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Sponsors

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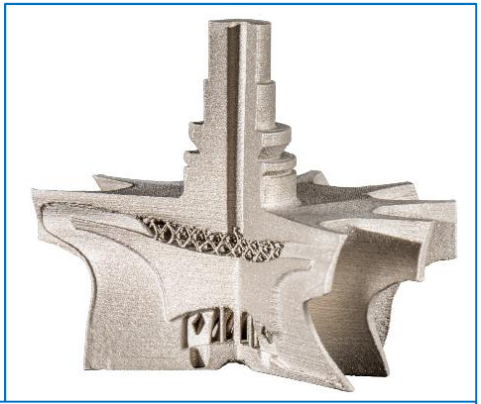
Additive Manufacturing for Highly Efficient & Compact Micro-Turbine Systems

Alex Redwood

HiETA Technologies

HiETA Technologies

- Specialists in thermal management and lightweighting solutions enabled by Additive Manufacturing (AM)
- Established five years with approximately 35 staff
- Based at Bristol and Bath Science Park
- Vision: Realise CO2 reduction via light weighting and efficiency through use of Additive Manufacturing



CASE STUDY: CHARM PROJECT

18 month project, Technical Feasibility of using AM to make lightweight, high-temp air cooled Radial Turbine Wheel for automotive applications

Project Objective:
Deliver AM air-cooled nickel superalloy radial turbine for automotive applications, capable of Operating ~1050C.

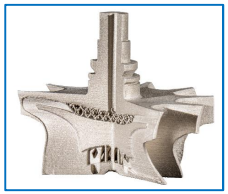
Project Partners

HiETA

Heat transfer & AM specialists, Engineering Design

Bath University

Turbo machinery design expertise & hot gas stand test apparatus

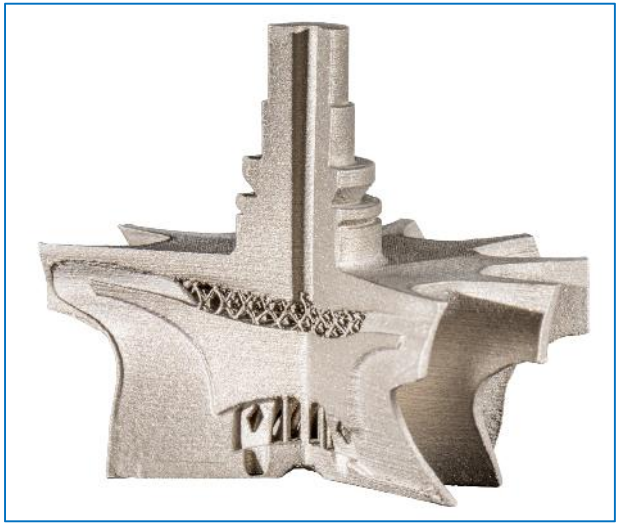


UNIVERSITY OF BATH

What Benefit does it bring?

Hollow/Lightweight & Cooled Turbine Wheels enable:

- Low Inertia
  - Faster spool up times
  - Solves shaft dynamic issues
  - Reduce surrounding component wear
- Increased Cycle efficiency
  - Higher Turbine Inlet Temps
- Increased Component Life
- Manufacture wheel & shaft as one component

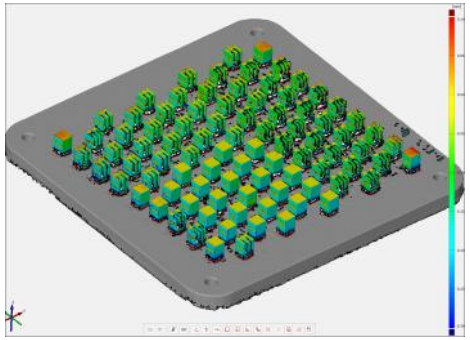


Our Approach to achieve objective:

