Rotor 74A2

- Français
- English

Downloadable files
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Open access

Git project

About

Compressor 74A is part of a research program to study fans and compressors for advanced airbreathing engines to assess and improve the technology needed for high pressure ratio, good efficiency, and adequate stall margin in as few stages as possible. This compressor consists of inlet guide vanes and five stages, and it is designed for a 9.271 pressure ratio. Rotor 74A2 is the rotor of the second stage of this compressor.

- Original technical report [(cite:steinke1986design>Steinke R.J. «Design of 9.271-Pressure-Ratio Five-Stage Core Compressor and Overall Performance for First Three Stages » 1986. pdf)]:

```
@TechReport{steinke1986design,
  author           = {Steinke, Ronald J.},
  date             = {1986},
  institution      = {NASA Lewis Research Center Cleveland, OH, United
States},
  title            = {Design of 9.271-Pressure-Ratio Five-Stage Core
Compressor and Overall Performance for First Three Stages},
  number           = {NASA-TP-2597},
  url              = {https://ntrs.nasa.gov/citations/19870008266},
}
```

- Picture :

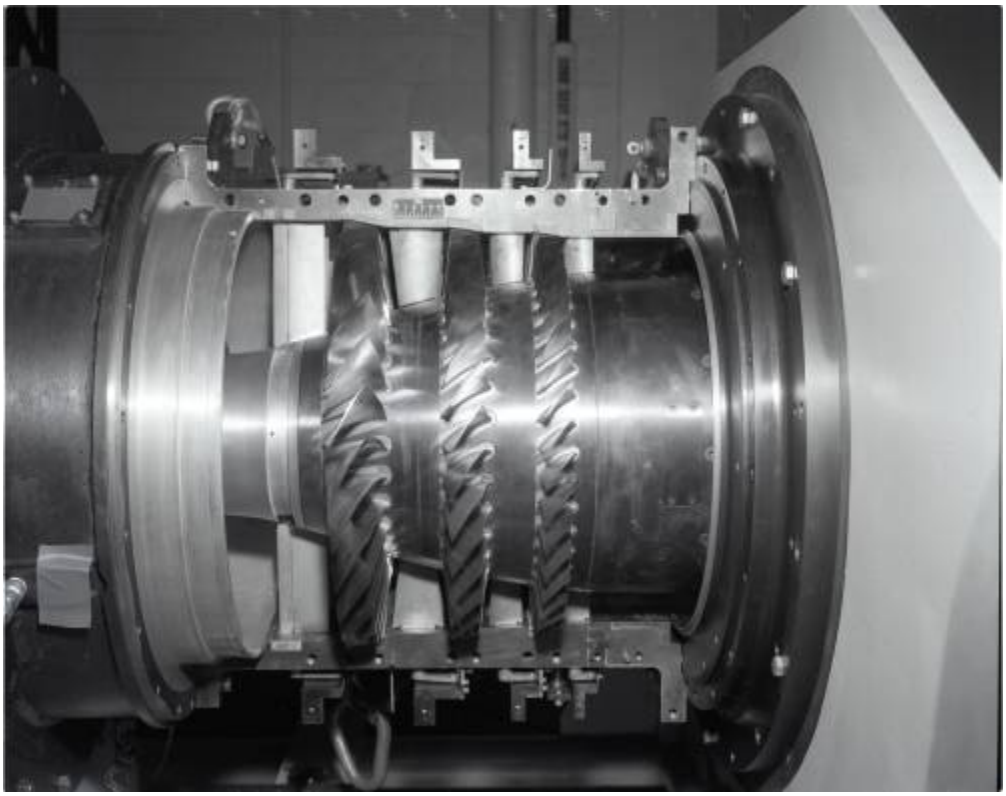


Fig. 1 https://catalog.archives.gov/id/17443470

- ```
  @Misc{Huebler1978records,
  author   = {Huebler, D.},
  title    = {74A Compressor. {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},
  year     = {1978},
  url     = {https://catalog.archives.gov/id/17443470}}
  ```

Useful documents

- downloadable models (Git project)
  - NASA technical report (.pdf)
  - geometrical parameters file (.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. open osurce code)] 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:steinke1986design)]. Corresponding models are computed with the open-source code OpenMCAD[(cite:Kojtych_2022_gene_aubes)].

