

Advanced Materials for the Impeller in an ORC radial micro-turbine



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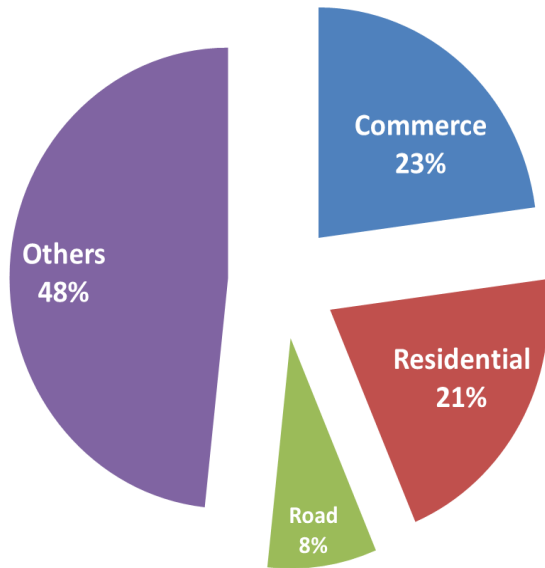
Outline

1. Motivation
2. State of the art
3. Aim
4. Methods
5. Set-up
6. Results
7. Conclusion



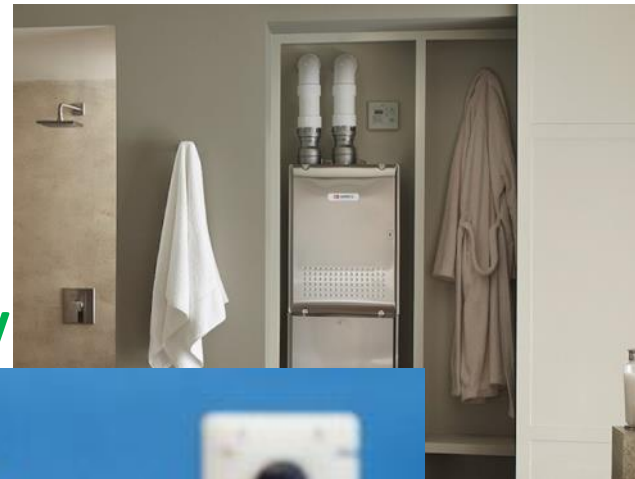
1. Motivation

World Energy Consumption 2013



Average Residential Energy, London 2016

Electricity



Water heating

Space heating



$\eta \in [35\% - 60\%]$

Gas ~ 0.05 £/kwh

Electricity ~ 0.17 £/kWh

0.2 kg CO₂/kwh

0.5 kgCO₂/kWh

Distributed Generation



Renewable



Solar



Wind



Hydro



ICE



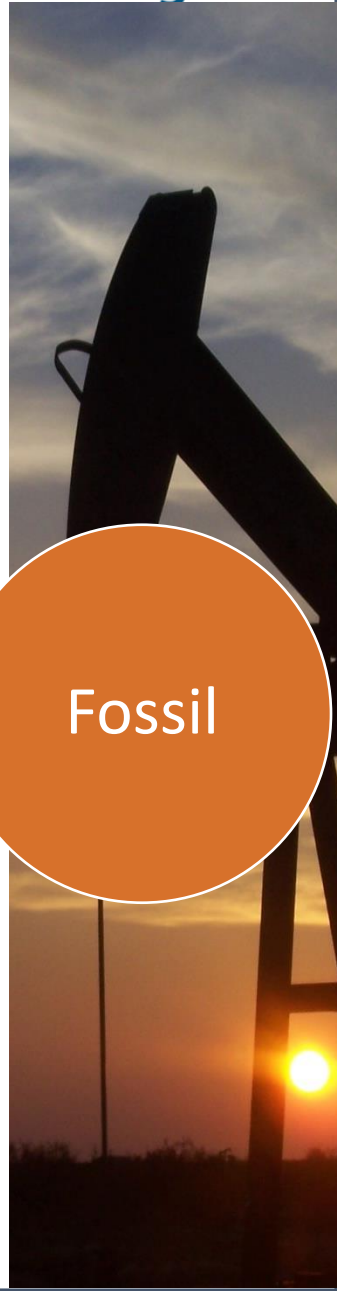
mCHP

$\eta \in [80\% - 95\%]$
~1kWe

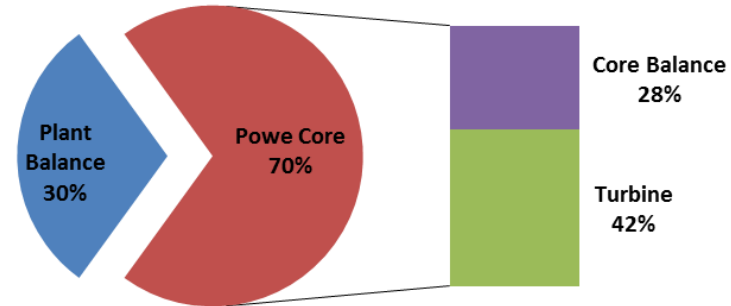


Fuel Cell

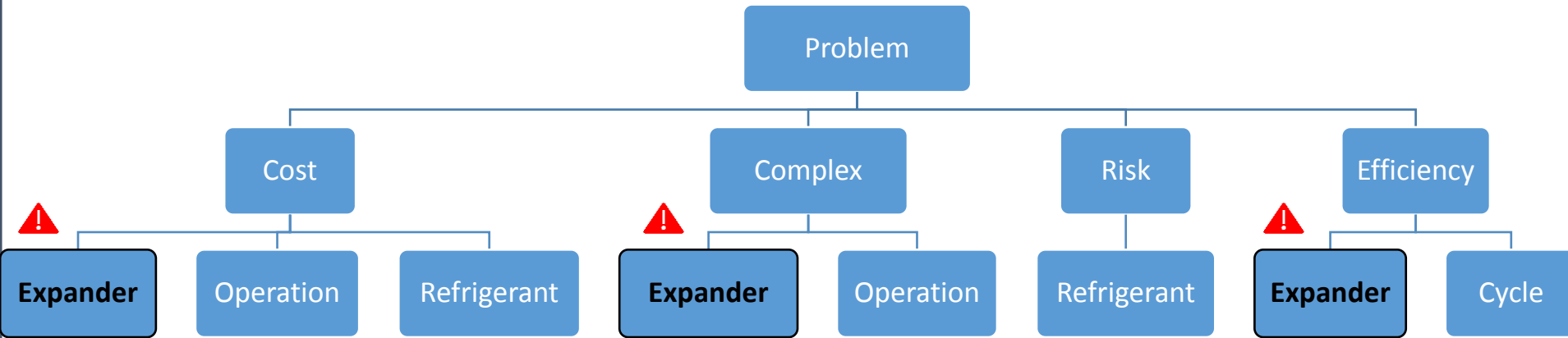
Fossil



micro-CHP typical costs



Lets improve ORC!



The expander!



