# Rotor 27A

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## Original model

Rotor 27A is part of a research program to study the effects of aspect ratio, diffusion factor, and solidity on rotors. To do so, experimental studies have been conducted on a series of high-hub-tip-radius-ratio compressor stages representative of the middle and latter stages of axial-flow compressors. In fact, 14 middle stages were tested to assess the effects on performance of varying both diffusion through the rotor and stator blades and blade aspect ratio. Among these 14 stages, there are rotors 23B, 24A, 25A, 26B, 27A and 28B. Both the tip diameter and the hub-tip radius ratio were held constant throughout each stage at 50.8 centimeters and 0.8, respectively.

- Original technical report [(cite:britsch1979design>Britsch. «Design and overall performance of four highly loaded, high speed inlet stages for an advanced high-pressure-ratio core compressor » 1979. pdf)]:

```
@TechReport{britsch1979design,
author      = {Britsch, Werner R. and Osborn, Walter M. and Laessig, Mark
R.},
title       = {Effects of Diffusion Factor, Aspect Ratio, and Solidity on
Overall Performance of 14 Compressor Middle Stages},
institution = {NASA Lewis Research Center Cleveland, OH, United States},
note        = {NASA-TP-1523, url~:
\url{https://ntrs.nasa.gov/citations/19790025039}, 1979 }}
```

- Picture :



https://catalog.archives.gov/id/17447129

```
@Misc{brown1975records,
author   = {Brown, M.},
title    = {Rotor 27. {R}ecords of the {N}ational {A}eronautics and {S}pace
{A}dministration, 1903 - 2006. {P}hotographs relating to agency activities,
facilities and personnel, 1975 - 2013},
note     =
{\href{https://catalog.archives.gov/id/17447129}{https://catalog.archives.gov/
id/17447129}, 1975 }, % for Fig. 1}
```

## Useful documents

- PDF of the NASA report :

  rotor27a.pdf

- CSV file of the blade geometry :

  rotor27a_original.csv

## Geometry

The geometry of rotor 27A is described in the original NASA report by the following tables. The length are in centimeters and the angles in degrees.

TABLE 12. – BLADE GEOMETRY FOR ROTOR 27A

| RP | PERCENT SPAN | RADII RI | RADII RO | BLADE ANGLES KIC | BLADE ANGLES KTC | BLADE ANGLES KOC | DELTA INC | CONE ANGLE |
|---|---|---|---|---|---|---|---|---|
| TIP | 0. | 25.400 | 25.400 | 63.52 | 56.76 | 49.69 | 2.61 | 0.057 |
| 1 | 5. | 25.177 | 25.146 | 63.19 | 56.32 | 48.85 | 2.73 | -0.446 |
| 2 | 10. | 24.927 | 24.892 | 62.85 | 55.81 | 47.95 | 2.96 | -0.501 |
| 3 | 15. | 24.673 | 24.638 | 62.52 | 55.28 | 46.95 | 3.15 | -0.491 |
| 4 | 30. | 23.895 | 23.876 | 61.64 | 53.78 | 43.96 | 3.72 | -0.259 |
| 5 | 50. | 22.852 | 22.860 | 60.54 | 51.80 | 39.60 | 4.45 | 0.107 |
| 6 | 70. | 21.806 | 21.844 | 59.40 | 49.68 | 34.47 | 5.13 | 0.451 |
| 7 | 85. | 21.027 | 21.082 | 58.57 | 47.95 | 29.81 | 5.60 | 0.621 |
| 8 | 90. | 20.773 | 20.828 | 58.29 | 47.25 | 27.79 | 5.74 | 0.606 |
| 9 | 95. | 20.525 | 20.574 | 58.02 | 46.39 | 25.19 | 5.87 | 0.525 |
| HUB | 100. | 20.320 | 20.320 | 57.79 | 45.61 | 22.37 | 5.98 | 0.057 |

