Rotor 20

- Français
- English

Downloadable files
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Open access

Git project

Original model

Rotor 20 is part of a research program to study the effect of tip velocity ratio on compressors performances. It has been designed for a stage tip velocity ratio of 0.8.

- Original technical report [(cite:moore1978design>Moore. «Performance of a Transonic Fan Stage Designed for a Low Meridional Velocity Ratio » 1978. pdf)]:

```
@TechReport{moore1978design,
  author           = {Moore, R. D. and Lewis, George W. and Osborn, Walter
M.},
  date             = {1978},
  institution      = {NASA Lewis Research Center Cleveland, OH, United
States},
  title            = {Performance of a Transonic Fan Stage Designed for a
Low Meridional Velocity Ratio},
  number           = {NASA-TP-1298},
  url              =
{https://ntrs.nasa.gov/api/citations/19780025164/downloads/19780025164.pdf
},
```

- Picture :

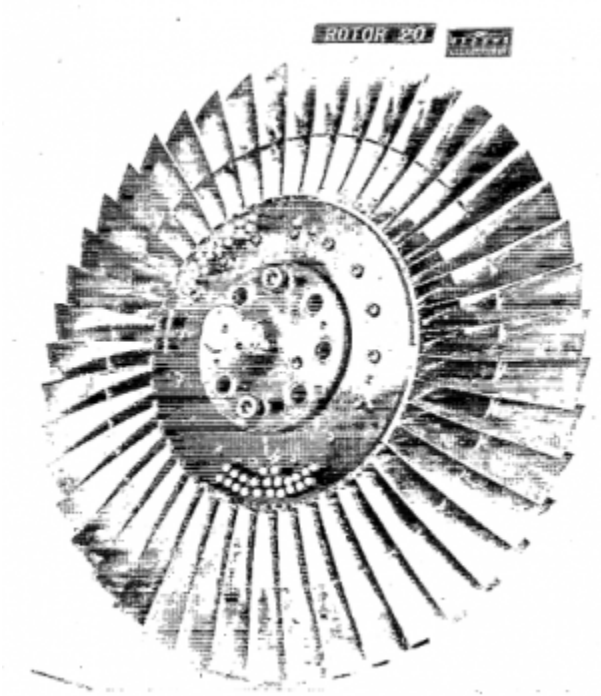


Fig1. https://ntrs.nasa.gov/api/citations/19780025164/downloads/19780025164.pdf p.61

Useful documents

- downloadable models (Git project)
- PDF of the NASA report :

  rotor20.pdf
- CSV file of the blade geometry :

  rotor20_original.csv

  , usable as input of OpenMCAD[(cite:Kojtych_2022_gene_aubes>Kojtych S., Batailly A. «OpenMCAD, an open blade generator: from Multiple-Circular-Arc profiles to Computer-Aided Design model» 2022. code en libre accès)] to generate reference blade models.

Reference blade

The **reference blade** is defined with multiple-circular arc profiles[(cite:Crouse_1969_computer)] given in the original NASA report[(cite:moore1978design)]. Corresponding models are computed with the open-source code OpenMCAD[(cite:Kojtych_2022_gene_aubes)].

Geometry

The geometry of rotor 20 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 20

RP	PERCENT SPAN	RADII RI	RADII RO	BLADE ANGLES KIC	BLADE ANGLES KTC	BLADE ANGLES KOC	DELTA INC	CONE ANGLE
TIP	0.	25.281	25.171	63.94	63.97	59.17	2.52	-3.006
1	5.	24.724	24.614	62.90	62.83	58.74	2.77	-2.925
2	10.	24.156	24.057	61.85	61.62	58.16	3.03	-2.520
3	30.	21.810	21.829	57.80	56.14	55.16	4.11	0.434
4	50.	19.385	19.601	53.76	50.05	49.12	5.19	4.227
5	55.	18.764	19.044	52.71	48.42	48.96	5.46	5.281
6	58.	18.451	18.766	52.18	47.58	45.80	5.59	5.854
7	60.	18.136	18.487	51.64	46.73	44.57	5.73	6.399
8	63.	17.819	18.209	51.09	45.86	43.29	5.86	6.974
9	70.	16.851	17.373	49.43	43.22	38.64	6.26	8.822
10	90.	14.130	15.145	44.69	36.03	20.60	7.25	14.611
11	95.	13.408	14.588	43.40	34.05	14.33	7.46	16.271
HUB	100.	12.700	14.031	42.12	32.06	7.30	7.64	17.597

RP	BLADE THICKNESSES TI	BLADE THICKNESSES TM	BLADE THICKNESSES TO	AXIAL DIMENSIONS ZIC	AXIAL DIMENSIONS ZMC	AXIAL DIMENSIONS ZTC	AXIAL DIMENSIONS ZOC
TIP	0.051	0.153	0.051	1.017	2.032	2.437	3.097
1	0.051	0.163	0.051	0.980	2.034	2.409	3.135
2	0.051	0.173	0.051	0.942	2.035	2.376	3.175
3	0.051	0.217	0.051	0.780	2.037	2.204	3.340
4	0.051	0.261	0.051	0.609	2.037	1.957	3.534
5	0.051	0.272	0.051	0.563	2.035	1.882	3.500
6	0.051	0.278	0.051	0.539	2.034	1.842	3.619
7	0.051	0.284	0.051	0.514	2.033	1.800	3.648
8	0.051	0.290	0.051	0.490	2.032	1.757	3.678
9	0.051	0.307	0.051	0.418	2.025	1.617	3.775
10	0.051	0.350	0.051	0.163	1.991	1.161	4.058
11	0.051	0.372	0.051	0.084	1.977	1.021	4.128
HUB	0.051	0.385	0.051	0.000	1.961	0.875	4.196

Aerodynamic design

	unit	values
pressure ratio	[-]	1.57
mass flow	[kg/s]	29.5
tip speed	[m/s]	425
tip solidity	[-]	1.3
aspect ratio	[-]	2.5
number of blades	[-]	44
rotative speed	[rad/s]	1686

Material properties

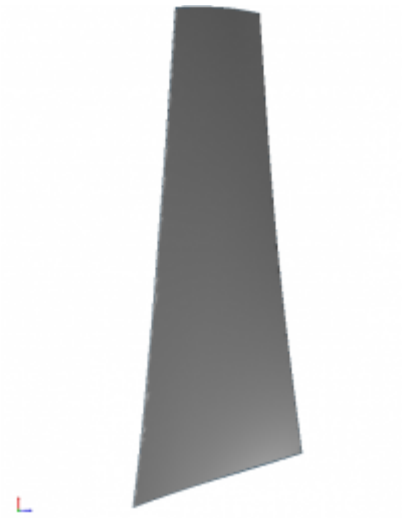
The original material of the rotor 20 is not defined in the NASA report.

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

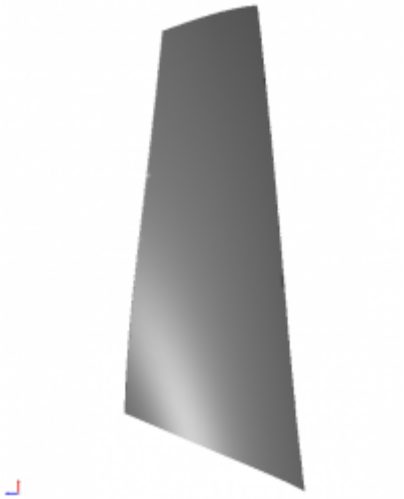
	unité	valeurs
alloy	[-]	Ti-6Al-4V
Young's modulus	[GPa]	108
density	[kg/m3]	4400
Poisson's ratio	[-]	0.34
yield stress	[GPa]	0.824

CAD model

The CAD model is computed with the open source code OpenMCAD[(cite:Kojtych_2022_gene_aubes)].



pressure side



suction side

Natural frequencies

First three natural frequencies (with clamped root) for the mesh computed with OpenMCAD[(cite:Kojtych_2022_gene_aubes)]:

Mode	Type	Natural angular frequency (rad/sec)	Natural frequency (Hz)
1	1B	1374.86	218.815
2	2B	5070.79	807.042
3	1T	7887.28	1255.3

Initial blade

The **initial blade** is defined with in-house LAVA parameters[(cite:Kojtych_2022_Methodology)] computed

from the reference blade CAD model. The initial blade is usually used as starting point for an optimization process. Its geometry is similar to the one of the reference blade.

Natural frequencies

First three natural frequencies (with clamped root)

- from the whole mesh:

Mode	Type	Natural angular frequency (rad/sec)	Natural frequency (Hz)
1	1B	1375.47	218.913
2	2B	5066.25	806.319
3	1T	7896.27	1256.73

- from the reduced order model:

Mode	Type	Natural angular frequency (rad/sec)	Natural frequency (Hz)
1	1B	1375.5	218.917
2	2B	5068.12	806.617
3	1T	7898.53	1257.09

Fichiers téléchargeables
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Libre accès

lien vers le projet Git

Modèle original

Le rotor 20 fait partie d'un programme de recherche visant à étudier l'effet du rapport de vitesse en tête sur les performances des compresseurs. Il a été conçu pour un rapport de vitesse en tête de 0,8.

- Rapport technique original [(cite:moore1978design>Moore. «Performance of a Transonic Fan Stage Designed for a Low Meridional Velocity Ratio » 1978. pdf)]:

```
@TechReport{moore1978design,
  author           = {Moore, R. D. and Lewis, George W. and Osborn, Walter
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- Photographie :

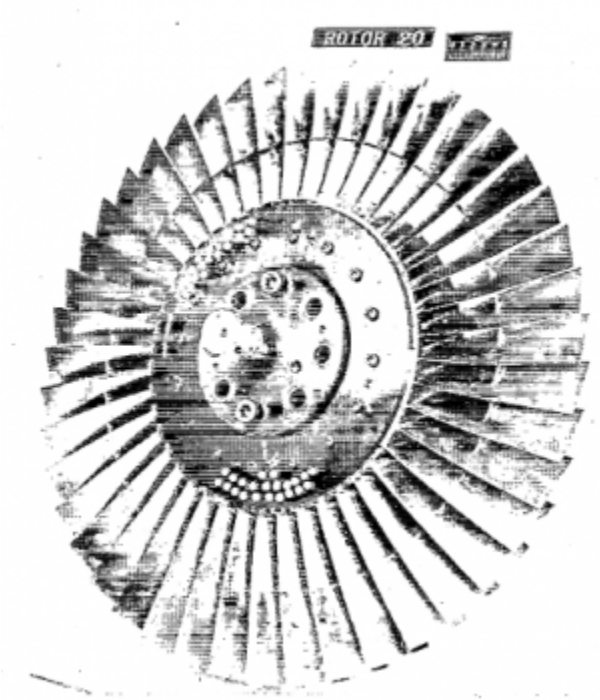

Fig1. https://ntrs.nasa.gov/api/citations/19780025164/downloads/19780025164.pdf p.61

Documents utiles

- modèles téléchargeables (lien vers projet Git)
- PDF du rapport de la NASA :

  rotor20.pdf
- Fichier CSV de la géométrie :

  rotor20_original.csv

  , utilisable en entrée de OpenMCAD[(cite:Kojtych_2022_gene_aubes>Kojtych S., Batailly A. «OpenMCAD, an open blade generator: from Multiple-Circular-Arc profiles to Computer-Aided Design model» 2022. code en libre accès)] pour générer l'aube de référence.

Aube de référence

L'**aube de référence** est définie par des profils de type arcs circulaires multiples[(cite:Crouse_1969_computer>Crouse *et al*. «A computer program for composing compressor blading from simulated circular-arc elements on conical surfaces » 1969. NASA-TN-D-5437. pdf)], donnés dans le rapport technique original de la NASA[(cite:moore1978design)]. Les modèles associés sont obtenus avec le code en libre accès OpenMCAD[(cite:Kojtych_2022_gene_aubes)].

Géométrie

La géométrie du rotor 20 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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1	0.051	0.163	0.051	0.980	2.034	2.409	3.135
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10	0.051	0.358	0.051	0.163	1.991	1.161	4.058
