

# Rotor 1

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## Original model

Rotor 1 is part of a research program to study aspect ratio because the use of high aspect ratio blading can lead to a decrease in the axial length of compressors and therefore a reduction of their size and weight. To investigate the effects of aspect ratio on compressor range and efficiency, two transonic rotors (rotor 1 and 2) were designed and tested. The variation in aspect ratio was based on a change in aerodynamic chord, and the solidity was kept the same by varying the number of blades.

- Original technical report <sup>[1]</sup>:

```
@TechReport{hager1974design,  
author      = {Hager, Roy D. and Lewis, George W.},  
title       = {Effect of damper on overall and blade-element performance  
of a compressor rotor having a tip speed of 1151 feet per second and an  
aspect ratio of 3.6},  
institution = {NASA Lewis Research Center Cleveland, OH, United States},  
note        = {NASA-TM X-3041, url~:  
\url{https://ntrs.nasa.gov/citations/19740018135}, 1974}}
```

- Pictures :

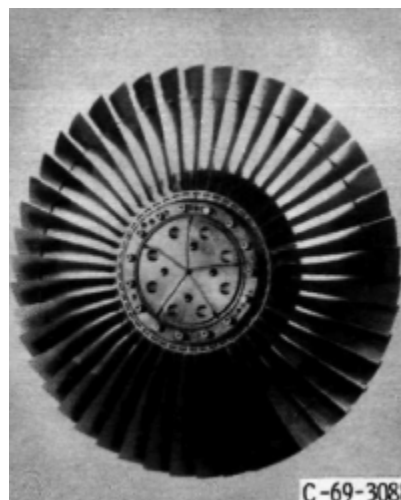


Fig1. <https://ntrs.nasa.gov/citations/19740018135> p.68

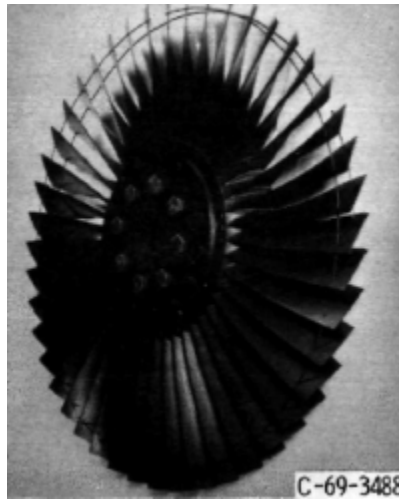


Fig2. <https://ntrs.nasa.gov/citations/19740018135> p.68

## Useful documents

- PDF of the NASA report :

rotor1.pdf

- CSV file of the blade geometry :

rotor1\_original.csv

## Geometry

The geometry of rotor 1 is described in the original [NASA report](#) by the following tables. The length are in inches and the angles in degrees.

ROTOR 1 - MOD 1

|     | PERCENT |        | RADII |       | BLADE ANGLES |        |      | DELTA |
|-----|---------|--------|-------|-------|--------------|--------|------|-------|
| RP  | SPAN    | RI     | RO    | KIC   | KTC          | KOC    | INC  |       |
| TIP | 0.      | 10.000 | 9.900 | 59.46 | 52.90        | 46.35  | 3.21 |       |
| 1   | 5.      | 9.730  | 9.657 | 57.70 | 51.81        | 45.80  | 3.31 |       |
| 2   | 10.     | 9.442  | 9.413 | 56.00 | 50.54        | 45.00  | 3.43 |       |
| 3   | 20.     | 8.883  | 8.927 | 53.05 | 47.75        | 42.30  | 3.64 |       |
| 4   | 22.     | 8.740  | 8.810 | 52.40 | 46.97        | 41.50  | 3.70 |       |
| 5   | 25.     | 8.604  | 8.684 | 51.70 | 46.21        | 40.40  | 3.75 |       |
| 6   | 28.     | 8.460  | 8.560 | 51.20 | 45.37        | 39.00  | 3.80 |       |
| 7   | 30.     | 8.313  | 8.430 | 50.50 | 44.48        | 37.80  | 3.87 |       |
| 8   | 33.     | 8.160  | 8.300 | 49.80 | 43.52        | 36.40  | 3.92 |       |
| 9   | 50.     | 7.193  | 7.467 | 45.70 | 36.53        | 26.30  | 4.33 |       |
| 10  | 70.     | 5.991  | 6.494 | 39.90 | 25.27        | 10.00  | 5.09 |       |
| 11  | 90.     | 4.630  | 5.521 | 33.45 | 10.69        | -10.50 | 6.38 |       |
| HUB | 100.    | 4.000  | 5.050 | 30.78 | 4.42         | -21.94 | 7.07 |       |

