Experimental Investigation of Turbulence Promoters effect on Characteristics of Linear Cascade Compressor

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Abstract
In this paper, considering the importance of inlet flow turbulence intensity in the combustion chamber, the effect of flow turbulence on characteristics of the flow wake within a linear compressor cascade has been experimentally investigated. To this purpose, two wires were installed along each blade and their effects on average velocity, turbulence intensity at Re. Number 45500 were studied. One–dimensional hot wire anemometer was used to measure wake parameters. The results showed that turbulence promoters increased the maximum turbulence intensity in blades wake.

Introduction

Re. Number of roughness is defined in accordance to the roughness height, size of local velocity on top of the redundancy (roughness), ud and kinematic viscosity υ: Red = ud *d / υ.

In subsonic flow velocities, if critical Re. Number of roughness is reached, the transition point will be close to roughness implemented in the desired position. Empirical results indicate that in subsonic range, critical Re. Number for a rough is approximately 600. It can be demonstrated that with an increase in the Mach number of flow (or increase in compressibility effects of the flow) the critical Re. Number exceeds 600. In this study, tripping wires have been implemented on blades of a linear compressor cascade and its effects on the wake characteristics have been studied.

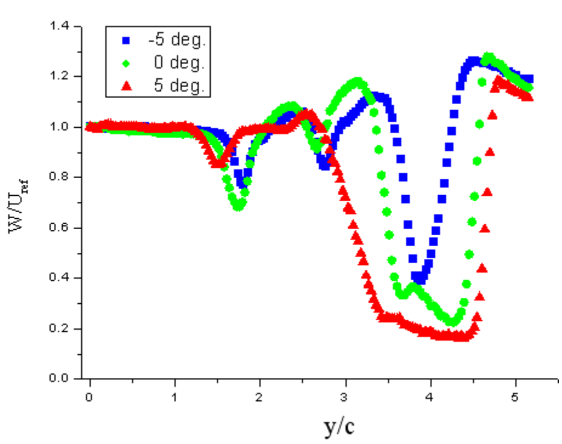
Review of literature

Trimmer and Rooij [1] investigated the effect of tripping wire embedded on DU 93-w-zlo airfoil nose in wind tunnel. The selected wire diameters were 1.2 mm and 5mm and Re. Number was 2*e6. Fukudome et al. [2] investigated the efficiency of NACA 0018 symmetrical airfoil using tripping wire. Embedding the desired wire at airfoil nose, they showed that using tripping wire increases lift coefficient in larger attack angles. James and Truong [3] and Igarashi [4] in conducted an experiment on effects of different diameters and various positions of turbulence wire on inlet flow passing through cylinder with Re. Hashemi et al. [5] analyzed effect of air turbulence intensity on forming no in combustion of hydrocarbon and hydrogen fuel mixes numerically , Their results show that increasing the intensity of air turbulence reduces No density the domain Where flam exists and also in the outlet of combustion vessel for the case of pure hydrogen fuel.

Laboratory equipment

The experiments were conducted in winter and device calibration was performed in 15 c temperature. Although environmental temperature of laboratory varied during the day, the variation range of 2 degrees is considered acceptable. A switching device with switching accuracy of 0.01 mm and 3 degrees of freedom was used for shifts of probe at various points.The compressor cascade tested had three NACA 6409 blades which had been installed with 40 deg standing angle in section of test vessel.

