ETN *October* Workshop
ETN Additive Manufacturing WG activities and future prospects

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12-13 October 2022, Park Inn by Radisson, Berlin, Germany

ETN Additive Manufacturing WG

Disruptive Technologies to enhance Rotating Equipment

AM challenges to be solved

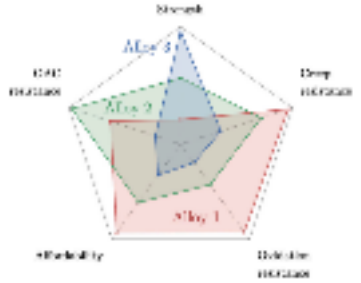
- Availability of qualified materials
- Predictable, stable & repeatable processes
- Quality Management
- Horizontal & vertical machine integration
- Productivity / cost
- Digital Twin & Simulation

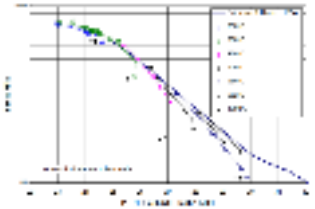
Current WG focus Activities 1

- AM productivity & product quality: Case study on AM Printers performance, quality and productivity

Current WG focus Activities 2

- High temperature AM materials for GT Blades development initiative.
- Analysis of Blades AM Materials current status,
- Materials development Specification set up





ETN Activities 2022

ETN's L-PBF Machine Evaluation Initiative

Objectives

Demonstrate performance & productivity of L-PBF machines from participating suppliers

Project scope

- Material: Nickel Alloy 718
- Post processing by central organisation (HIP, surface treatment …)
- Component: GT Heat Shield
- Deliverables:
  - printed component
  - criticality application
  - test specimen
  - cubes
  - powder capsule
  - report

Status & next steps

- All print jobs from all L-PBF suppliers done
- Heat treatment started
- After heat treatment heat shields will be extracted from the plate
- Visual inspection and 3D scanning will be done and reported
- Printing precision will be defined and compared
- Printing quality will be examined
- Material properties will be defined & compared
- Productivity of different machines will be compared
- Expect results in end of December-beginning of January

ETN Activities 2022

High temperature materials development Initiative

Objectives

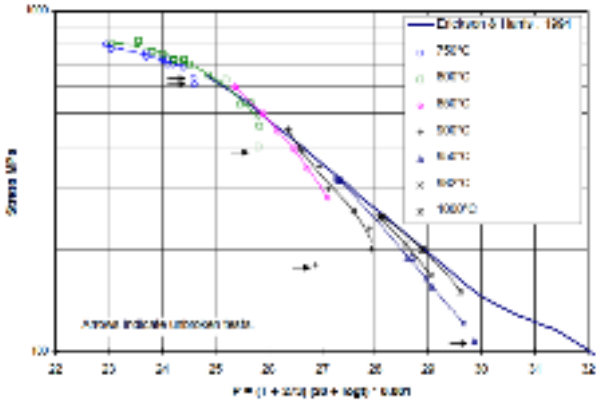
Initiate development of Hight temperature AM materials for turbine blades

Project scope

- Show High temperature AM materials status for gas turbine components (search in the open literature)
- High temperature Material development specification
- Industry & Academy collaboration set up under ETN coordination
- Government funding application
- Technology project execution

Status and next steps

- **Project** proposed and **agreed to start**
- **PM** (Project manager) **assigned** (Yogi Pardhi)
- **Search in the open literature** for high temperature materials developments status **started**
- Material development **specification preparation initiated**
- Based on the search results the next steps in the **project** will **be defined**



AM contribution to Decarbonized World and Energy Transformation

GT's sustainable value & flexibility generated by AM technology

Business Value Improvement

Generated value:

- Efficiency improvement to reduce OpEx and Emissions
- Longer Life of GT-components to reduce Lifecycle cost
- Operation flexibility enhancement
- Increased Power Plant Profitability

