Experimental Investigation and Analysis of an Axial Compressor Stage with 45° Circumferential Inlet Flow Pressure Distortion

J. Huang*, H. Wu, W. H. Du

School of power and Energy, Northwestern Polytechnical University, Xi'an 710072, China

Email: huj7292@mail.nwpu.edu.cn

Abstract

When designing compressors, inlet flow is always assumed to be uniform and axisymmetric. In fact, inlet flow is non-uniform and can cause quite a different result. The inlet flow distortion is caused by many reasons, such as aircraft attitude changes and inlet airframe effects. Usually, distortion is characterized by nonuniformity in the inlet flow parameters of velocity, pressure, temperature, flow angle, or gas constituency. In this field, inlet flow total pressure distortion is quite an important subject where the attention is concentrated on “steady-state” distortion patterns (magnitude and extent nonfluctuating with time). A lot of work has been done to better understand the aerodynamics of compressor flow under distorted conditions and enable more distortion-tolerant designs to be evolved. Limited by the expenses shortage and the complexity of experiment, the data of inlet flow total pressure distortion are insufficient and more researches are necessarily needed on this subject [1].

A 45° circumferential metal screen is designed to produce circumferential inlet flow total pressure distortion. The effects of screen-induced circumferential inlet total pressure distortion on an axial flow compressor stage are investigated with the help of a high speed subsonic compressor test rig. The overall performance for rotor with and without circumferential inlet flow total pressure distortion are obtained at middle equivalent-speed (8130 rpm). Detailed flow measurements around the circumference at 5 radial positions are made at 3 axial locations. The results show that, at middle equivalent-speed, the compressor stage is weakly affected under a low magnitude distortion. With inlet flow total pressure distortion, stall pressure ratio of rotor is improved 1.8 percent and the equivalent mass flow is decreased from 3.23 kg/s to 3.16 kg/s if compared with clean inlet flow. The influenced sector of absolute flow angle is about a 90° circumferential extent at rotor inlet and a 75° circumferential extent at rotor outlet. In addition, there are some differences between the distorted circumferential extent of absolute flow angle and the distorted circumferential extent of pressure. Enlargement and traverse of the distorted circumferential extent of pressure are not obvious at rotor outlet. Indeed, circumferential pressure distortion extent enlarged about 100 percent at stator outlet. The magnitude of circumferential total pressure distortion is enhanced at rotor outlet and attenuated at stator outlet.

REFERENCES

1. Sanger NL. Performance of a 1.57-pressure-ratio transonic fan stage with a screen-induced 90° circumferential inlet flow distortion. NASA TND-8163,1976