Rotor 55

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Original model

Rotor 55 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 55 has a pressure ratio of 1.2.

* Original technical report [1]:

```
@TechReport{lewis1973design,
author      = {Lewis, George W. and Moore, R. D. and Kovich, George},
title       = {Performance of a 1.20-pressure-ratio STOL fan stage at three
rotor blade setting angles},
institution = {NASA Lewis Research Center Cleveland, OH, United States},
note        = {NASA-TM X-2837, url~:
\url{https://ntrs.nasa.gov/citations/19730018974}, 1973}}
```

- Picture :

Fig1. https://catalog.archives.gov/id/17426841

```
@Misc{marton1975records,
author   = {Marton, J.},
title    = {STOL short take off landing 55 GE General Electric 15 blade rotor
showing blade damage. {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/17426841}{https://catalog.archives.gov/
id/17426841}, 1975 }, % for Fig. 1}
```

Useful documents

- PDF of the NASA report :

  rotor55.pdf

- CSV file of the blade geometry :

  rotor55_original.csv

Geometry

The geometry of rotor 55 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 55

RP	PERCENT SPAN	RADII RI	RADII RO	BLADE ANGLES KIC	BLADE ANGLES KTC	BLADE ANGLES KOC	CONE ANGLE
TIP	0.	25.400	25.400	50.40	41.08	32.00	0.057
1	5.	24.730	24.714	50.29	38.96	27.64	-0.124
2	10.	24.026	24.028	50.05	37.05	24.05	0.057
3	15.	23.323	23.343	49.67	35.44	21.21	0.152
4	30.	21.172	21.285	47.72	30.64	13.56	0.892
5	50.	18.320	18.542	43.95	24.18	4.41	1.806
6	70.	15.539	15.799	39.62	17.42	-4.79	2.239
7	85.	13.541	13.741	34.40	11.69	-11.02	1.813
8	90.	12.907	13.056	32.39	9.69	-13.01	1.375
9	95.	12.288	12.370	30.27	7.66	-14.95	0.769
HUB	100.	11.684	11.684	28.06	5.61	-16.84	0.057

RP	BLADE THICKNESSES TI	TM	TO	AXIAL DIMENSIONS ZI	ZMC	ZTC	ZO
TIP	0.019	0.239	0.019	-0.636	2.690	2.690	6.522
1	0.025	0.264	0.025	-0.671	2.650	2.650	6.546
2	0.031	0.293	0.031	-0.685	2.639	2.639	6.588
3	0.036	0.326	0.036	-0.680	2.658	2.658	6.644
4	0.050	0.441	0.050	-0.659	2.648	2.648	6.597
5	0.063	0.591	0.063	-0.572	2.669	2.669	6.455
6	0.083	0.741	0.083	-0.371	2.753	2.753	6.284
7	0.091	0.839	0.091	-0.206	2.824	2.824	6.116
8	0.090	0.862	0.090	-0.142	2.852	2.852	6.057
9	0.088	0.881	0.088	-0.073	2.881	2.881	5.998
HUB	0.084	0.896	0.084	0.	2.912	2.912	5.938

Aerodynamic design

	unit	values
pressure ratio	[-]	1.2
mass flow	[kg/s]	31.2
tip speed	[m/s]	213.3
tip solidity	[-]	0.89
aspect ratio	[-]	1.43
number of blades	[-]	15
rotative speed	[rad/s]	839.85

Material properties

The original material of the rotor 55 is not defined in the NASA report.

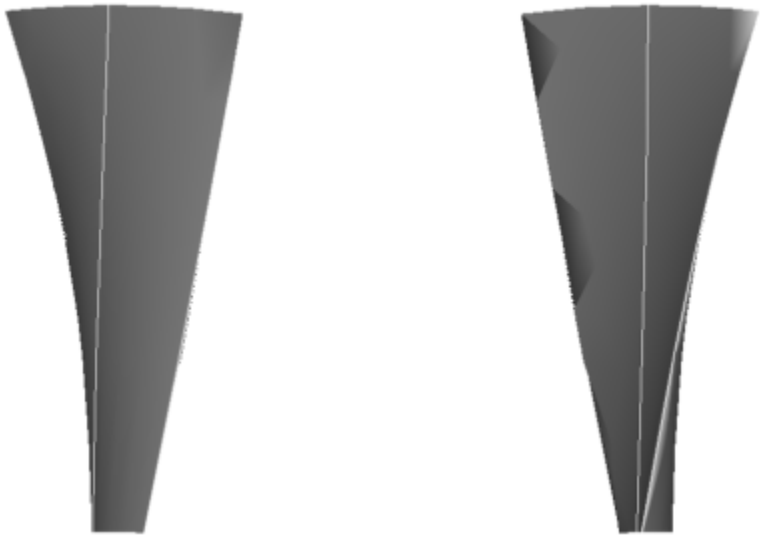
Considered properties: Ti-6Al-4V, generic titanium :