Lead Time Reduction

Speed:

- Rapid development, prototyping, validation and manufact.
- Spare Parts on Demand
- Quick response to Customer demands

Environmental Contribution

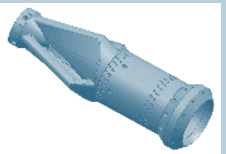
Sustainable value:

- 30% less carbon footprint due to less waste materials and transportation
- Fuel Flexibility (e.g. , biofuel, H2, towards zero CO2)
- Energy efficiency enhancement (more Power for less fuel & emissions)
- Opportunity for AM components re-cycling

Fuel flexibility enabled by AM

AM burners enabling H_2

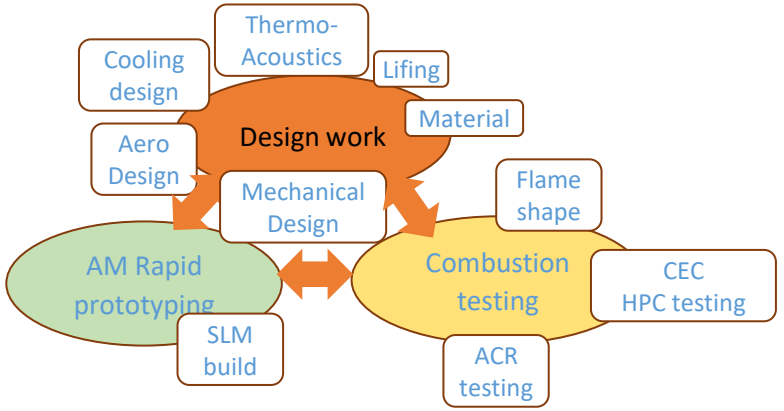
Braskem

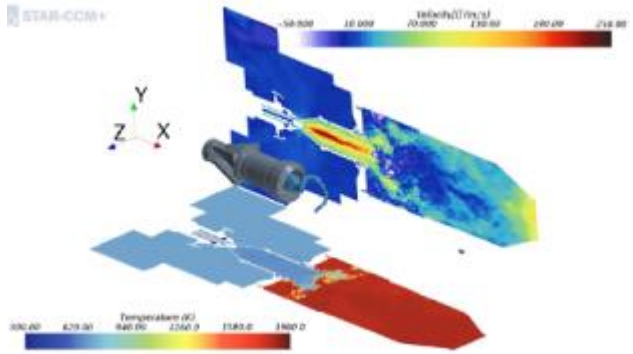


- 2x SGT-600 DLE Sold to Braskem – Brazil
- In operation beginning of 2022
- **60% H2** content in natural gas

