NASA Rotor 37

- Français
- English

This page contains various informations associated to one of the rotor 37 blade model used in LAVA publications.

Downloadable files

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Open access

Git project

Original model

- Original technical report [1]:

```
@TechReport{reid1978design,
author      = {Reid, L. and Moore, R. D.},
title       = {Design and overall performance of four highly loaded, high
speed inlet stages for an advanced high-pressure-ratio core compressor},
institution = {NASA Lewis Research Center Cleveland, OH, United States},
note        = {NASA-TP-1337, url~:
\url{https://ntrs.nasa.gov/citations/19780025165}, 1978 (accessed
2020-10-29)}}
```

- Pictures :

Fig1. https://catalog.archives.gov/id/17468361

Fig2. https://catalog.archives.gov/id/17468389

```
@Misc{huebler1977records,
author   = {Huebler, D.},
title    = {Rotor 37 and stator 37 assembly. {R}ecords of the {N}ational
{A}eronautics and {S}pace {A}dministration, 1903 - 2006. {P}hotographs
relating to agency activities, facilities and personnel, 1973 - 2013},
note     =
{\href{https://catalog.archives.gov/id/17468361}{https://catalog.archives.
gov/id/17468361}, 1977 (accessed 2020-10-29)}, % for Fig. 1
```

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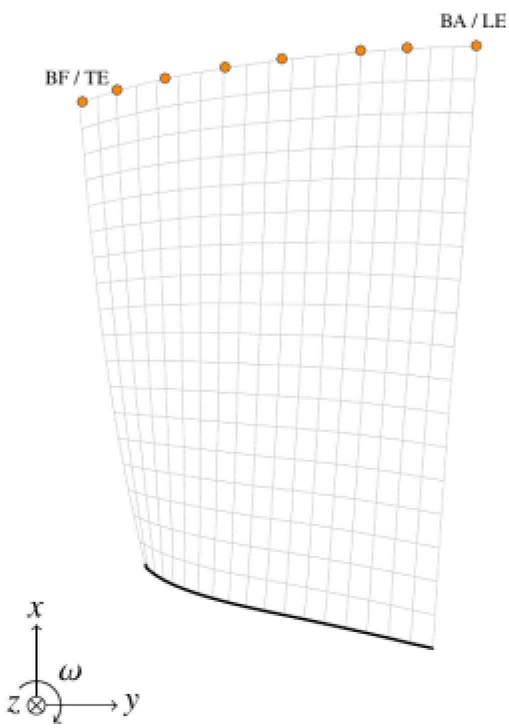
note     =
{\href{https://catalog.archives.gov/id/17468389}{https://catalog.archives.
gov/id/17468389}, 1977 (accessed 2020-10-29)}, % for Fig. 2}
```

Finite element mesh

- Number of nodes: 5745
- Total number of elements: 1800
- Number of degrees of freedom: 16524
- Element type: quadratic pentahedron



finite element mesh overview (coarse mesh)

- Number of nodes: 20657
- Total number of elements: 6664
- Number of degrees of freedom: 60588
- Element type: quadratic pentahedron

finite element mesh overview (refined mesh) -
LaTeX source files

Material properties

- Rotor 37 is made of a 200-grade maraging steel [1]
- Considered properties : 18-Ni 200-maraging alloy [2] [3]:
    1. Young's modulus E = 180 GPa

2. densityρ = 8000 kg/m3
3. Poisson's ratio ν = 0.3
4. yield stress σ_Y = 1.38 GPa (200 000 psi)

- First three predicted natural frequencies (with clamped root) for the coarse mesh:
  1. 1B: 5272.3 rad/s / 839.1 Hz
  2. 1T: 15760.5 rad/s / 2508.4 Hz
  3. 2B: 19071.3 rad/s / 3035.3 Hz
- First three predicted natural frequencies (with clamped root) for the refined mesh:
  1. 1B: 5368.7 rad/s / 838.5 Hz
  2. 1T: 15754.7 rad/s / 2507.4 Hz
  3. 2B: 19032.9 rad/s / 3029.2 Hz

Featured articles from the LAVA

- *The harmonic balance method with arc-length continuation in blade-tip/casing contact problems* [2]
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```
  @Article{colaitis2021harmonic,
  author   = {Cola\"{i}tis, Y. and Batailly, A},
  title    = {{The harmonic balance method with arc-length continuation in
blade-tip/casing contact problems}},
  journal  = {J. Sound Vib.},
  year     = {2021},
  volume   = {502},
  pages    = {116070},
  issn     = {0022-460X},
  note     = {\href{https://doi.org/10.1016/j.jsv.2021.116070}{doi~:
10.1016/j.jsv.2021.116070} -
\href{https://hal.archives-ouvertes.fr/hal-03163560}{oai: hal-03163560}},
  abstract = {This article presents a Harmonic Balance Method-based
numerical strategy to provide a qualitative numerical characterization of
a compressor blade’s dynamics when structural contacts occur with the
surrounding casing. The mitigation of the Gibbs phenomenon follows a two-
pronged approach: (1) a regularization of the unilateral contact law and
(2) the adjustment of the Fourier coefficients by means of a Lanczos
filtering technique. In order to validate the proposed approach, it is
first applied to an academic cantilever rod undergoing unilateral contact
constraints. An in-depth comparative analysis of the obtained results—with
an emphasis on displacements, contact forces and velocities—with respect
to a time integration-based reference numerical strategy underlines the
relevance and accuracy of the proposed methodology. The latter is then
applied to the vibration analysis of an industrial compressor blade: NASA
rotor 37. For a given contact configuration, obtained results are
thoroughly compared to those obtained with a previously published time
integration-based numerical strategy with a distinct contact treatment
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algorithm. Particular attention is paid to demonstrate the accuracy of the
methodology for the prediction of displacements, contact forces,
velocities as well as stress fields within the blade. Notably, it is
evidenced that the proposed methodology, contrary to the reference time
integration-based numerical strategy, is able to capture the exact
location of the blade’s nonlinear resonance.}}
```