| RP | BLADE THICKNESSES TI | TM | TO | AXIAL DIMENSIONS ZIC | ZMC | ZTC | ZOC |
|---|---|---|---|---|---|---|---|
| TIP | 0.051 | 0.213 | 0.051 | 0.609 | 2.388 | 2.330 | 4.524 |
| 1 | 0.051 | 0.224 | 0.051 | 0.586 | 2.388 | 2.305 | 4.560 |
| 2 | 0.051 | 0.256 | 0.051 | 0.559 | 2.388 | 2.276 | 4.598 |
| 3 | 0.051 | 0.248 | 0.051 | 0.532 | 2.387 | 2.245 | 4.638 |
| 4 | 0.051 | 0.284 | 0.051 | 0.453 | 2.384 | 2.148 | 4.754 |
| 5 | 0.051 | 0.330 | 0.051 | 0.348 | 2.381 | 2.009 | 4.914 |
| 6 | 0.051 | 0.375 | 0.051 | 0.229 | 2.374 | 1.849 | 5.086 |
| 7 | 0.051 | 0.406 | 0.051 | 0.131 | 2.368 | 1.716 | 5.231 |
| 8 | 0.051 | 0.416 | 0.051 | 0.092 | 2.366 | 1.665 | 5.289 |
| 9 | 0.051 | 0.426 | 0.051 | 0.044 | 2.362 | 1.606 | 5.361 |
| HUB | 0.051 | 0.434 | 0.051 | -0.000 | 2.359 | 1.554 | 5.438 |

# Aerodynamic design

| | unit | values |
|---|---|---|
| **pressure ratio** | [-] | 1.328 |
| **mass flow** | [kg/s] | 9.46 |
| **tip speed** | [m/s] | 243.8 |
| **tip solidity** | [-] | 1.8 |
| **aspect ratio** | [-] | 0.7 |
| **number of blades** | [-] | 40 |
| **rotative speed** | [rad/s] | 960.28 |

# Material properties

The original material of the rotor 27A is not defined in the NASA report.

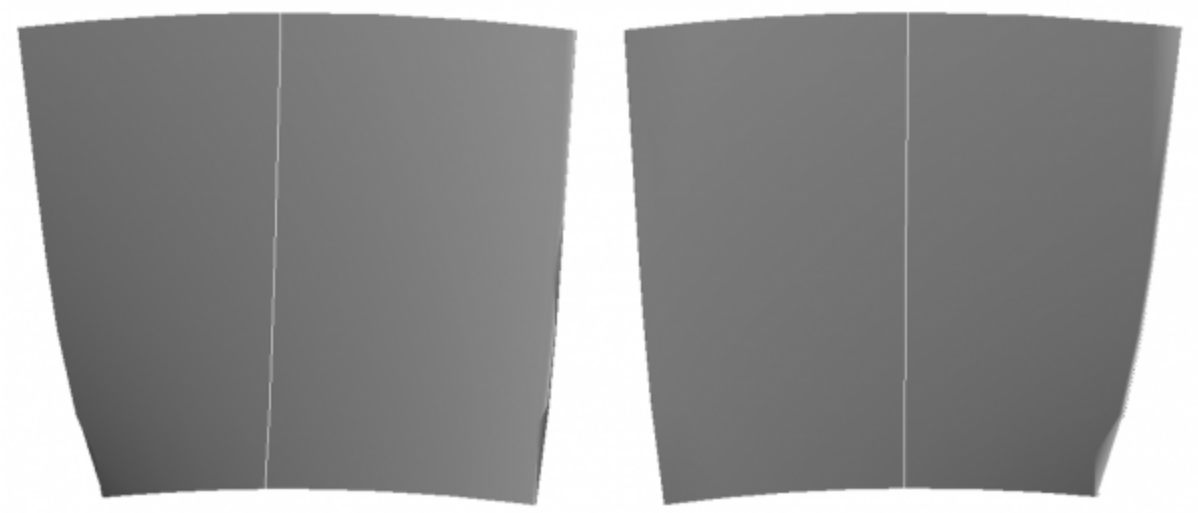
Considered properties: 200-grade maraging steel :

| | unité | valeurs |
|---|---|---|
| **alloy** | [-] | 18-Ni-200-maraging |
| **Young's modulus** | [GPa] | 180 |
| **density** | [kg/m3] | 8000 |
| **Poisson's ratio** | [-] | 0.3 |
| **yield stress** | [GPa] | 1.38 |

First three natural frequencies (with clamped root) for the mesh:

1. (1B): 8846.6 rad/s / 1408.0 Hz
2. (1T): 17556.5 rad/s / 2794.2 Hz
3. (2B): 27182.0 rad/s / 4326.1 Hz

# CAD



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# Modèle original

Le rotor 27A fait partie d'un programme de recherche visant à étudier les effets de l'allongement, du facteur de diffusion et de la solidité des rotors. Pour ce faire, des études expérimentales ont été menées sur une série d'étages de compresseurs à fort rapport entre les rayons du moyeu et de la tête d'aube, représentatifs des étages moyens et avancés des compresseurs à flux axial. En effet, 14 étages intermédiaires ont été testés pour évaluer les effets sur les performances de la variation de la diffusion et de l'allongement des aubes. Parmi ces 14 étages, on trouve les rotors 23B, 24A, 25A, 26B, 27A et 28B. Le diamètre de l'extrémité des aubes et le rapport entre les rayons du moyeu et de la tête d'aube ont été maintenus constants tout au long de chaque étage à 50.8 centimètres et 0.8, respectivement.

- Rapport technique original [(cite:britsch1979design>Britsch. «Design and overall performance of four highly loaded, high speed inlet stages for an advanced high-pressure-ratio core compressor » 1979. pdf)]:

```
@TechReport{britsch1979design,
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institution = {NASA Lewis Research Center Cleveland, OH, United States},
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- Photographie :



https://catalog.archives.gov/id/17447129

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note     =
{\href{https://catalog.archives.gov/id/17447129}{https://catalog.archives.gov/
id/17447129}, 1975 }, % for Fig. 1}
```

# Documents utiles

- PDF du rapport de la NASA :

rotor27a.pdf

- Fichier CSV de la géométrie :

rotor27a_original.csv

# Géométrie

Le matériau original du rotor 27A n'est pas défini dans le rapport de la NASA.

Propriétés considérées : un acier maraging de grade 200 :

TABLE 12. – BLADE GEOMETRY FOR ROTOR 27A

| RP | PERCENT SPAN | RADII RI | RADII RO | BLADE ANGLES KIC | BLADE ANGLES KTC | BLADE ANGLES KOC | DELTA INC | CONE ANGLE |
|---|---|---|---|---|---|---|---|---|
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| 3 | 15. | 24.673 | 24.638 | 62.52 | 55.28 | 46.95 | 3.15 | -0.491 |
| 4 | 30. | 23.895 | 25.876 | 61.64 | 53.78 | 43.96 | 3.72 | -0.259 |
| 5 | 50. | 22.852 | 22.860 | 60.54 | 51.80 | 39.60 | 4.45 | 0.107 |
| 6 | 70. | 21.806 | 21.844 | 59.40 | 49.68 | 34.47 | 5.13 | 0.451 |
| 7 | 85. | 21.027 | 21.082 | 58.57 | 47.95 | 29.81 | 5.60 | 0.621 |
| 8 | 90. | 20.773 | 20.828 | 58.29 | 47.25 | 27.79 | 5.74 | 0.606 |
| 9 | 95. | 20.525 | 20.574 | 58.02 | 46.39 | 25.19 | 5.87 | 0.525 |
| HUB | 100. | 20.320 | 20.320 | 57.79 | 45.61 | 22.37 | 5.98 | 0.057 |

| RP | BLADE THICKNESSES TI | BLADE THICKNESSES TM | BLADE THICKNESSES TO | AXIAL DIMENSIONS ZIC | AXIAL DIMENSIONS ZMC | AXIAL DIMENSIONS ZTC | AXIAL DIMENSIONS ZOC |
|---|---|---|---|---|---|---|---|
| TIP | 0.051 | 0.213 | 0.051 | 0.609 | 2.388 | 2.330 | 4.524 |
| 1 | 0.051 | 0.224 | 0.051 | 0.586 | 2.388 | 2.305 | 4.560 |
| 2 | 0.051 | 0.236 | 0.051 | 0.559 | 2.388 | 2.276 | 4.598 |
| 3 | 0.051 | 0.248 | 0.051 | 0.532 | 2.387 | 2.245 | 4.638 |
| 4 | 0.051 | 0.284 | 0.051 | 0.453 | 2.384 | 2.148 | 4.754 |
| 5 | 0.051 | 0.330 | 0.051 | 0.348 | 2.381 | 2.009 | 4.914 |
| 6 | 0.051 | 0.375 | 0.051 | 0.229 | 2.374 | 1.849 | 5.086 |
| 7 | 0.051 | 0.406 | 0.051 | 0.131 | 2.368 | 1.716 | 5.231 |
| 8 | 0.051 | 0.416 | 0.051 | 0.092 | 2.366 | 1.665 | 5.289 |
| 9 | 0.051 | 0.426 | 0.051 | 0.044 | 2.362 | 1.606 | 5.361 |
| HUB | 0.051 | 0.434 | 0.051 | -0.000 | 2.359 | 1.554 | 5.438 |