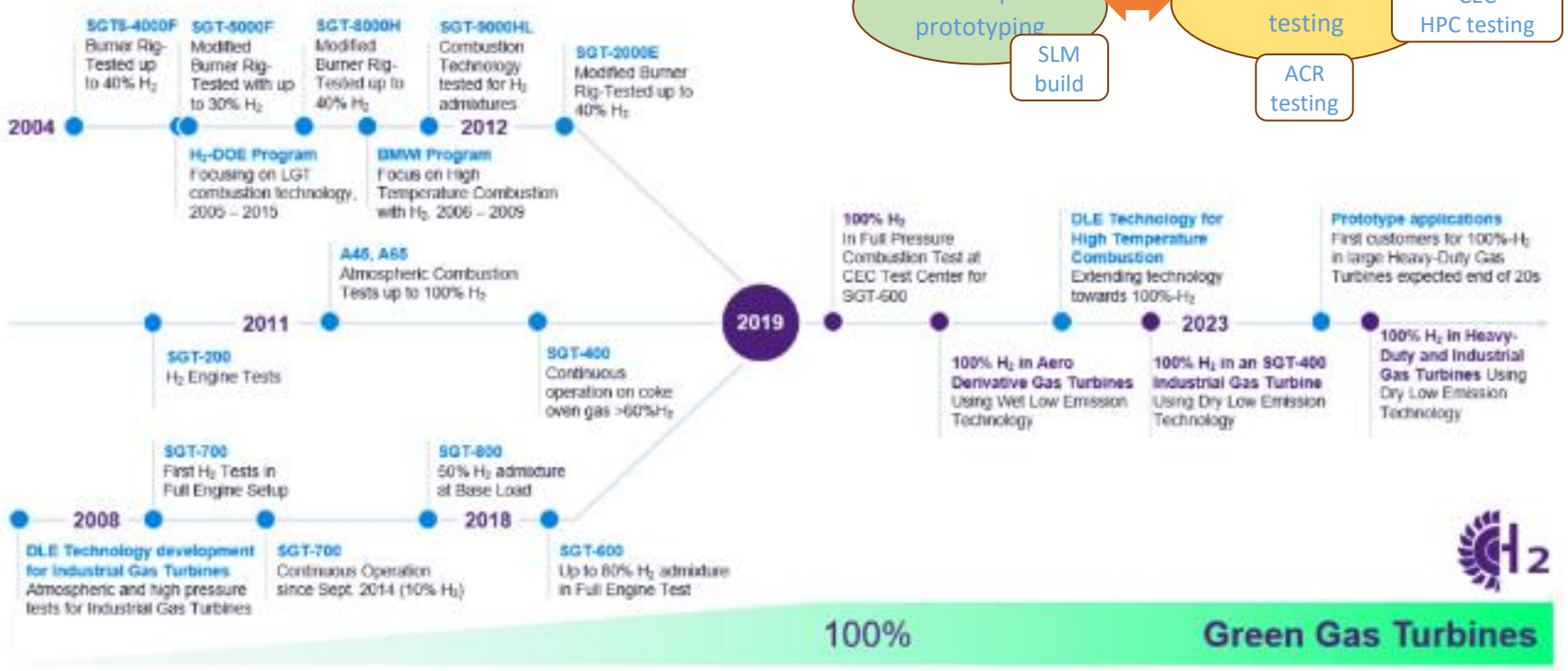
AM contribution to Decarbonized

Acceleration of H2 development towards 100% enabled by AM





iBuMa H2 concept iterations
Theory guides but experiment decides!

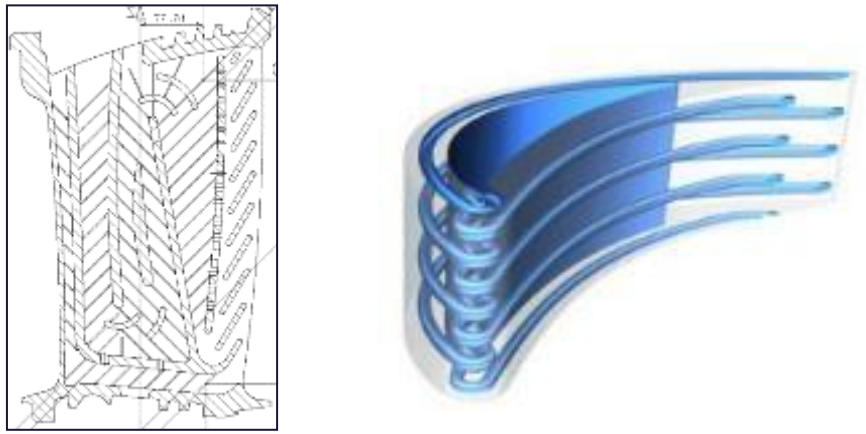


Additive Manufacturing as a Key Enabler

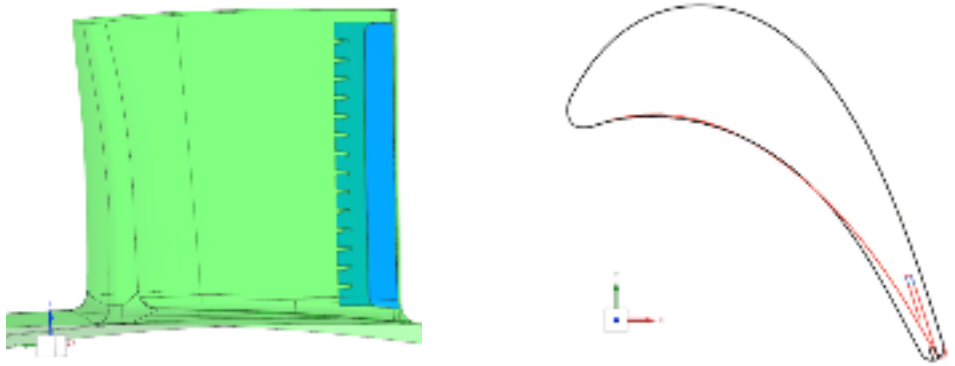
GT efficiency enhancement by Additive Manufacturing

Key approaches for GT efficiency improvement:

- **Turbine blades and vanes aerodynamic enhancement**
  - 3D airfoils profiling w/o any geometry limitation (compared to casting)
  - Thin trailing edge
  - Cooled light-weight shrouds
- **Blades & Vanes Cooling air saving**
  - Less cooling air for blades and vanes to improve turbine efficiency



Traditional and additive cooling systems

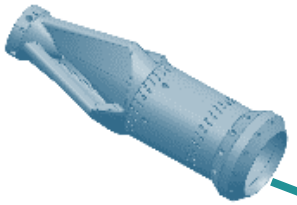


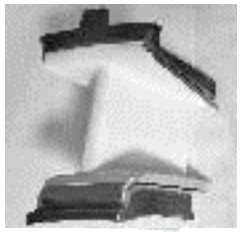
Cast vs.AM airfoils overlay with TE emphasis

Additive Manufacturing as a Key Enabler

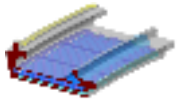
Through energy efficiency towards decarbonization

