Rotor 38

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Original model

Rotor 38 is part of a research program to study a advanced-core compressor design with a high compression ratio (20:1). It is therefore the fourth stage rotor of this eight stage transonic compressor. Of these eight stages, the first four have been designed and tested : rotors 35, 36, 37 and 38. For more information, here is a link to report from NASA.

- Original technical report [1]:

```
@TechReport{moore1982design,
author      = {Moore, R. D. and Reid, Lonnie},
title       = {Performance of Single-Stage Axial-Flow Transonic Compressor
With Rotor and Stator Aspect Ratios of 1.63 and 1.77, Respectively, and
With Design Pressure Ratio of 2.05},
institution = {NASA Lewis Research Center Cleveland, OH, United States},
note        = {NASA-TP-2001, url~:
\url{https://ntrs.nasa.gov/citations/19820014395}, 1982}}
```

- Picture :

Fig1. https://catalog.archives.gov/id/17466806

```
@Misc{brown1977records,
author   = {Brown, M.},
title    = {Rotor 35 - Rotor 38 - Stator 35 in casing. {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}, 1977 }, % for Fig. 1}
```

Useful documents

- PDF of the NASA report :

  rotor38.pdf
- CSV file of the blade geometry :

  rotor38_original.csv

Geometry

The geometry of rotor 38 is described in the original NASA report by the following tables. The length are in centimeters and the angles in degrees.

(a) Rotor 38

RP	PERCENT SPAN	RADII RI	RADII RO	BLADE ANGLES KIC	BLADE ANGLES KTC	BLADE ANGLES KOC	DELTA INC	CONE ANGLE
TIP	0.	25.283	24.770	62.69	65.32	55.39	2.38	-15.363
1	5.	24.979	24.459	62.05	64.34	53.70	2.68	-14.949
2	10.	24.641	24.148	61.34	63.25	52.12	2.98	-13.674
3	15.	24.297	23.837	60.59	62.14	50.83	3.22	-12.304
4	30.	23.231	22.904	58.53	58.87	47.21	3.63	-7.979
5	50.	21.762	21.660	56.51	54.97	41.52	4.35	-2.243
6	70.	20.236	20.416	54.16	51.32	34.46	5.63	3.612
7	85.	19.020	19.483	52.74	48.16	26.64	6.61	8.643
8	90.	18.593	19.172	52.55	47.49	23.76	6.88	10.561
9	95.	18.151	18.861	52.51	47.06	20.74	7.18	12.701
HUB	100.	17.780	18.550	52.52	46.76	17.69	7.43	13.547

RP	BLADE THICKNESSES TI	TM	TO	AXIAL DIMENSIONS ZI	ZMC	ZTC	ZO
TIP	.021	.149	.021	.504	1.738	1.717	2.371
1	.022	.157	.022	.479	1.717	1.706	2.425
2	.022	.166	.022	.450	1.695	1.687	2.477
3	.023	.174	.023	.418	1.672	1.656	2.525
4	.025	.202	.026	.311	1.622	1.526	2.648
5	.029	.239	.030	.200	1.586	1.409	2.797
6	.032	.278	.033	.109	1.522	1.304	2.958
7	.036	.311	.036	.039	1.485	1.277	3.083
8	.037	.323	.037	.021	1.468	1.226	3.122
9	.038	.336	.038	.009	1.452	1.179	3.159
HUB	.039	.346	.039	.000	1.438	1.138	3.194

Aerodynamic design

	unit	values
pressure ratio	[-]	2.05
mass flow	[kg/s]	20.2
tip speed	[m/s]	455
tip solidity	[-]	1.3
aspect ratio	[-]	1.63
number of blades	[-]	48
rotative speed	[rad/s]	1800

Material properties

Rotor 38 is made of a 200-grade maraging steel[2], but the exact material properties are not provided in the NASA report.