2.State of the art

ORC

Scroll



Screw



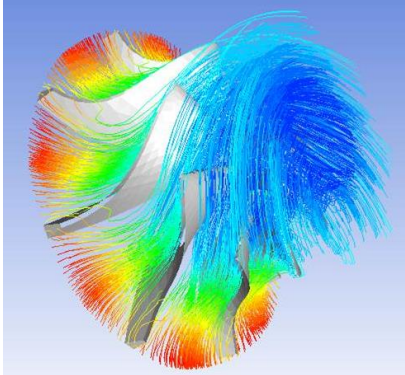
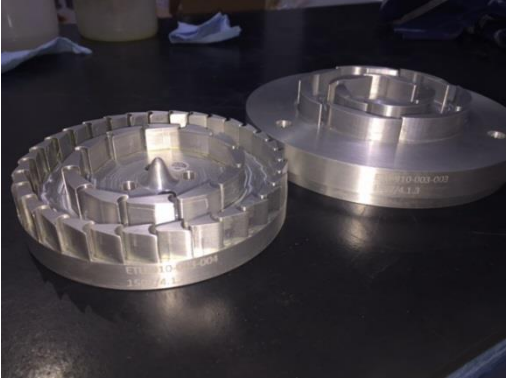
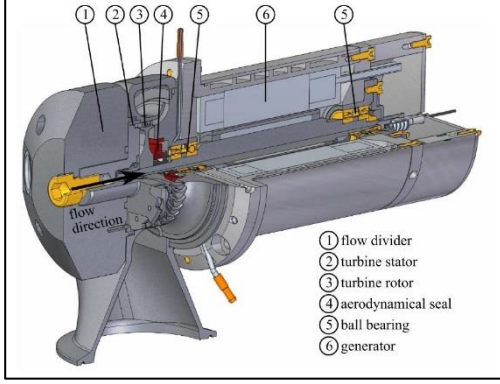
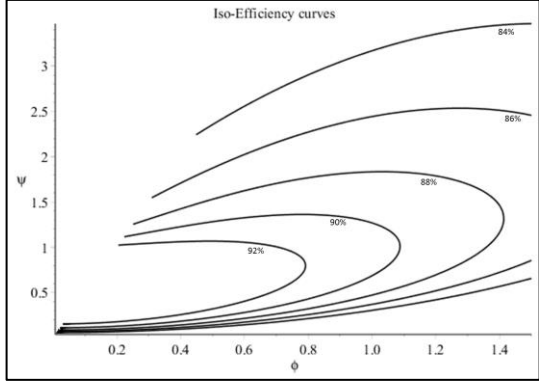
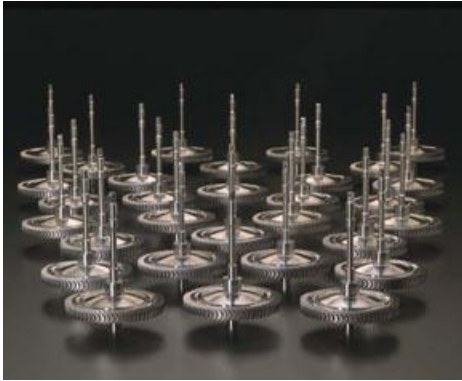
Vane motor



micro-turbine



Research



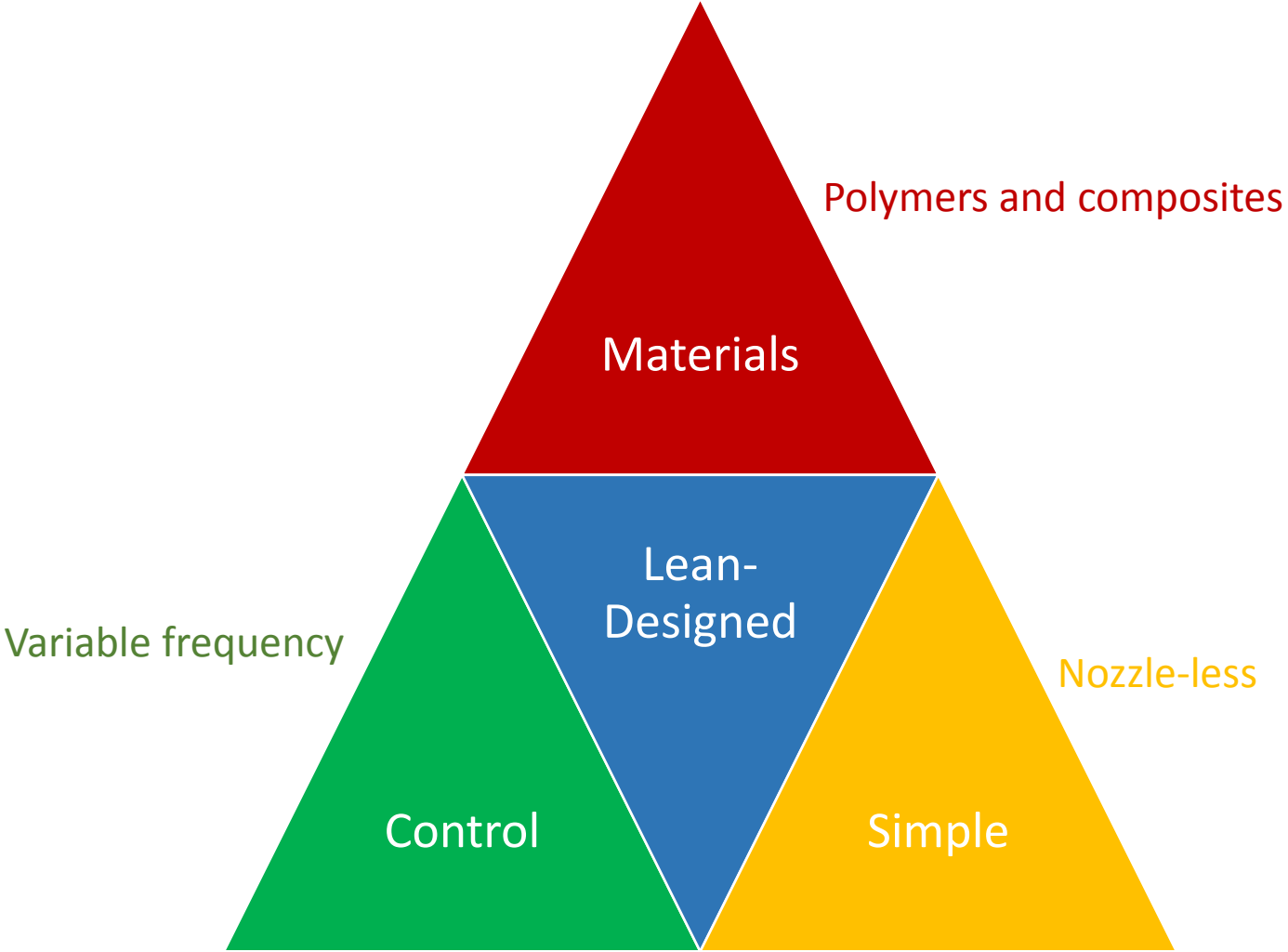


3.AIM



How to lean-design a ORC micro-turbine?

