Task 4 - Compressor Map

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Overview

This folder contains the code for designing a row of the Compressor map for the Axial Compressor. This task is full of tables, which will be broken down into detail down below.

`task4_main.py` is the main file which calls the other files and runs the code. Readers are to run this code to perfom the analysis.

`Table2.1.csv` contains the data from Table 2.1 in Dr. Cizmas' notes. This data is used to calculate the values for the compressor map. This table is read in by `task4_main.py` and is used to calculate the values for the compressor map. Table 2.1 is shown below:

$\bar{n}$	0.5	0.6	0.7	0.8	0.9	1.0	1.05	1.1
$\bar{\eta_{base}}$	0.9	0.924	0.955	0.97	1.0	1.0	0.98	0.975
$\bar{\dot{m}_{base}}$	0.37	0.47	0.58	0.714	0.86	1.0	1.02	1.04
$\bar{\pi_{base}}$	0.47	0.51	0.59	0.7	0.82	1.0	1.1	1.2

Where;

$$\bar{n} = \frac{n}{n_{ref}}$$
$$\bar{\eta_{base}} = \frac{\eta_{base}}{\eta_{ref}}$$
$$\bar{\dot{m}_{base}} = \frac{\dot{m}_{base}}{\dot{m}_{ref}}$$
$$\bar{\pi_{base}} = \frac{\pi^*_{base}}{\pi^*_{ref}}$$

`Table2.3.csv` contains the data from Table 2.3 in Dr. Cizmas' notes. This data is used to calculate the values for the compressor map. This table is read in by `task4_main.py` and is used to calculate the values for the compressor map. Table 2.3 is shown below:

$\frac{\bar{C}_a}{C_{a_{base}}}$	0.8	0.9	1.0	1.1	1.2
$\frac{\eta}{\eta_{base}}$	0.92	0.98	1	0.97	0.88
$\frac{w}{w_{base}}$	1.25	1.12	1	0.9	0.82

Where;

$$w = \frac{h_1^*}{\eta}({\pi^*}^{\frac{\gamma-1}{\gamma}} - 1)$$
$$h_1^* = \frac{w\eta}{{\pi^*}^{\frac{\gamma-1}{\gamma}} - 1}$$

Similarly we can say,

$$h_1^* = \frac{w_{base}\eta_{base}}{({\pi^*}^{\frac{\gamma-1}{\gamma}})_{base} - 1}$$

Making use of these equations, we can write the following:

$$\pi^* = \left[1 + (({\pi^*}^{\frac{\gamma-1}{\gamma}})_{base} - 1)\frac{w\eta}{w_{base}\eta_{base}}\right]^{\frac{\gamma}{\gamma-1}}$$

`steps.py` contains the 4 different steps that Dr. Cizmas has outlined in his notes. The steps are as follows:

1. Calculate $\pi^* = \pi^*(\bar{n}, \frac{\bar{C}_a}{C_{a_{base}}})$ and $\frac{\pi^*}{\pi^*_{base} = f(\bar{n}, \frac{\bar{C}_a}{C_{a_{base}}})}$, where where $\bar{n} \in (0.5, 1.1)$ and $\frac{\bar{C}_a}{C_{abase}} \in (0.8, 1.2)$ producing a table as shown in Table 2.4.1 and Table 2.4.2. (Tables are in `Table_2_4_1.csv` and `Table_2_4_2.csv` respectively)

$\frac{\bar{C}_a}{\bar{C}_{a_{base}}}$	0.8	0.9	1.0	1.1	1.2	$\bar{n}$
$\bar{\pi}^*$						0.5
$\bar{\pi}^*$						0.6
$\bar{\pi}^*$						0.7
$\bar{\pi}^*$						0.8
$\bar{\pi}^*$						0.9
$\bar{\pi}^*$						1.0
$\bar{\pi}^*$						1.05
$\bar{\pi}^*$						1.1

$\frac{\bar{C}_a}{\bar{C}_{a_{base}}}$	0.8	0.9	1.0	1.1	1.2	$\bar{n}$
$\frac{\bar{\pi}^*}{\bar{\pi}^*_{base}}$						0.5
$\frac{\bar{\pi}^*}{\bar{\pi}^*_{base}}$						0.6
$\frac{\bar{\pi}^*}{\bar{\pi}^*_{base}}$						0.7
$\frac{\bar{\pi}^*}{\bar{\pi}^*_{base}}$						0.8
$\frac{\bar{\pi}^*}{\bar{\pi}^*_{base}}$						0.9
$\frac{\bar{\pi}^*}{\bar{\pi}^*_{base}}$						1.0
$\frac{\bar{\pi}^*}{\bar{\pi}^*_{base}}$						1.05
$\frac{\bar{\pi}^*}{\bar{\pi}^*_{base}}$						1.1

2. Calculate $\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}} = f(\bar{n}, \frac{\bar{C}_a}{\bar{C}_{a_{base}}})$, by making use of:

$$\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}} = \frac{\bar{C}_a}{\bar{C}_{a_{base}}} \left[\frac{\bar{\pi}^*}{\bar{\pi}^*_{base}}\right]^{\frac{1}{3}}$$

Similar to step 1. Table 2.5 is produced. (Table is in `Table_2_5_csv`)

$\frac{\bar{C}_a}{\bar{C}_{a_{base}}}$	0.8	0.9	1.0	1.1	1.2	$\bar{n}$
$\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}}$						0.5
$\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}}$						0.6
$\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}}$						0.7
$\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}}$						0.8
$\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}}$						0.9
$\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}}$						1.0
$\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}}$						1.05
$\frac{\bar{\dot{m}}}{\bar{\dot{m}}_{base}}$						1.1

3. Calculate $\bar{\pi} = \bar{\pi}(\bar{n}, \frac{\bar{C_a}}{C_{a_{base}}})$ and $\bar{\dot{m}} = \bar{\dot{m}}(\bar{n}, \frac{\bar{C_a}}{C_{a_{base}}})$, by making use of:

$$\bar{\pi} = \pi_{\bar{base}} \frac{\pi^*}{\pi^*_{base}}$$

Where $\bar{pi_{base}}$ comes from `Table2.1.csv` and $\frac{\pi^*}{\pi^*_{base}}$ comes from `Table_2_4_2.csv`. Similarly,

$$\bar{\dot{m}} = \bar{\dot{m}_{base}} \frac{\bar{\dot{m}}}{\bar{\dot{m}_{base}}}$$

Where $\bar{\dot{m}_{base}}$ comes from `Table2.1.csv` and $\frac{\bar{\dot{m}}}{\bar{\dot{m}_{base}}}$ comes from `Table_2_5.csv`.

4. Calculate $\eta = \eta(\bar{n}, \frac{\bar{C_a}}{C_{a_{base}}})$ using tables `Table2.1.csv`, `Table2.3.csv`.

5. Lastly we are to draw the Compressor map, with axes of $\dot{m}\frac{\sqrt{T_1^*}}{p_1^*}$, π^* and η. The map is drawn: