

# Rotor 57

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## About

Rotor 57 is part of a research program to study fan stages suitable for use in engines for quiet powered lift aircraft. Experimental studies have been conducted on fan stages suitable for use in engines for quiet powered lift aircraft using the externally blown flap. The externally blown flap aircraft requires a large flow of low velocity air for effective lift and low noise during take-off and landing. To meet the low noise requirement, the fans will be required to have low tip speed and low-pressure ratio. The pressure ratios of interest in the program range from 1.15 to 1.4. Rotor 57 has a pressure ratio of 1.38.

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

```
@TechReport{moore1979design,
  author      = {Moore, Royce D. and Osborn, Walter M.},
  date        = {1979},
  institution = {NASA Lewis Research Center Cleveland, OH, United
States},
  title       = {Aerodynamic Performance of 1.38-Pressure-Ratio,
Variable-Pitch Fan Stage},
  number      = {NASA-TP-1502},
  url         = {https://ntrs.nasa.gov/citations/19790023042},
}
```

- Picture :

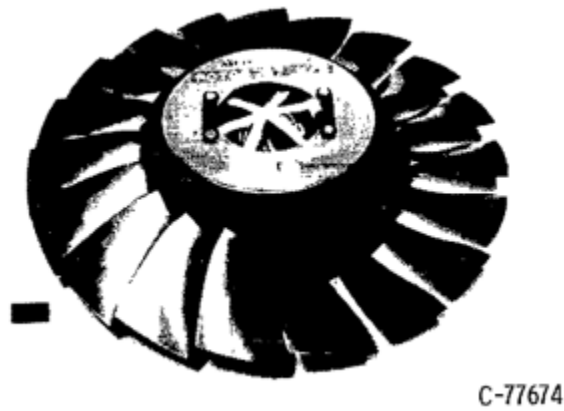


Fig1. <https://ntrs.nasa.gov/citations/19790023042> p.56

### Useful documents

- NASA technical report  
(.pdf)
- geometrical parameters file  
(.csv), usable as input of OpenMCAD<sup>[2]</sup> to generate reference blade models.

## Reference blade

The **reference blade** is defined with multiple-circular arc profiles<sup>[3]</sup> given in the original NASA report<sup>[1]</sup>. Corresponding models are computed with the open-source code OpenMCAD<sup>[2]</sup>.

## Geometry

[The geometry of rotor 57 is described in the original NASA report](#) by the following tables. The length are in centimeters and the angles in degrees.

TABLE IV. - BLADE GEOMETRY FOR ROTOR 57

|     | PERCENT |        |        | RADII |       | BLADE ANGLES |       |       | DELTA | CONE |
|-----|---------|--------|--------|-------|-------|--------------|-------|-------|-------|------|
| RP  | SPAN    | RI     | RO     | KIC   | KTC   | KOC          | INC   | ANGLE |       |      |
| TIP | 0.      | 25.400 | 25.400 | 54.70 | 48.96 | 43.29        | 2.32  | .057  |       |      |
| 1   | 5.      | 24.840 | 24.853 | 53.95 | 47.77 | 41.59        | 2.83  | .121  |       |      |
| 2   | 10.     | 24.253 | 24.305 | 53.16 | 46.52 | 39.88        | 3.29  | .494  |       |      |
| 3   | 15.     | 23.657 | 23.758 | 52.32 | 45.23 | 38.14        | 3.65  | .926  |       |      |
| 4   | 30.     | 21.826 | 22.116 | 49.35 | 40.34 | 31.33        | 4.33  | 2.412 |       |      |
| 5   | 50.     | 19.338 | 19.926 | 44.86 | 33.47 | 22.10        | 5.14  | 4.385 |       |      |
| 6   | 70.     | 16.831 | 17.737 | 40.11 | 24.97 | 9.84         | 7.18  | 6.189 |       |      |
| 7   | 85.     | 14.950 | 16.095 | 35.94 | 18.02 | .13          | 10.29 | 7.494 |       |      |
| 8   | 90.     | 14.349 | 15.577 | 32.74 | 14.72 | -3.27        | 11.72 | 7.879 |       |      |
| 9   | 95.     | 13.763 | 15.000 | 28.62 | 10.89 | -6.82        | 13.31 | 8.247 |       |      |
| HUB | 100.    | 13.208 | 14.453 | 24.19 | 6.93  | -10.45       | 14.93 | 8.473 |       |      |