|     | BLADE THICKNESSES |       |       | AXIAL DIMENSIONS |       |       | CONE   |
|-----|-------------------|-------|-------|------------------|-------|-------|--------|
| RP  | TI                | TM    | TO    | ZMC              | ZTC   | ZOC   | ANGLE  |
| TIP | 0.020             | 0.073 | 0.020 | 0.501            | 0.501 | 1.084 | -3.800 |
| 1   | 0.020             | 0.074 | 0.020 | 0.520            | 0.520 | 1.116 | -2.100 |
| 2   | 0.020             | 0.075 | 0.020 | 0.540            | 0.540 | 1.149 | -0.900 |
| 3   | 0.020             | 0.078 | 0.020 | 0.574            | 0.574 | 1.215 | 1.600  |
| 4   | 0.020             | 0.078 | 0.020 | 0.582            | 0.582 | 1.231 | 2.300  |
| 5   | 0.020             | 0.079 | 0.020 | 0.589            | 0.589 | 1.248 | 2.900  |
| 6   | 0.020             | 0.080 | 0.020 | 0.597            | 0.597 | 1.265 | 3.700  |
| 7   | 0.020             | 0.081 | 0.020 | 0.604            | 0.604 | 1.282 | 4.400  |
| 8   | 0.020             | 0.082 | 0.020 | 0.612            | 0.612 | 1.300 | 5.100  |
| 9   | 0.020             | 0.089 | 0.020 | 0.659            | 0.659 | 1.409 | 10.100 |
| 10  | 0.020             | 0.103 | 0.020 | 0.710            | 0.710 | 1.513 | 16.900 |
| 11  | 0.020             | 0.127 | 0.020 | 0.720            | 0.720 | 1.506 | 29.600 |
| HUB | 0.020             | 0.143 | 0.020 | 0.686            | 0.686 | 1.398 | 36.600 |

Aerodynamic design

|                | unit    | values  |
|----------------|---------|---------|
| pressure ratio | [-]     | 1.53    |
| mass flow      | [kg/s]  | 33.5    |
| tip speed      | [m/s]   | 350.8   |
| tip solidity   | [-]     | 1.3     |
| aspect ratio   | [-]     | 3.6     |
| rotative speed | [rad/s] | 1381.25 |

Material properties

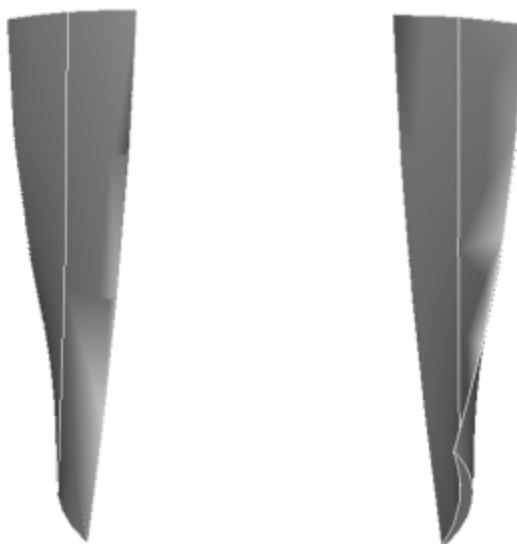
Rotor 1 is made of a 200-grade maraging steel

|                 | 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. (1F) : 940.8 rad/s / 149.7 Hz
2. (1T) : 3479.2 rad/s / 553.7 Hz
3. (2F) : 5530.2 rad/s / 880.2 Hz

## CAD



Modèles téléchargeables

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### Libre accès

#### [lien vers le projet Git](#)

Le rotor 1 fait partie d'un programme de recherche visant à étudier l'allongement des aubes, car l'utilisation d'un fort allongement peut conduire à une diminution de la longueur axiale des compresseurs et donc à une réduction de leur taille et poids. Pour étudier les effets de cet allongement sur les rendements des compresseurs, deux rotors transsoniques (rotor 1 et 2) ont été conçus et testés. La variation d'allongement entre ces deux rotors a été effectuée grâce à une modification de la corde aérodynamique et la solidité a été maintenue identique en faisant varier le nombre d'aubes.

- Rapport technique original <sup>[1]</sup>:

```
@TechReport{hager1974design,  
  author      = {Hager, Roy D. and Lewis, George W.},  
  institution  = {NASA Lewis Research Center Cleveland, OH, United  
States},  
  title       = {Effect of damper on overall and blade-element  
performance of a compressor rotor having a tip speed of 1151 feet per
```

```
second and an aspect ratio of 3.6},  
  year      = {1974},  
  number    = {NASA-TM X-3041},  
  url       = {https://ntrs.nasa.gov/citations/19740018135},  
}
```

- Photographies :

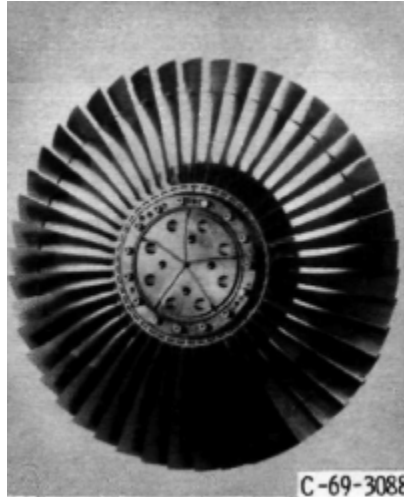


Fig1. <https://ntrs.nasa.gov/citations/19740018135> p.68

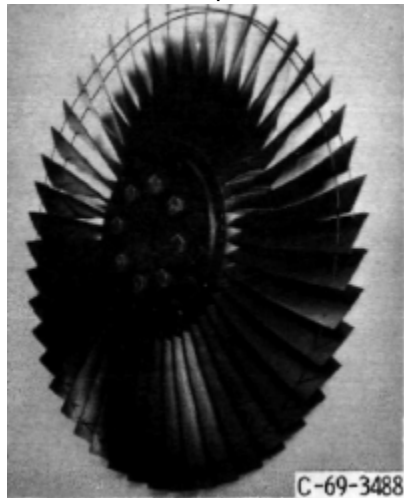


Fig2. <https://ntrs.nasa.gov/citations/19740018135> p.68

### Documents utiles

- [modèles téléchargeables](#) (lien vers projet Git)
  - rapport technique original de la NASA (.pdf)
  - fichier de paramètres géométriques (.csv), utilisable en entrée de OpenMCAD<sup>[2]</sup> pour générer l'aube de référence

# Aube de référence

L'**aube de référence** est définie par des profils de type arcs circulaires multiples<sup>[3]</sup>, donnés dans le rapport technique original de la NASA<sup>[1]</sup>. Les modèles associés sont obtenus avec le code open source OpenMCAD<sup>[2]</sup>.

## Géométrie

La géométrie du rotor 1 est décrite dans le [rapport d'origine de la NASA](#) par les tableaux suivants. Les grandeurs sont en pouces et en degrés.

| ROTOR 1 - MOD 1 |         |        |       |              |       |        |       |
|-----------------|---------|--------|-------|--------------|-------|--------|-------|
| RP              | PERCENT | RADII  |       | BLADE ANGLES |       |        | DELTA |
|                 | SPAN    | R1     | R0    | K1C          | KTC   | KOC    | INC   |
| TIP             | 0.      | 10.000 | 9.900 | 59.46        | 52.90 | 46.35  | 3.21  |
| 1               | 5.      | 9.730  | 9.657 | 57.70        | 51.81 | 45.80  | 3.31  |
| 2               | 10.     | 9.442  | 9.413 | 56.00        | 50.54 | 45.00  | 3.43  |
| 3               | 20.     | 8.883  | 8.927 | 53.05        | 47.75 | 42.30  | 3.64  |
| 4               | 22.     | 8.740  | 8.810 | 52.40        | 46.97 | 41.50  | 3.70  |
| 5               | 25.     | 8.604  | 8.684 | 51.70        | 46.21 | 40.40  | 3.75  |
| 6               | 28.     | 8.460  | 8.560 | 51.20        | 45.37 | 39.00  | 3.80  |
| 7               | 30.     | 8.313  | 8.430 | 50.50        | 44.48 | 37.80  | 3.87  |
| 8               | 33.     | 8.160  | 8.300 | 49.80        | 43.52 | 36.40  | 3.92  |
| 9               | 50.     | 7.193  | 7.467 | 45.70        | 36.53 | 26.30  | 4.33  |
| 10              | 70.     | 5.991  | 6.494 | 39.90        | 25.27 | 10.00  | 5.09  |
| 11              | 90.     | 4.630  | 5.521 | 33.45        | 10.69 | -10.50 | 6.38  |
| HUB             | 100.    | 4.000  | 5.050 | 30.78        | 4.42  | -21.94 | 7.07  |