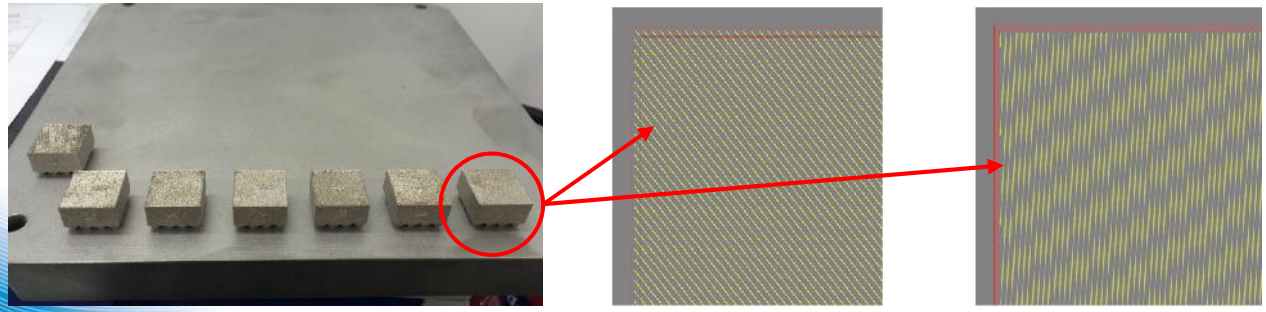
- Develop High Temp resilient Material
- Introduce Novel Design

Develop High Temp Resilient Material

- Require material with excellent high temperature strength, oxidation & creep resistance
- CM247LC chosen:
  - High Gamma Prime Nickel Alloy
  - Originally Developed as DS casting alloy for Turbine Blades
  - Deemed “un weldable”, very susceptible to micro-cracking

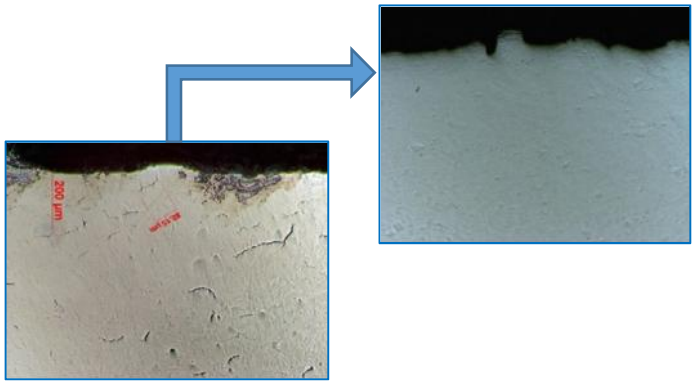


- Must develop AM parameter set to process the material:
  - 100’s of machine parameters – layer thickness/hatch & contour strategy
  - Requires DoE approach to down select optimum

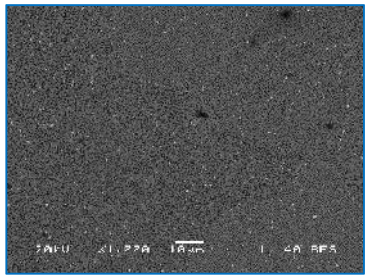


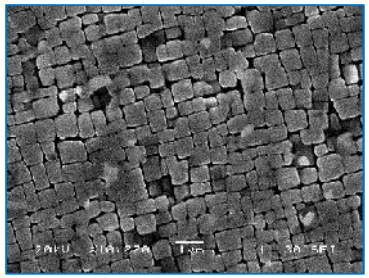
Develop High Temp Resilient Material

- With optimum AM parameter set chosen, then need to define heat treatment cycle



- HIP:
  - Objective: Find cycle that closes up micro-cracks giving 100% dense material
- Solution Treat & Age:
  - Objective: Improve microstructure for optimum mechanical properties
  - Regular, large grain structure desirable

