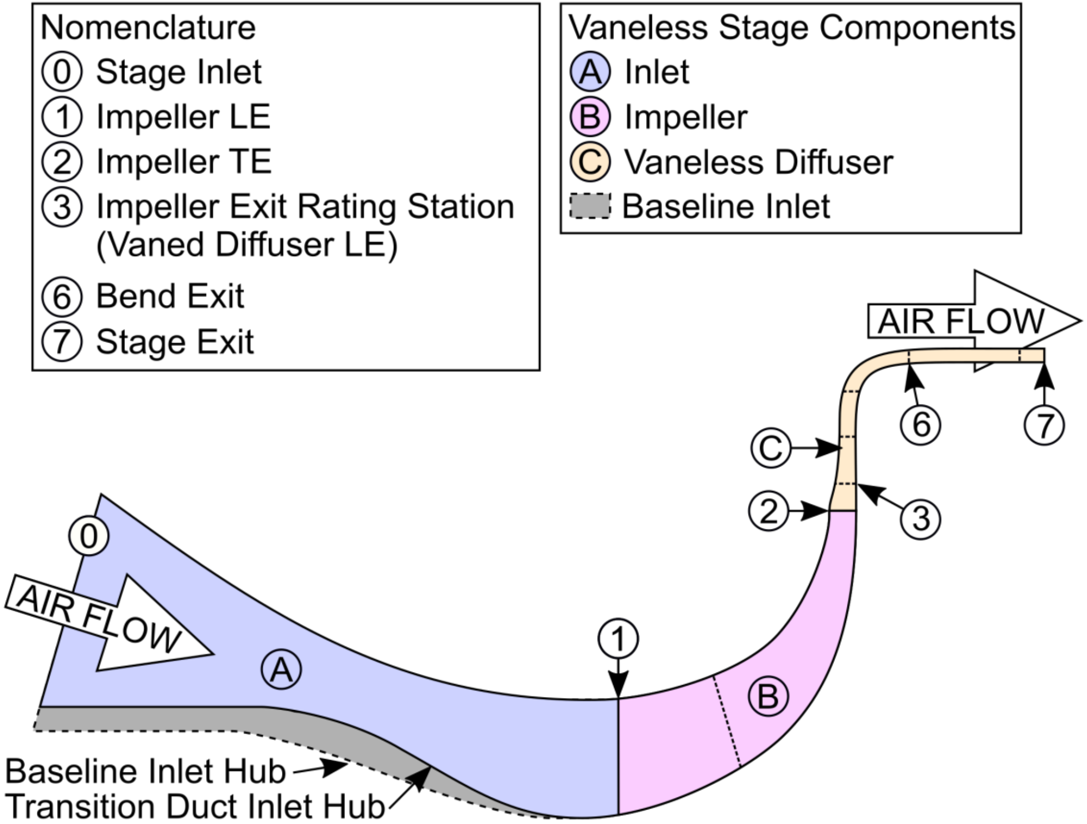


HECC configurations: vaned and vaneless diffusers; baseline and transition duct inlets

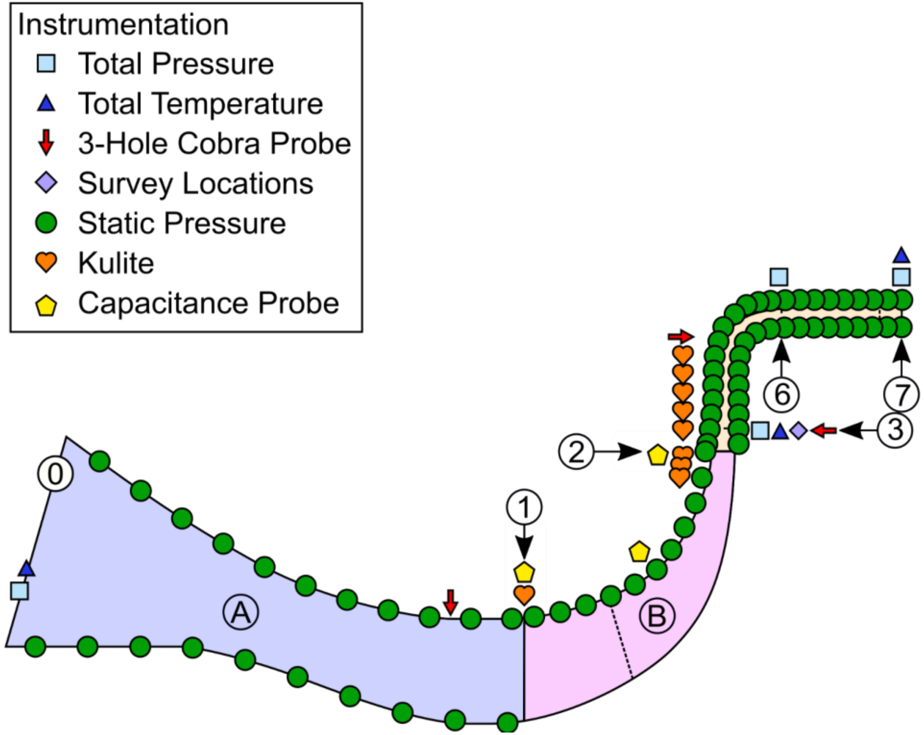


HECC is a highly loaded machine representative of modern designs

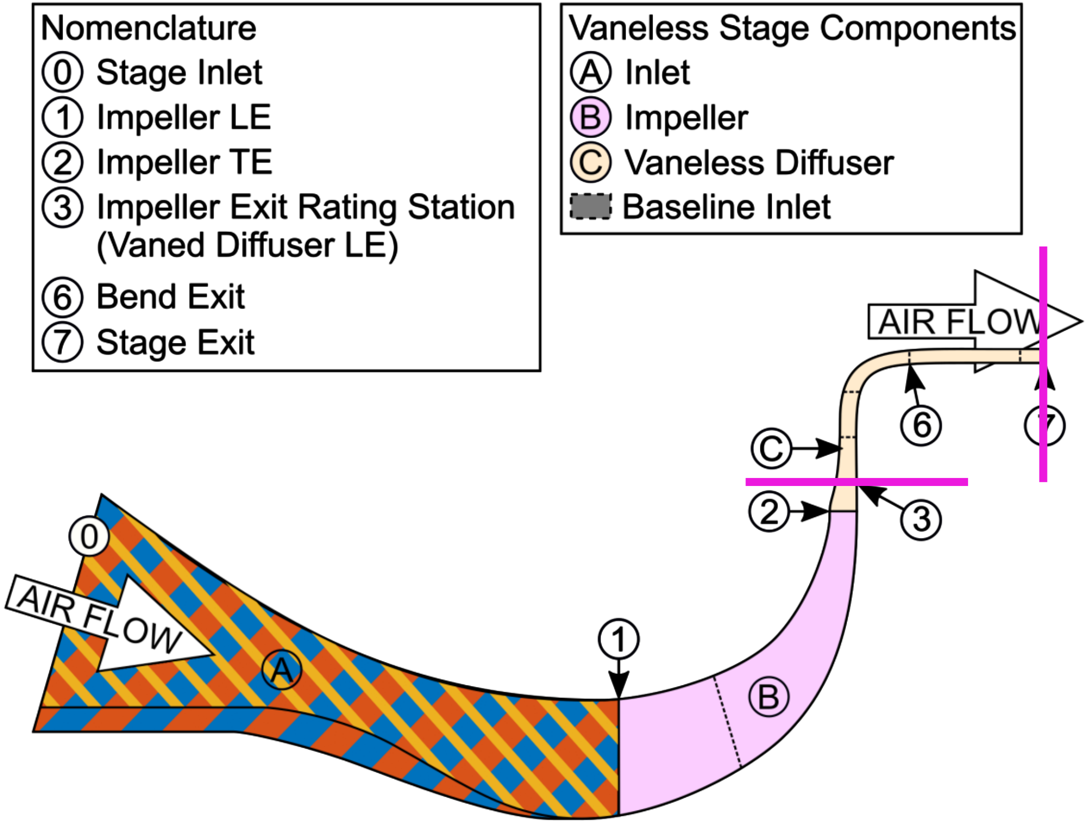


Parameter	Value
Mass Flow Rate	11 lbm/s
Stage Pressure Ratio	4.55
Impeller Pressure Ratio	5.1
Rotational Speed	21,789 rpm
Machine Mach No.	1.45
Impeller Blade Count	15/15
Diffuser Vane Count	n/a
Backsweep Angle*	30°
Inlet Flow Coefficient (Φ)	0.045
Loading Coefficient (ψ)	0.78

HECC is equipped with detailed instrumentation throughout the flow path



Forthcoming discussion focuses on impeller exit and stage exit for 3 inlet configurations



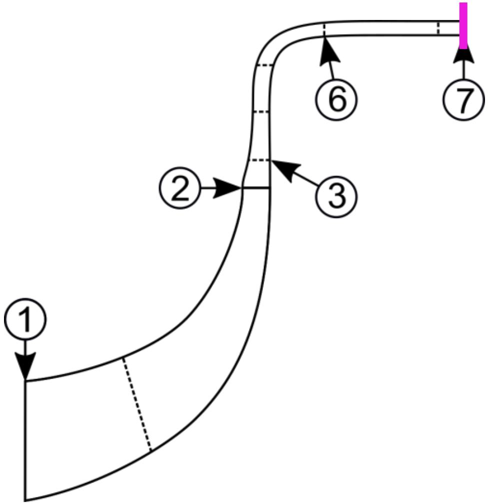
Baseline Metal Inlet (BLM)

Baseline Plastic Inlet (BLP)

Modified Hub Inlet (MH)