IBUMA:
- H2 capability



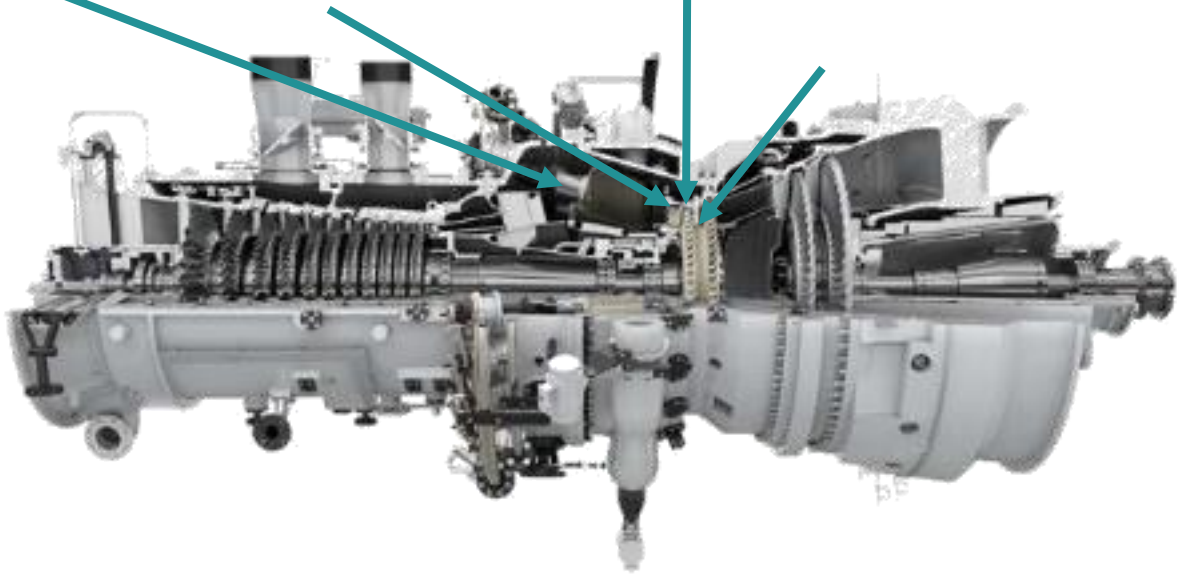


GV1:
- Performance improvement or life extension

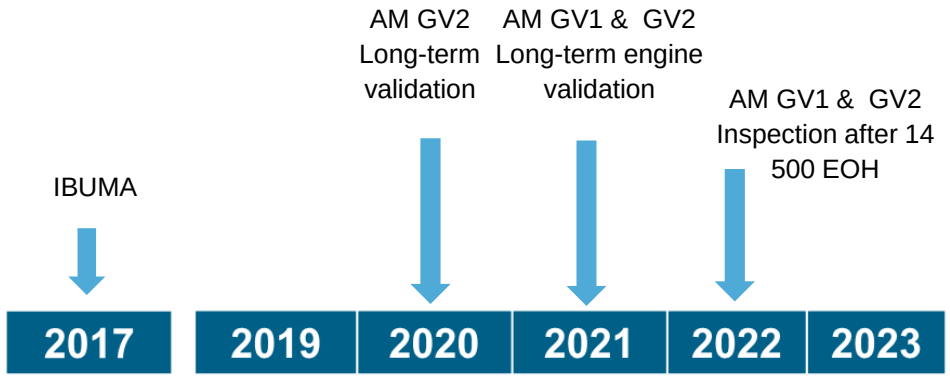


HS1:
- Performance improvement or life extension
- Reduced perform. degradation

GV2:
- Performance improvement or life extension



AM Component field Validation



Additive Manufacturing as a Key Enabler

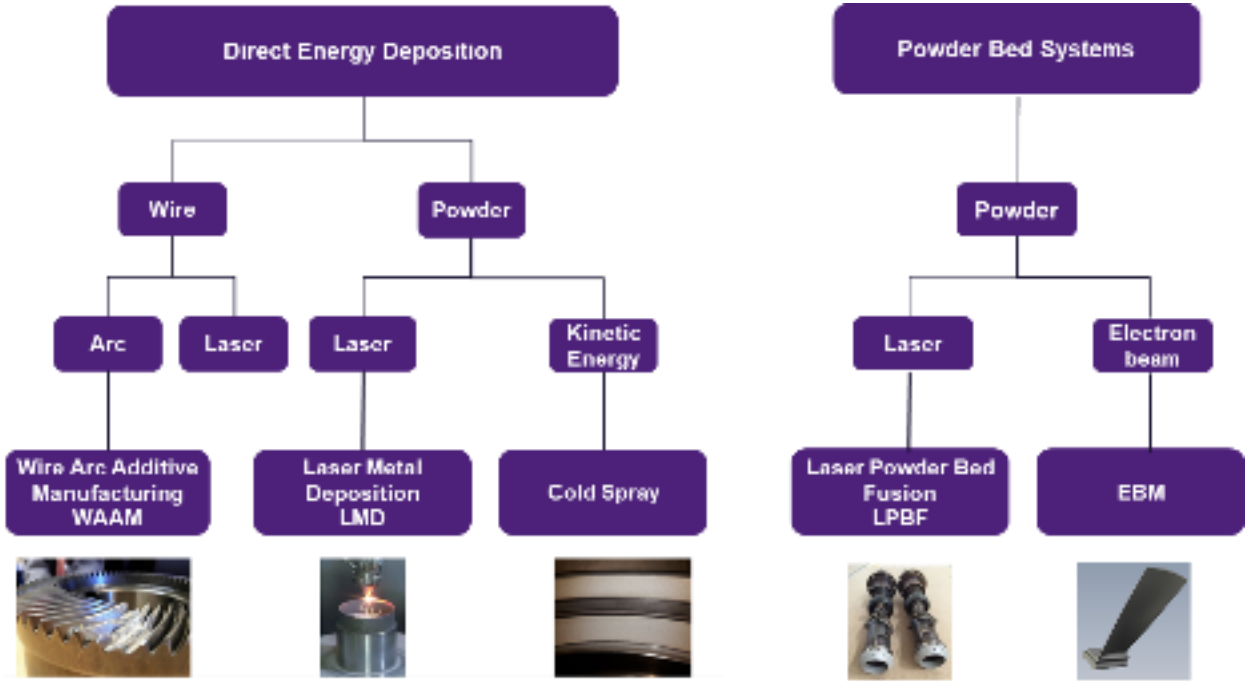
AM enables not only life cycle cost reduction, but generates sustainable value