|     | BLADE THICKNESSES |       |      | AXIAL DIMENSIONS |       |       |       |
|-----|-------------------|-------|------|------------------|-------|-------|-------|
| RP  | TI                | TM    | TO   | ZI               | ZMC   | ZTC   | ZO    |
| TIP | .015              | .190  | .017 | 1.646            | 4.248 | 4.248 | 7.162 |
| 1   | .018              | .211  | .020 | 1.541            | 4.247 | 4.247 | 7.295 |
| 2   | .021              | .235  | .023 | 1.431            | 4.250 | 4.250 | 7.437 |
| 3   | .022              | .264  | .027 | 1.321            | 4.260 | 4.260 | 7.590 |
| 4   | .030              | .351  | .037 | .969             | 4.181 | 4.181 | 7.852 |
| 5   | .040              | .482  | .050 | .543             | 4.129 | 4.129 | 8.218 |
| 6   | .054              | .655  | .064 | .182             | 4.102 | 4.102 | 8.536 |
| 7   | .069              | .842  | .085 | .067             | 4.195 | 4.195 | 8.772 |
| 8   | .082              | .981  | .098 | .042             | 4.185 | 4.185 | 8.705 |
| 9   | .100              | 1.159 | .114 | .020             | 4.149 | 4.149 | 8.553 |
| HUB | .119              | 1.350 | .132 | -.000            | 4.103 | 4.103 | 8.355 |

## Aerodynamic design

|                  | unit    | values  |
|------------------|---------|---------|
| pressure ratio   | [-]     | 1.38    |
| mass flow        | [kg/s]  | 29.6    |
| tip speed        | [m/s]   | 289.6   |
| aspect ratio     | [-]     | 1.26    |
| number of blades | [-]     | 19      |
| rotative speed   | [rad/s] | 1139.98 |

## Material properties

The original material of the rotor 57 is not defined in the NASA report.

Considered properties: Ti-6Al-4V, generic titanium :

|                 | unité   | valeurs   |
|-----------------|---------|-----------|
| alloy           | [-]     | Ti-6Al-4V |
| Young's modulus | [GPa]   | 108       |
| density         | [kg/m3] | 4400      |
| Poisson's ratio | [-]     | 0.34      |
| yield stress    | [GPa]   | 0.824     |

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

1. (1B): 4256.6 rad/s / 677.5 Hz
2. (2B): 11745.8 rad/s / 1869.4 Hz
3. (1T): 14867.1 rad/s / 2366.2 Hz

## CAD model

The CAD model is computed with the open source code OpenMCAD<sup>[2]</sup>.



pressure side



suction side



## Natural frequencies

First three natural frequencies (with clamped root) for the mesh computed with OpenMCAD<sup>[2]</sup>:

Currently not available because of a problem to compute them with aster from the mesh of the reference blade.

Fichiers téléchargeables

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## Libre accès

[lien vers le projet Git](#)

## À propos

Le rotor 57 fait partie d'un programme de recherche visant à étudier les étages de soufflante susceptibles d'être utilisés dans des moteurs d'avions plus silencieux. Des études expérimentales ont été menées sur des étages de soufflante utilisant un volet à soufflage externe. L'utilisation de tel volets nécessite un grand débit d'air à faible vitesse pour une portance efficace et un faible niveau de bruit au décollage et à l'atterrissage. Pour répondre à cette exigence de faible bruit, les soufflantes devront avoir une faible vitesse en tête et un faible taux de compression. Les taux de compression d'intérêt dans le programme varient de 1,15 à 1,4. Le rotor 57 possède un taux de compression de 1,38.

