Rotor 27A

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Original model

Rotor 27A is part of a research program to study the effects of aspect ratio, diffusion factor, and solidity on rotors. To do so, experimental studies have been conducted on a series of high-hub-tip-radius-ratio compressor stages representative of the middle and latter stages of axial-flow compressors. In fact, 14 middle stages were tested to assess the effects on performance of varying both diffusion through the rotor and stator blades and blade aspect ratio. Among these 14 stages, there are rotors 23B, 24A, 25A, 26B, 27A and 28B. Both the tip diameter and the hub-tip radius ratio were held constant throughout each stage at 50.8 centimeters and 0.8, respectively.

- Original technical report [1]:

```
@TechReport{britsch1979design,
author      = {Britsch, Werner R. and Osborn, Walter M. and Laessig, Mark
R.},
title       = {Effects of Diffusion Factor, Aspect Ratio, and Solidity on
Overall Performance of 14 Compressor Middle Stages},
institution = {NASA Lewis Research Center Cleveland, OH, United States},
note        = {NASA-TP-1523, url~:
\url{https://ntrs.nasa.gov/citations/19790025039}, 1979 }}
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- Picture :

https://catalog.archives.gov/id/17447129

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@Misc{brown1975records,
author   = {Brown, M.},
title    = {Rotor 27. {R}ecords of the {N}ational {A}eronautics and {S}pace
{A}dministration, 1903 - 2006. {P}hotographs relating to agency activities,
facilities and personnel, 1975 - 2013},
note     =
{\href{https://catalog.archives.gov/id/17447129}{https://catalog.archives.gov/
id/17447129}, 1975 }, % for Fig. 1}
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Useful documents

- PDF of the NASA report : rotor27a.pdf
- CSV file of the blade geometry : rotor27a_original.csv

Geometry

The geometry of rotor 27A is described in the original NASA report by the following tables. The length are in centimeters and the angles in degrees.

TABLE 12. – BLADE GEOMETRY FOR ROTOR 27A

RP	PERCENT SPAN	RADII RI	RADII RO	BLADE ANGLES KIC	BLADE ANGLES KTC	BLADE ANGLES KOC	DELTA INC	CONE ANGLE
TIP	0.	25.400	25.400	63.52	56.76	49.69	2.61	0.057
1	5.	25.177	25.146	63.19	56.32	48.85	2.73	-0.446
2	10.	24.927	24.892	62.85	55.81	47.95	2.96	-0.501
3	15.	24.673	24.638	62.52	55.28	46.95	3.15	-0.491
