

Rotor 53

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Original model

Rotor 53 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 53 has a pressure ratio of 1.35.

- [Original technical report ^{\[1\]}](#):

```
@TechReport{osborn1978design,  
author      = {Osborn, Walter M. and Moore, R. D. and Steinke, Ronald J.},  
title       = {Aerodynamic Performance of a 1.35-Pressure-Ratio Axial-Flow  
Fan Stage},  
institution = {NASA Lewis Research Center Cleveland, OH, United States},  
note        = {NASA-TP-1299, url~:  
\url{https://ntrs.nasa.gov/citations/19790001851}, 1978}}
```

- [Picture](#) :



Fig1. <https://catalog.archives.gov/id/17423389>

```
@Misc{brown1974records,
author   = {Brown, M.},
title    = {Rotor 53 and stator 53. {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/17466806}{https://catalog.archives.gov/
id/17466806}, 1974 }, % for Fig. 1}
```

Useful documents

- PDF of the NASA report :

rotor53.pdf

- CSV file of the blade geometry :

rotor53_original.csv

Geometry

The geometry of rotor 53 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 53

| RP | PERCENT RADII | | | BLADE ANGLES | | | DELTA INC | CONE ANGLE |
|-----|---------------|--------|--------|--------------|-------|--------|--------------|---------------|
| | SPAN | RI | RO | KIC | KTC | KOC | | |
| TIP | 0. | 25.235 | 24.498 | 57.67 | 48.68 | 39.79 | 3.67 | -12.422 |
| 1 | 5. | 24.422 | 23.781 | 55.43 | 46.98 | 38.52 | 3.70 | -10.420 |
| 2 | 10. | 23.568 | 23.064 | 53.48 | 45.16 | 36.85 | 3.79 | -7.939 |
| 3 | 15. | 22.737 | 22.348 | 52.00 | 43.36 | 34.72 | 3.93 | -5.957 |
| 4 | 30. | 20.285 | 20.197 | 47.02 | 37.48 | 27.95 | 4.60 | -1.242 |
| 5 | 50. | 17.170 | 17.329 | 40.30 | 28.51 | 16.72 | 5.70 | 2.014 |
| 6 | 70. | 14.231 | 14.461 | 33.67 | 18.58 | 3.50 | 6.64 | 2.712 |
| 7 | 85. | 12.144 | 12.311 | 28.86 | 10.59 | -7.69 | 7.04 | 1.891 |
| 8 | 90. | 11.473 | 11.594 | 27.30 | 8.05 | -11.21 | 7.09 | 1.364 |
| 9 | 95. | 10.814 | 10.877 | 25.75 | 5.55 | -14.65 | 7.12 | .710 |
| HUB | 100. | 10.160 | 10.160 | 24.22 | 3.08 | -18.08 | 7.14 | .057 |

| RP | BLADE THICKNESSES | | | AXIAL DIMENSIONS | | | |
|-----|-------------------|------|------|------------------|-------|-------|-------|
| | TI | TM | TO | ZI | ZMC | ZTC | ZO |
| TIP | .041 | .207 | .041 | .899 | 2.426 | 2.426 | 4.243 |
| 1 | .041 | .209 | .041 | .828 | 2.433 | 2.433 | 4.310 |
| 2 | .041 | .214 | .041 | .762 | 2.438 | 2.438 | 4.375 |
| 3 | .042 | .222 | .041 | .705 | 2.440 | 2.440 | 4.439 |
| 4 | .051 | .258 | .052 | .537 | 2.449 | 2.449 | 4.620 |
| 5 | .065 | .319 | .063 | .327 | 2.460 | 2.460 | 4.843 |
| 6 | .073 | .375 | .074 | .155 | 2.480 | 2.480 | 5.020 |
| 7 | .083 | .406 | .083 | .061 | 2.509 | 2.509 | 5.107 |
| 8 | .084 | .410 | .084 | .038 | 2.519 | 2.519 | 5.122 |
| 9 | .083 | .411 | .083 | .019 | 2.530 | 2.530 | 5.129 |
| HUB | .082 | .412 | .082 | .000 | 2.540 | 2.540 | 5.135 |

Aerodynamic design

| | unit | values |
|------------------|---------|--------|
| pressure ratio | [-] | 1.35 |
| mass flow | [kg/s] | 32.7 |
| tip speed | [m/s] | 302.8 |
| tip solidity | [-] | 1 |
| aspect ratio | [-] | 2.86 |
| number of blades | [-] | 30 |
| rotative speed | [rad/s] | 1200 |

Material properties

The original material of the rotor 53 is not defined in the NASA report.