Target:

Development and application of repair technology to reduce cost / outage time

Flexible refurbishment options

Factory in the field

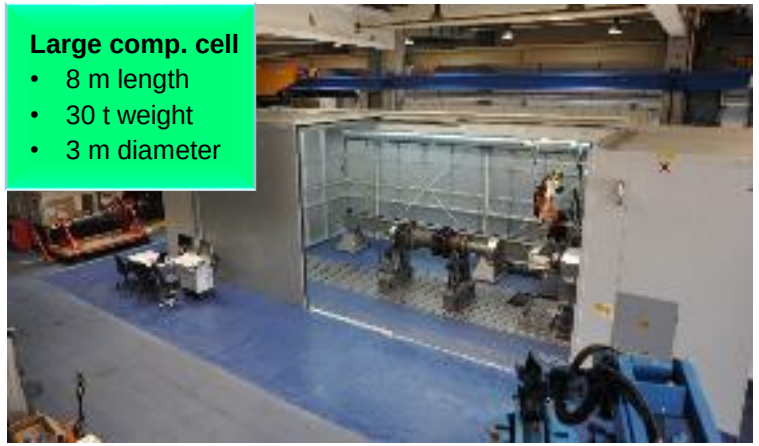


Additive Manufacturing as a Key Enabler

SE LMD CoC in Nuremberg as blueprint for future regional roll-out

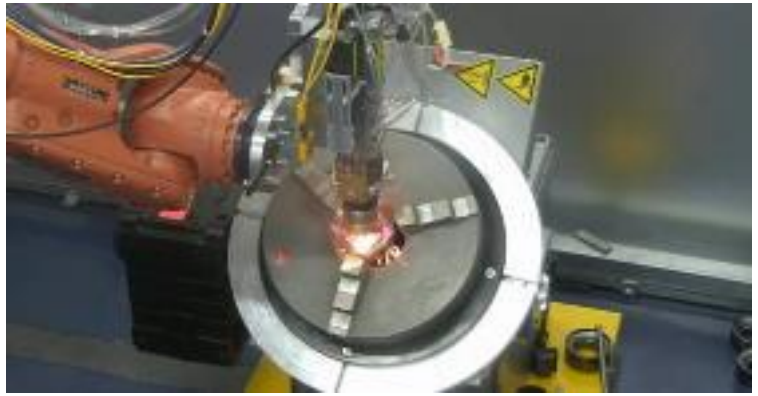
LMD CoC “Laser cladding center”

Large comp. cell
- 8 m length
- 30 t weight
- 3 m diameter



Rotor repair solutions

Spare part manufacturing and repair



Additive Manufacturing as a Key Enabler

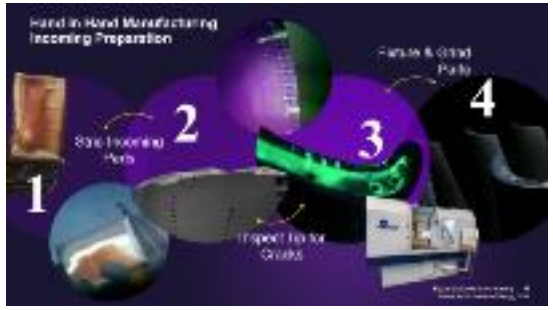
Our First Additive Manufacturing technologies application was started from SGT-700/800 burners repair in FY2013