The analysis of dimensionless mean velocity



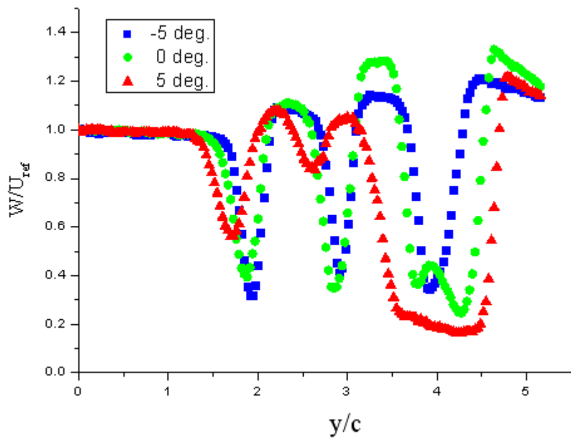
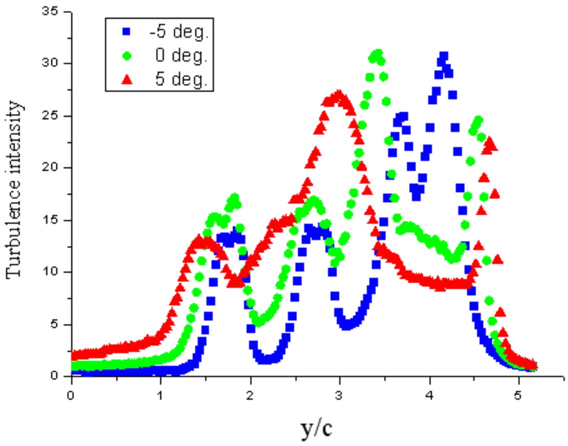


Figure (1, 2): comparison of dimension less mean velocity of 3 different attack angles 1) cascade without tripping wires 2) cascade in the presence of tripping wires

Since the central blade of cascade is affected by its adjacent blades, we concentrate on the resulted profiles in our analysis. As it is evident in Figure 1, with a rise in attack angle, the velocity profile shifts to the left side and gradually decreased to the point of disappearance. This also occurs in cascade blades with wire, the only difference is that the velocity profiles are more stretched and their disappearance takes place at higher attack angles (Figure 2).
The disappearance phenomenon of velocity profile is due to the fact that the increased embedding angle changes the cascade into a turbine cascade while the decreased angle changes it into the compressor cascade. The generation of turbulence by wires in boundary layer brings about separation at further distance from attack edge and decreases wake width [6]. This effect is qualitatively similar to natural transfer for turbulence which develops in incremental situations on cylinder as the velocity increases.

Turbulence intensity analysis



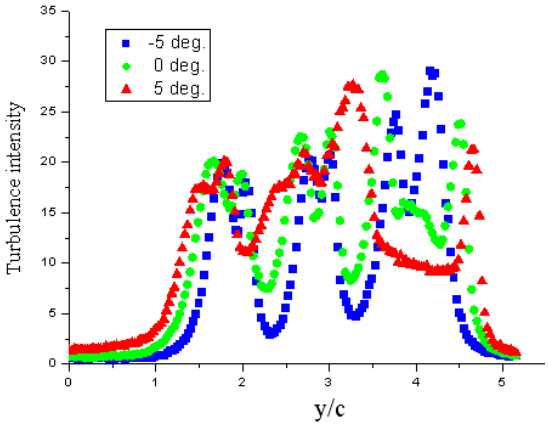


Figure (3, 4): comparison of turbulence intensity at three different attack angles 3) cascade in the absence of turbulence-making wires 4) cascade in the presence of tripping wires.

Since turbulence intensity of central blade is important to us, according to Figure 3, it can be concluded that as attack angle increases, the maximum turbulence increases and its peak moves to the right. Each fluid particle tends to retain its momentum and when due to a small turbulence or fluctuation, a particle oscillates between a layer with low momentum and a layer with high momentum in the fluid inside the boundary layer without the required potential and only due to the unsteady nature of flow, to retain or regain the particle momentum to its original value, the particle in its new position, makes a small movement but at opposite direction of momentum from the corresponding layer.
The aggregate of these movements along with tendency of flow to maintain the continuity law, leads to formation of eddy. The presence of eddy can result in proportional distribution of momentum, turbulence, thermal energy, pressure and temperature within the domain. In a flow without the presence of gradient in mean velocity profile, an oscillation in velocity would not necessary lead to formation of an eddy, and the turbulence gets damped under the effects of viscosity after a while. The use of tripping wires increases maximum of turbulences in blade wake and changes the one-peak diagram into a two-peak one. The width of diagram increases in all three attacks unlike the width of velocity profile in which decreased after installment of the wire.

References

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