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

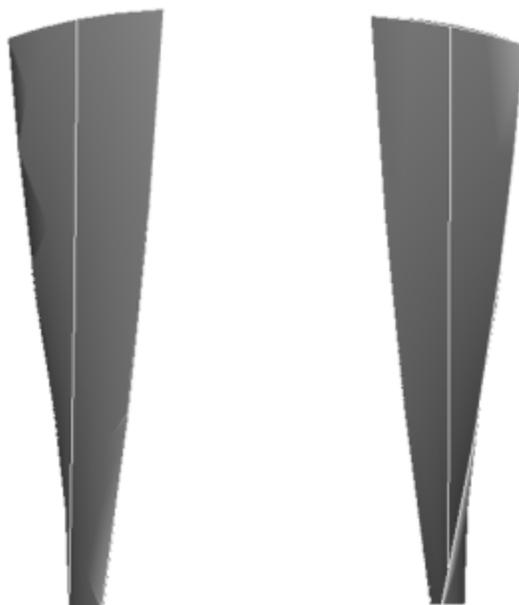
| | unité | valeurs |
|--|-------|---------|
| | | |

| | unité | valeurs |
|------------------------|----------------------|-----------|
| alloy | [-] | Ti-6Al-4V |
| Young's modulus | [GPa] | 108 |
| density | [kg/m ³] | 4400 |
| Poisson's ratio | [-] | 0.34 |
| yield stress | [GPa] | 0.824 |

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

1. (1B): 1160.3 rad/s / 184.7 Hz
2. (2B): 4092.4 rad/s / 651.3 Hz
3. (1T): 7127.5 rad/s / 1134.4 Hz

CAD



Fichiers téléchargeables

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Libre accès

[lien vers le projet Git](#)

Modèle original

Le rotor 53 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 53 possède un taux de compression de 1,35.

- Rapport technique original ^[1]:

```
@TechReport{osborn1978design,  
author      = {Osborn, Walter M. and Moore, R. D. and Steinke, Ronald J.},  
title       = {Aerodynamic Performance of a 1.35-Pressure-Ratio Axial-Flow  
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- Photographie :



Fig1. <https://catalog.archives.gov/id/17423389>

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note     =  
{\href{https://catalog.archives.gov/id/17466806}{https://catalog.archives.gov/  
id/17466806}, 1974 }, % for Fig. 1}
```

Documents utiles

- PDF du rapport de la NASA :

rotor53.pdf

- Fichier CSV de la géométrie :

rotor53_original.csv

Géométrie

La géométrie du rotor 53 est décrite dans le [rapport d'origine de la NASA](#) par les tableaux suivants. Les grandeurs sont en centimètres et en degrés.

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| RP | PERCENT RADII | | | BLADE ANGLES | | | DELTA INC | CONE ANGLE |
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| 3 | 15. | 22.737 | 22.348 | 52.00 | 43.36 | 34.72 | 3.93 | -5.957 |
| 4 | 30. | 20.285 | 20.197 | 47.02 | 37.48 | 27.95 | 4.60 | -1.242 |
| 5 | 50. | 17.170 | 17.329 | 40.30 | 28.51 | 16.72 | 5.70 | 2.014 |
| 6 | 70. | 14.231 | 14.461 | 33.67 | 18.58 | 3.50 | 6.64 | 2.712 |
| 7 | 85. | 12.144 | 12.311 | 28.86 | 10.59 | -7.69 | 7.04 | 1.891 |
| 8 | 90. | 11.473 | 11.594 | 27.30 | 8.05 | -11.21 | 7.09 | 1.364 |
| 9 | 95. | 10.814 | 10.877 | 25.75 | 5.55 | -14.65 | 7.12 | .710 |
| HUB | 100. | 10.160 | 10.160 | 24.22 | 3.08 | -18.08 | 7.14 | .057 |