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

```
@TechReport{moore1979design,  
  author      = {Moore, Royce D. and Osborn, Walter M.},  
  date        = {1979},  
  institution = {NASA Lewis Research Center Cleveland, OH, United  
States},  
  title       = {Aerodynamic Performance of 1.38-Pressure-Ratio,  
Variable-Pitch Fan Stage},  
  number      = {NASA-TP-1502},  
  url         = {https://ntrs.nasa.gov/citations/19790023042},  
}
```

- Photographie :

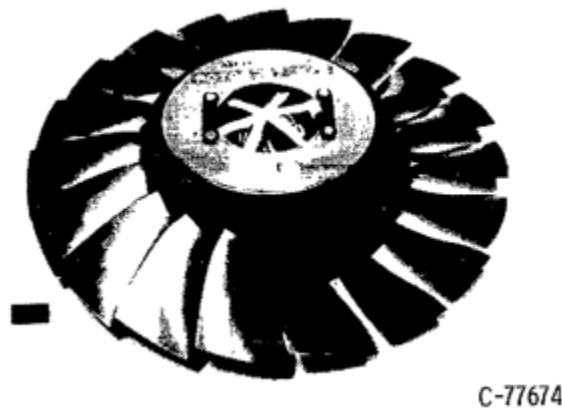


Fig1. <https://ntrs.nasa.gov/citations/19790023042> p.56

### Documents utiles

- 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 en libre accès OpenMCAD<sup>[2]</sup>.

## Géométrie

La géométrie du rotor 57 est décrite dans le [rapport d'origine de la NASA](#) par les tableaux suivants. Les grandeurs sont en centimètres et en degrés.

TABLE IV. - BLADE GEOMETRY FOR ROTOR 57

| RP  | PERCENT |        | RADII  |       | BLADE ANGLES |        |       | DELTA | CONE |
|-----|---------|--------|--------|-------|--------------|--------|-------|-------|------|
|     | SPAN    | RI     | RO     | KIC   | KTC          | KOC    | INC   |       |      |
| TIP | 0.      | 25.400 | 25.400 | 54.70 | 48.96        | 43.29  | 2.32  |       |      |
| 1   | 5.      | 24.840 | 24.853 | 53.95 | 47.77        | 41.59  | 2.83  |       | .057 |
| 2   | 10.     | 24.253 | 24.305 | 53.16 | 46.52        | 39.88  | 3.29  |       | .121 |
| 3   | 15.     | 23.657 | 23.758 | 52.32 | 45.23        | 38.14  | 3.65  |       | .194 |
| 4   | 20.     | 21.826 | 22.116 | 49.35 | 40.34        | 31.33  | 4.33  |       | .242 |
| 5   | 30.     | 19.338 | 19.926 | 44.86 | 33.47        | 22.10  | 5.14  |       | .385 |
| 6   | 40.     | 16.831 | 17.737 | 40.11 | 24.97        | 9.84   | 7.18  |       | .618 |
| 7   | 50.     | 14.950 | 16.095 | 35.94 | 18.02        | .13    | 10.29 |       | .749 |
| 8   | 60.     | 14.349 | 15.577 | 32.74 | 14.72        | -3.27  | 11.72 |       | .787 |
| 9   | 75.     | 13.763 | 15.000 | 28.62 | 10.89        | -6.82  | 13.31 |       | .824 |
| HUB | 100.    | 13.208 | 14.453 | 24.19 | 6.93         | -10.45 | 14.93 |       | .847 |

