

Rotor 8

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Original model

Rotor 8 is part of a research program to study the effects of blade row spacing on the performance of an axial-flow compressor rotor. It is one of a series of rotors designed to study the effects of solidity : rotor 8 with a tip solidity of 1.5, rotor 12 with a tip solidity of 1.3. Tip solidity are being changed by varying the number of blades. The same velocity diagrams and flow path. These stages were designed such that the rotor and stator blades are the same.

- Original technical report [(cite:osborn1973design>Osborn. «Performance of a single-stage transonic compressor with a blade-tip solidity of 1.5 and comparison with 1.3- and 1.7-solidity stages » 1973):

```
@TechReport{osborn1973design,
  author      = {Osborn, Walter M. and Urasek, Donald C. and Moore, R. D.},
  date        = {1973},
  institution = {NASA Lewis Research Center Cleveland, OH, United States},
  title       = {Performance of a single-stage transonic compressor with a blade-tip solidity of 1.5 and comparison with 1.3- and 1.7-solidity stages},
  number      = {NASA-TM X-2926},
  url         = {https://ntrs.nasa.gov/citations/19740002621},
}
```

- Picture :

Fig 1. <https://ntrs.nasa.gov/citations/19740002621>

Useful documents

- [downloadable model project](#)
- PDF of the NASA report :
`rotor8.pdf`
- CSV file of the blade geometry :
`rotor8_original.csv`
utilisable en entrée de OpenMCAD[(cite:Kojtych_2022_gene_aubes)
«OpenMCAD, an open blade generator: from Multiple-Circular-Arc
Design model»(cite:2022enlibre)] pour générer l'aube de référence

Reference blade

The reference blade is defined with multiple-circular arc profiles[(cite:Crouse_1973design)]. The original NASA report[(cite:osborn1973design)]. Corresponding model source code OpenMCAD[(cite:Kojtych_2022_gene_aubes)].

Geometry

The geometry of rotor 8 is described in the following tables. The lengths in centimeters and the angles in degrees.

Aerodynamic design

	unit	values
pressure ratio	[-]	1.75
mass flow	[kg/s]	9.5
tip speed	[m/s]	123
tip solidity	[-]	1.5
aspect ratio	[-]	2.4
number of blades		49
rotative speed	[rad/s]	186

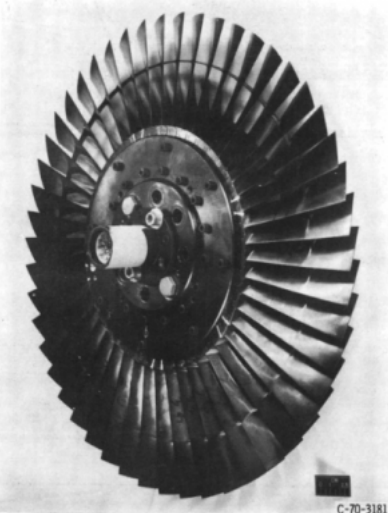
Material properties

The material of rotor 8 is not defined in the original NASA report. A generic material is considered:

	unit	values
alloy	[-]	Ti-6Al-4V
Young's modulus	[GPa]	108
density	[kg/m ³]	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:



pressure side

TABLE IV. - BLADE GEOMETRY FOR ROTOR 8

	PERCENT	RADI	BLADE ANGLES			DELTA	CONC
RP	SPAN	RO	KIC	KIC	KIC	INC	
1	0.25, 0.82, 2.4, 7.91	62.32	69.48	70.74	2.49	-0.29	
2	5.2, 24.68, 24.181	61.67	59.64	51.79	2.72	-0.85	
3	10.24, 21.21, 23.685	60.41	58.43	45.24	2.98	-1.64	
4	20.1, 21.754, 21.695	55.93	52.88	46.07	2.66	-1.99	
5	43.2, 20.287, 20.383	52.47	49.53	41.81	2.74	1.77	
6	45.18, 19.989, 20.129	52.99	48.87	40.74	4.88	2.54	
7	48.18, 19.693, 19.875	52.52	48.23	39.60	5.01	3.32	
8	50.18, 19.389, 19.621	52.06	47.58	38.38	5.15	4.14	
9	53.18, 19.085, 19.678	51.60	46.87	37.09	5.28	4.98	
10	76.16, 18.91, 17.589	49.51	45.25	26.37	6.19	10.81	
11	90.14, 17.175, 15.507	45.39	39.25		7.20	23.05	
12	95.15, 13.477, 15.049	44.77	38.93		7.20	23.05	
13	100.14, 12.00, 14.541	44.22	38.93	-7.94	7.20	23.05	

RP	BLADE THICKNESSES			AXIAL DIMENSIONS		
	T ₁	T ₂	T ₃	Z ₁	Z ₂	Z ₃
1	0.051	0.152	0.051	1.129	2.104	2.350
2	0.051	0.162	0.051	1.129	2.104	2.350
3	0.051	0.172	0.051	0.918	2.094	2.280
4	0.051	0.176	0.051	0.918	2.094	2.280
5	0.051	0.216	0.051	0.723	1.882	1.975
6	0.051	0.244	0.051	0.609	1.872	1.879
7	0.051	0.250	0.051	0.586	2.069	1.844
8	0.051	0.256	0.051	0.564	2.068	1.808
9	0.051	0.262	0.051	0.542	2.063	1.772
10	0.051	0.267	0.051	0.519	2.057	1.736
11	0.051	0.308	0.051	0.359	2.032	1.439
12	0.051	0.359	0.051	0.136	1.971	1.037
13	0.051	0.373	0.051	0.071	1.958	0.937
14	0.051	0.387	0.051	0.000	1.935	0.827

suction side

Natural frequencies

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

Mode	Type	Natural angular frequency (rad/s)	Natural frequency (Hz)
1	1B	1779.57	283.228
2	2B	6407.97	1019.86
3	1T	8746.82	1392.1

Initial blade

The initial bias is defined with in-house LAVA parameters [(cite:Kojtych 2022

from the reference blade CAD model. The initial blade is usually used as a starting point for the 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/s)	Natural cyclic frequency (Hz)
1	1B	1778.69	283.088
2	2B	6413.56	1020.75
3	1T	8747.83	1392.26

- from the reduced order model:

Mode	Type	Natural angular frequency (rad/s)	Natural cyclic frequency (Hz)
1	1B	1778.75	283.098
2	2B	6416.20	1021.17
3	1T	8750.91	1392.75

Fichiers tØlØchargeables

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Libre accØs

[lien vers le projet Git](#)

À propos

Le rotor 8 fait partie d'un programme de recherche visant à Øtudier les effets d'aubes sur l'effcacitØ et la marge de dØcrochage d'un rotor de compression d'une sØrie de rotors conçus pour Øtudier plus profondØment les effets de soliditØ en tØte de 1.5, le rotor 12 avec une soliditØ en tØte de 1.7 et de 1.3. La soliditØ est modifiØe en faisant varier le nombre d'aubes tout en maintenant la forme des aubes, la vitesse de rotation et le mØme trajet d'Øcoulement. Ces Øtages ont Øt conçus pour Øtudier les effets de la soliditØ en tØte du rotor et du stator soit la mØme.

- Rapport technique original [(cite:osborn1973design>Osborn. «Performance of a single-stage transonic compressor with a blade-tip solidity of 1.5 and comparison with a stage » 1973]:

```
@TechReport{osborn1973design,
  author      = {Osborn, Walter M. and Urasek, Donald C. and Moore, R. D.},
  date        = {1973},
  institution = {NASA Lewis Research Center Cleveland, OH, United States},
  title       = {Performance of a single-stage transonic compressor stage}}
```

```
with a blade-tip solidity of 1.5 and comparison with 1.3- and 1.7-solidity stages},
  number      = {NASA-TM X-2926},
  url         = {https://ntrs.nasa.gov/citations/19740002621},
}
```

- Photographie :

Fig 1. <https://ntrs.nasa.gov/citations/19740002621>

Documents utiles

- [modèles tØlØcha \(bienveillants\)](#) (bienveillants projet Git)
 - rapport technique original de la NASA (.pdf)
 - Fichier de paramètres gØomØtriques (.csv), utilisable en entrØe de OpenMCAD[(cite:Kojtych_2022_gencad)] (Batailly A. «OpenMCAD, an open blade generator: from Multiple-Computer-Aided Design model » 2022) pour gØnØrer l'aube de rØfØrence

Aube de référence

L'aube de référence est définie par des profils de type arcs circulaires multiples[(cite:Crouse_1969_computer)«ArcCompu»er program for composing c blading from simulated circular-arc elements on conical surfaces]cedon1969 dans le rapport technique original de la NASA[(cite:osborn1973design)] obtenus avec le code en libre accès OpenMCAD[(cite:Kojtych_2022_gene

Géométrie

La géométrie du rotor 8 est [rapportée d'origine de la NASA](#) dans les tableaux suivants. Les grandeurs sont en centimètres et en degrés.

Caractéristiques aérodynamiques

	unités	valeurs
taux de compression	-	1,75
débit massique	[kg/s]	19,5
vitesse en tête	[m/s]	123
solidité en tête	[-]	1,5
allongement	[-]	2,4
nombre d'aubes	[-]	49

	unit	valeurs
vitesse de rotation	[rad / s]	186

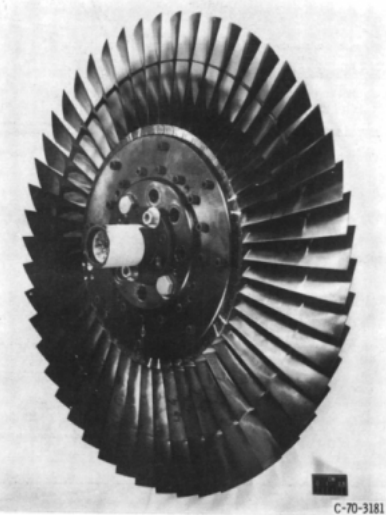
Propriétés matériau

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

	unit	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_aube)]



intrados

TABLE IV. - BLADE GEOMETRY FOR ROTOR 8											
RP	PERCENT RADII			BLADE ANGLES			DELTA INC	CONE ANGLE			
	SPAN	R _i	R _o	KTC	KTC	KOC					
TIP	0	25.082	24.701	62.92	60.67	52.54	2.49	-9.298			
1	5	24.568	24.193	61.67	59.64	51.79	2.72	-8.836			
2	10	24.021	23.685	60.41	58.43	51.04	2.98	-7.644			
3	30	21.754	21.653	55.93	52.88	46.27	4.06	-1.996			
4	43	20.287	20.383	53.47	49.53	41.81	4.74	1.771			
5	45	19.989	20.129	52.99	48.87	40.74	4.88	2.542			
6	48	19.690	19.875	52.52	48.23	39.60	5.01	3.325			
7	50	19.388	19.621	52.06	47.59	38.38	5.15	4.114			
8	53	19.085	19.367	51.60	46.97	37.09	5.28	4.908			
9	70	16.891	17.589	48.50	42.58	26.07	6.19	10.851			
10	90	14.175	15.957	45.39	39.25	6.42	7.05	18.759			
11	95	13.447	15.049	44.77	38.97	-0.40	7.20	20.972			
HUB	100	12.700	14.541	44.22	38.93	-7.94	7.32	23.205			
RP	BLADE THICKNESSES			AXIAL DIMENSIONS							
	T _i	T _M	T _o	Z _{1C}	Z _M	Z _{2C}	Z _{oC}				
TIP	0.051	0.192	0.051	1.020	2.104	2.330	3.347				
1	0.051	0.162	0.051	0.970	2.098	2.290	3.379				
2	0.051	0.172	0.051	0.918	2.094	2.246	3.417				
3	0.051	0.216	0.051	0.723	2.082	2.039	3.598				
4	0.051	0.244	0.051	0.609	2.072	1.879	3.715				
5	0.051	0.250	0.051	0.586	2.069	1.844	3.739				
6	0.051	0.256	0.051	0.564	2.066	1.808	3.764				
7	0.051	0.262	0.051	0.542	2.063	1.772	3.789				
8	0.051	0.267	0.051	0.519	2.060	1.734	3.815				
9	0.051	0.309	0.051	0.354	2.032	1.439	4.000				
10	0.051	0.359	0.051	0.138	1.977	1.037	4.208				
11	0.051	0.373	0.051	0.071	1.958	0.920	4.253				
HUB	0.051	0.387	0.051	0.000	1.935	0.797	4.295				

extrados

Fréquences propres

Fréquences des trois premiers modes (nœuds du pied d'aube encastrés OpenMCAD[(cite:Kojtych_2022_gene_aubes)] :

Mode	Type	Pulsation propre (rad/s)	Fréquence propre (Hz)
1	1B	1779,57	283,228
2	2B	6407,97	1019,86
3	1T	8746,82	1392,1

Aube initiale

L'aube initiale est définie par des paramètres spécifiques au LAVA[(cite:Kojtych_2022_Methodology for the Redesign of Compressor Blades Undergoing Nonlinear Structural Interactions: Application to Blade Flow and Vibration)] Journal of Engineering for Gas Turbines and Power, Vol. 145, No. 5, pp. 051001, 2022. L'aube initiale est classiquement utilisée comme procédure d'optimisation; sa géométrie est similaire à celle de l'aube

Fréquences propres

Fréquences des trois premiers modes (nœuds du pied d'aube encastrés

- pour le maillage complet :

Mode	Type	Pulsation propre (rad/s)	Fréquence propre (Hz)
1	1B	1778,69	283,088
2	2B	6413,56	1020,75
3	1T	8747,83	1392,26

- pour le modèle réduit :

Mode	Type	Pulsation propre (rad/s)	Fréquence propre (Hz)
1	1B	1778,75	283,098
2	2B	6416,20	1021,17
3	1T	8750,91	1392,75

Document issu de la page wiki:

https://lava-wiki.meca.polymtl.ca/public/modeles/rotor_08/accueil?rev=

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