| RP | BLADE THICKNESSES | | | AXIAL DIMENSIONS | | | |
|-----|-------------------|------|------|------------------|-------|-------|-------|
| | TI | TH | TO | ZI | ZMC | ZTC | ZO |
| TIP | .041 | .207 | .041 | .899 | 2.426 | 2.426 | 4.243 |
| 1 | .041 | .209 | .041 | .828 | 2.433 | 2.433 | 4.310 |
| 2 | .041 | .214 | .041 | .762 | 2.438 | 2.438 | 4.375 |
| 3 | .042 | .222 | .041 | .705 | 2.440 | 2.440 | 4.439 |
| 4 | .051 | .258 | .052 | .537 | 2.449 | 2.449 | 4.620 |
| 5 | .065 | .319 | .063 | .327 | 2.460 | 2.460 | 4.843 |
| 6 | .073 | .375 | .074 | .155 | 2.480 | 2.480 | 5.020 |
| 7 | .083 | .406 | .083 | .061 | 2.509 | 2.509 | 5.107 |
| 8 | .084 | .410 | .084 | .038 | 2.519 | 2.519 | 5.122 |
| 9 | .083 | .411 | .083 | .019 | 2.530 | 2.530 | 5.129 |
| HUB | .082 | .412 | .082 | .000 | 2.540 | 2.540 | 5.135 |

Caractéristiques aérodynamiques

| | unités | valeurs |
|---------------------|--------|---------|
| taux de compression | [-] | 1,35 |
| débit massique | [kg/s] | 32,7 |
| vitesse en tête | [m/s] | 302,8 |
| solidité en tête | [-] | 1 |
| allongement | [-] | 2,86 |
| nombre d'aubes | [-] | 30 |

| | unités | valeurs |
|----------------------------|---------|---------|
| vitesse de rotation | [rad/s] | 1200 |

Propriétés matériau

Le matériau original du rotor 8 n'est pas défini dans le rapport de la NASA.

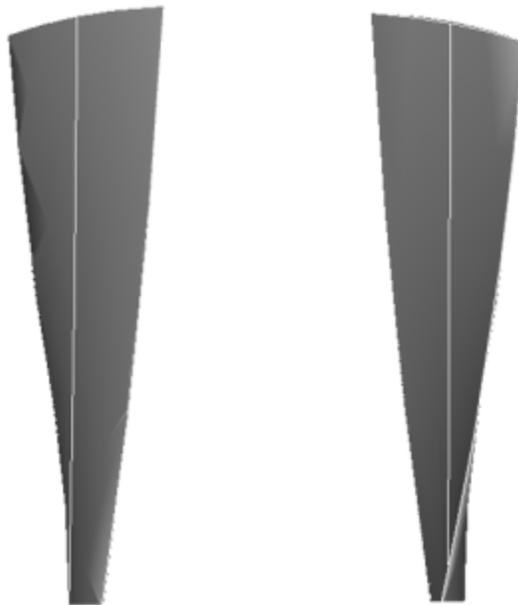
Propriétés considérées : alliage de titane Ti-6Al-4v :

| | unité | valeurs |
|-------------------------------|----------------------|-----------|
| alliage | [-] | Ti-6Al-4v |
| module d'Young | [GPa] | 108 |
| masse volumique | [kg/m ³] | 4400 |
| coefficient de Poisson | [-] | 0,34 |
| limite élastique | [GPa] | 0,824 |

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

1. (1B): 1160,3 rad/s / 184,7 Hz
2. (2B): 4092,4 rad/s / 651,3 Hz
3. (1T): 7127,5 rad/s / 1134,4 Hz

CAO



1. ^{a, b} Osborn. «Aerodynamic Performance of a 1.35-Pressure-Ratio Axial-Flow Fan Stage » 1978. [pdf](#)

Document issu de la page wiki:

https://wiki.lava.polymtl.ca/public/modeles/rotor_53/accueil?rev=1663351548

Dernière mise à jour: **2023/04/05 08:59**