| RP  | BLADE THICKNESSES |       |      | AXIAL DIMENSIONS |       |       |       |
|-----|-------------------|-------|------|------------------|-------|-------|-------|
|     | TI                | TM    | TO   | ZI               | ZMC   | ZTC   | ZO    |
| TIP | .015              | .190  | .017 | 1.646            | 4.248 | 4.248 | 7.162 |
| 1   | .018              | .211  | .020 | 1.541            | 4.247 | 4.247 | 7.295 |
| 2   | .021              | .235  | .023 | 1.431            | 4.250 | 4.250 | 7.437 |
| 3   | .022              | .264  | .027 | 1.321            | 4.260 | 4.260 | 7.590 |
| 4   | .030              | .351  | .037 | .969             | 4.181 | 4.181 | 7.852 |
| 5   | .040              | .482  | .050 | .543             | 4.129 | 4.129 | 8.218 |
| 6   | .054              | .655  | .064 | .182             | 4.102 | 4.102 | 8.536 |
| 7   | .069              | .842  | .085 | .067             | 4.195 | 4.195 | 8.772 |
| 8   | .082              | .981  | .098 | .042             | 4.185 | 4.185 | 8.705 |
| 9   | .100              | 1.159 | .114 | .020             | 4.149 | 4.149 | 8.553 |
| HUB | .119              | 1.350 | .132 | -.000            | 4.103 | 4.103 | 8.355 |

## Caractéristiques aérodynamiques

|                     | unités  | valeurs |
|---------------------|---------|---------|
| taux de compression | [-]     | 1,38    |
| débit massique      | [kg/s]  | 29,6    |
| vitesse en tête     | [m/s]   | 289,6   |
| allongement         | [-]     | 1,26    |
| nombre d'aubes      | [-]     | 19      |
| vitesse de rotation | [rad/s] | 1139,98 |

## Propriétés matériau

Le matériau original du rotor 57 n'est pas défini dans le rapport de la NASA.

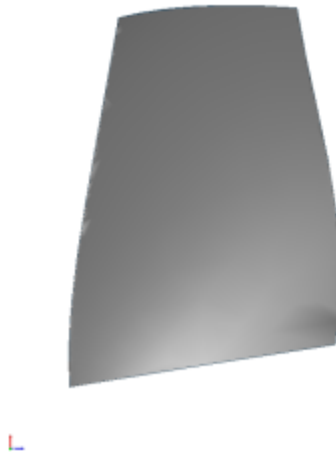
Propriétés considérées : alliage de titane Ti-6Al-4v :

|                               | unité   | valeurs   |
|-------------------------------|---------|-----------|
| <b>alliage</b>                | [-]     | Ti-6Al-4v |
| <b>module d'Young</b>         | [GPa]   | 108       |
| <b>masse volumique</b>        | [kg/m3] | 4400      |
| <b>coefficient de Poisson</b> | [-]     | 0,34      |
| <b>limite élastique</b>       | [GPa]   | 0,824     |

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

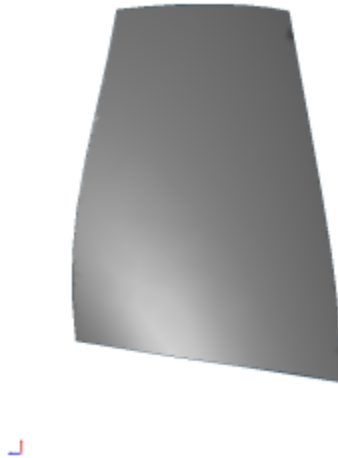
1. (1B): 4256,6 rad/s / 677,5 Hz
2. (2B): 11745,8 rad/s / 1869,4 Hz
3. (1T): 14867,1 rad/s / 2366,2 Hz

## Modèle CAO



intrados

</col>



extrados

## Fréquences propres

Fréquences des trois premiers modes (noeuds du pied d'aube encastres) pour le maillage obtenu avec OpenMCAD<sup>[2]</sup> :

Il y a actuellement un problème sur le calcul des fréquences propres dans Aster.

</tabs>

1. <sup>a, b, c, d</sup> Moore R. D., Osborn W. M. «Aerodynamic Performance of 1.38-Pressure-Ratio, Variable-Pitch Fan Stage» 1979. [pdf](#)
2. <sup>a, b, c, d, e, f, g</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](#)
3. <sup>a, b</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](#)

Document issu de la page wiki:

[https://wiki.lava.polymtl.ca/public/modeles/rotor\\_57/accueil?rev=1681096678](https://wiki.lava.polymtl.ca/public/modeles/rotor_57/accueil?rev=1681096678)

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