Geometry

The geometry of rotor 74A2 is described in the original NASA report by the following tables. The length are in centimeters and the angles in degrees.

(d) Rotor 2

RP	PERCENT SPAN	RADII RI	RADII RO	BLADE ANGLES KIC	BLADE ANGLES KTC	BLADE ANGLES KOC	DELTA INC	CONE ANGLE
TIP	0.	24.778	24.300	63.49	54.90	46.37	3.35	-8.299
1	5.	24.307	23.868	61.92	53.79	45.88	3.64	-7.345
2	10.	23.867	23.504	60.51	52.77	45.40	3.92	-5.895
3	20.	23.025	22.800	58.15	50.89	44.17	4.46	-3.478
4	30.	22.201	22.110	56.40	49.13	42.43	4.97	-1.351
5	40.	21.390	21.433	54.91	47.30	40.06	5.47	.610
6	50.	20.581	20.765	53.48	45.47	37.09	5.96	2.505
7	60.	19.773	20.107	52.11	43.53	33.48	6.43	4.367
8	70.	18.966	19.462	50.81	41.51	29.22	6.88	6.218
9	80.	18.161	18.835	49.63	39.37	24.01	7.30	8.087
10	90.	17.355	18.230	48.67	36.98	16.95	7.64	9.992
11	95.	16.950	17.937	48.30	35.61	12.43	7.78	10.961
HUB	100.	16.487	17.556	47.87	34.05	6.70	7.94	11.527

RP	BLADE THICKNESSES TI	BLADE THICKNESSES TM	BLADE THICKNESSES TO	AXIAL DIMENSIONS ZI	AXIAL DIMENSIONS ZMC	AXIAL DIMENSIONS ZTC	AXIAL DIMENSIONS ZO
TIP	.028	.201	.027	14.275	15.749	16.341	17.549
1	.030	.219	.030	14.201	15.745	16.279	17.603
2	.032	.236	.032	14.136	15.743	16.221	17.647
3	.037	.268	.038	14.029	15.741	16.103	17.729
4	.042	.300	.042	13.941	15.737	15.979	17.806
5	.046	.331	.047	13.859	15.732	15.849	17.888
6	.051	.362	.051	13.778	15.727	15.711	17.976
7	.055	.393	.056	13.697	15.721	15.564	18.070
8	.059	.425	.061	13.611	15.710	15.405	18.166
9	.064	.457	.065	13.520	15.698	15.237	18.270
10	.069	.490	.070	13.414	15.681	15.048	18.384
11	.071	.506	.072	13.349	15.665	14.941	18.443
HUB	.074	.525	.074	13.275	15.647	14.820	18.519

Aerodynamic design

	units	values
pressure ratio	[-]	1.691
mass flow	[kg/s]	29.71
tip speed	[m/s]	416
tip solidity	[-]	1.25
aspect ratio	[-]	1.17
number of blades	[-]	32
rotative speed	[rad/s]	1680

Material properties

Rotor 74A2 is made of titanium according to the NASA report, but the exact properties are not provided. A generic titanium Ti-6Al-4V is considered:

	units	values

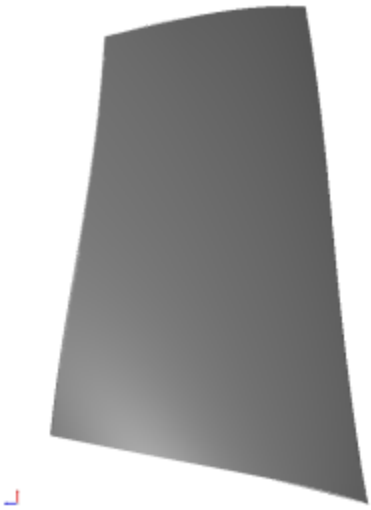
	units	values
alloy	[-]	Ti-6Al-4V
Young's modulus	[GPa]	108
density	[kg/m3]	4400
Poisson's ratio	[-]	0.34
yield stress	[GPa]	0.824

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	4884.844	777.447
2	1T	15222.59	2422.75
3	2B	17870.82	2844.23

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	4883.512	777.235
2	1T	15179.04	2415.82
3	2B	17886.78	2846.77

- from the reduced order model:

Mode	Type	Natural angular frequency (rad/sec)	Natural frequency (Hz)
1	1B	4884.14	777.335
2	1T	15188.03	2417.25
3	2B	17907.64	2850.09

Fichiers téléchargeables
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Libre accès

lien vers le projet Git

À propos

Le compresseur 74A fait partie d'un programme de recherche visant à étudier les soufflantes et les compresseurs pour des moteurs à air comprimé afin d'évaluer et d'améliorer les technologies nécessaires pour obtenir un rapport de pression élevé, un bon rendement et une marge de décrochage adéquate avec le moins d'étage possible. Ce compresseur comporte des redresseurs d'admission et cinq étages, et il est conçu pour un rapport de pression de 9,271. Le rotor 74A2 appartient au deuxième étage de ce compresseur.

- Rapport technique original [(cite:steinke1986design>)]:

```
@TechReport{steinke1986design,
  author           = {Steinke, Ronald J.},
```

```
  date              = {1986},
  institution       = {NASA Lewis Research Center Cleveland, OH, United
States},
  title             = {Design of 9.271-Pressure-Ratio Five-Stage Core
Compressor and Overall Performance for First Three Stages},
  number            = {NASA-TP-2597},
  url               = {https://ntrs.nasa.gov/citations/19870008266},
}
```

- Photographie :

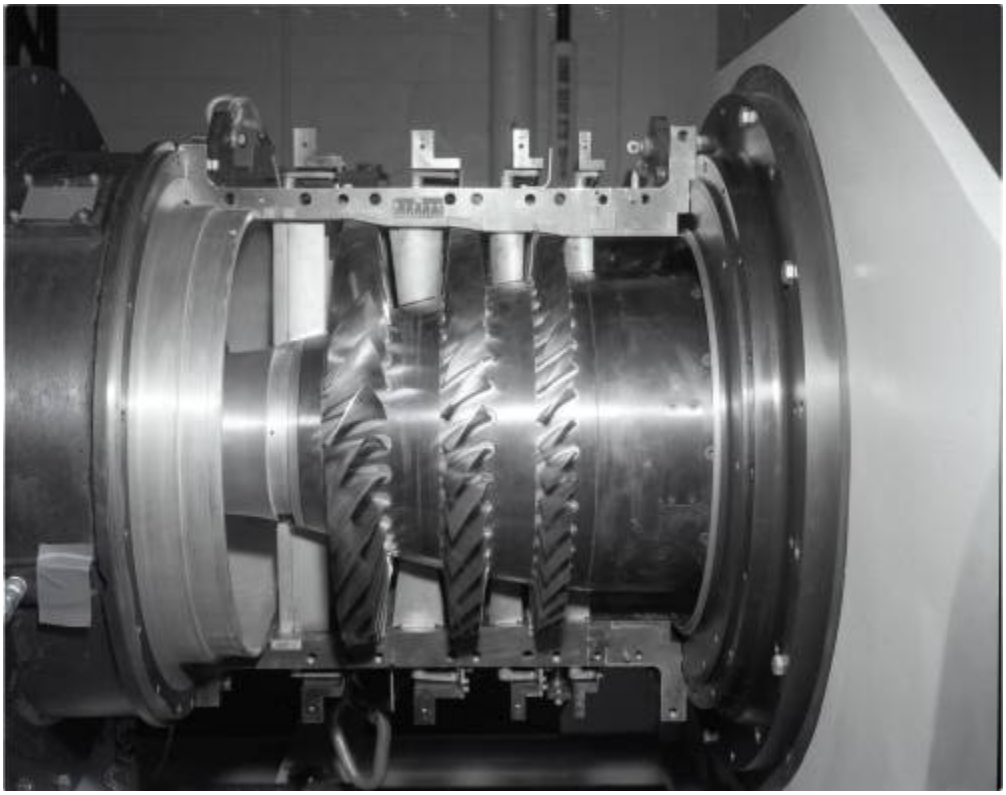


Fig. 1 https://catalog.archives.gov/id/17443470

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  @Misc{Huebler1978records,
  author   = {Huebler, D.},
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  {S}pace {A}dministration, 1903 - 2006. {P}hotographs relating to agency
  activities, facilities and personnel, 1973 - 2013},
  year     = {1978},
  url     = {https://catalog.archives.gov/id/17443470}}
  ```

Documents utiles

- modèles téléchargeables (lien vers projet Git)
  ```

- rapport technique original de la NASA (.pdf)
- fichier de paramètres géométriques (.csv), utilisable en entrée de OpenMCAD[(cite:Kojtych_2022_gene_aubes>)] 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:steinke1986design)]. Les modèles associés sont obtenus avec le code en libre accès OpenMCAD[(cite:Kojtych_2022_gene_aubes)].