search



Advanced Materials



Turbomachinery



High-performance materials

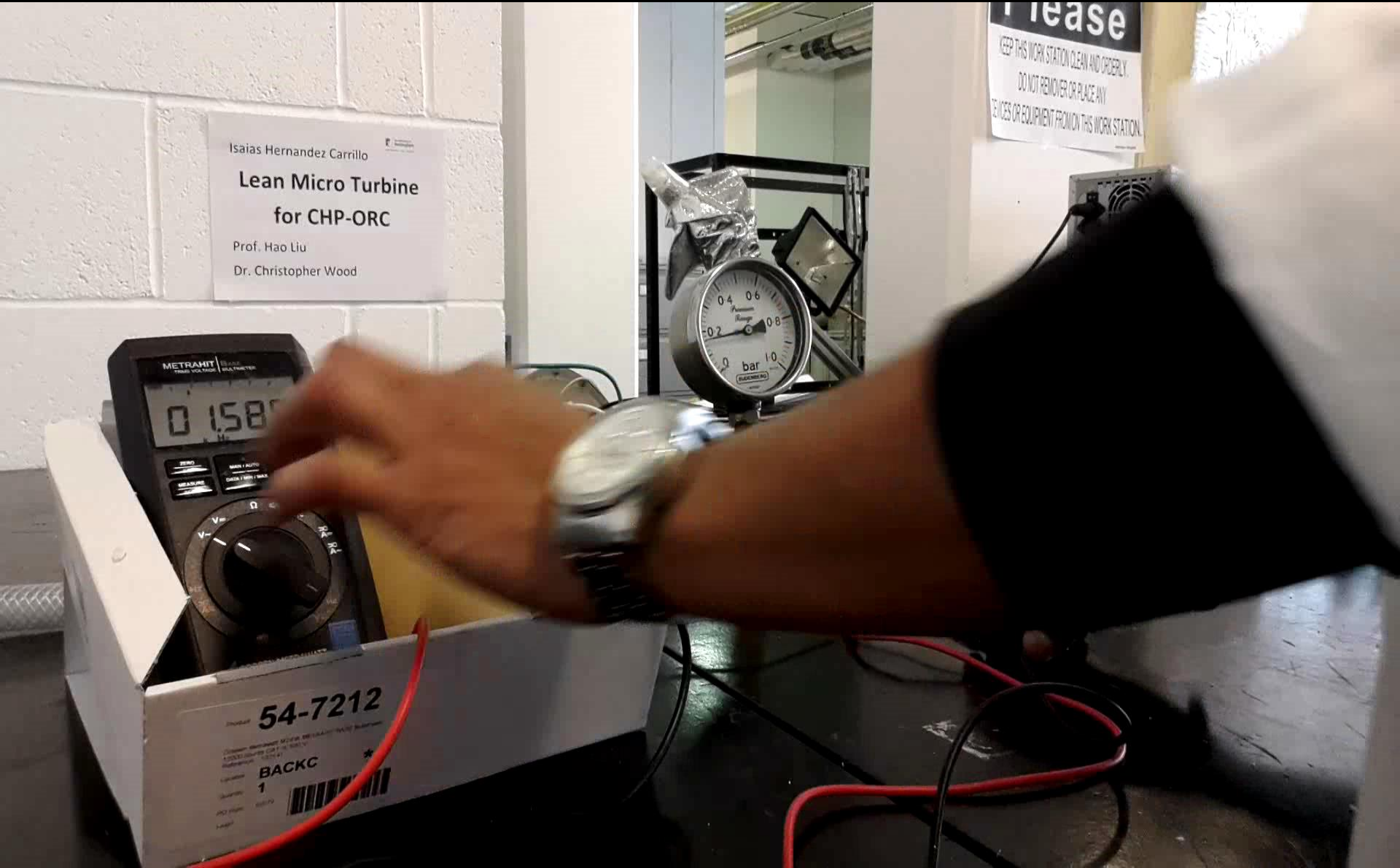


Mass production techniques



Novel applications

Production Cost reduction in
25-50%

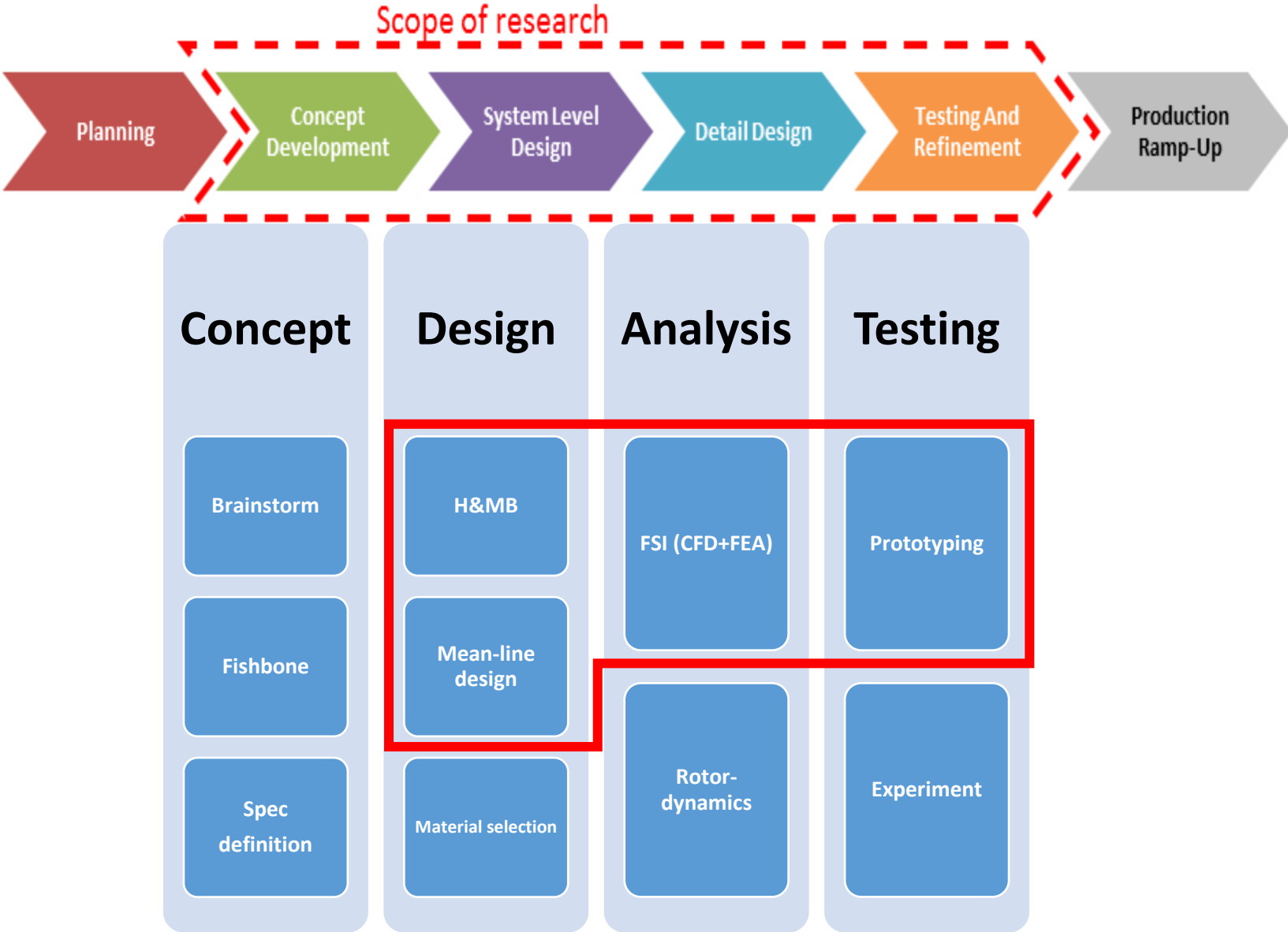


The concept had first to be proven in the lab

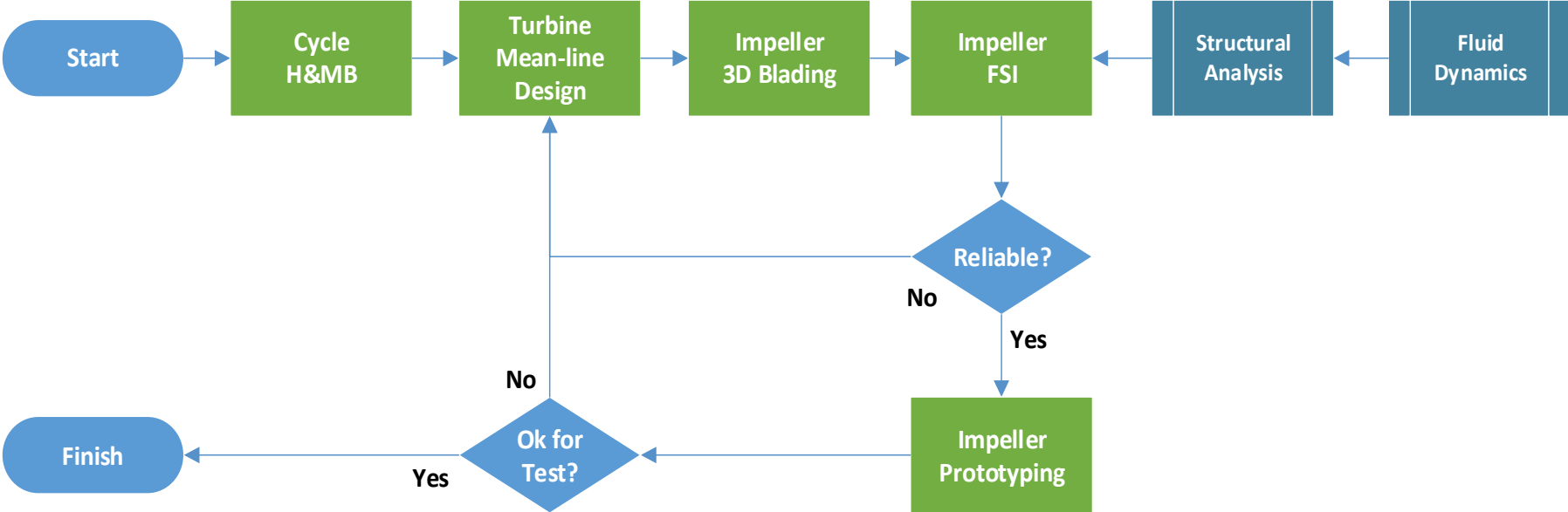


4. Methods

Dieter's product development method:



Flow Chart of the Process

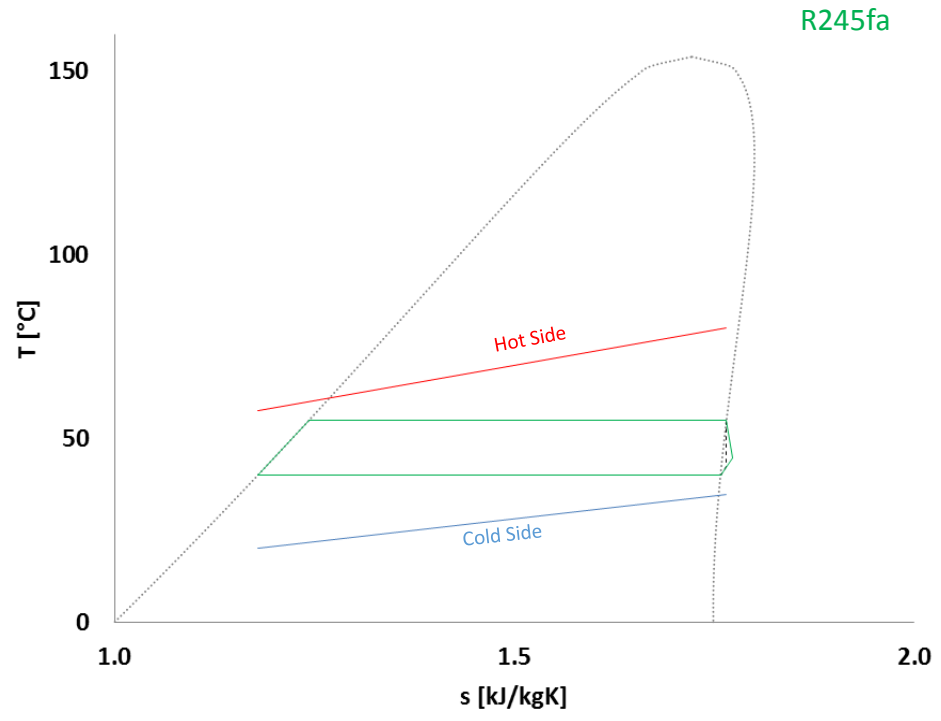
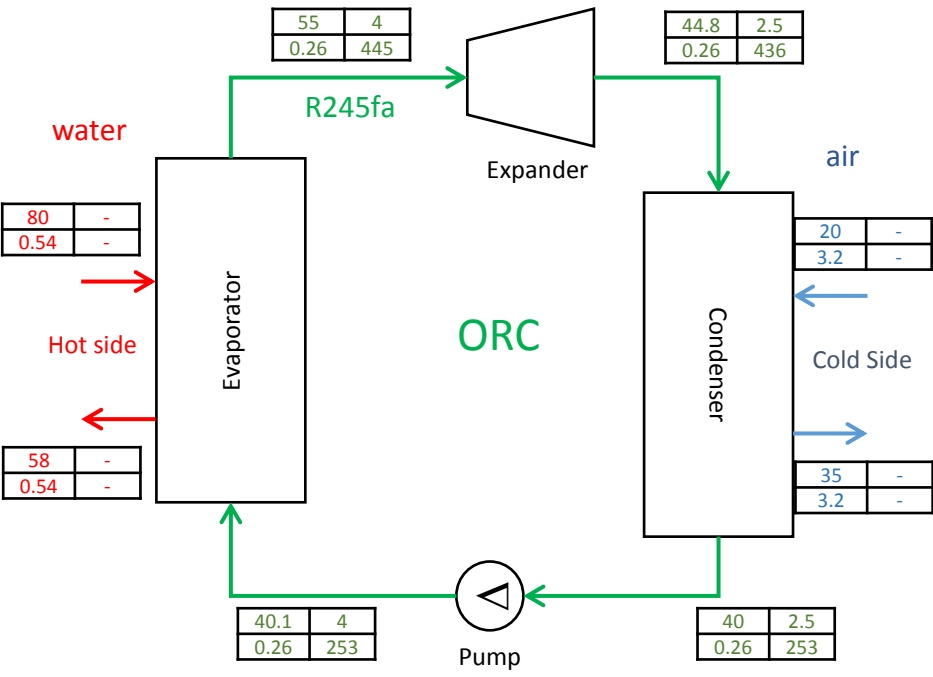




5. Set-up



Temperature [°C]	Pressure [Bara]
Mass flow [kg/s]	Enthalpy [kJ/kg]