11	0.051	0.372	0.051	0.084	1.977	1.021	4.128
HUB	0.051	0.385	0.051	0.000	1.961	0.875	4.196

Caractéristiques aérodynamiques

	unités	valeurs
taux de compression	[-]	1,57
débit massique	[kg/s]	29,5
vitesse en tête	[m/s]	425
solidité en tête	[-]	1,3
allongement	[-]	2,5
nombre d'aubes	[-]	44
vitesse de rotation	[rad/s]	1686

Propriétés matériau

Le matériau original du rotor 20 n'est pas défini dans le rapport de la NASA.

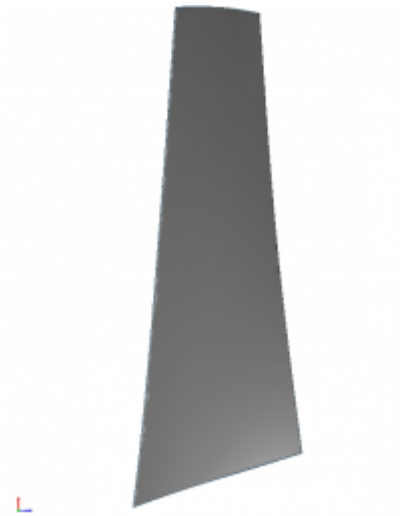
Propriétés considérées : alliage de titane Ti-6Al-4v :

	unité	valeurs

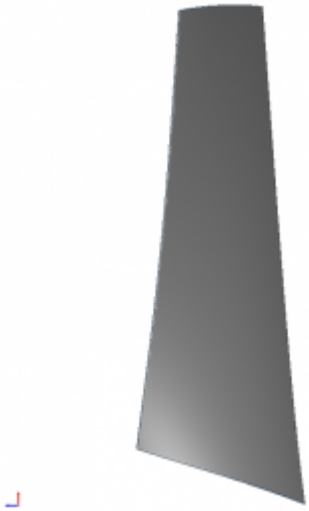
	unité	valeurs
alliage	[-]	Ti-6Al-4v
module d'Young	[GPa]	108
masse volumique	[kg/m3]	4400
coefficient de Poisson	[-]	0,34
limite élastique	[GPa]	0,824

Modèle CAO

Le modèle CAO est obtenu avec OpenMCAD[(cite:Kojtych_2022_gene_aubes)].



intrados



extrados

Fréquences propres

Fréquences des trois premiers modes (noeuds du pied d'aube encastrés) pour le maillage obtenu avec OpenMCAD[(cite:Kojtych_2022_gene_aubes)] :

Mode	Type	Pulsation propre (rad/sec)	Fréquence propre (Hz)
1	1B	1374,86	218,815
2	2B	5070,79	807,042
3	1T	7887,28	125,3

Aube initiale

L'**aube initiale** est définie par des paramètres spécifiques au LAVA[(cite:Kojtych_2022_Methodology>Kojtych S. *et al*. «Methodology for the Redesign of Compressor Blades Undergoing Nonlinear Structural Interactions: Application to Blade-Tip/Casing Contacts » 2022. Journal of Engineering for Gas Turbines and Power, Vol. 145, No. 5. pdf)] obtenus à partir du modèle CAO de l'aube de référence. L'aube initiale est classiquement utilisée comme point de départ dans le cadre de procédures d'optimisation; sa géométrie est similaire à celle de l'aube de référence.

Fréquences propres

Fréquences des trois premiers modes (noeuds du pied d'aube encastrés),

- pour le maillage complet :

Mode	Type	Pulsation propre (rad/sec)	Fréquence propre (Hz)
1	1B	1375,47	218,913
2	2B	5066,25	806,319
3	1T	7896,27	1256,73

- pour le modèle réduit :

Mode	Type	Pulsation propre (rad/sec)	Fréquence propre (Hz)
1	1B	1375,5	218,917
2	2B	5068,12	806,617
3	1T	7898,53	1257,09

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Document issu de la page wiki:
https://lava-wiki.meca.polymtl.ca/public/modeles/rotor_20/accueil?rev=1677214096

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