| RP  | BLADE THICKNESSES |       |       | AXIAL DIMENSIONS |       |       | CONE   |
|-----|-------------------|-------|-------|------------------|-------|-------|--------|
|     | T1                | TM    | TO    | ZMC              | ZTC   | ZOC   | ANGLE  |
| TIP | 0.020             | 0.073 | 0.020 | 0.501            | 0.501 | 1.084 | -3.800 |
| 1   | 0.020             | 0.074 | 0.020 | 0.520            | 0.520 | 1.116 | -2.100 |
| 2   | 0.020             | 0.075 | 0.020 | 0.540            | 0.540 | 1.149 | -0.900 |
| 3   | 0.020             | 0.078 | 0.020 | 0.574            | 0.574 | 1.215 | 1.600  |
| 4   | 0.020             | 0.078 | 0.020 | 0.582            | 0.582 | 1.231 | 2.300  |
| 5   | 0.020             | 0.079 | 0.020 | 0.589            | 0.589 | 1.248 | 2.900  |
| 6   | 0.020             | 0.080 | 0.020 | 0.597            | 0.597 | 1.265 | 3.700  |
| 7   | 0.020             | 0.081 | 0.020 | 0.604            | 0.604 | 1.282 | 4.400  |
| 8   | 0.020             | 0.082 | 0.020 | 0.612            | 0.612 | 1.300 | 5.100  |
| 9   | 0.020             | 0.089 | 0.020 | 0.659            | 0.659 | 1.409 | 10.100 |
| 10  | 0.020             | 0.103 | 0.020 | 0.710            | 0.710 | 1.513 | 16.900 |
| 11  | 0.020             | 0.127 | 0.020 | 0.720            | 0.720 | 1.506 | 29.600 |
| HUB | 0.020             | 0.143 | 0.020 | 0.686            | 0.686 | 1.398 | 36.600 |

## Caractéristiques aérodynamiques

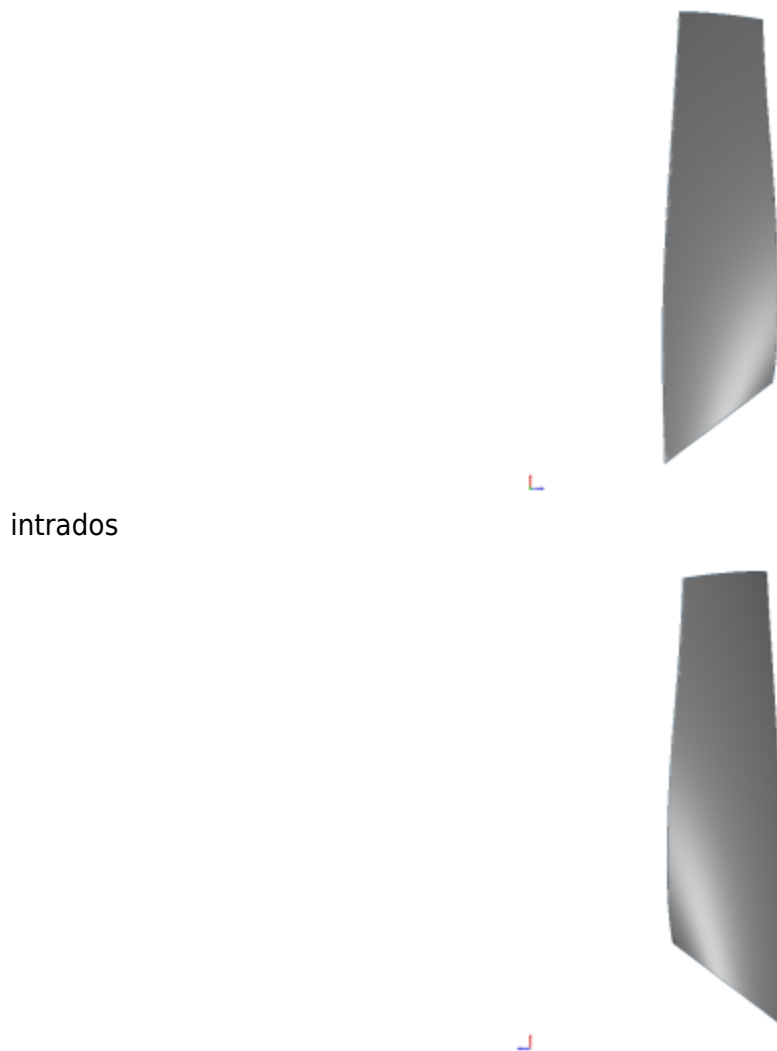
|                     | unités  | valeurs |
|---------------------|---------|---------|
| taux de compression | [-]     | 1,53    |
| débit massique      | [kg/s]  | 33,5    |
| vitesse en tête     | [m/s]   | 350,8   |
| solidité en tête    | [-]     | 1,3     |
| allongement         | [-]     | 3,6     |
| vitesse de rotation | [rad/s] | 1381,25 |