ANSYS VISTA RTD

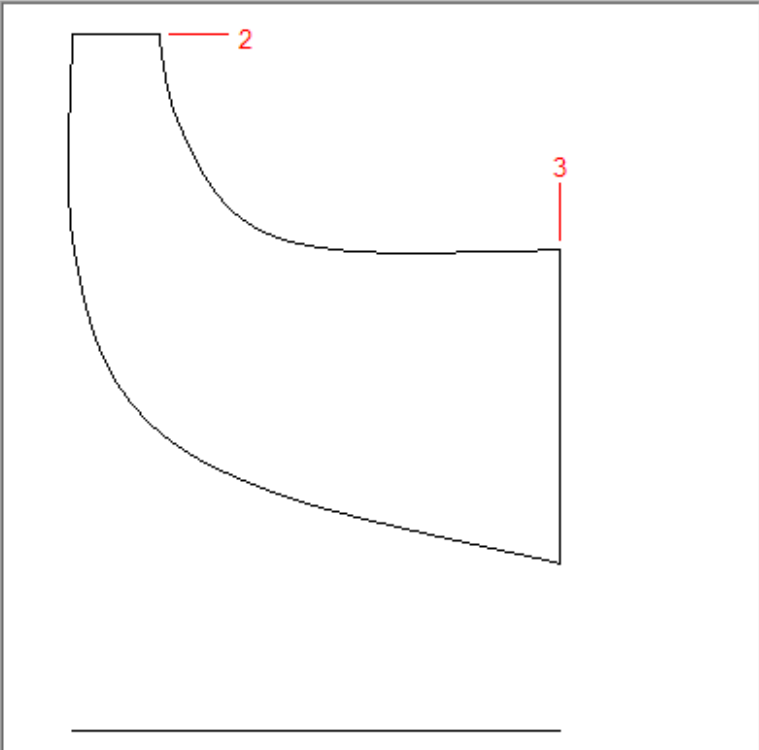
Units

SI

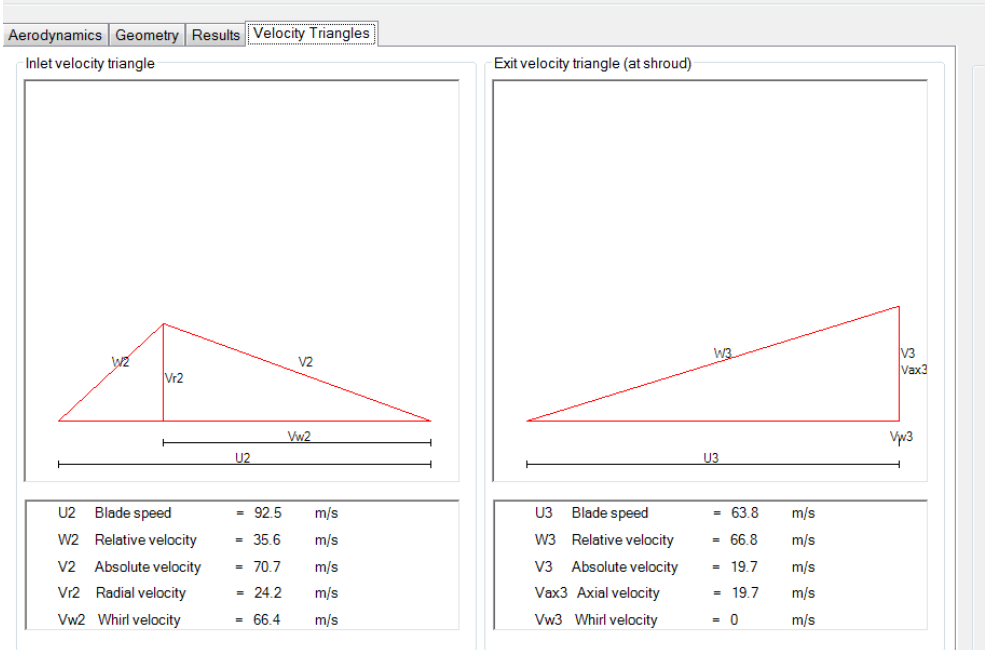
Imperial

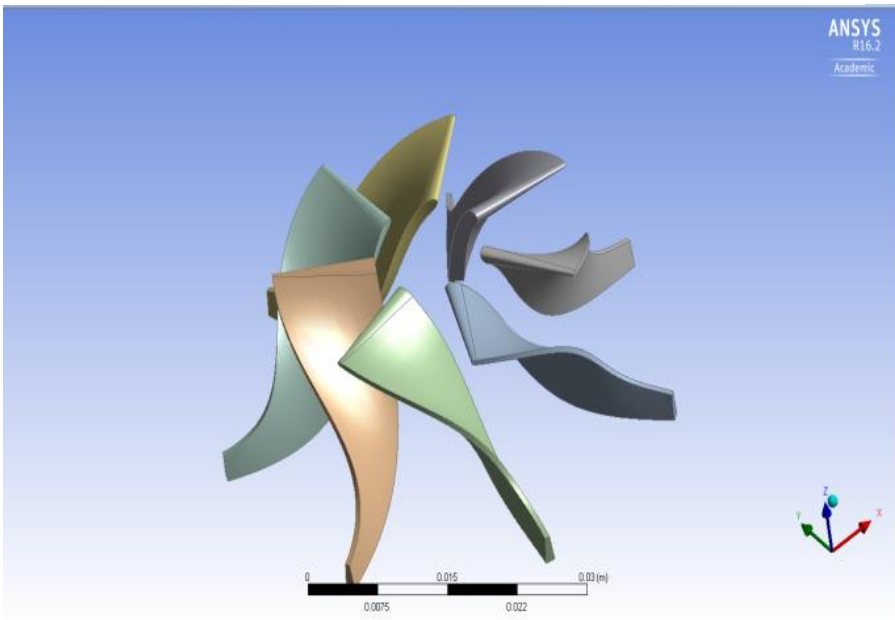
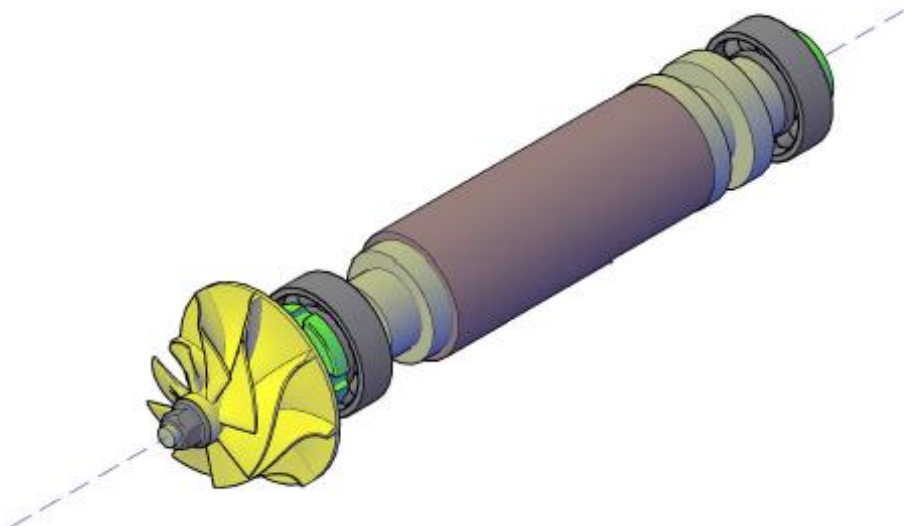
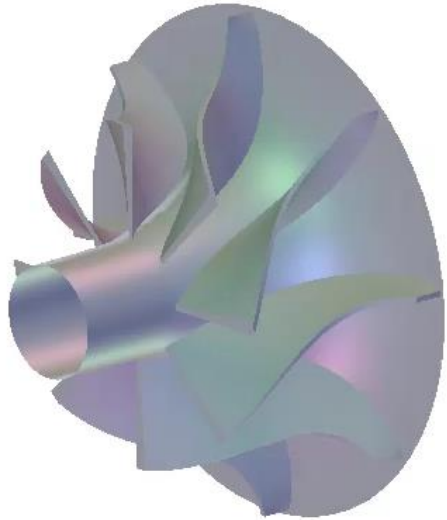
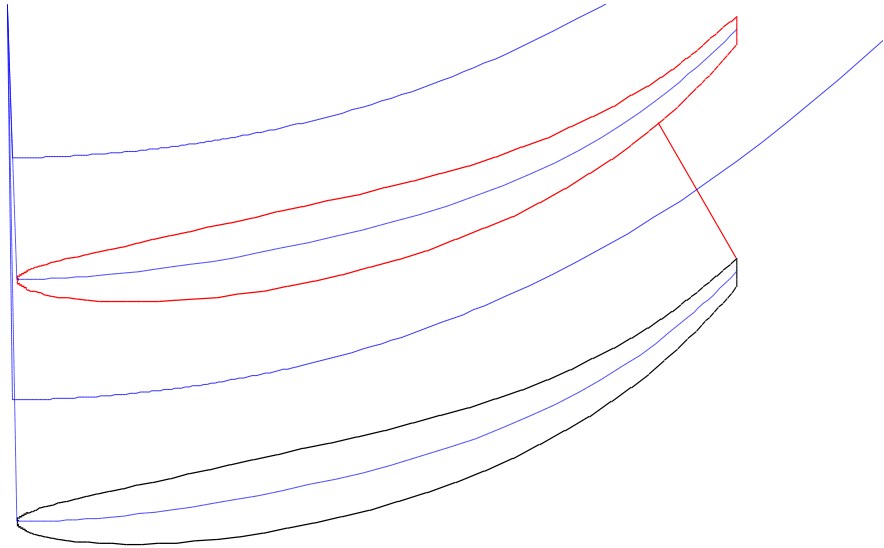
Calculate

Close



- ✓ 1.5 kW gross
- ✓ 36,000 rpm
- ✓ 49mm diameter
- ✓ 70% efficiency (Suhmann)