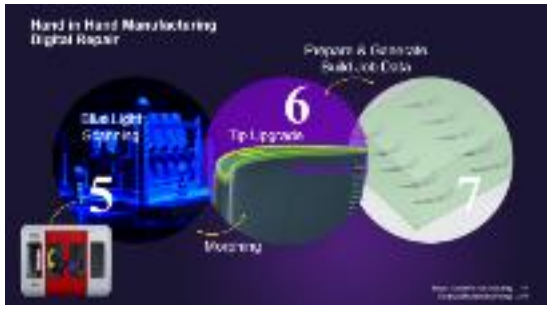
Rapid Repair- 90 % lead time reduction

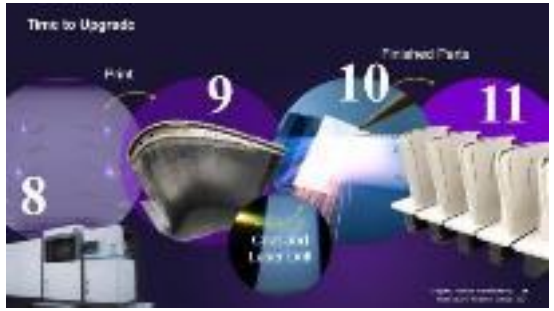
- **Product**: SGT-700/800
- **Component/scope**: Burner tip
- **Benefits**:
  - Quick burners upgrade to latest design
  - Life extension
  - Lifecycle cost reduction
  - Decarbonization
- **Status**:
  - In commercial application since 2013
  - **> 1 500 000 hours** accumulated operating field experience

Additive Manufacturing as a Key Enabler

AM enables not only life extension, but also GT performance enhancement and sustainability

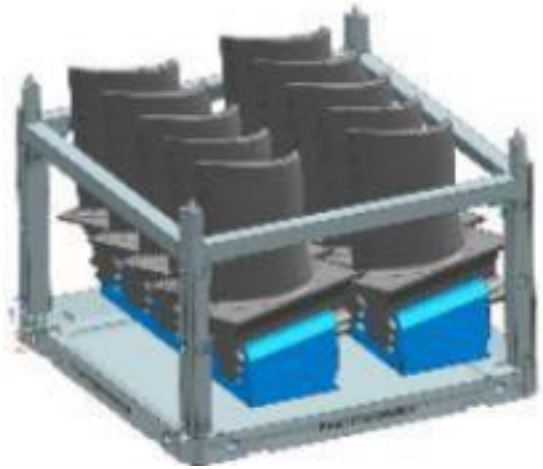


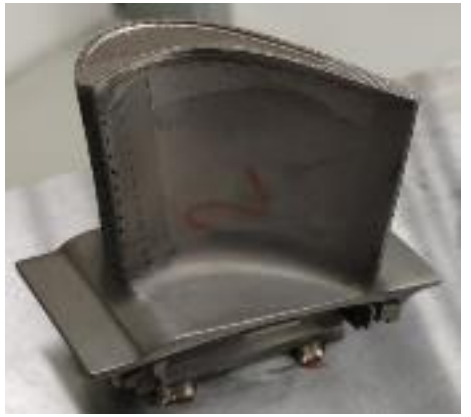




Blade tip repair

- Laser Powder Bed Fusion qualified since 2020
- > 24 000 EOH field experience
- Life extension + performance enhancement
- Significant reduction of blade tip temperature (>100 ºC) by improved cooling of blade's tip
- Turbine performance degradation rate slows down





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