UCLouvain

Design of a low-tech water turbine

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1 Introduction

The preliminary design phase is a crucial step in the development of a new product, as it lays the foundation for the subsequent detailed design and manufacturing processes. This phase involves defining the product's specifications, identifying potential design concepts, and evaluating their feasibility. We will have some constraints to respect, and some design parameters to choose.

1.1 Input Data

- The working fluid is a calorifically perfect diatomic gas with the following properties:
  - The ratio of specific heats $\gamma = 1.35$,
  - The specific gas constant $R = 287.06\,\mathrm{J\,kg^{-1}\,K^{-1}}$.
- Turbine mass flow rate $\dot{m} = 140.0\,\mathrm{kg/s}$.
- Turbine stage (extracted) power at shaft $P = 50.0\,\mathrm{MW}$.
- $M_1 = 0.45$.
- Turbine inlet total pressure $P_{01} = 70\,\mathrm{bars}$ (absolute).
- Turbine inlet total temperature $T_{01} = 1900\,\mathrm{K}$.
- Turbine inlet yaw angle $\alpha_1 = 0°$ (fully axial).
- The high-pressure shaft speed $N = 15,000\,\mathrm{RPM}$.
- The blading efficiencies of both stator and rotor rows are to remain fixed throughout the 1D design at the value of $\eta_{S,R} = 0.90$.

Design Constraints:

- The maximum allowable disc rim speed $U_{\text{disc, max}} < 465\,\mathrm{m/s}$ (the disc rim radius can be taken to be equal to the rotor blade hub radius).
- The AN^2 value must be lower than $1.7 \times 10^7\,\mathrm{m^2\,r\,pm^2}$.

Design Parameters:

- The pressure reaction degree $R_p \approx \frac{p_2 - p_3}{p_{01} - p_3}$.
- The stage loading factor $\Psi = \frac{\Delta H}{U^2}$.
- The stage flow factor $\Phi = \frac{V_{2x}}{U_m}$.
- The axial velocity ratio $\chi = \frac{V_{3x}}{V_{2x}}$
- The rotor blade aspect ratio $AR = \frac{h}{R}$.

2 State of the Art

Test pour voir si git fonctionne bien

On continue encore

2.1 Test de subsection