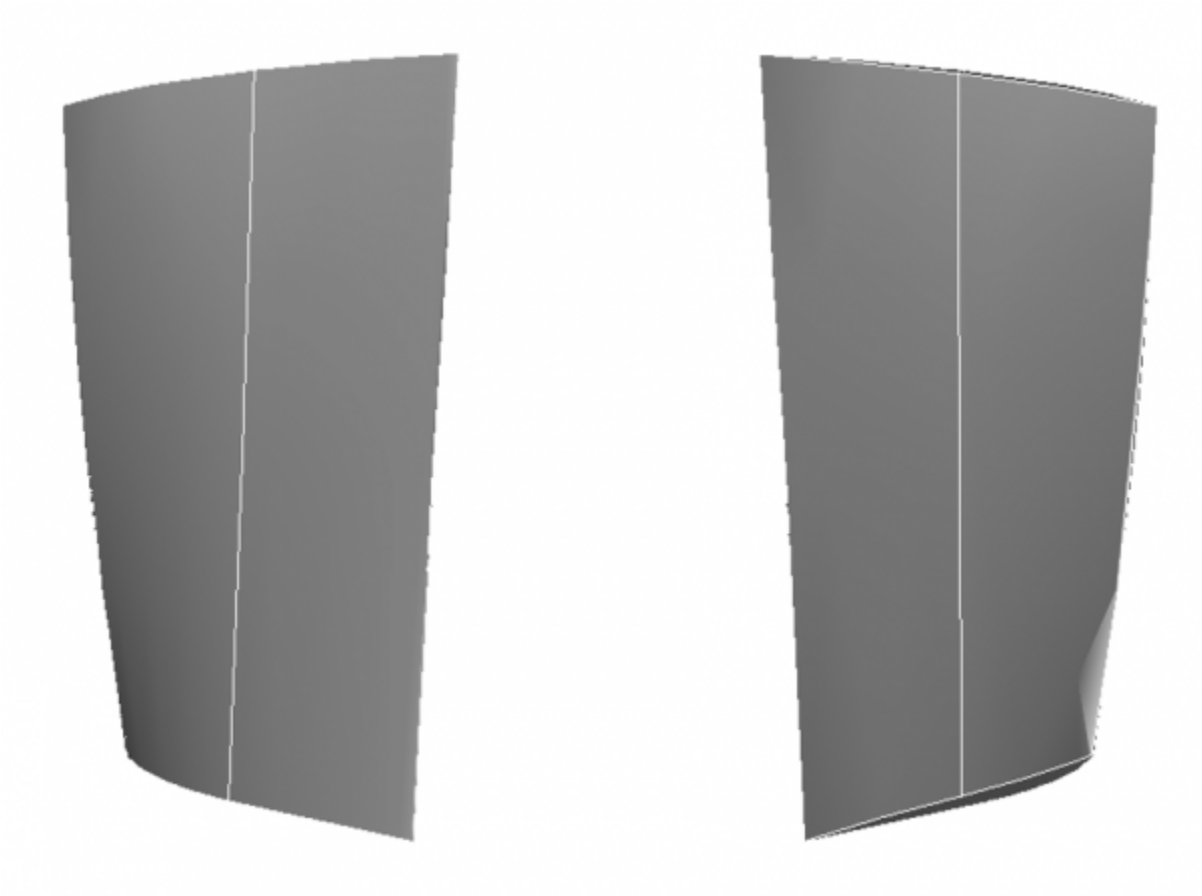
Considered properties: 18-Ni-200-maraging steel :

	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): 3773.4 rad/s / 600.5 Hz
2. (1T): 13583.8 rad/s / 2161.9 Hz
3. (2B): 14937.7 rad/s / 2377.4 Hz

CAD



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Modèle original

Le rotor 38 appartient à un programme de recherche visant à étudier une conception de compresseur possédant un grand taux de compression (20:1). Il est donc le rotor du quatrième étage de ce compresseur transsonique de huit étages. Parmi ces huit étages, les quatre premiers ont été conçus et testés, ils correspondent aux rotors 35, 36, 37 et 38. Pour plus d'information, voici un lien vers rapport de la NASA.

- Rapport technique original[1]:

```
@TechReport{moore1982design,
author      = {Moore, R. D. and Reid, Lonnie},
title       = {Performance of Single-Stage Axial-Flow Transonic Compressor
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- Photographie :

Fig1. https://catalog.archives.gov/id/17466806

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note     =
{\href{https://catalog.archives.gov/id/17466806}{https://catalog.archives.gov/
id/17466806}, 1977 }, % for Fig. 1}
```

Documents utiles

- PDF du rapport de la NASA :

rotor38.pdf

- Fichier CSV de la géométrie :

rotor38_original.csv

Géométrie

La géométrie du rotor 38 est décrite dans le rapport d'origine de la NASA par les tableaux suivants. Les grandeurs sont en centimètres et en degrés.

(a) Rotor 38

RP	PERCENT SPAN	RADII RI	RADII RO	BLADE ANGLES KIC	BLADE ANGLES KTC	BLADE ANGLES KOC	DELTA INC	CONE ANGLE
TIP	0.	25.283	24.770	62.69	65.32	55.39	2.38	-15.363
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HUB	100.	17.780	18.550	52.52	46.76	17.69	7.43	13.547

RP	BLADE THICKNESSES TI	BLADE THICKNESSES TM	BLADE THICKNESSES TO	AXIAL DIMENSIONS ZI	AXIAL DIMENSIONS ZMC	AXIAL DIMENSIONS ZTC	AXIAL DIMENSIONS ZO
TIP	.021	.149	.021	.504	1.738	1.717	2.371
1	.022	.157	.022	.479	1.717	1.706	2.425
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8	.037	.323	.037	.021	1.468	1.226	3.122
9	.038	.336	.038	.009	1.452	1.179	3.159
HUB	.039	.346	.039	.000	1.438	1.138	3.194

Caractéristiques aérodynamiques

	unités	valeurs
taux de compression	[-]	2,05
débit massique	[kg/s]	20,2
vitesse en tête	[m/s]	455
solidité en tête	[-]	1,3
allongement	[-]	1,63
nombre d'aubes	[-]	48
vitesse de rotation	[rad/s]	1800

Propriétés matériau

Le matériau du rotor 38 est un alliage à base de nickel : un acier maraging de grade 200[2], mais ses caractéristiques ne sont pas fournies dans le raport de la NASA.