HECC Baseline Metal and Baseline Plastic Inlet Performance

Stage TPR is consistent between the BLM and BLP inlets



Design Point Parameters	Value
Mass Flow Rate	11 lbm/s
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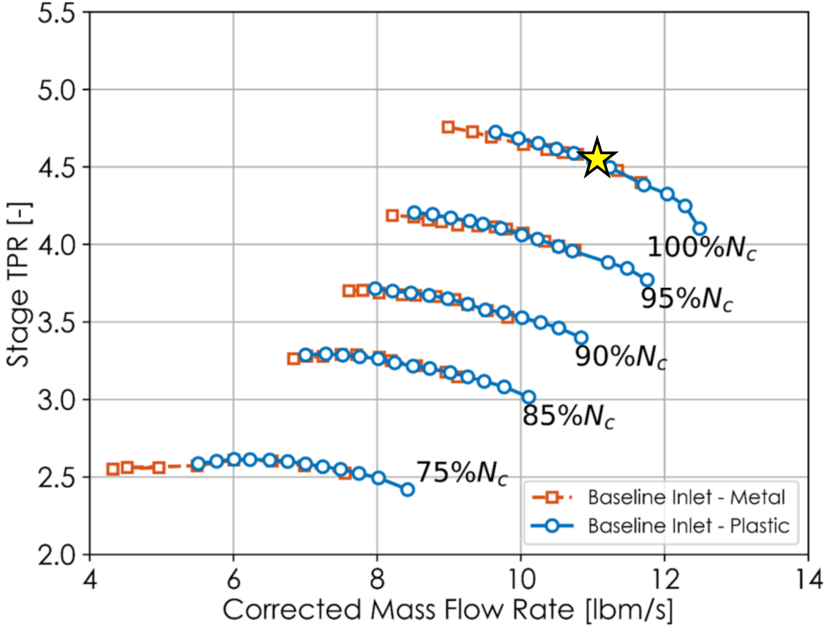
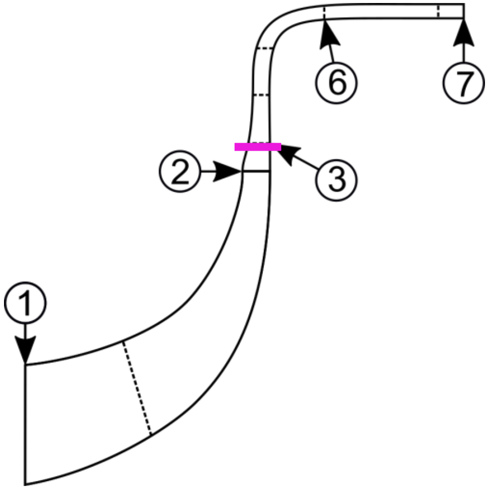


Stage and impeller TPR are consistent between the BLM and BLP inlets



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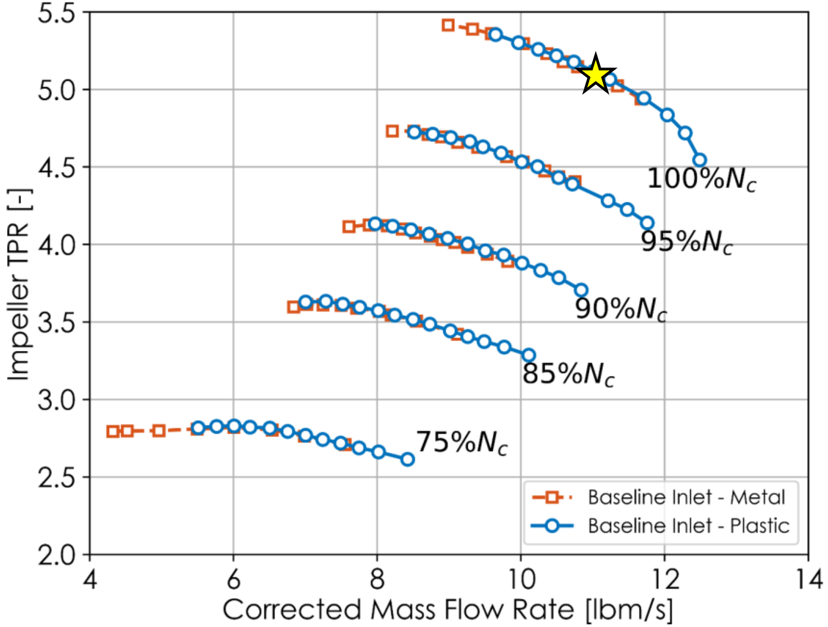
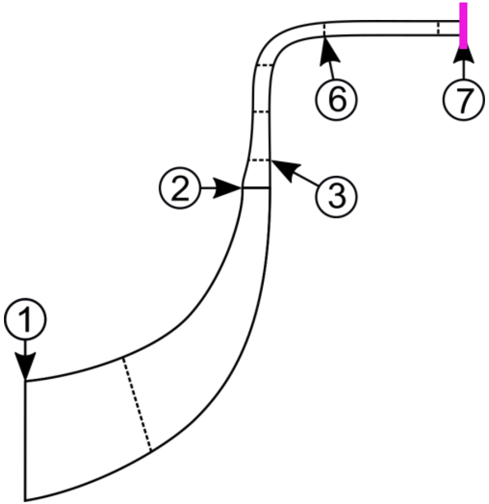
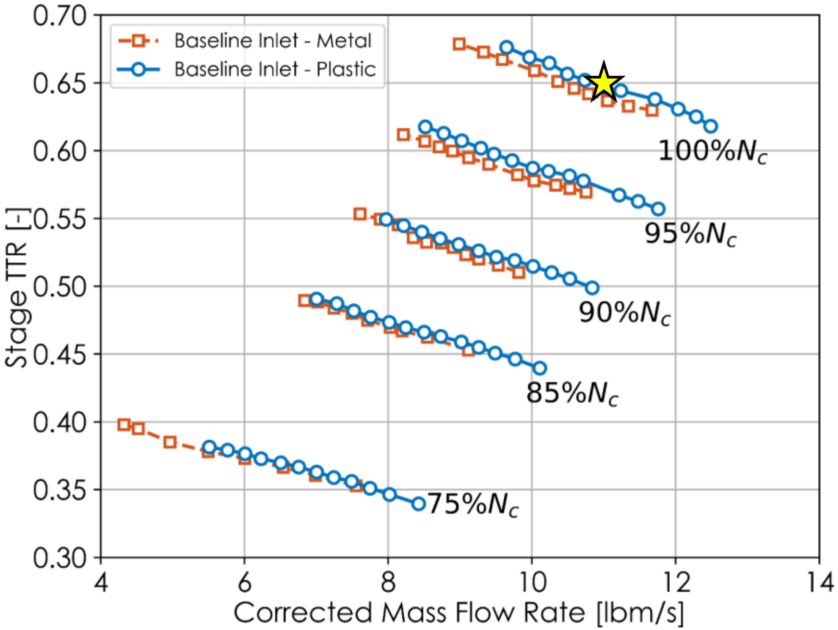


Stage TTR is slightly increased with the BLP inlet relative to the BLM inlet



Design Point Parameters	Value
Mass Flow Rate	11 lbm/s
Stage Pressure Ratio	4.55
Impeller Pressure Ratio	5.1
Rotational Speed	21,789 rpm



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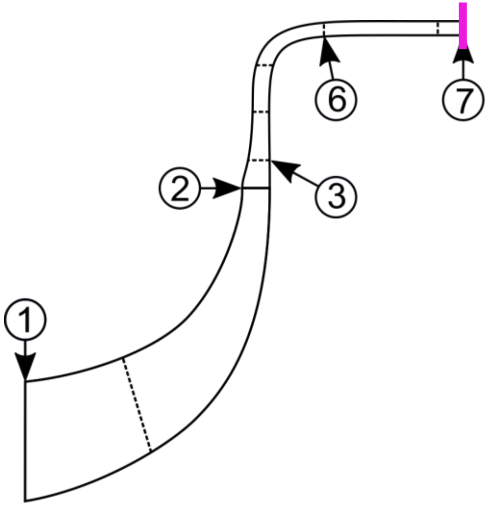
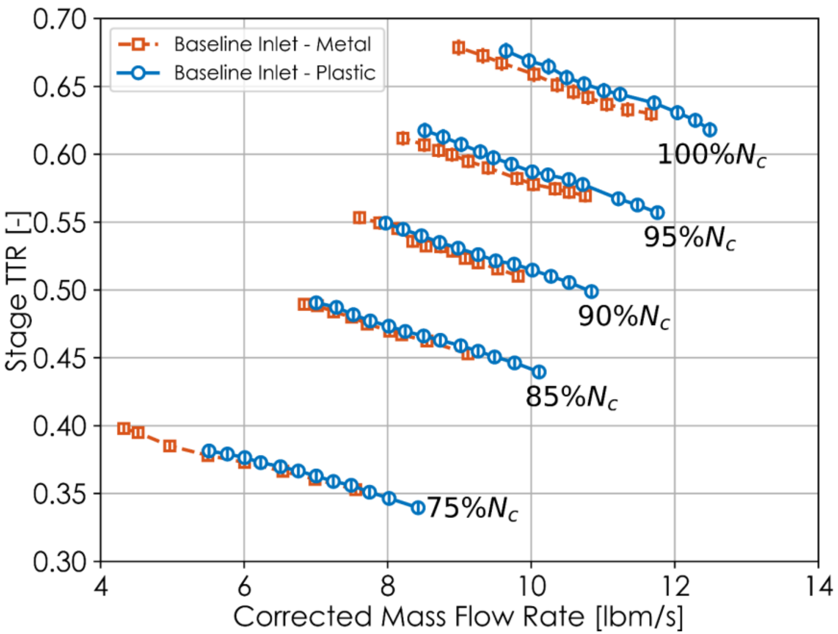
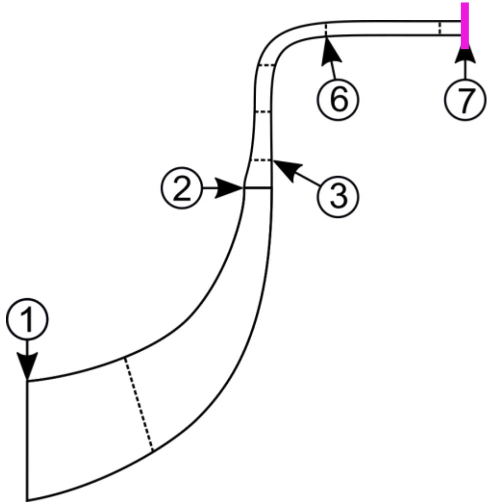


