



# Hard Material Small-Batch Industrial Machining Robot

## HEPHESTOS Project

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*Use Case I: Flexible robotic machining cell*  
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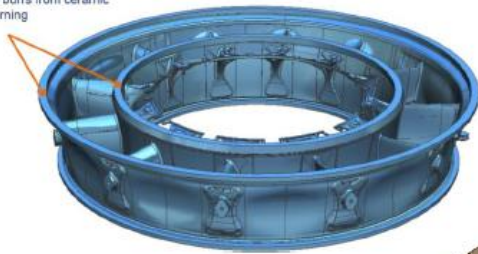
# 1. Main goal of demo

- Adaptive control system for robotic manipulators performing milling and surface finishing operations.
- Flexible robotic machining demo cell based on standard robotic cells architecture developed at MAG
- Intended applications involve: machining of large parts such as propellers blades, motor blocks, gas turbine components etc. with complex surface geometry
- The novel **Hephestos** cell will integrate the entire Hephestos development

## 2. Workpiece examples

1. Finishing of fabricated gas turbine frame structures
2. Milling of blades for large marine propellers and hydraulic turbine runners
3. Dressing of repaired gas turbine airfoils

Edges with hard burrs from ceramic turning



# 1. Finishing of fabricated gas turbine frame structures

- Large workpieces, diameter up to 2.5 meters
- Typically hard and thick burrs (due to machining with ceramic tools)
- Some burrs near to finished surfaces that can not be machined
- Fabricated parts: Difficulties to define burr location because of the geometrical distortions of the part due to welding and heat treatment processes
- Irregular burrs (interrupted, irregular thickness, ...)
- Big amount of different features to deburr
- Complex geometries with difficult to access burrs
- Typical materials : Inconel, Waspaloy, M152 Jethete, Greek Ascaloy

## 2. Milling of blades for large marine propellers and hydraulic turbine runners

- Large workpieces, diameter typically up to:
  - 6 meters for Fixed Pitch Propellers (monoblock)
  - 3x3 meters for Controllable Pitch Propeller
- Complex geometries
- Hard tool milling required
- Typical materials:
  - Marine Propellers: high strength copper nickel alloy (Nibron), Cunial bronze, Nickel Aluminium Bronze, CuNi 90-10 (CuNi10Fe1Mn) and CuAl9Ni3Fe2,
  - Hydraulic turbine runners: martensitic stainless steel, X3CrNiMo13.4, ASTM A743 GrCA6NM

### 3. Dressing of repaired airfoils

- Distorted part geometry and significant complex shape variation between blades due to the service-run components.
- Some brazed areas near to finished surfaces that can not be machined
- Irregular areas to be finished (interrupted, irregular thickness, ...)
- Hard to access areas for imaging sensors and tools
- Complex geometries
- Adaptive toolpath generation for repaired areas
- Typical materials : Ti64, Inconel

# System description

## Demonstration Cell (DEMO1) features:

- Wet or dry milling/finishing
- Different spindle tools available
- Possibility to use ABB or Comau robot
- Possibility to compare ABB FC performance to Hephestos FC/impedance control performance
- 6 or 7 DOF
- Auto tool exchange w/ tool storage and automatic TCP calibration