- *Blade/casing rubbing interactions in aircraft engines: Numerical benchmark and design guidelines based on NASA rotor 37* [3] BibTex
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  @Article{piollet2019blade,
  author   = {Piollet, E. and Nyssen, F. and Batailly, A.},
  title    = {Blade/casing rubbing interactions in aircraft engines:
Numerical benchmark and design guidelines based on NASA rotor 37},
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  year     = {2019},
  volume   = {460},
  pages    = {114878},
  issn     = {0022-460X},
  note     = {\href{https://doi.org/10.1016/j.jsv.2019.114878}{doi~:
10.1016/j.jsv.2019.114878} -
\href{https://hal.archives-ouvertes.fr/hal-02281666}{oai: hal-02281666}},
  abstract = {In order to improve the efficiency of aircraft engines, the
reduction of clearances between blade tips and their surrounding casing is
one avenue manufacturers consider to lower aerodynamic losses. This
reduction increases the risk of blade tip/casing contact interactions
under nominal operating conditions. Designers need tools to accurately
predict subsequent nonlinear vibrations. Engineers and researchers have
developed a variety of sophisticated numerical models to predict blades'
responses. These models are related to distinct frameworks (time/frequency
domain) and various solution algorithms (explicit/implicit time
integration schemes, penalty/Lagrange multiplier contact treatment…) which
calls for comparative analyses. However, published results are often
limited for the sake of confidentiality thus preventing any detailed
confrontation. While qualitative understanding can be gained from
simplified academic models, full scale models are needed to predict
complex interactions in a realistic manner. In this context, this paper
proposes a benchmark featuring detailed simulations and analyses of a full
3D finite element model based on the open NASA rotor 37 compressor blade
to facilitate reproducibility and collaboration across the research
community. NASA rotor 37, a compressor stage widely used as a test case in
aerodynamic simulations and validations, has the advantage of presenting a
realistic blade geometry. The geometry of the blade is built from publicly
available reports. The paper provides details on the geometry, the
numerical model and the results to allow an easy use of this model across
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one with direct contact against the casing, and one with abradable
material deposited on the casing to mitigate contact severity through
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time domain. It is evidenced that the addition of the abradable material
decreases the amplitude of vibration for most of the angular speeds
investigated. However, new interactions appear for some angular speeds.
The obtained results are consistent with previous simulations on
industrial geometries. Based on works showing improved aerodynamic
performances when the blade is tilted, a total of seven geometries are
investigated: the reference blade, with a straight vertical stacking line
similar to the original rotor 37, two forward-leaned blades, two backward-
swept blades and two full forward chordwise swept blades. The sweep and
lean variations are shown to have a dramatic impact on the vibration
response: the backward sweep results in an increased blade's robustness to
contact events and the full forward chordwise sweep in a reduced
robustness, while the forward lean leads to a robustness similar to the
reference blade.}}
```

Cette page contient diverses informations associées à l'un des modèles de l'aube NASA rotor 37 utilisé dans les publications du LAVA.

Fichiers téléchargeables

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Libre accès

lien vers le projet Git

Modèle original

- Rapport technique original [1]:

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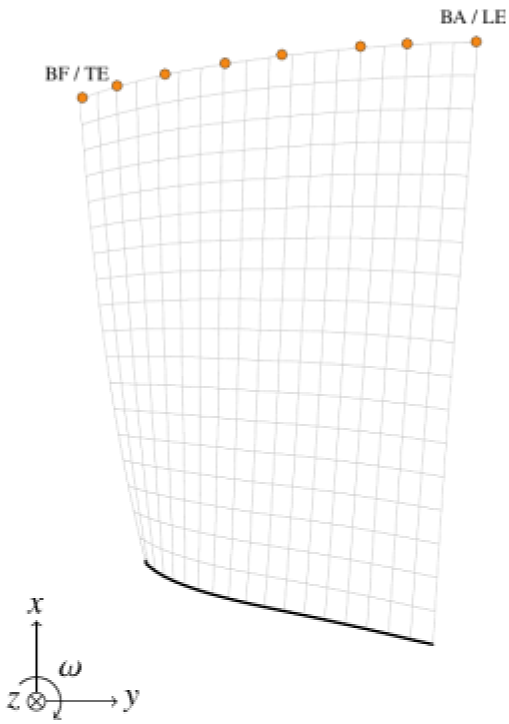
Maillage éléments finis

- Nombre de noeuds : 5745
- Nombre total d'éléments : 1800
- Nombre de degrés de liberté : 16524
- Type d'élément : pentaèdre quadratique



aperçu du maillage éléments finis (maillage grossier)

- Nombre de noeuds : 20657
- Nombre total d'éléments : 6664
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aperçu du maillage éléments finis (maillage fin) - sources LaTeX

Propriétés matériau

- Le matériau du rotor 37 est un alliage à base de nickel : un acier maraging de grade 200 [1]
- Propriétés considérées : alliage 18-Ni 200-maraging [2] [3]:

1. Module d'Young E = 180 GPa
2. masse volumique ρ = 8000 kg/m3
3. coefficient de Poisson ν = 0,3
4. limite élastique σ_Y = 1,38 GPa (200 000 psi)

- Trois premiers modes prévus (noeuds de la base encastrés) pour le maillage grossier :
  1. 1F : 5272,3 rad/s / 839,1 Hz
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Articles du laboratoire

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```

1. [a, b, c, d] Reid. «Design and overall performance of four highly loaded, high speed inlet stages for an advanced high-pressure-ratio core compressor » 1978. p64 pdf
2. [a, b, c, d] Colaïtis. «The harmonic balance method with arc-length continuation in blade-tip/casing contact problems » 2021. doi/oai
3. [a, b, c, d] Piollet. «Blade/casing rubbing interactions in aircraft engines: Numerical benchmark and design guidelines based on NASA rotor 37 » 2019. doi/oai