# Caractéristiques aérodynamiques

| | unités | valeurs |
|---|---|---|
| **taux de compression** | [-] | 1,328 |
| **débit massique** | [kg/s] | 9,46 |
| **vitesse en tête** | [m/s] | 243,8 |
| **solidité en tête** | [-] | 1,8 |
| **allongement** | [-] | 0,7 |
| **nombre d'aubes** | [-] | 40 |
| **vitesse de rotation** | [rad/s] | 960,28 |

# Propriétés matériau

Le matériau supposé du rotor 23B est un alliage à base de nickel : un acier maraging de grade 200

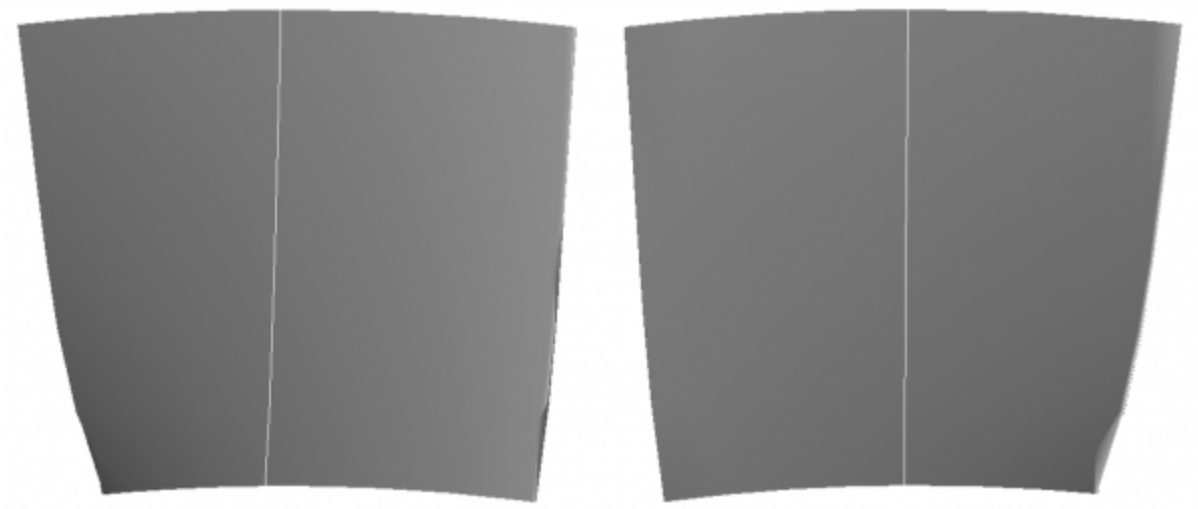
| | unité | valeurs |
|---|---|---|
| **alliage** | [-] | 18-Ni-200-maraging |
| **module d'Young** | [GPa] | 180 |

| | unité | valeurs |
|---|---|---|
| **masse volumique** | [kg/m3] | 8000 |
| **coefficient de Poisson** | [-] | 0,3 |
| **limite élastique** | [GPa] | 1,38 |

Fréquences des trois premiers modes (noeuds de la base encastrés) pour le maillage :

1. (1B): 8846,6 rad/s / 1408,0 Hz
2. (1T): 17556,5 rad/s / 2794,2 Hz
3. (2B): 27182,0 rad/s / 4326,1 Hz

# CAO



Document issu de la page wiki:
**https://wiki.lava.polymtl.ca/public/modeles/rotor_27a/accueil?rev=1663351706**

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