	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): 2765.7 rad/s / 440.2 Hz
2. (2B): 7258.8 rad/s / 1155.3 Hz
3. (1T): 10935.4 rad/s / 1740.4 Hz

CAD



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Modèle original

Le rotor 55 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 55 possède un taux de compression de 1,2.

- Rapport technique original [1]:

```
@TechReport{lewis1973design,
author      = {Lewis, George W. and Moore, R. D. and Kovich, George},
title       = {Performance of a 1.20-pressure-ratio STOL fan stage at
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- Photographie :

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id/17426841}, 1975 }, % for Fig. 1}
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Documents utiles

- PDF du rapport de la NASA : rotor55.pdf
- Fichier CSV de la géométrie : rotor55_original.csv

Géométrie

La géométrie du rotor 55 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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5	50.	18.320	18.542	43.95	24.18	4.41	1.806
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RP	BLADE THICKNESSES TI	BLADE THICKNESSES TM	BLADE THICKNESSES TO	AXIAL DIMENSIONS ZI	AXIAL DIMENSIONS ZMC	AXIAL DIMENSIONS ZTC	AXIAL DIMENSIONS ZO
TIP	0.019	0.239	0.019	-0.636	2.690	2.690	6.522
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HUB	0.084	0.896	0.084	0.	2.912	2.912	5.938

Caractéristiques aérodynamiques

	unités	valeurs
taux de compression	[-]	1,2
débit massique	[kg/s]	31,2
vitesse en tête	[m/s]	213,3
solidité en tête	[-]	0,89
allongement	[-]	1,43
nombre d'aubes	[-]	15
vitesse de rotation	[rad/s]	839,85

Propriétés matériau

Le matériau original du rotor 55 n'est pas défini dans le rapport de la NASA.

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

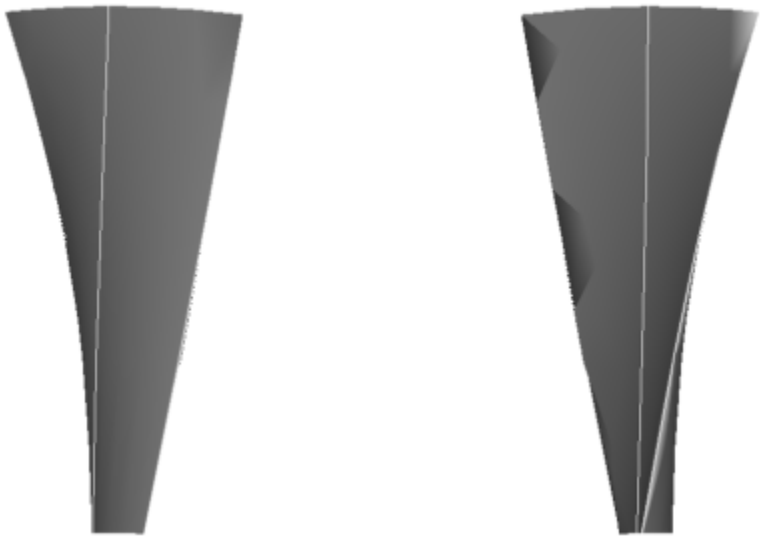
	unité	valeurs
alliage	[-]	Ti-6Al-4v
module d'Young	[GPa]	108
masse volumique	[kg/m3]	4400
coefficient de Poisson	[-]	0,34

	unité	valeurs
limite élastique	[GPa]	0,824

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

1. (1B): 2765,7 rad/s / 440,2 Hz
2. (2B): 7258,8 rad/s / 1155,3 Hz
3. (1T): 10935,4 rad/s / 1740,4 Hz

CAO



1. [a, b] Lewis. «Performance of a 1.20-pressure-ratio STOL fan stage at three rotor blade setting angles » 1973. pdf