Accepted Manuscript

Optimization of rough transonic axial compressor

Li Zhihui, Liu Yanming

PII: S1270-9638(17)30449-2
DOI: https://doi.org/10.1016/j.ast.2018.03.031
Reference: AESCTE 4485

To appear in: *Aerospace Science and Technology*

Received date: 17 March 2017
Revised date: 17 February 2018
Accepted date: 20 March 2018

Please cite this article in press as: L. Zhihui, L. Yanming, Optimization of rough transonic axial compressor, *Aerosp. Sci. Technol.* (2018), https://doi.org/10.1016/j.ast.2018.03.031

Optimization of Rough Transonic Axial Compressor

Li Zhihui[1,2,*] **Liu Yanming**[1]

1 School of Aerospace Engineering, Beijing Institute of Technology, Beijing 100081, China

2 School of Mechanical Engineering, Washington University in St. Louis, St. Louis, MO, 63130

[*] Corresponding Author

Email address: lizhihuibit@outlook.com

Telephone number: (314)2037575

Abstract

The influence of wall roughness on the performance of the axial transonic compressor stage was investigated with different values of roughness added to the blade, hub and shroud sections. The dimensionless sand-grain roughness model was used to capture the roughness effect and the results indicated that the increment of both end wall and blade surface roughness caused the deterioration of compressor stage performance. The sensitivity analysis method was used to distinguish which section mostly contributes to the whole performance degradation. Approximately a 95.31% degradation of the compressor peak efficiency came from the induced blade roughness, 3.58% from the hub surface roughness and only 1.08% from the casing surface. The present study also investigated how the optimized design of compressor blades was affected by considering a surface roughness effect representative of in-service use. Two optimization strategies were proposed to improve the compressor efficiency and total pressure ratio by changing the distributions of the blade angles along the chord. The first strategy considered the compressor surface to be hydraulically smooth and the consequent Pareto Front designs were degraded by increasing the level of surface roughness with the second approach considering the surface roughness from the outset of optimization. The optimization result showed that the degraded compressors from the first strategy was still among the best performing Pareto Front designs in terms of adiabatic efficiency and pressure ratio when compared to the second approach. This means that the roughness effect can be regarded as an additional factor and be considered in the end of the design process for single-stage compressors.

Key words Wall roughness, Transonic axial compressor, Design of experiment, Analysis of variance, Boundary layer, Tip leakage flow, Losses, Corner separation, Multi-objective optimization.

1. Introduction

The degradation of gas turbines with service is a serious problem that must be appropriately addressed for efficient and safe operation of both land-based (power) and aero-propulsion gas turbines. As mentioned in Ref. [1], almost 70-85% of the gas turbine performance loss can be attributed to compressor fouling. Due to the importance of this topic, there have been rising trend to explore its root causes and measures shown in the article [2], where the number of degradation-related journal articles that have