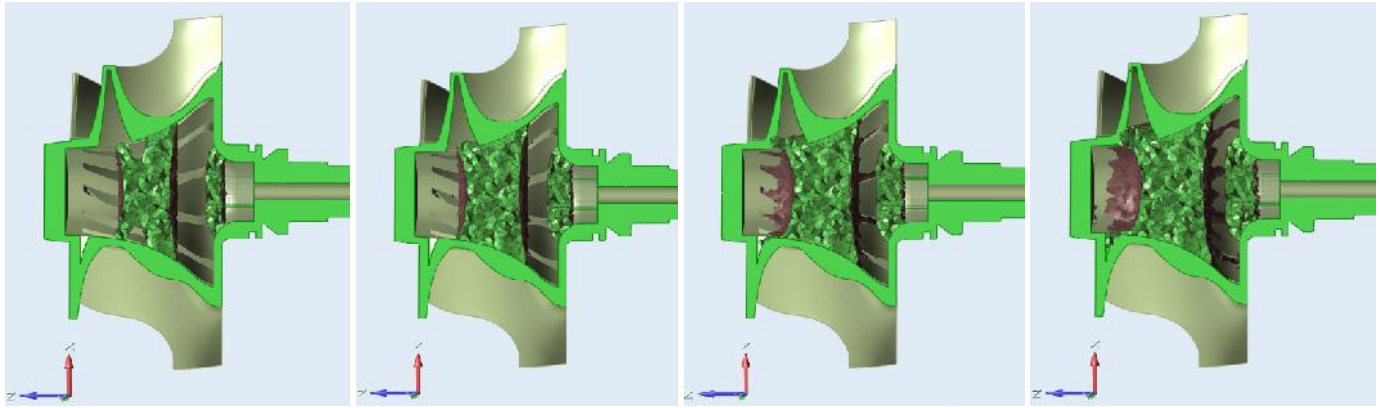


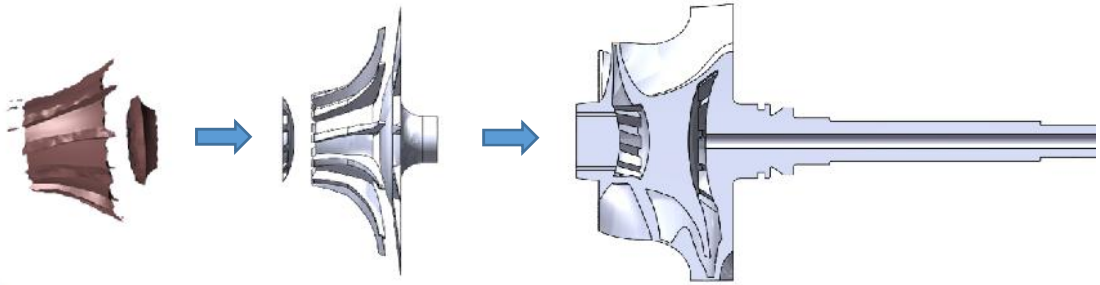


- Generate Mechanical properties to design against – tensile / fatigue/creep

Introduce Novel Design

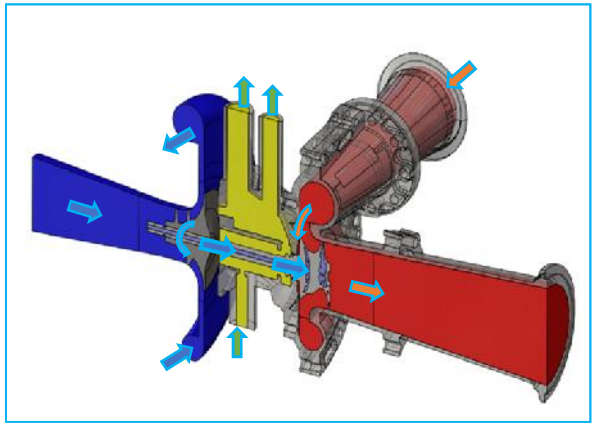
- Topology Optimisation used to lightweight design
  - Identifies where material is most required
  - Gives Understanding of load paths through wheel

