INSTRUMENTATION INTERFERENCE IN TRANSONIC LINEAR CASCADES

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ABSTRACT

The current work exposes the impact of aerodynamic probes, placed upstream and downstream of the testing article, on the aerodynamics of a transonic low-pressure turbine blade investigated in a linear cascade under representative outlet Mach and Reynolds number. The probe impact can be precepted as far as to the inlet of the cascade when the probe is placed downstream. The quantification of the probe impact is presented on the blade loading, passage endwall as well as on the instrumentation placed upstream and downstream of the cascade to survey the operating conditions during testing. In addition, the interference of pressure taps on the blade SS on the downstream flow field is also detailed.

It is shown that the presence of the probe can be partially compensated and that the monitoring of the flow conditions can be performed by correlating the impacted instrumentation downstream of the cascade with measurements performed in a different location of the rig. The impact of compensating for the probe intrusiveness on the low-pressure turbine blade losses is also presented.

INTRODUCTION

The need to investigate the combined effect of the flow physics present in high-speed low-pressure turbines encountered in geared turbofans requires high-fidelity experimental data at engine-representative conditions. High-speed turbomachinery rigs are often characterized by constrained accessibility, requiring the use of intrusive probes to perform aerodynamic measurements. The attempt to investigate the flow physics by means of finite size instrumentation, such as probes, introduces non-negligible effects in the flow topology of the testing article [1], [2] and the flow field itself [3]. This impact of the probe becomes more severe as the Mach number of the flow being measured reaches transonic regime [4]. For this reason, it becomes necessary to quantify the impact on the aerodynamics of the turbomachinery component being tested. In addition, strategies to compensate for probe blockage must be introduced.

RESULTS AND DISCUSSION

A reduction of the blade isentropic Mach number due to the probe intrusiveness has been observed. The measured blade static pressure is dependent on the location of the probe relative to the instrumented blade as displayed in Figure 1 – left where y/g is the normalized location along the cascade pitch. Based on measurements performed upstream of the cascade, the impact is caused by a redistribution of the massflow to passages not obstructed by the probe placed downstream.

The probe intrusiveness was reduced by increasing the overall massflow through the cascade to retrieve the nominal massflow on the passage obstructed by the probe. As displayed in Figure 1 – right, the blade isentropic Mach number distribution was fully retrieved by increasing the outlet Mach number, which happens in the form of increased cascade massflow.

This study revealed that the accounting for massflow redistribution due to probe blockage must be accounted when investigating turbomachinery articles to ensure that the aerodynamics are representative of the desired operating point.

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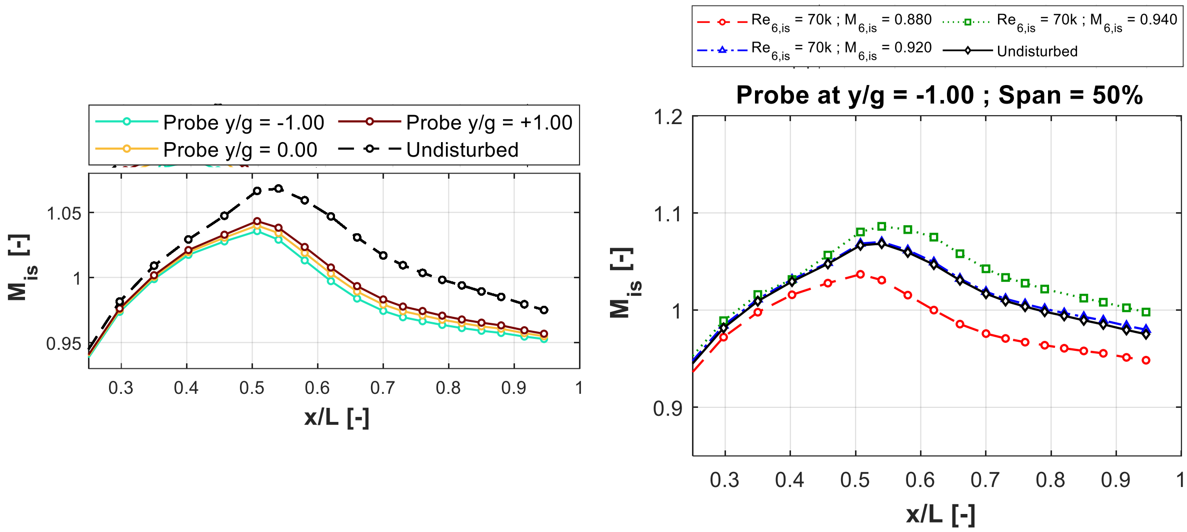

Figure 1. Impact of L-shape 5-hole probe location on the blade isentropic Mach number distribution (left) and impact of outlet isentropic Mach number in compensation of probe interference (right)

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