Subscripts

$_{exc}$: Excitation.
$_{L}$: Laminar.
$_{max}$: Maximum.
$_{n}$: Neutral point.
$_{o}$: Reference value.
$_{smooth}$: Smoothed.
$_{T}$: Turbulent.
$_{tr}$: Transition.
$_{v}$: Virtual.
$_{x}$: Streamwise coordinate.
$_{\delta^*}$: Displacement thickness.

1 Introduction

The importance of the basic study of transition in the particular case of flow around turbomachinery airfoils is stressed in the following items:

1 - Experimental evidence indicates that for certain gas turbine airfoils the boundary layer is transitional for over half the chord length (Blair, 1983).

2 - Heat transfer to the turbine blades is augmented in the transitional and turbulent regions of the boundary layer.

3 - There is a direct relation between the transition onset location on the blade surface and the induced losses.

The poor predictability of the transition onset as well as the extension of the transitional flow over turbine blades have had as a consequence a reduced engine longevity and performance. Wang (1984) pointed out that the partial inability to predict transition is due to a lack of experimental data based on the separate effects of heat transfer and hydrodynamics taking place in the transition phenomena.

Transition can be influenced by many different factors from which we restrict ourselves to quote the following ones:

- Freestream turbulence
- Acoustic disturbances
- Surface vibration

- Surface roughness
- Streamwise acceleration
- Cross-stream straining
- Film cooling injection
- Flow separation
- Compressibility effects
- Streamwise curvature

Since transition ultimately depends on the referred factors mutual interaction, monitoring them is of paramount importance, if transition is to be better understood. Morkovin (1978) stated that from the available base of information, the transition process will remain non-deterministic, however the possibility of providing the designer with a reliable range of critical Reynolds numbers for certain flow conditions would enable in the future a much more economical engine design.

This contribution focus on a particular aspect of boundary layer transition when its triggering is due to the presence of discrete frequencies in the freestream turbulence spectrum. Spangler and Wells (1968) showed that, independently of the freestream turbulence intensity, the type of freestream turbulence spectrum is responsible for the transition onset location in a boundary layer. These authors proved the importance of the peaks observed in the energy spectrum, especially when they are within the unstable domain predicted by stability theory.

Examples of this type of transition are found in axial turbomachines where the interaction of the wakes shed by rotor blades with the boundary layers developing onto the downstream stator blades create an upstream shift of the transition onset location. The freestream flow (in an absolute reference frame sense) in the gap of a rotor and stator of a typical turbomachine stage is characterized by a non-uniform pressure field due to the alternating wake/potential core flows. These pressure fluctuations have a precise frequency and energy that is revealed by a spectral analysis of the freestream flow (Hourmouziadis et al, 1986) (Fig. 1). Furthermore the frequency of these pressure fluctuations is related to the rotor speed and to its number of blades.

1.1 Research Aim

The aim of the present contribution is to show that, as observed in a turbomachinery environment, freestream perturbations characterized by well defined frequencies have