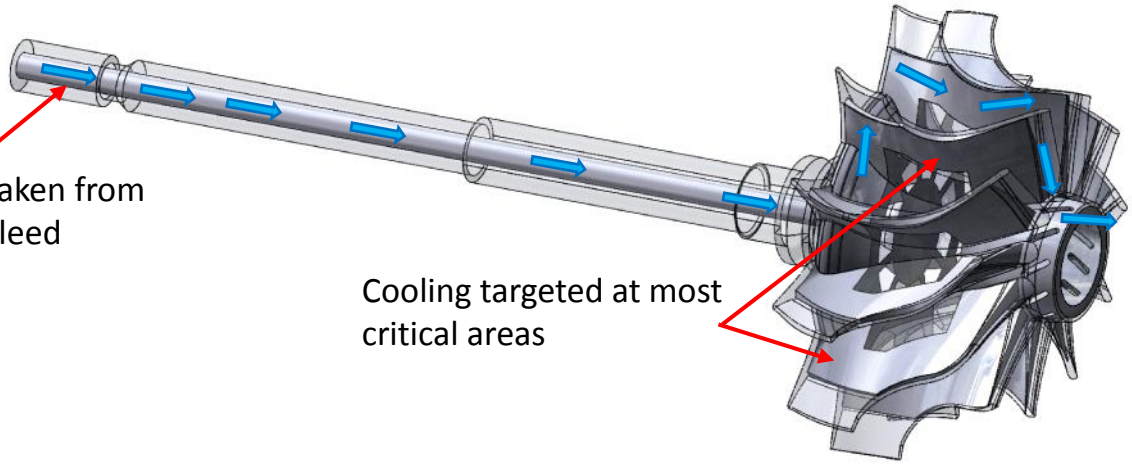




Introduce Novel Design

- Targeted cooling system then introduced
  - Arrangement for Physical Test considered
  - Cooling targeted at hot spots – LE & blade surface
  - DFAM considerations brought
  - Full CFD/FE carried out to ensure component fit for purpose & predict performance





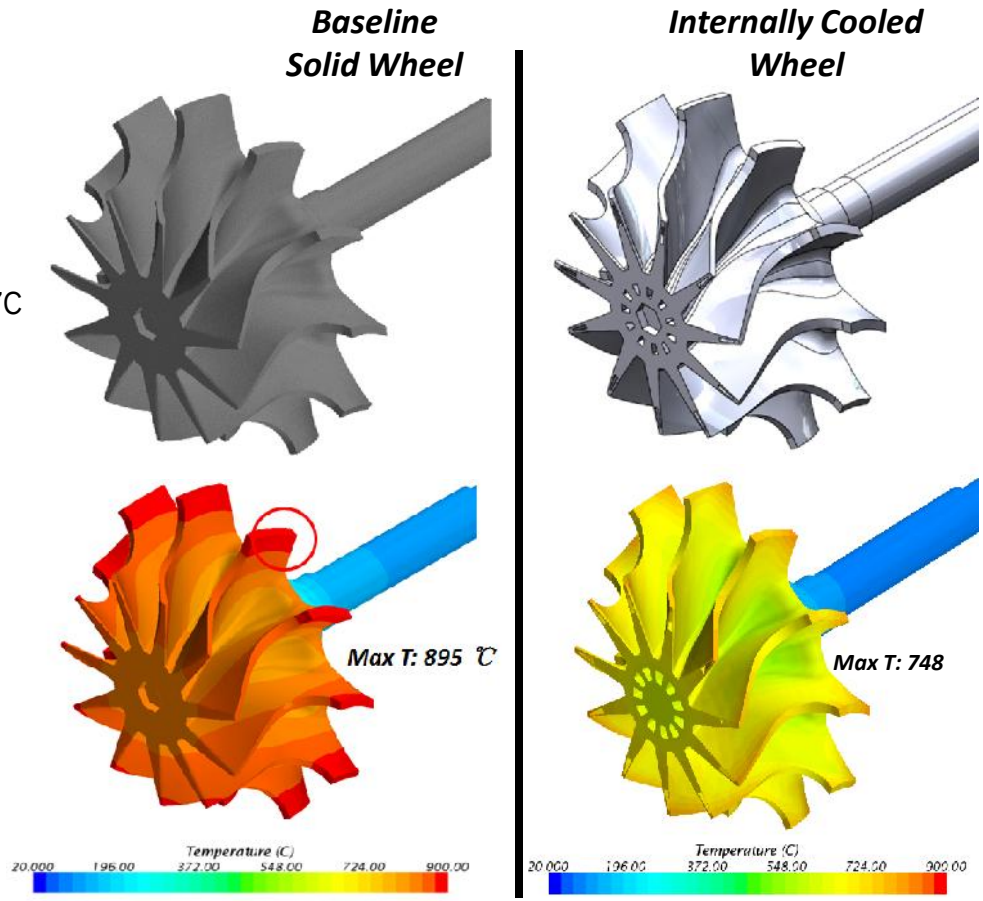
How does it perform?