Géométrie

La géométrie du rotor 74A2 est décrite dans le rapport d'origine de la NASA par les tableaux suivants. Les grandeurs sont en centimètres et en degrés.

(d) Rotor 2

RP	PERCENT SPAN	RADII RI	RD	BLADE ANGLES KIC	KTC	KOC	DELTA INC	CONE ANGLE
TIP	0.	24.778	24.300	63.49	54.90	46.37	3.35	-8.299
1	5.	24.307	23.868	61.92	53.79	45.88	3.64	-7.345
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4	30.	22.201	22.110	56.40	49.13	42.43	4.97	-1.351
5	40.	21.390	21.433	54.91	47.30	40.06	5.47	.610
6	50.	20.581	20.765	53.48	45.47	37.09	5.96	2.505
7	60.	19.773	20.107	52.11	43.53	33.48	6.43	4.367
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HUB	100.	16.487	17.556	47.87	34.05	6.70	7.94	11.527

RP	BLADE THICKNESSES TI	TM	TO	AXIAL DIMENSIONS ZI	ZMC	ZTC	ZO
TIP	.028	.201	.027	14.275	15.749	16.341	17.549
1	.030	.219	.030	14.201	15.745	16.279	17.603
2	.032	.236	.032	14.136	15.743	16.221	17.647
3	.037	.268	.038	14.029	15.741	16.103	17.729
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5	.046	.331	.047	13.859	15.732	15.849	17.888
6	.051	.362	.051	13.778	15.727	15.711	17.976
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9	.064	.457	.065	13.520	15.698	15.237	18.270
10	.069	.490	.070	13.414	15.681	15.048	18.384
11	.071	.506	.072	13.349	15.665	14.941	18.443
HUB	.074	.525	.074	13.275	15.647	14.820	18.519

Caractéristiques aérodynamiques

	unités	valeurs
taux de compression	[-]	1,691
débit massique	[kg/s]	29,71
vitesse en tête	[m/s]	416
solidité en tête	[-]	1,25
allongement	[-]	1,17

	unités	valeurs
nombre d'aubes	[-]	32
vitesse de rotation	[rad/s]	1680

Propriétés matériau

Le matériau du rotor 74A2 est le titane d'après le rapport, mais ses caractéristiques ne sont pas fournies. Un alliage de titane Ti-6Al-4v est considéré :

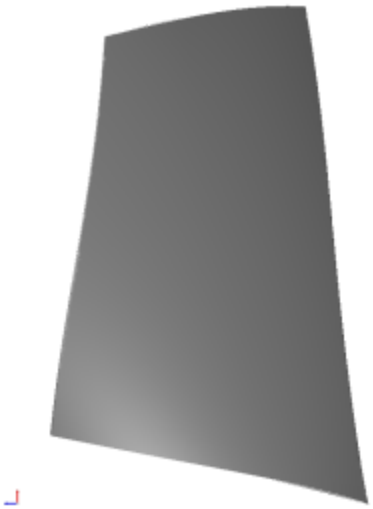
	unité	valeurs
alliage	[-]	Ti-6Al-4V
module d'Young	[GPa]	108
masse volumique	[kg/m3]	4400
coefficient de Poisson	[-]	0,34
limite élastique	[GPa]	0,824

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	1F	4884,844	777,447
2	1T	15222,59	2422,75
3	2F	17870,82	2844,23

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	1F	4883,512	777,235
2	1T	15179,04	2415,82
3	2F	17886,78	2846,77

- pour le modèle réduit :

Mode	Type	Pulsation propre (rad/sec)	Fréquence propre (Hz)
1	1F	4884,14	777,335
2	1T	15188,03	2417,25
3	2F	17907,64	2850,09

Document issu de la page wiki:
https://wiki.lava.polymtl.ca/public/modeles/rotor_74a2/accueil?rev=1682700242

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