Flowfield Measurements in a Single Row of Low Aspect Ratio Pin-Fins

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GAS TURBINE NEEDS

Pin-fins are used to remove excess heat from the trailing edge of turbine airfoils. While much research has focused on heat transfer, little work has focused on flowfield measurements which can provide insight into further optimization of pin-fin array geometries.

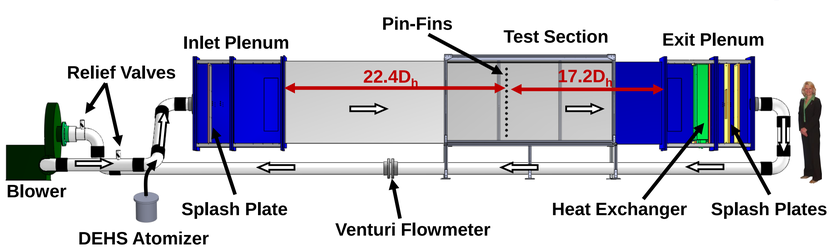
OBJECTIVES

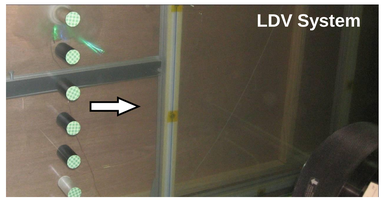
Establish large scale facility and high resolution experimental measurement techniques

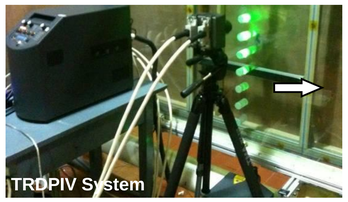
Determine which flow features contribute most to heat transfer for a single row of pin-fins

PROJECT APPROACH

Large scale facility was constructed with optical access for non-intrusive measurement techniques







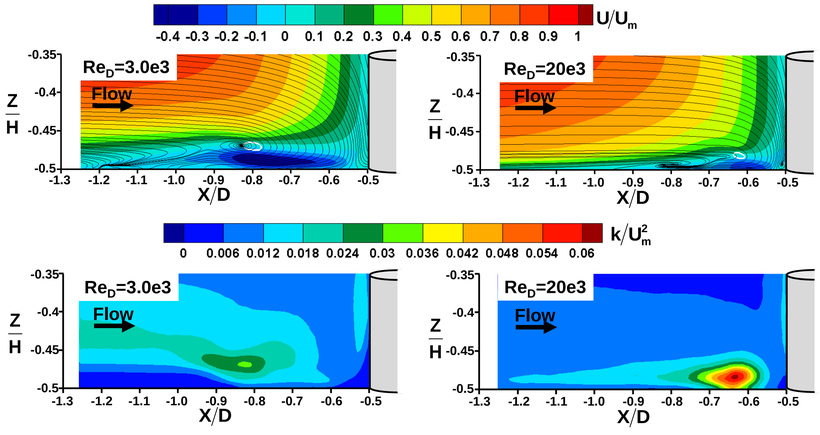
A single row of pin-fins having height-to-diameter ratio of 1 and span-to-diameter ratio of 2.5 was tested

Re_D	3.0e3	10e3	20e3
Re	7.2e3	24e3	48e3
LDV beam waist, y^+	0.15	0.42	0.77
PIV (16x16 pixels, 50% overlap), y^+	1.9	5.2	9.5

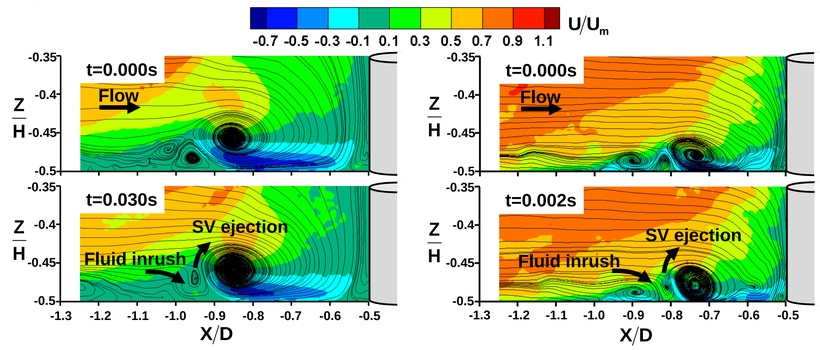
Large scale facility allowed for high spatial resolution

HORSESHOE VORTEX

The horseshoe vortex decreases in size with increasing Reynolds number

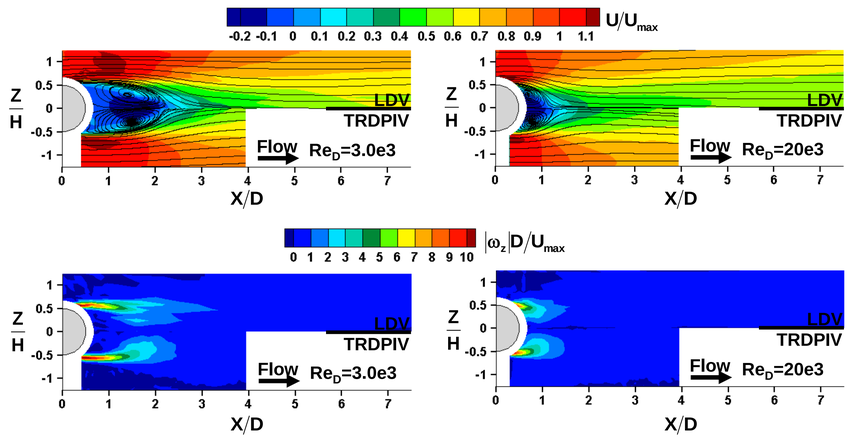


Secondary vortex is periodically ejected and replaced by core fluid causing a transient rise in heat transfer



NEAR-WAKE FLOW

Near-wake region is shortened as Reynolds number increases



HEAT TRANSFER

Leading edge heat transfer enhancement decreases with increasing Reynolds number

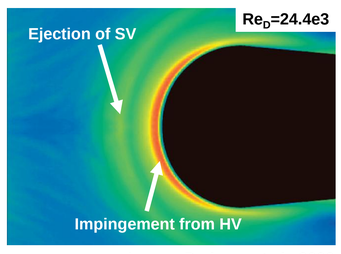


Image: Praisner et al., 2006

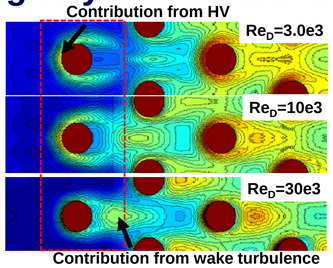
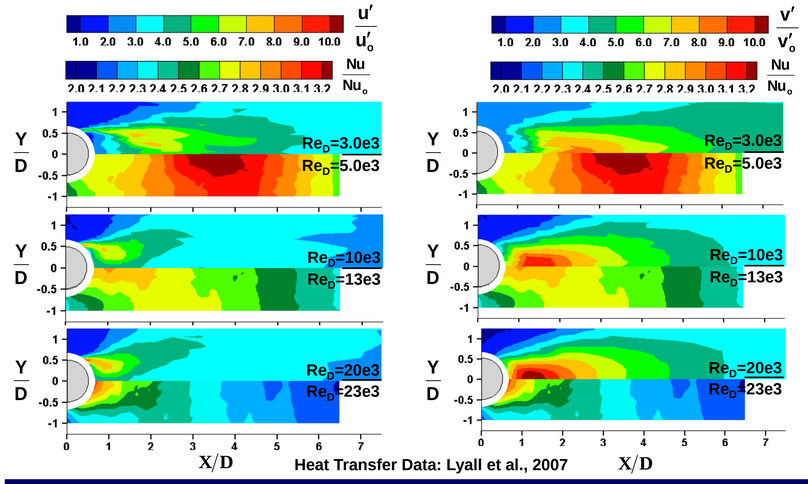


Image: Ames et al., 2007

Transverse fluctuations correlate well with endwall heat transfer



Heat Transfer Data: Lyall et al., 2007

SUMMARY AND CONCLUSIONS

Kármán vortices contribute most to endwall heat transfer in a single row of pin-fins

Transverse turbulent fluctuations correlate well with endwall heat transfer indicating that the Karman vortices are key to energy transport in the wake. Core fluid is entrained in the Kármán vortices and transported to the wall as these vortices break down.

The horseshoe vortex contributes to heat transfer augmentation adjacent to the pin-fin.

REFERENCES/PUBLICATIONS

T. J. Praisner and C. R. Smith, "The Dynamics of the Horseshoe Vortex and Associated Endwall Heat Transfer---Part II: Time-Mean Results," *Journal of Turbomachinery, vol. 128, pp. 755-762, 2006.*

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