- 22% mass reduction vs Solid wheel baseline

@ 1050C TiT Des point:

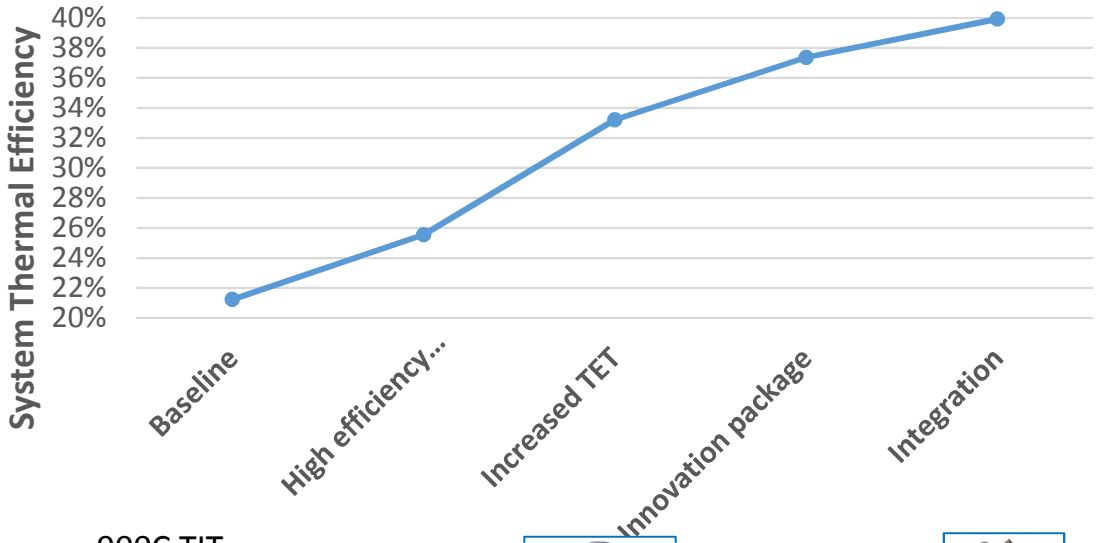
- LE temperature reduction of 147C
- Hub temperature reduction of over 200C
- TE temperature reduction of approx. 150C

- Up next Physical test...



The Bigger Picture...

- Real gains come when innovations are brought together...
  - Low-Mid kW Micro-Turbine systems (15kWe)
  - Feasible to get to 40% thermal efficiency



900C TIT
73% η_c
78% η_t
90%

76% η_c
78% η_t

78% η_c
82% η_t
92% $\varepsilon_{recuperator}$

Lower pressure losses
93% $\varepsilon_{recuperator}$

Thank you


LCV
cenex