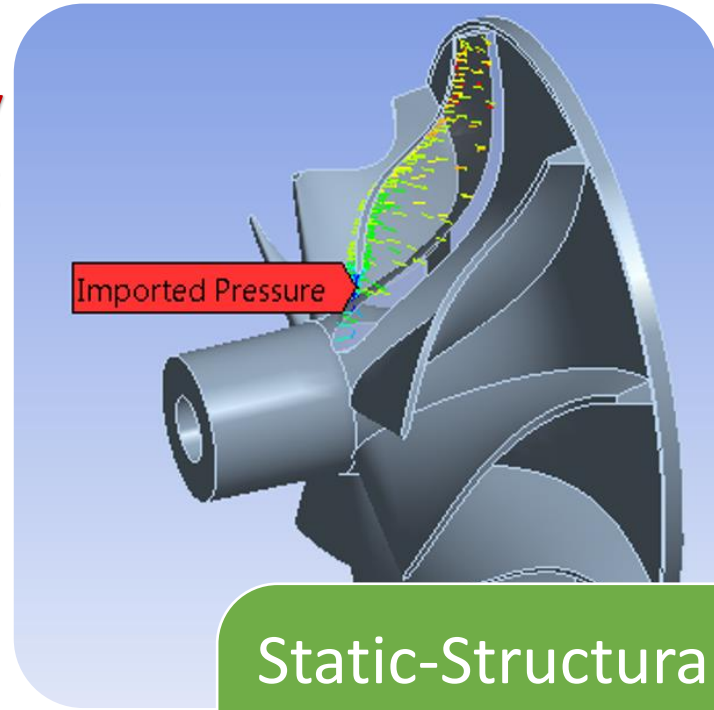
ANSYS
R16.2
Academic

0 0.0075 0.015 0.022 0.03 (m)





One-way
coupling



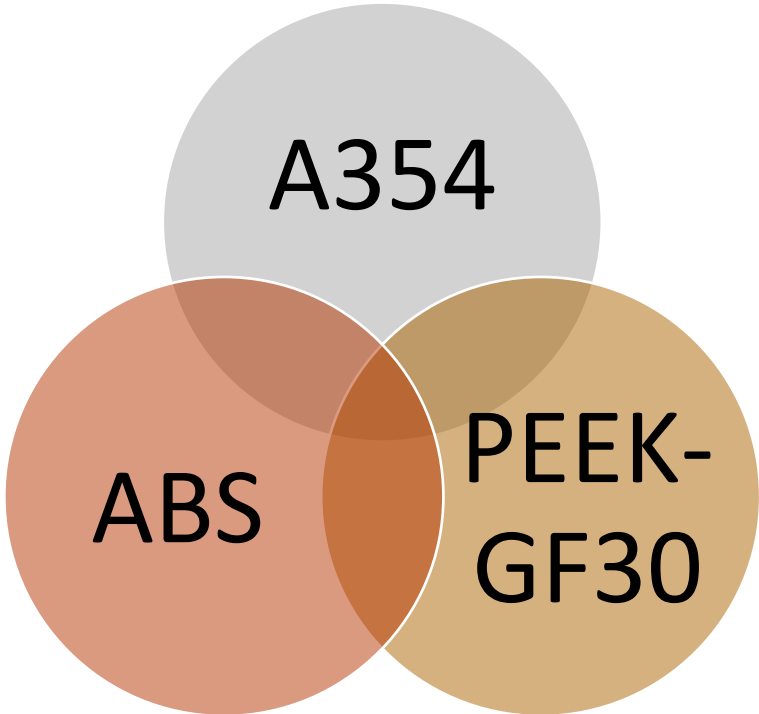
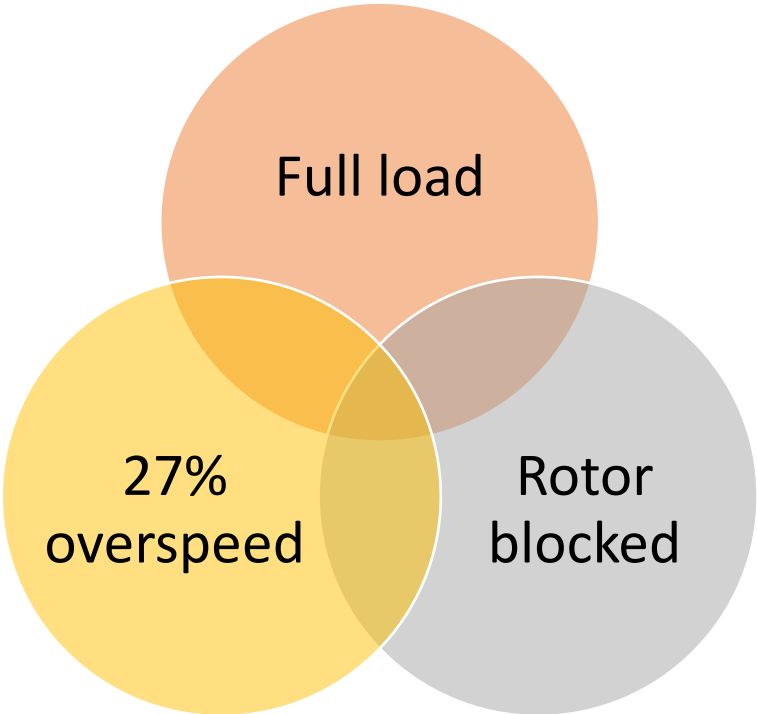
Fluid dynamics

- RANS steady state
- Rotational symmetry
- k-omega turbulence
- Real gas REFPROP EoS

Static-Structural

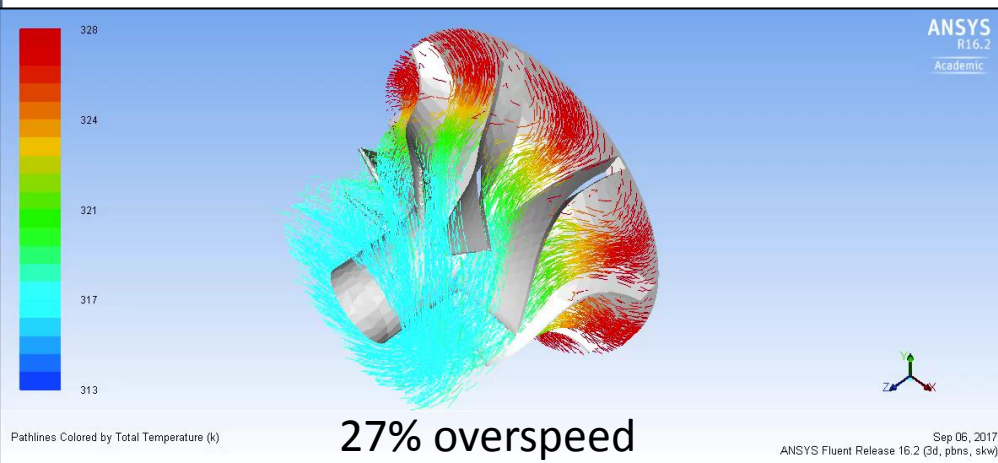
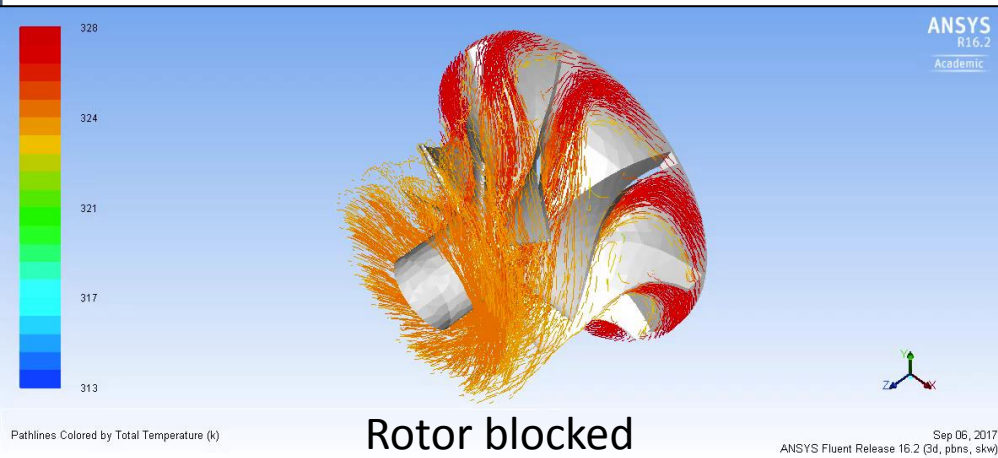
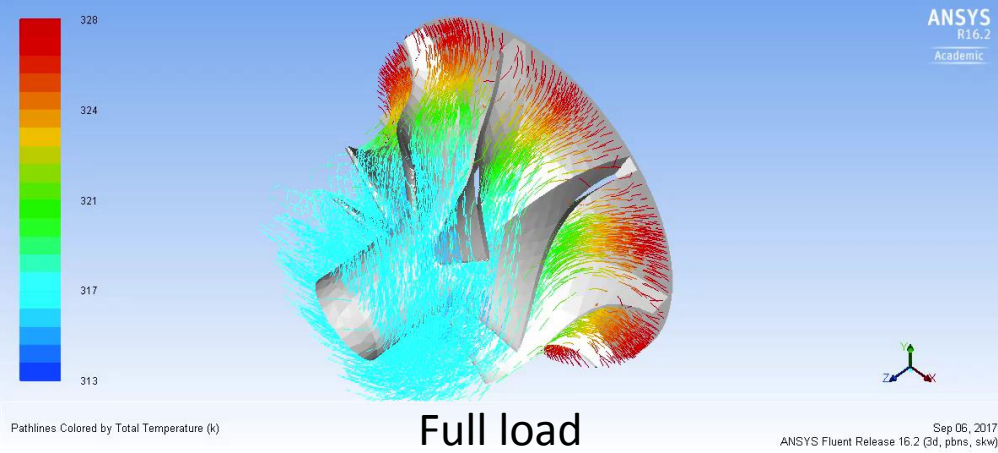
- Elastic
- Isotropic material properties
- Loads
 - Pressure-velocity field
 - Rotational speed