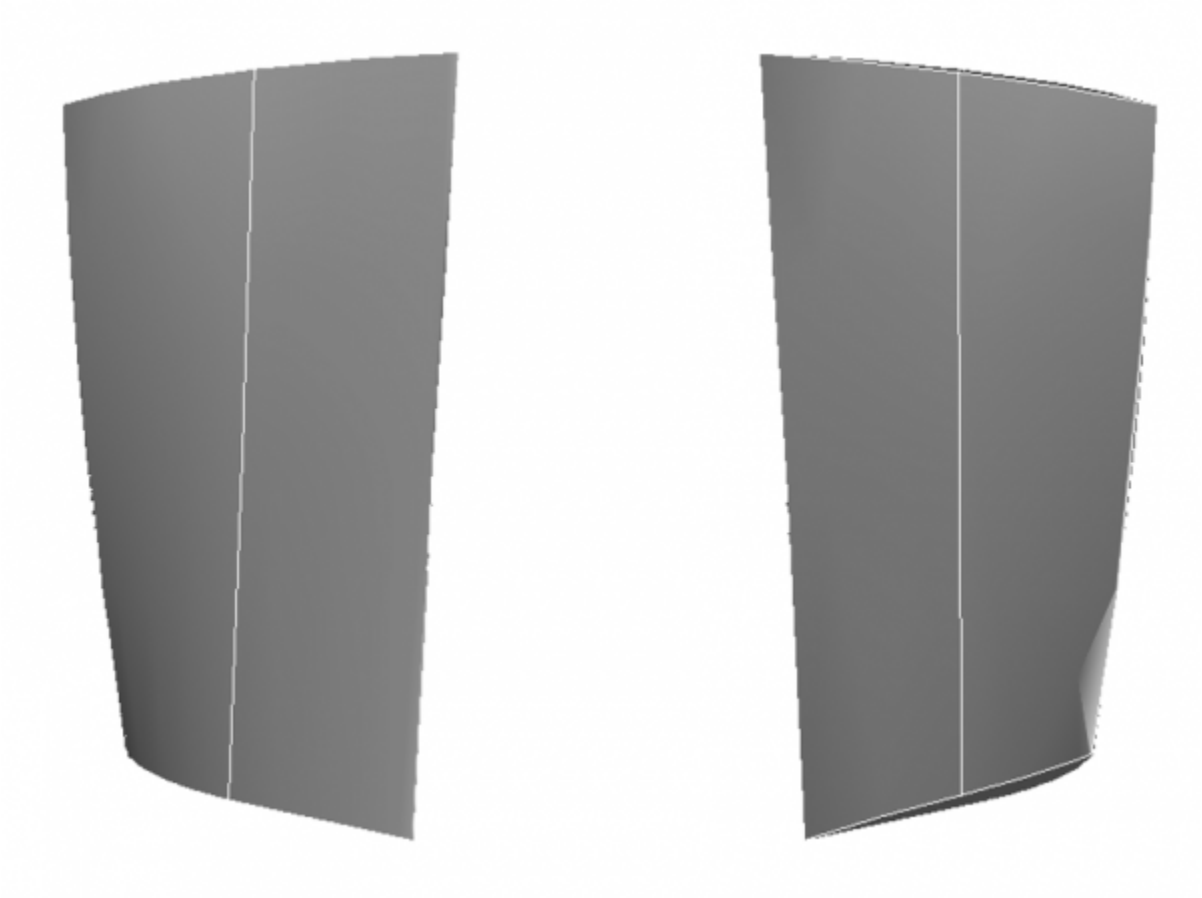
Propriétés considérées : alliage 18-Ni-200-maraging

	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): 3773,4 rad/s / 600,5 Hz
2. (1T): 13583,8 rad/s / 2161,9 Hz
3. (2B): 14937,7 rad/s / 2377,4 Hz

CAO



1. [a, b] Moore. «Performance of Single-Stage Axial-Flow Transonic Compressor With Rotor and Stator Aspect Ratios of 1.63 and 1.77, Respectively, and With Design Pressure Ratio of 2.05 » 1982. pdf
2. [a, b] Reid. «Design and overall performance of four highly loaded, high-speed inlet stages for and advanced high-pressure-ratio core compressor» 1978. pdf