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 [(cite:osborn1978design>Osborn. «Aerodynamic Performance of a 1.35-Pressure-Ratio Axial-Flow Fan Stage » 1978. pdf)]:

```
@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

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@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 SPAN	RADII RI	RO	BLADE ANGLES KIC	KTC	KOC	DELTA INC	CONE ANGLE
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 TI	TM	TO	AXIAL DIMENSIONS 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 :

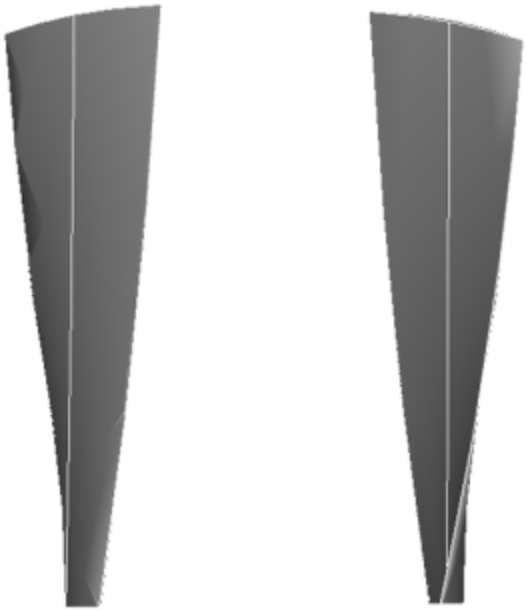
	unité	valeurs

	unité	valeurs
alloy	[-]	Ti-6Al-4V
Young's modulus	[GPa]	108
density	[kg/m3]	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



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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 [(cite:osborn1978design>Osborn. «Aerodynamic Performance of a 1.35-Pressure-Ratio Axial-Flow Fan Stage » 1978. pdf)]:

```
@TechReport{osborn1978design,
author      = {Osborn, Walter M. and Moore, R. D. and Steinke, Ronald J.},
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- Photographie :



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

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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.

TABLE IV. - BLADE GEOMETRY FOR ROTOR 53

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RP	SPAN	RI	RO	KIC	KTC	KOC	INC	ANGLE
TIP	0.	25.235	24.498	57.67	48.68	39.79	3.67	-12.422
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5	50.	17.170	17.329	40.30	28.51	16.72	5.70	2.014
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	BLADE THICKNESSES			AXIAL DIMENSIONS			
RP	TI	TM	TO	ZI	ZMC	ZTC	ZO
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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

	unités	valeurs
vitesse en tête	[m/s]	302,8
solidité en tête	[-]	1
allongement	[-]	2,86
nombre d'aubes	[-]	30
vitesse de rotation	[rad/s]	1200

Propriétés matériau

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

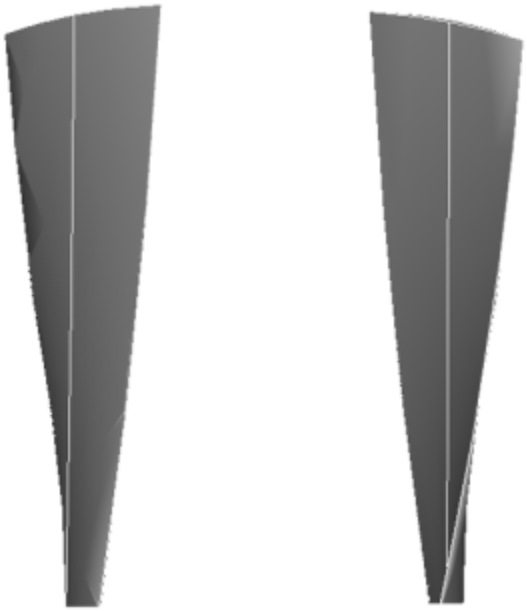
Propriétés considérées : alliage de titane Ti-6Al-4v :

	unité	valeurs
alliage	[-]	Ti-6Al-4v
module d'Young	[GPa]	108
masse volumique	[kg/m3]	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



Document issu de la page wiki:
https://wiki.lava.polymtl.ca/public/modeles/rotor_53/accueil?rev=1663351548

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