3 working conditions x 3 Materials = 9 Scenarios





6. Results



Total temperature



The University of Nottingham

Computational Fluid Dynamics

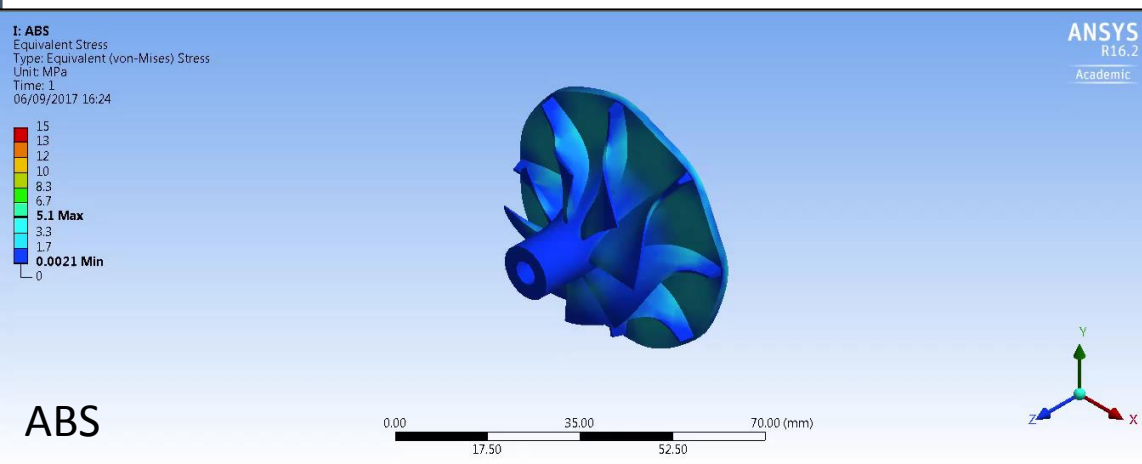
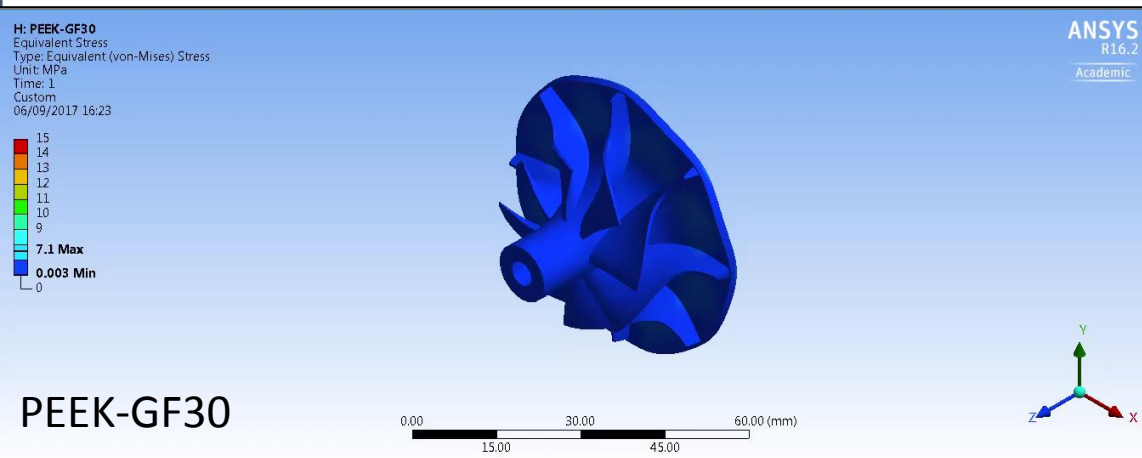
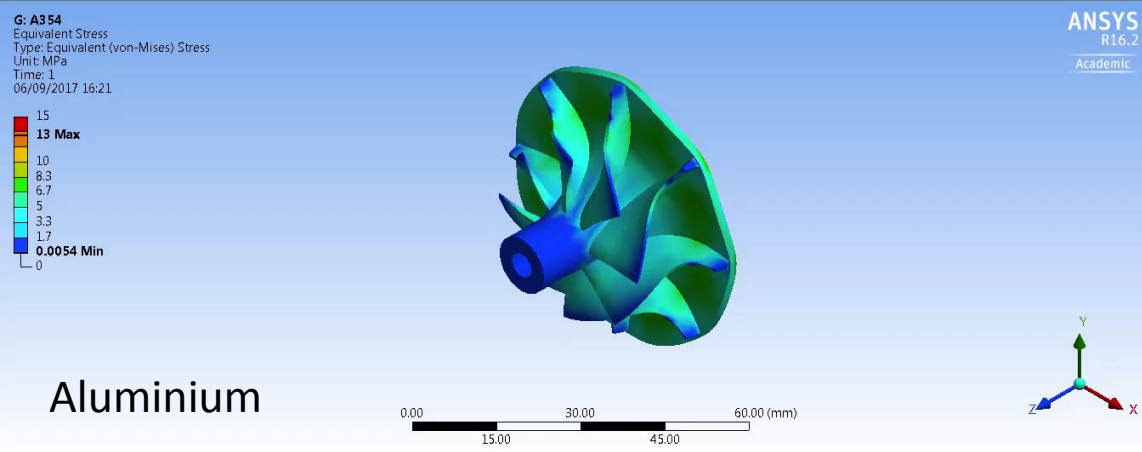
- Impeller Total-total Efficiency $\sim 86\%$
- Full load: smooth flow
- Rotor blocked: Pressure face of the blade is under stress
- Overspeed: Suction face of the blade is under stress