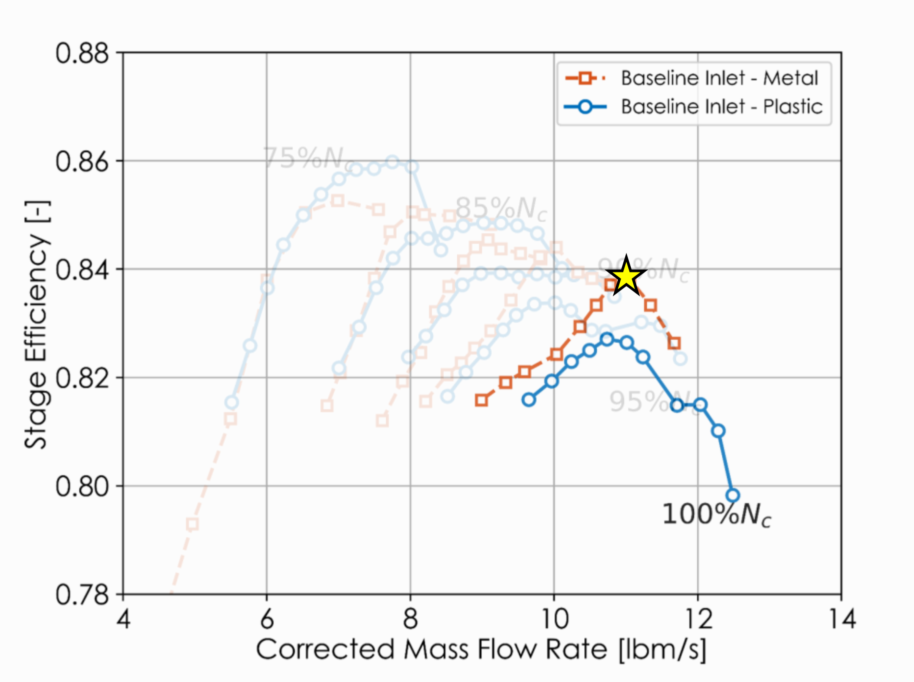
Design Point Parameters	Value
Mass Flow Rate	11 lbm/s
Stage Pressure Ratio	4.55
Impeller Pressure Ratio	5.1
Rotational Speed	21,789 rpm



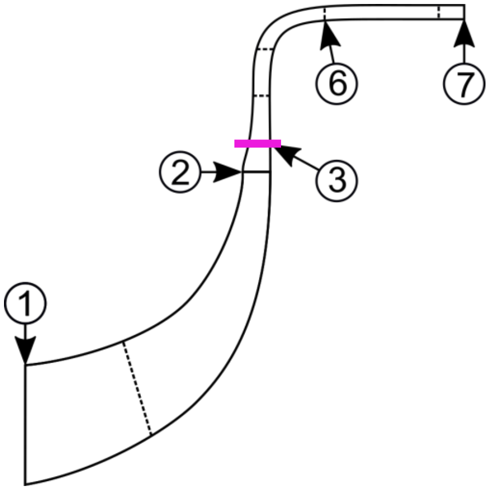
Increased BLP TTR for similar TPR leads to reduced efficiency for the BLP configuration

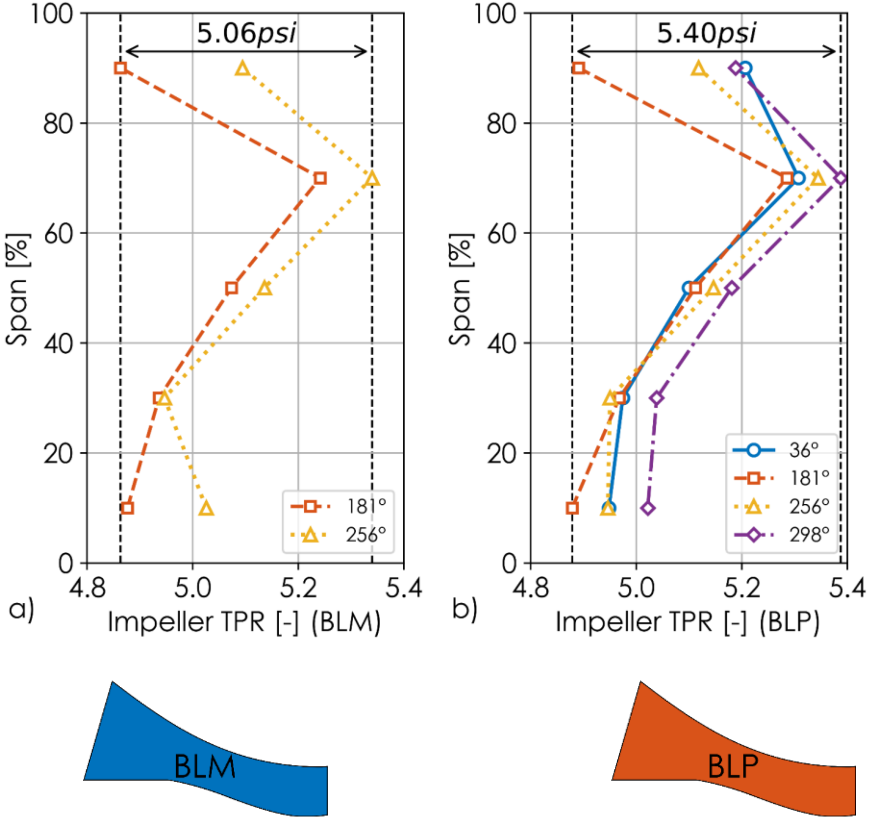


Design Point Parameters	Value
Mass Flow Rate	11 lbm/s
Stage Isentropic Efficiency	0.84
Rotational Speed	21,789 rpm