## Propriétés matériau

Le matériau du rotor 1 est un alliage à base de nickel : un acier maraging de grade 200

|                               | unité   | valeurs            |
|-------------------------------|---------|--------------------|
| <b>alliage</b>                | [-]     | 18-Ni-200-maraging |
| <b>module d'Young</b>         | [GPa]   | 180                |
| <b>masse volumique</b>        | [kg/m3] | 8000               |
| <b>coefficient de Poisson</b> | [-]     | 0,3                |
| <b>limite élastique</b>       | [GPa]   | 1,38               |

## Modèle CAO



intrados

extrados

## Fréquences propres

Fréquences des trois premiers modes (noeuds du pied d'aube encastres) pour le maillage :

| Mode | Type | Pulsation propre (rad/sec) | Fréquence propre (Hz) |
|------|------|----------------------------|-----------------------|
| 1    | 1F   | 1018.5                     | 162,1                 |
| 2    | 1T   | 3542.5                     | 563,8                 |
| 3    | 2F   | 6094.7                     | 970,0                 |

## Aube initiale

L'**aube initiale** est définie par des paramètres spécifiques au LAVA<sup>[4]</sup> obtenus à partir du modèle CAO de l'aube de référence. La géométrie de l'aube initiale est similaire à celle de l'aube de référence.

## Fréquences propres

Fréquences des trois premiers modes (noeuds du pied d'aube encastres),

- pour le maillage complet :

| Mode | Type | Pulsation propre (rad/sec) | Fréquence propre (Hz) |
|------|------|----------------------------|-----------------------|
| 1    | 1F   | 1019.1                     | 162,2                 |
| 2    | 1T   | 3539.3                     | 563,3                 |
| 3    | 2F   | 6074.0                     | 966,7                 |

- pour le modèle réduit :

| Mode | Type | Pulsation propre (rad/sec) | Fréquence propre (Hz) |
|------|------|----------------------------|-----------------------|
| 1    | 1F   | 1019.1                     | 162,2                 |
| 2    | 1T   | 3540.8                     | 563,5                 |
| 3    | 2F   | 6075.8                     | 967,0                 |

</tabs>

- <sup>a, b, c</sup> Hager. «Effect of damper on overall and blade-element performance of a compressor rotor having a tip speed of 1151 feet per second and an aspect ratio of 3.6 » 1974. NASA-TM X-3041. [pdf](#)
- <sup>a, b</sup> Kojtych S., Batailly A. «OpenMCAD, an open blade generator: from Multiple-Circular-Arc profiles to Computer-Aided Design model» 2022. [code en libre accès](#)
- <sup>a</sup> Crouse *et al.* «A computer program for composing compressor blading from simulated circular-arc elements on conical surfaces » 1969. NASA-TN-D-5437. [pdf](#)
- <sup>a</sup> Kojtych S. *et al.* «Methodology for the Redesign of Compressor Blades Undergoing Nonlinear Structural Interactions: Application to Blade-Tip/Casing Contacts » 2022. Journal of Engineering for Gas Turbines and Power, Vol. 145, No. 5. [pdf](#)

Document issu de la page wiki:

[https://lava-wiki.meca.polymtl.ca/public/modeles/rotor\\_01/accueil?rev=1673890711](https://lava-wiki.meca.polymtl.ca/public/modeles/rotor_01/accueil?rev=1673890711)

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