27% Over-speed condition

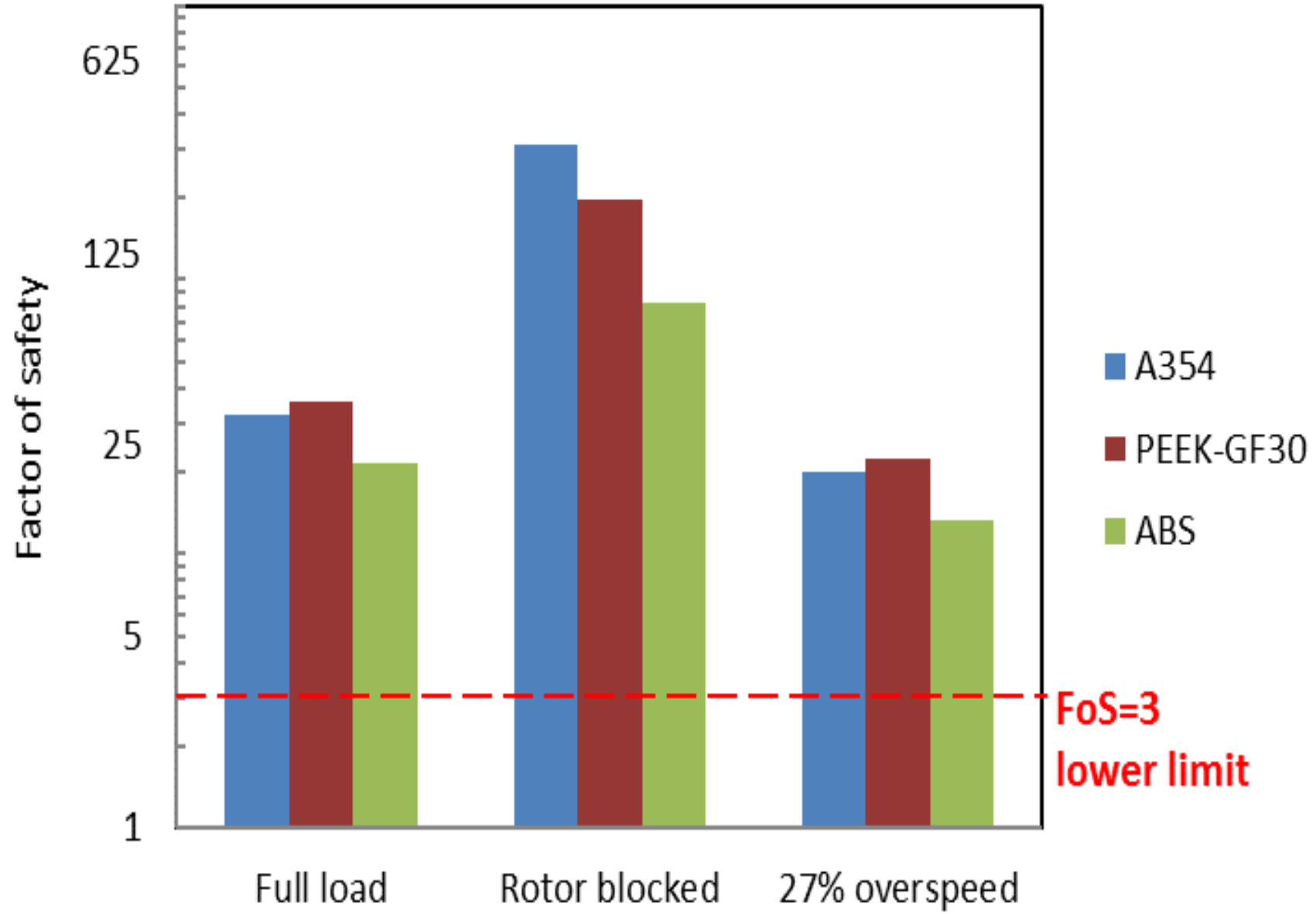
Structural Analysis

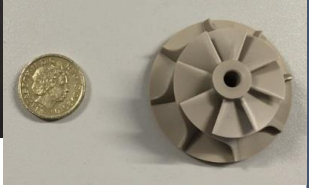
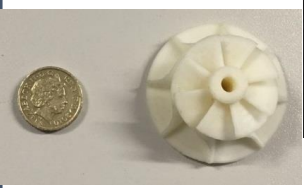
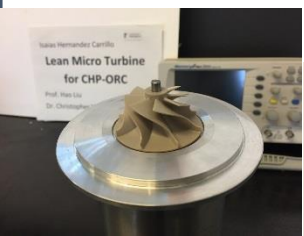
- Finite Element Analysis
- Blade loading has minimum effect
- Centrifugal forces limit the structural strength



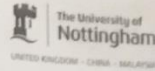


Comparison





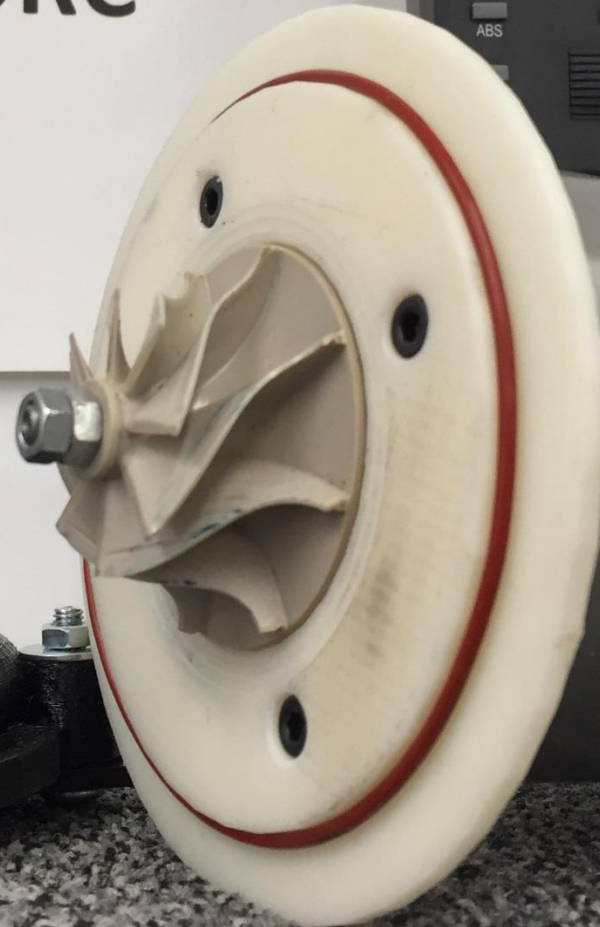
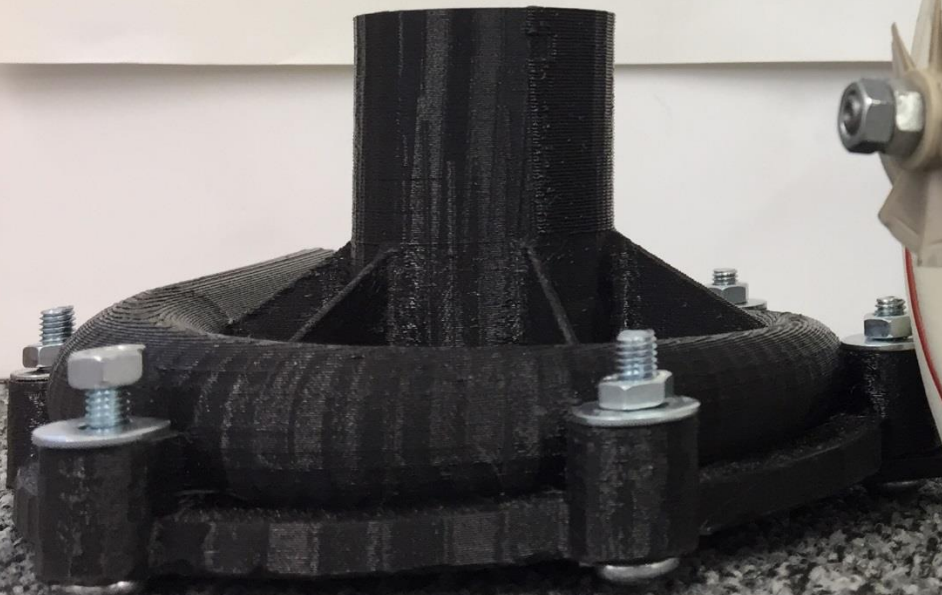
Isaias Hernandez Carrillo



Lean Micro Turbine for CHP-ORC

Prof. Hao Liu

Dr. Christopher Wood





7. Conclusion

Findings!

1. Lean-Designed = **Materials** + Geometry + Control
2. Competitive performance can be achieved: Efficiency around **70%**
3. Advanced materials = **Broad range** of plastics and **composites** may be used
 - ✓ Low temperature = Allow **Plastics** to be used
 - ✓ Up to 11% **stronger** than aluminium = suitable
 - ✓ 25-50% less expensive = **cost effective**
 - ✓ Up to 50% Lighter = lower inertia => longer lifespan of bearings



Gracias

Thank you