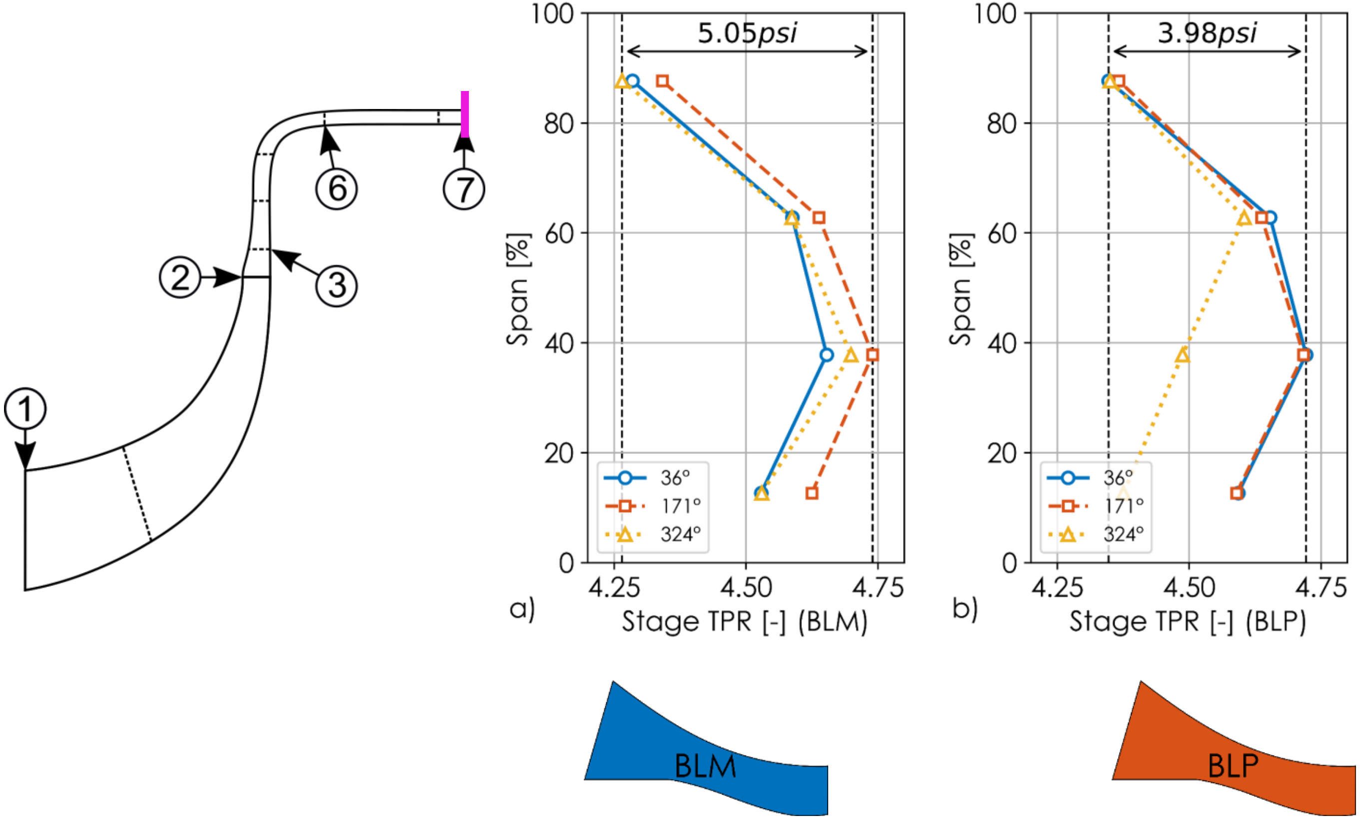


Impeller exit profiles are circumferentially uniform at design point

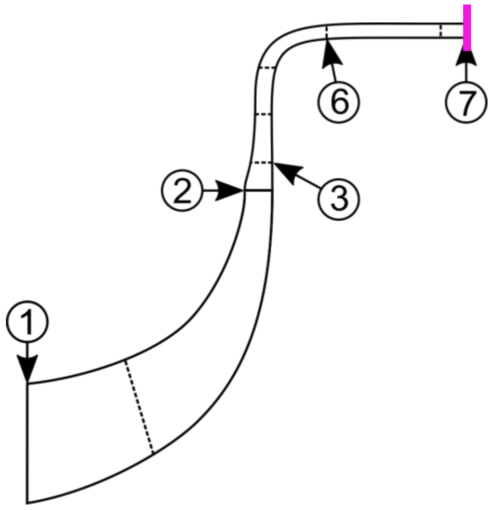


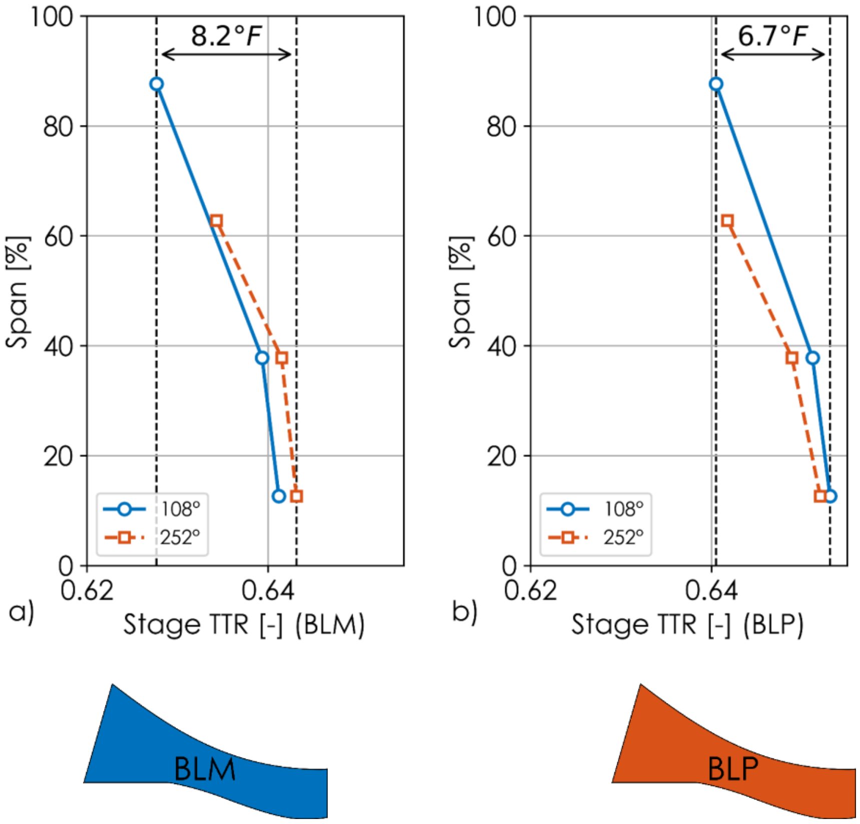


Stage exit TPR profiles develop some nonuniformity



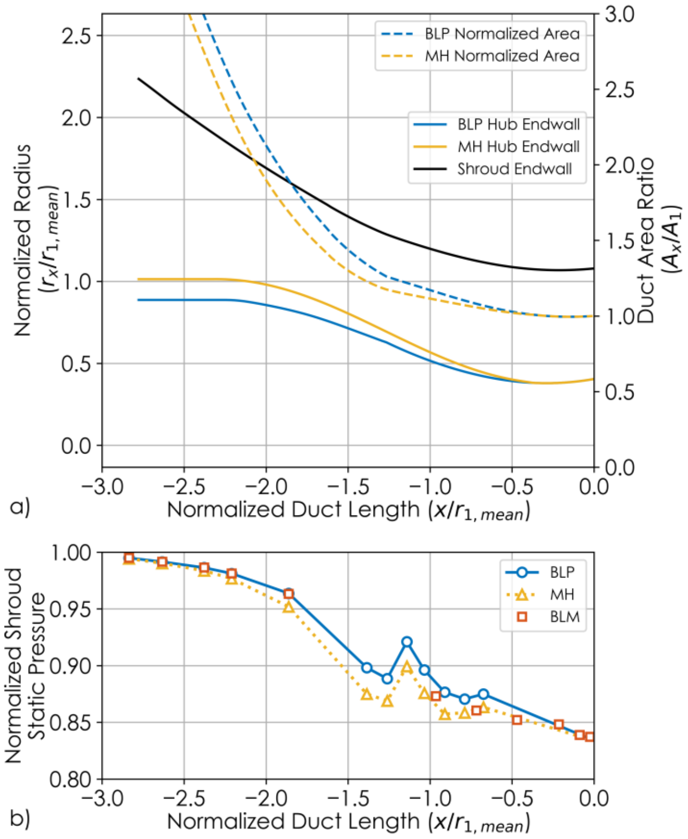
Discrepancy in TTR profiles can be observed between inlets



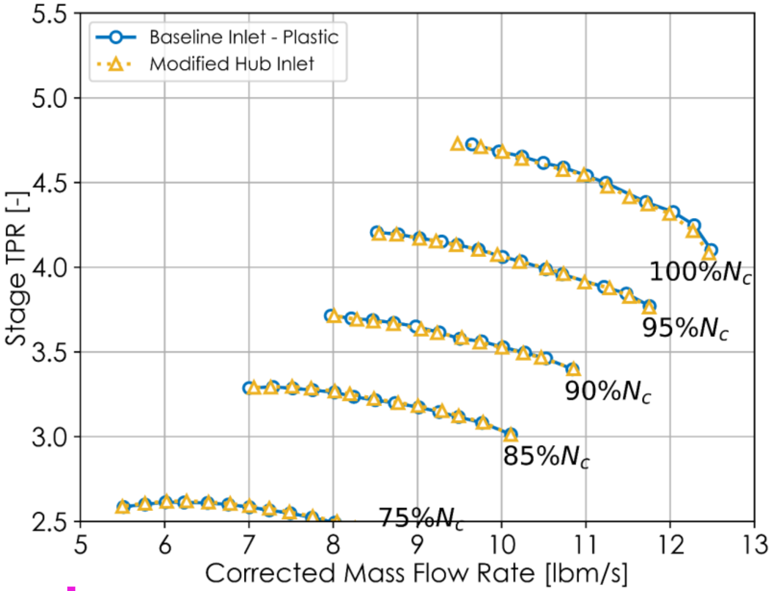


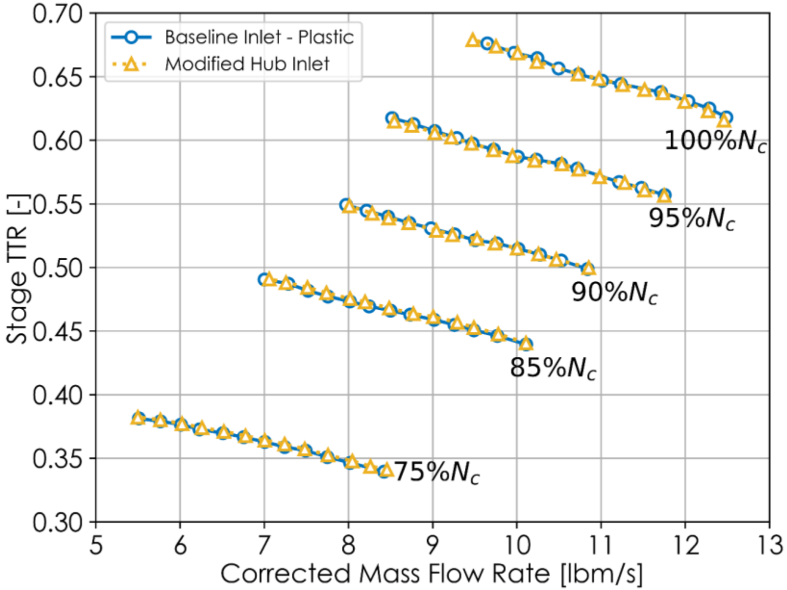
HECC Baseline Plastic and Modified Hub Inlet Performance

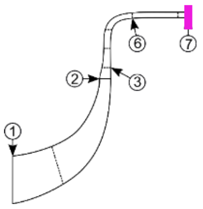
The modified hub inlet is representative of an axi-centrif transition duct



