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Disc Requirements

- Bare Disc Dimensions and Tolerances
  - Inner radius: 267 mm ±0.5 mm
  - Outer radius: 567 mm ±0.5 mm
  - Concentricity: 0.3 mm
  - Thickness: 8.7 mm ±0.2 mm
  - Flatness: 0.5 mm

- Dimensional Stability Requirements
  - At running conditions the dimensional changes should be less than 10 µm/meter for a period of 24 hours
  - Following a change of assembly conditions to running conditions the dimensional changes must be less than 300 µm/meter
Disc Requirements

- Stiffness Requirements
  - The natural frequency of the fully assembled disc shall be higher than 15 Hz
  - The maximum displacement permitted on the statically loaded assembled disc shall be:
    - <10 µm in plane for combined loading
    - <100 µm out-of-plane for combined loading
    - <50 µm out-of-plane between two mounts of one module for combined loading

- Insert Requirements
  - Disc thickness: ± 0.1 mm
  - Any two inserts on same module: ± 0.05 mm
  - Slope: 1 mrad
  - Position screw holes: ± 0.1 mm

- Mounting Block Requirements
Disc Design
Disc Design

Design Considerations:

- Thermal loads → Low and stable CTE
- Low moisture absorbent materials
- Mechanical loads → High stiffness structural elements
- Acceptable cost
Disc Design

- Facing material
  - High modulus fibers
  - Low CTE and CME
  - Quasi-isotropic and balanced lay-up
  - Thick enough faces

- Core Material
  - High enough shear strength and stiffness
  - Low enough CTE and CME
  - High enough Flatwise Tensile Strength

- Other Considerations:
  - Long-term radiation effects
Disc Design

Disc Material chosen:

- Facesheet: XN50A/RS-3 UD prepreg
  (+60°/-60°/0°) 3 plies per facesheet lay-up

- Rings: RS-3/T300 Fabric Prepreg
  (±45°) 9 plies per lay-up

- Film adhesive: RS4-A, 100 g/m²

- Honeycomb: Korex-5/32-2.4
Disc Design

Inserts/Pads

- Provide z-location of the cooling blocks and hence modules
- Should hold the modules in stable positions
- Precision machined down to give accurate height and take out non-flatness in disc surface
- Must have sufficient strength to withstand loads

- Several Insert/Pad designs have been tested
- Displacement due to torques and forces were within requirements
- Two-sided inserts only at the corners of the cooling circuit
- Glue-on pads are adequate where forces are low
- Good bonding strength between core and facesheet needed
Disc Design
Disc Design

Disc preparation:
- Disc will be manufactured in industry with the inner and outer diameter machined
- Bond 12 mounting blocks
- Machine apertures and insert holes
- Bond inserts and pads
- Machine the inserts/pads flat

- Experience exists preparing a quarter disc section
Disc Design

Mounting Block - Disc Fixing

- Provide 12 attachment points between disc and support cylinder
- Should hold the discs in stable positions
- Must have sufficient strength to withstand loads
- Allow for radial movement of disc in cylinder

- Natural frequency with 12 mounting points are within requirements
- Successfully loaded a mounting block with 100 N
- Calculations and individual tests of disc fixing are promising
- Tests with 12 disc fixings will be done very soon
Disc Design
Disc FEA

- The final disc design has been modelled in FEA

- Two prototype discs have been used to obtain a reasonable and acceptable model:
  - Dummy disc
  - Cheap O

- The tests which have been performed are:
  - Vibration tests to measure resonance frequencies
  - Stiffness tests to measure the out-of-plane stiffness
The results obtained from the prototypes are in good accordance with the FEA model.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Natural Frequency [Hz]</th>
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<td>Forced vibration</td>
<td>Test</td>
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<tr>
<td>12 mounting points</td>
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<td>2</td>
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<td>Free vibration</td>
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Disc FEA

- Calculations that have been performed with the final disc design are:
  - Frequency calculations
  - Out-of-plane stiffness calculations
  - In-plane stiffness calculations
  - Deflection calculations after cooling down
  - CTE and CME calculations

- All the results are within the requirements specified
First natural frequency mode of the final disc design – 22.1 Hz
Disc Prototyping and Tests

- 3 prototype discs have been manufactured:
  - Dummy Disc
  - Cheap O
  - Good O

- The goal was to get experience with
  - Discs
  - Manufacturing discs
  - Machining discs
  - Korex
  - QA/QC
  - Obtain a reasonable and acceptable FEA model
  - Problems
Disc Prototyping and Tests

- Measurements that have been performed are:
  - Flatness
  - Concentricity of inner and outer ring
  - Thickness
  - Natural frequency
  - Static stiffness
  - Influence of apertures on the disc stiffness

- We learned that:
  - Making a disc according to the dimensions and tolerances required is not an easy task, but with proper tooling and an experienced contractor can be achieved.
Disc Prototyping and Tests

Height vs. r-phi
Cheap O side 1 Height Map

Height vs. r-phi
Good O side 1 Height Map
Summary

- The results obtained from the prototypes are in good accordance with the FEA model.

- From the prototype and FEA results we are confident that with the current disc design we have reached the dimensional stability requirements and the stiffness requirements.

- With the proper tooling and experience, we are confident that, a contractor can manufacture 20 bare discs within the specified dimensions and tolerances. From an other project and experienced people in the field we learned that with similar product sizes, as the disc, a flatness up to 0.2 mm was achieved.
Summary

- With Korex as honeycomb material we reached a reliable skin-core attachment, acceptable CME and CTE, and acceptable cost for the disc.

- Several inserts are designed, manufactured and tested and found to be within requirements. Two-sided inserts will be used at the corners of the cooling circuit and glue-on pads at the intermediate positions where the forces are low.

- 12 mounting points are needed for stiffness requirements. The disc fixings will be tested within weeks.

- For disc preparation we have conceptual solutions. Further testing and developments will be made in the next months.