4	30.	23.895	23.876	61.64	53.78	43.96	3.72	-0.259
5	50.	22.852	22.860	60.54	51.80	39.60	4.45	0.107
6	70.	21.806	21.844	59.40	49.68	34.47	5.13	0.451
7	85.	21.027	21.082	58.57	47.95	29.81	5.60	0.621
8	90.	20.773	20.828	58.29	47.25	27.79	5.74	0.606
9	95.	20.525	20.574	58.02	46.39	25.19	5.87	0.525
HUB	100.	20.320	20.320	57.79	45.61	22.37	5.98	0.057

RP	BLADE THICKNESSES TI	TM	TO	AXIAL DIMENSIONS ZIC	ZMC	ZTC	ZOC
TIP	0.051	0.213	0.051	0.609	2.388	2.330	4.524
1	0.051	0.224	0.051	0.586	2.388	2.305	4.560
2	0.051	0.256	0.051	0.559	2.388	2.276	4.598
3	0.051	0.248	0.051	0.532	2.387	2.245	4.638
4	0.051	0.284	0.051	0.453	2.384	2.148	4.754
5	0.051	0.330	0.051	0.348	2.381	2.009	4.914
6	0.051	0.375	0.051	0.229	2.374	1.849	5.086
7	0.051	0.406	0.051	0.131	2.368	1.716	5.231
8	0.051	0.416	0.051	0.092	2.366	1.665	5.289
9	0.051	0.426	0.051	0.044	2.362	1.606	5.361
HUB	0.051	0.434	0.051	-0.000	2.359	1.554	5.438

Aerodynamic design

	unit	values
pressure ratio	[-]	1.328
mass flow	[kg/s]	9.46
tip speed	[m/s]	243.8
tip solidity	[-]	1.8
aspect ratio	[-]	0.7
number of blades	[-]	40
rotative speed	[rad/s]	960.28

Material properties

The original material of the rotor 27A is not defined in the NASA report.

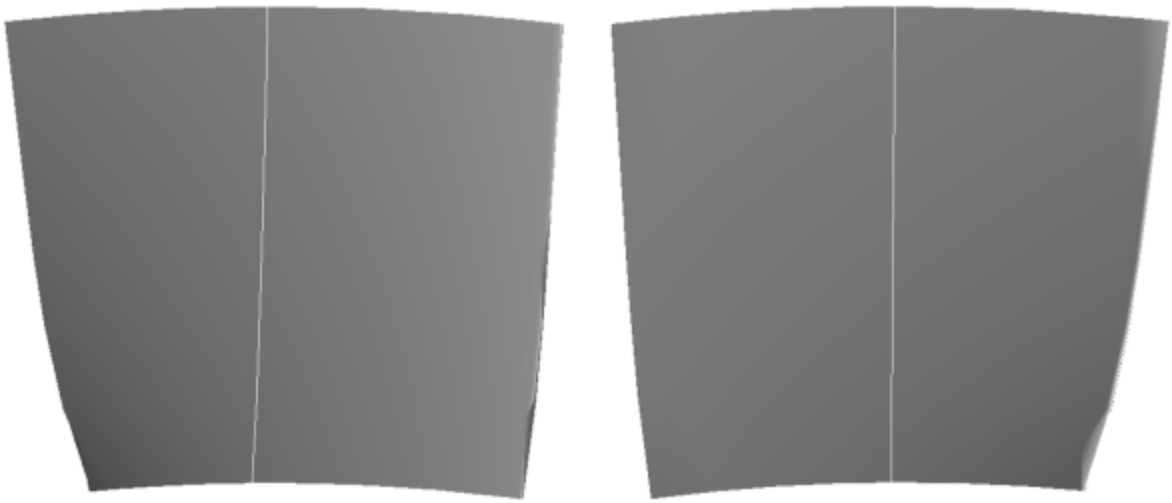
Considered properties: 200-grade maraging steel :

	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. (1B): 8846.6 rad/s / 1408.0 Hz
2. (1T): 17556.5 rad/s / 2794.2 Hz
3. (2B): 27182.0 rad/s / 4326.1 Hz

CAD



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Modèle original

Le rotor 27A fait partie d'un programme de recherche visant à étudier les effets de l'allongement, du facteur de diffusion et de la solidité des rotors. Pour ce faire, des études expérimentales ont été menées sur une série d'étages de compresseurs à fort rapport entre les rayons du moyeu et de la tête d'aube, représentatifs des étages moyens et avancés des compresseurs à flux axial. En effet, 14 étages intermédiaires ont été testés pour évaluer les effets sur les performances de la variation de la diffusion et de l'allongement des aubes. Parmi ces 14 étages, on trouve les rotors 23B, 24A, 25A, 26B, 27A et 28B. Le diamètre de l'extrémité des aubes et le rapport entre les rayons du moyeu et de la tête d'aube ont été maintenus constants tout au long de chaque étage à 50.8 centimètres et 0.8, respectivement.

- Rapport technique original [1]:

```
@TechReport{britsch1979design,
author      = {Britsch, Werner R. and Osborn, Walter M. and Laessig, Mark
R.},
title       = {Effects of Diffusion Factor, Aspect Ratio, and Solidity on
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```

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\url{https://ntrs.nasa.gov/citations/19790025039}, 1979 }}
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- Photographie :

https://catalog.archives.gov/id/17447129

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id/17447129}, 1975 }, % for Fig. 1}
```

Documents utiles

- PDF du rapport de la NASA : rotor27a.pdf
- Fichier CSV de la géométrie : rotor27a_original.csv

Géométrie

Le matériau original du rotor 27A n'est pas défini dans le rapport de la NASA.

Propriétés considérées : un acier maraging de grade 200 :

TABLE 12. – BLADE GEOMETRY FOR ROTOR 27A

	PERCENT	RADII		BLADE ANGLES			DELTA	CONE
RP	SPAN	RI	RO	KIC	KTC	KOC	INC	ANGLE
TIP	0.	25.400	25.400	63.52	56.76	49.69	2.61	0.057
1	5.	25.177	25.146	63.19	56.32	48.85	2.73	-0.446
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3	15.	24.673	24.638	62.52	55.28	46.95	3.15	-0.491
4	30.	23.895	23.876	61.64	53.78	43.96	3.72	-0.259
5	50.	22.852	22.860	60.54	51.80	39.60	4.45	0.107
6	70.	21.806	21.844	59.40	49.68	34.47	5.13	0.451
7	85.	21.027	21.082	58.57	47.95	29.81	5.60	0.621
8	90.	20.773	20.828	58.29	47.25	27.79	5.74	0.606
9	95.	20.525	20.574	58.02	46.39	25.19	5.87	0.525
HUB	100.	20.320	20.320	57.79	45.61	22.37	5.98	0.057

	BLADE THICKNESSES			AXIAL DIMENSIONS			
RP	TI	TM	TO	ZIC	ZMC	ZTC	ZOC
TIP	0.051	0.213	0.051	0.609	2.388	2.330	4.524
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4	0.051	0.284	0.051	0.453	2.384	2.148	4.754
5	0.051	0.330	0.051	0.348	2.381	2.009	4.914
6	0.051	0.375	0.051	0.229	2.374	1.849	5.086
7	0.051	0.406	0.051	0.131	2.368	1.716	5.231
8	0.051	0.416	0.051	0.092	2.366	1.665	5.289
9	0.051	0.426	0.051	0.044	2.362	1.606	5.361
HUB	0.051	0.434	0.051	-0.000	2.359	1.554	5.438

Caractéristiques aérodynamiques

	unités	valeurs
taux de compression	[-]	1,328
débit massique	[kg/s]	9,46
vitesse en tête	[m/s]	243,8
solidité en tête	[-]	1,8
allongement	[-]	0,7
nombre d'aubes	[-]	40
vitesse de rotation	[rad/s]	960,28

Propriétés matériau

Le matériau supposé du rotor 23B est un alliage à base de nickel : un acier maraging de grade 200

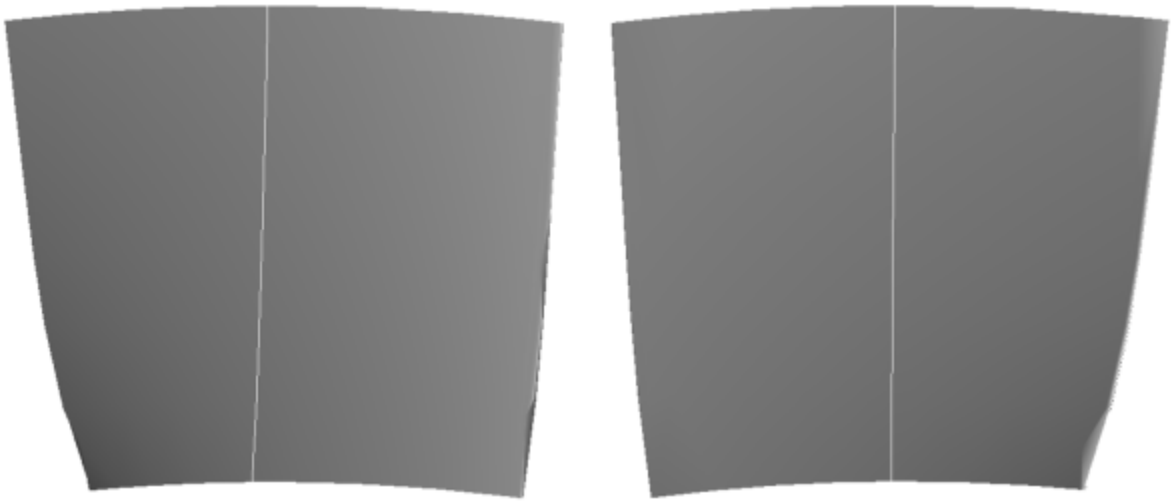
	unité	valeurs
alliage	[-]	18-Ni-200-maraging
module d'Young	[GPa]	180
masse volumique	[kg/m3]	8000
coefficient de Poisson	[-]	0,3
limite élastique	[GPa]	1,38

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

1. (1B): 8846,6 rad/s / 1408,0 Hz

2. (1T): 17556,5 rad/s / 2794,2 Hz
3. (2B): 27182,0 rad/s / 4326,1 Hz

CAO



1. [a, b] Britsch. «Design and overall performance of four highly loaded, high speed inlet stages for an advanced high-pressure-ratio core compressor » 1979. pdf