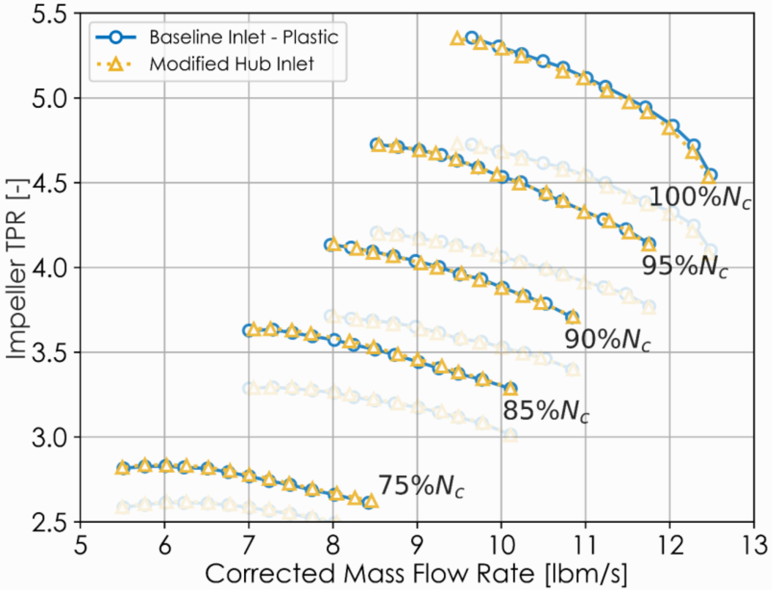
The MH inlet has negligible impact on stage performance

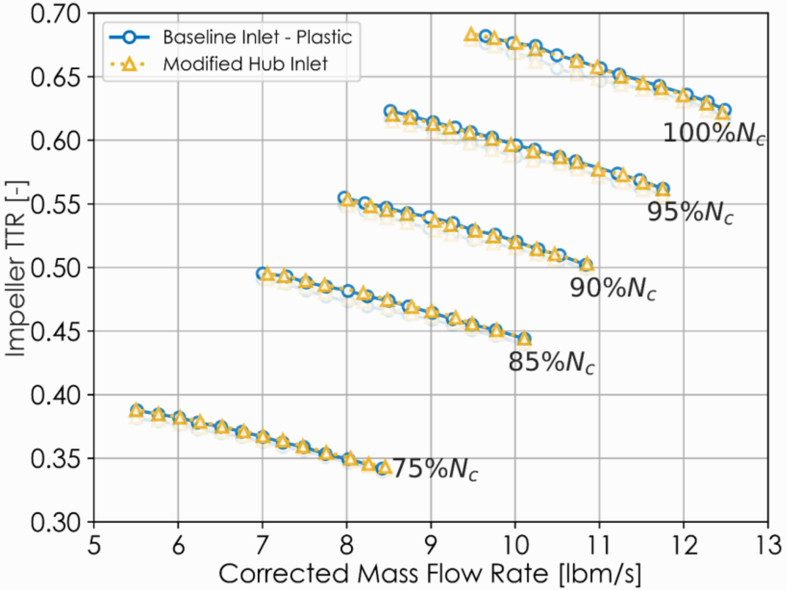


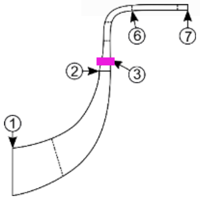




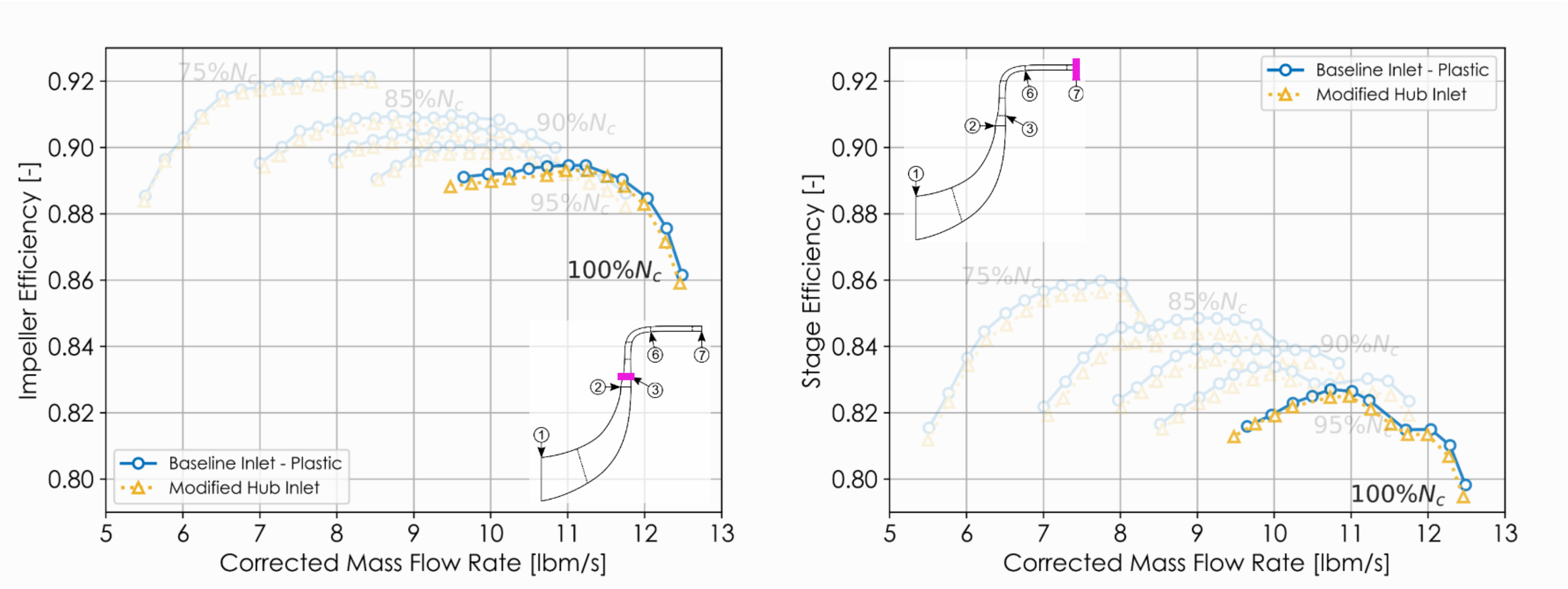
Considering component performance, impeller TPR & TTR are greater than stage TPR & TTR



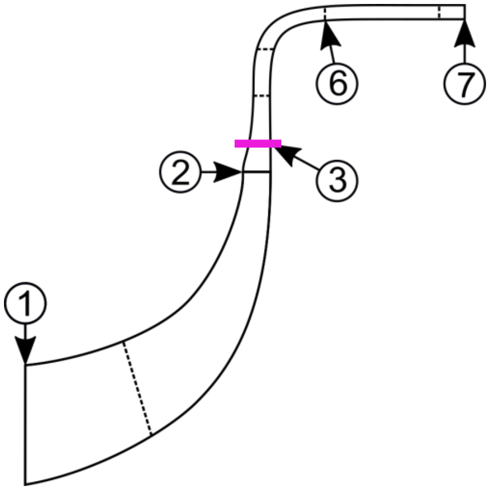


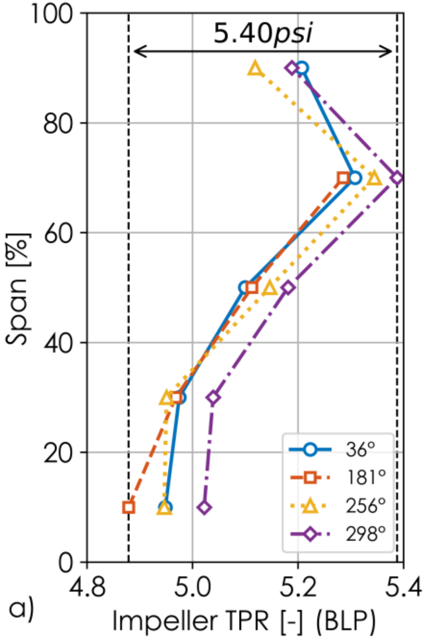


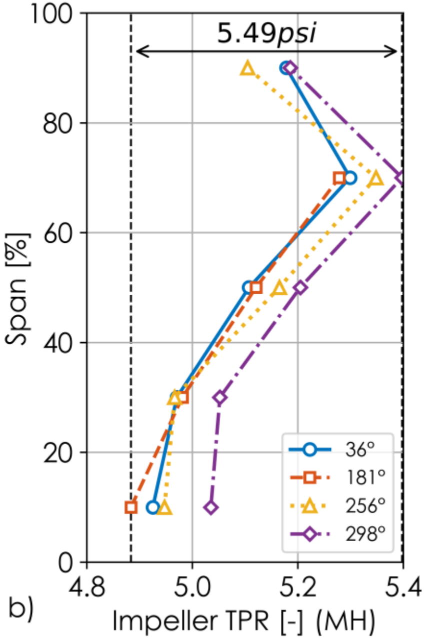
The impeller has a wide efficient operating range

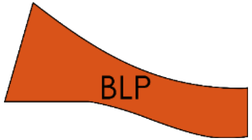


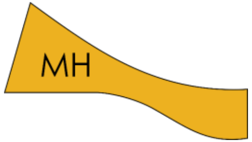
Impeller exit flow properties are also not impacted by MH inlet











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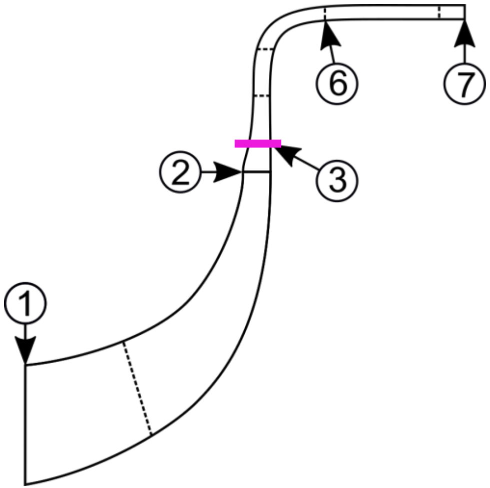
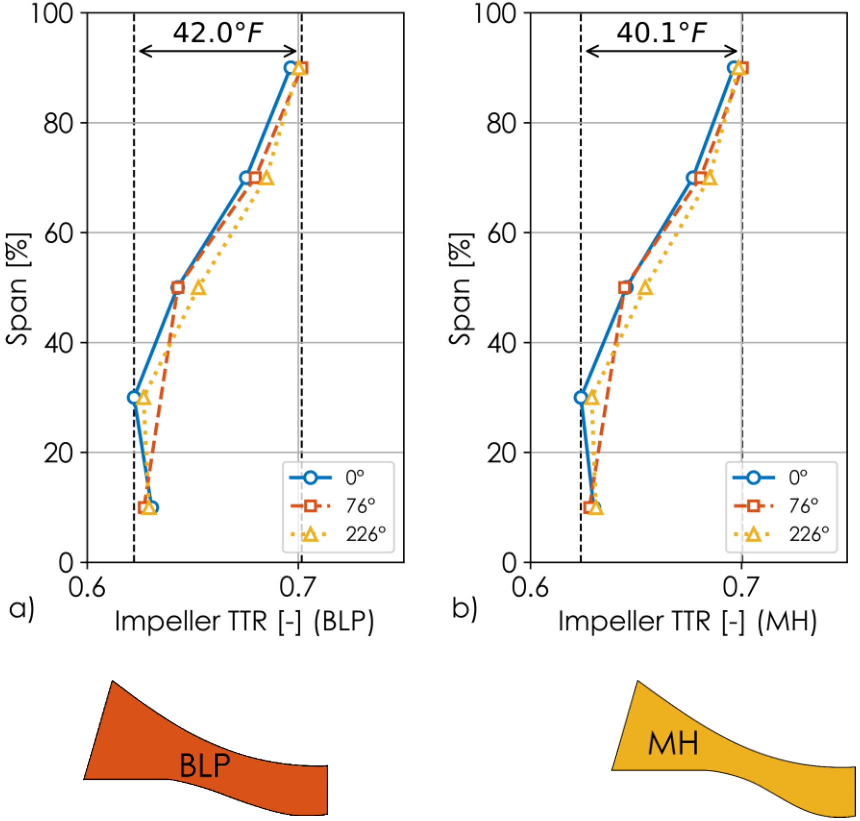
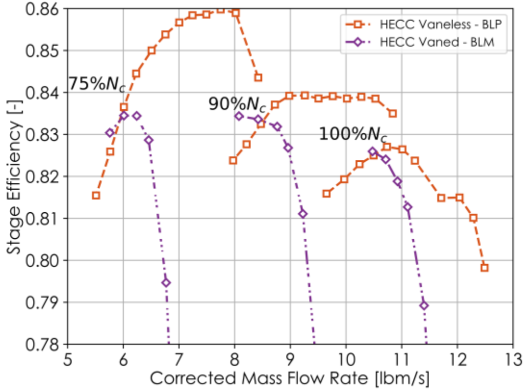
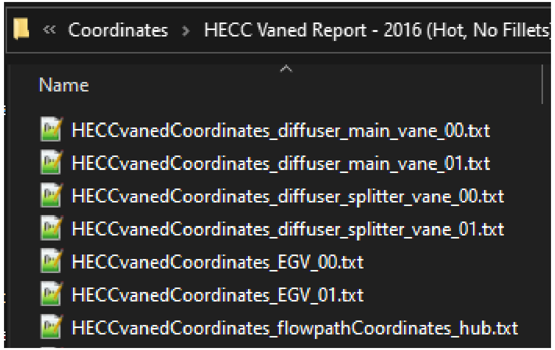


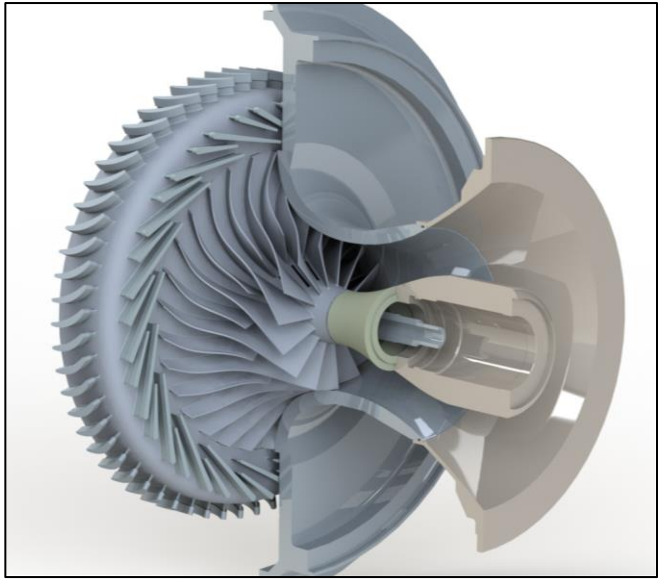


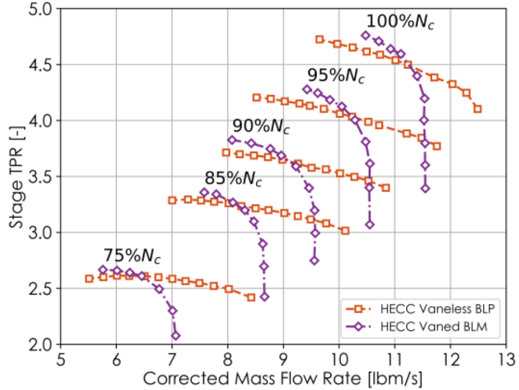
HECC Data Archive

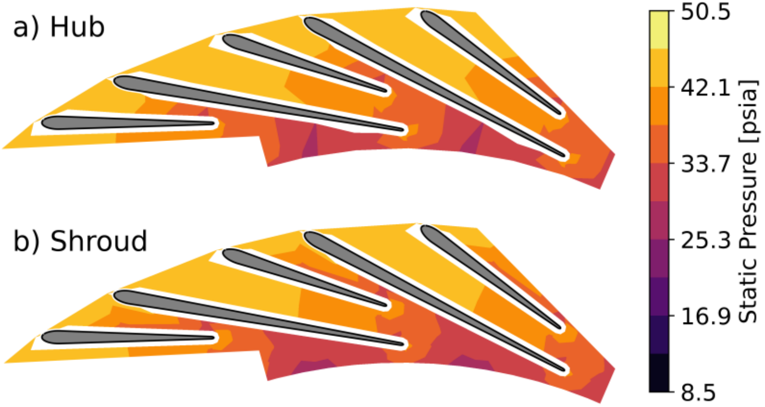
HECC data archive contains…











HECC data archive contains…

CN	DESCRIPTI	UNITS	CAT	SCAT
T7021	Rake #2 Te	DEG R	AERO	TT
T7022	Rake #2 Te	DEG R	AERO	TT
T7031	Rake #3 Te	DEG R	AERO	TT
T7032	Rake #3 Te	DEG R	AERO	TT
T7041	Rake #4 Te	DEG R	AERO	TT
T7042	Rake #4 Te	DEG R	AERO	TT
T7051	Rake #5 Te	DEG R	AERO	TT
T7052	Rake #5 Te	DEG R	AERO	TT
T7061	Rake #6 Te	DEG R	AERO	TT

NASA HIGH EFFICIENCY CENTRIFUGAL COMPRESSOR DATA ARCHIVE

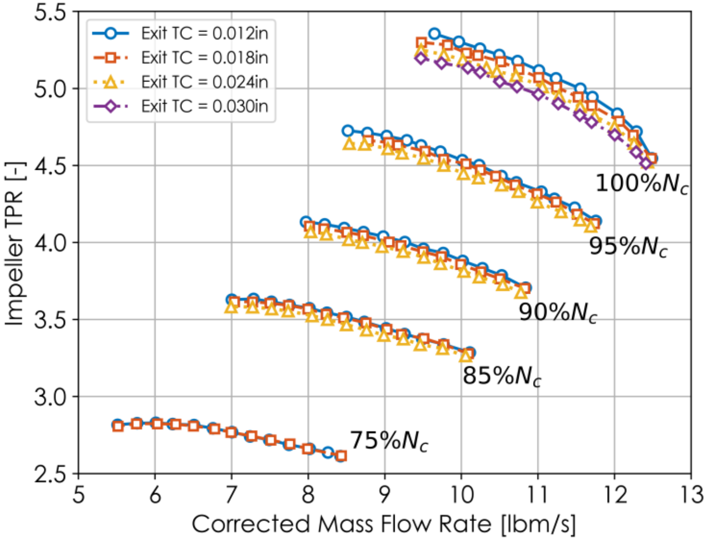
Contact and Maintainer: Herbert "Trey" Harrison
herbert.harrison@nasa.gov
NASA Glenn Research Center
Cleveland, OH

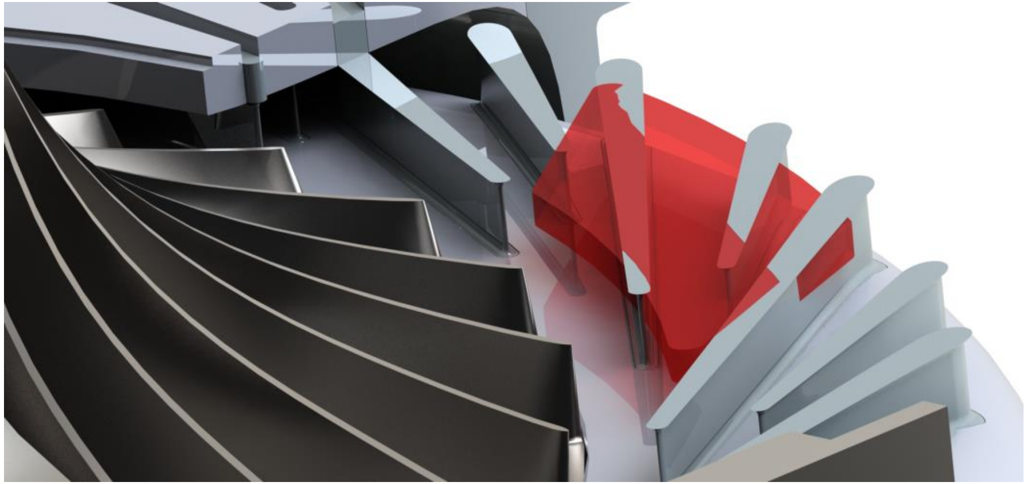
SUMMARY

The datasets contained in this archive are associated with the High Efficiency Centrifugal Compressor (HECC) in the Small Engine Components Compressor Test Facility, colloquially referred to as CE-18, at NASA Glenn Research Center. The archive is accessible at https://storage.googleapis.com/hecc-data/NASA-HECC-Data-Archive.zip. The documentation contained herein provides context for the data hosted on data.nasa.gov. The datasets and accompanying content in this document will be updated periodically as additional data is procured analyzed. The revision of the document is provided by date in the footer, and the revision updates are provided in the Revisions section. Please contact Trey Harrison (email: herbert.harrison@nasa.gov) for inquiries related to the dataset and documentation or to be added to an email list to be notified of updates and additions to the archive.

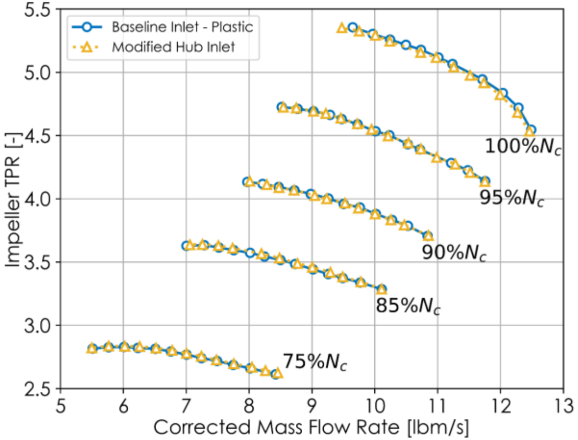
1. CONTENTS

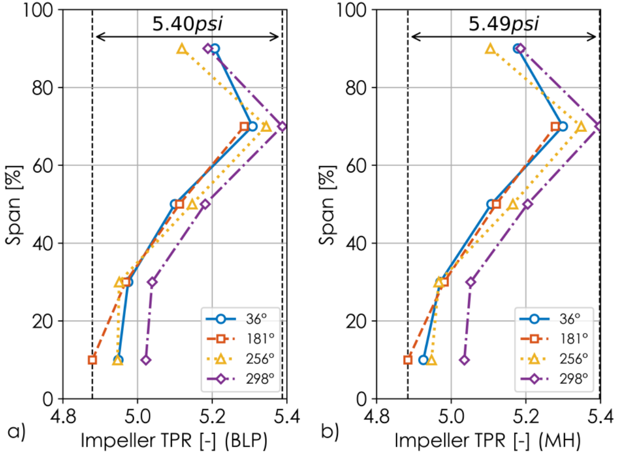
The HECC data archive is publicly available and actively maintained





CE-18 and HECC support state of the art research on an open access turbomachinery case

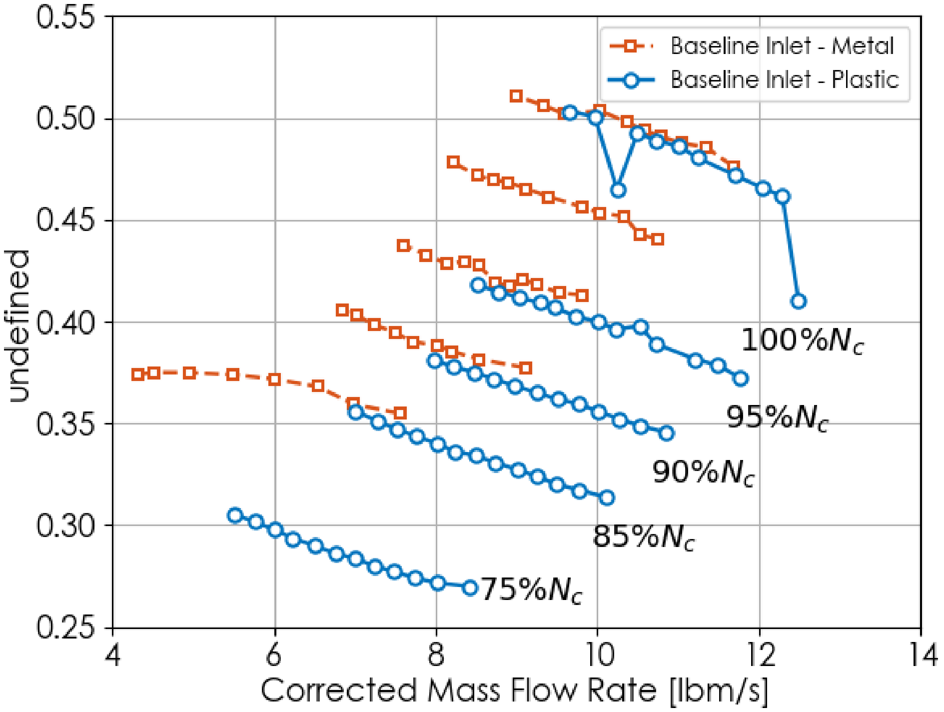




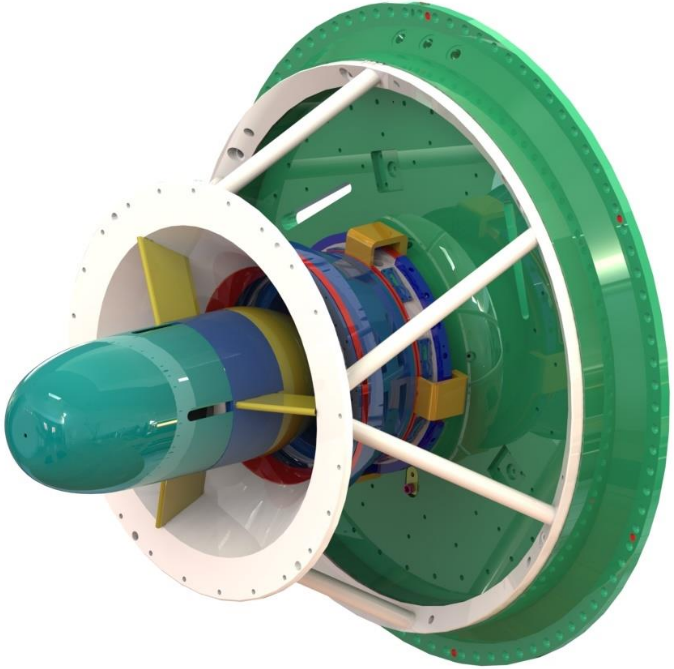
This work funded by the NASA
Revolutionary Vertical Lift Technology and
Transformational Tools & Technologies Projects.

Backup

Metal temps do not agree with exit temps



This work documents the NASA CE-18 compressor test facility and the effect of a transition duct on centrifugal compressor performance



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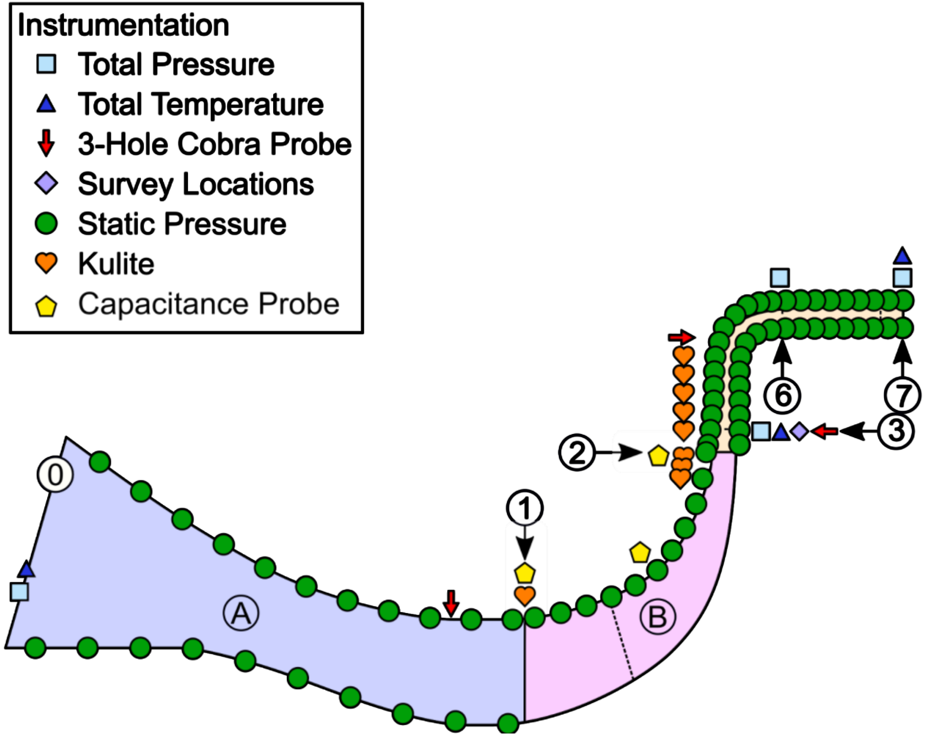
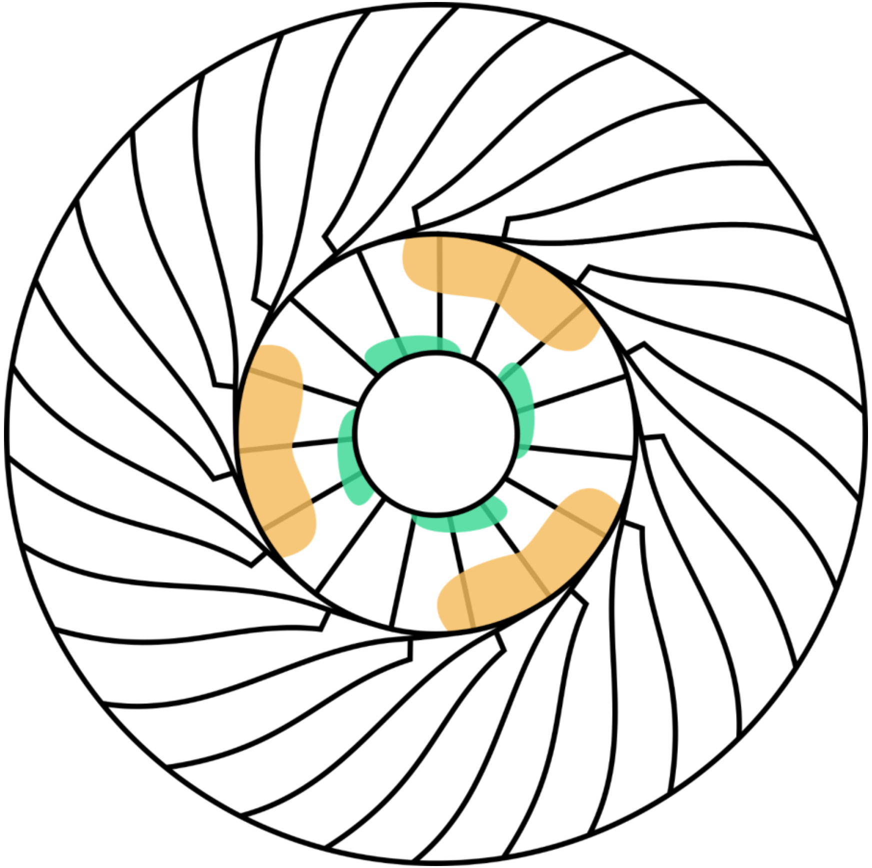


Open datasets support technological advancement in turbomachinery and propulsion



$P_0 < P_{avg}$

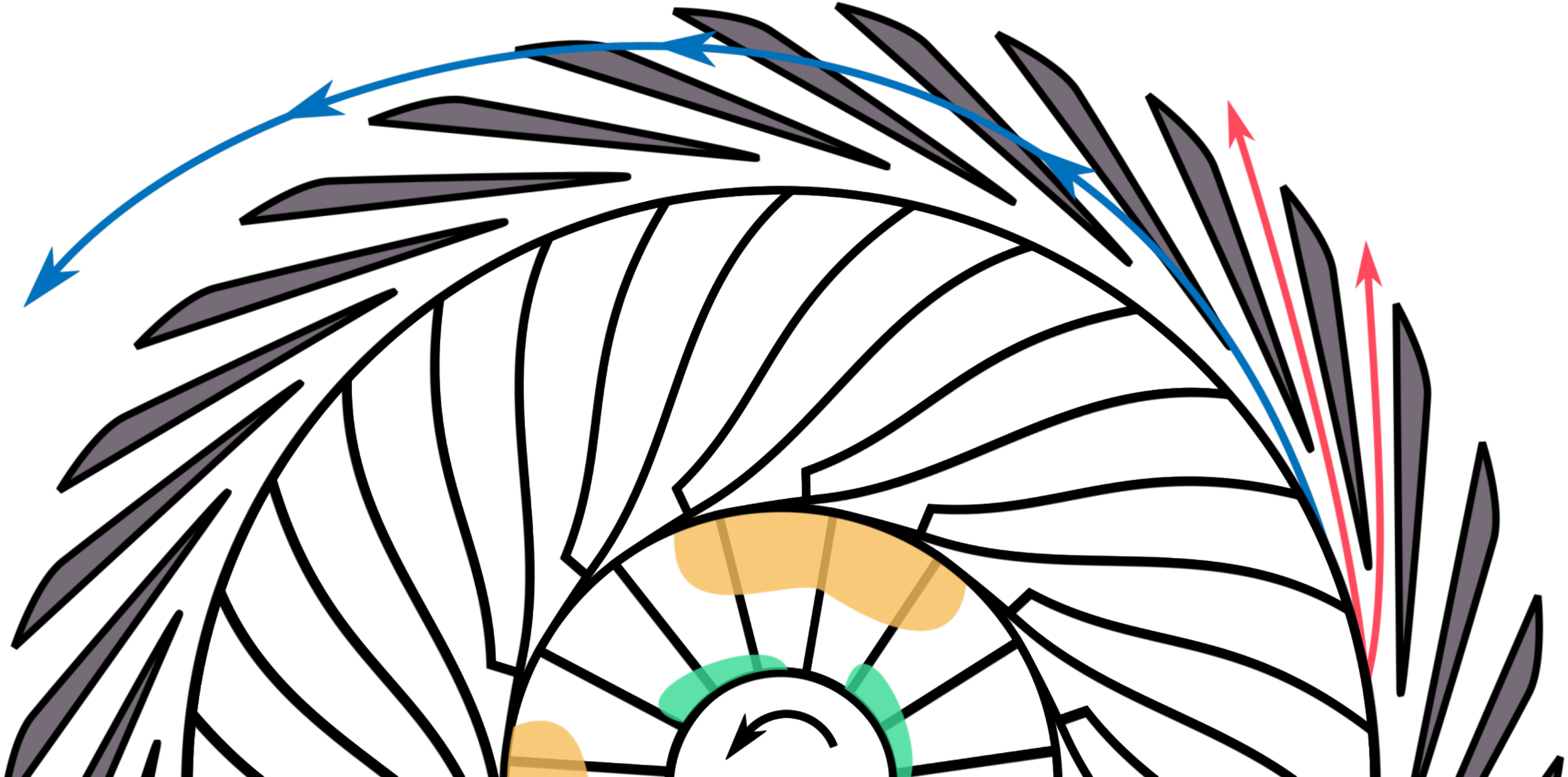
$P_0 > P_{avg}$

or

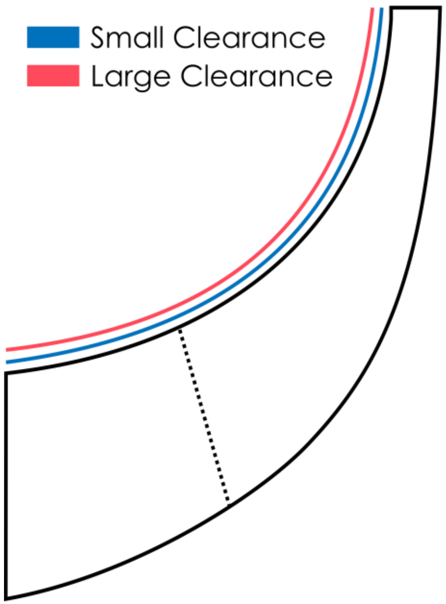
$\alpha < \alpha_{avg}$

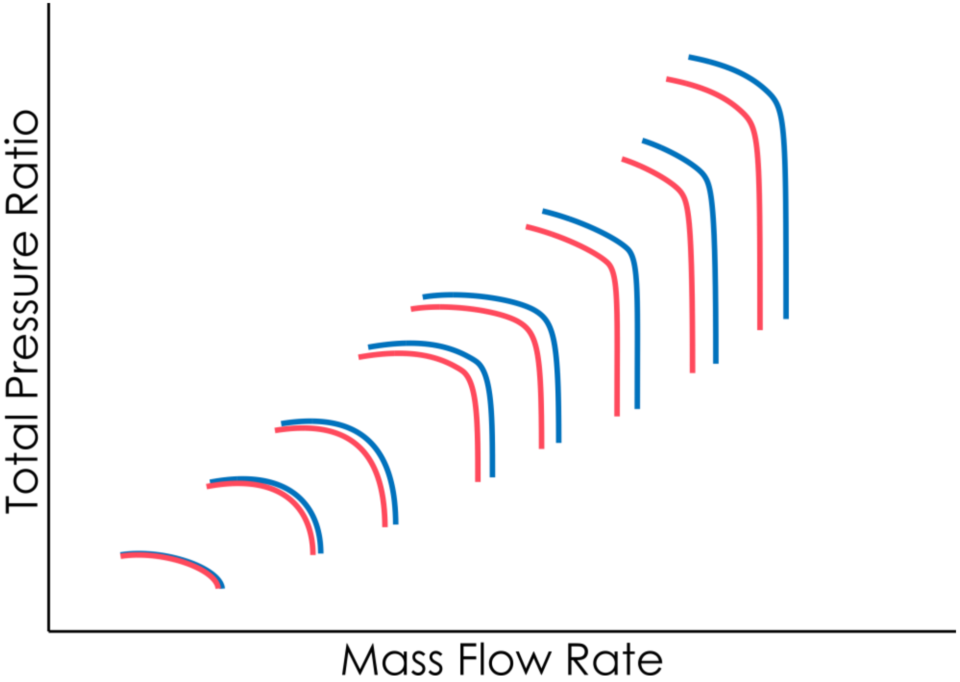
$\alpha > \alpha_{avg}$

Impeller diffuser interactions are still not well understood



Stage performance decreases with increasing tip clearance, but the trend is unique to each machine





Accurate prediction of instability onset and stall/surge suppression requires high fidelity data