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A thesis for the degree of

Doctor of Philosophy

September 2022

University of Southampton

Abstract

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Accompanying material

All data supporting this study are openly available from the University of Southampton repository at DOI: .

This includes the following:

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Acknowledgements

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Definitions and Abbreviations

Acronyms

FFT fast fourier transform

NDE non-destructive evaluation

NGV nozzle guide vane

NO_x nitrogen oxide

TBC thermal barrier coating

TGO thermally grown oxide

Symbols

α coefficient of thermal expansion ($^{\circ}C^{-1}$)

c wave velocity ($m\,s^{-1}$)

c_L bulk longitudinal velocity ($m\,s^{-1}$)

c_T bulk shear velocity ($m\,s^{-1}$)

d propagation distance (m)

K rate of change of wave velocity with temperature ($m\,s^{-1}\,^{\circ}C^{-1}$)

T temperature (°C)

t_F time of flight (s)

CHAPTER 1

Introduction

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1.1 Examples

Bagavathiappan *et al.* [1] suggest that this is a great template, but Liu *et al.* [2] aren't so sure. Maybe these equation examples will convince you:

$$v = \left(\frac{d_{\text{aligned}} + d_{\text{offset}}}{t_{\text{aligned}} - t_{\text{wedge}}}\right) \qquad [\mathrm{m\,s^{-1}}] \tag{1.1}$$

$$5099.18 = \left(\frac{0.1 + 0.04587}{5.812\times10^{-5} - 2.951\times10^{-5}}\right) \qquad [\mathrm{m\,s^{-1}}] \tag{1.2}$$

Figure 1.1 – Royal Victoria Chapel, Southampton.

Measurement Hardware
2x Olympus ABWX-2001 Variable angle wedges
2x Olympus A539S-SM 1 MHz transducers
Olympus ultrasonic couplant B
GW Instek MFG-2203M Signal generator
Picoscope 3406DMSO USB Oscilloscope
Thermadata T-type temperature loggers
VWR Hot plate

Table 1.1 – Experimental measurement hardware.

List of references

[1] S. Bagavathiappan et al. ‘Infrared thermography for condition monitoring – A review’. In: *Infrared Physics & Technology* 60 (24th Mar. 2013), pp. 35–55. DOI: 10.1016/j.infrared.2013.03.006.

[2] He Liu et al. ‘Digital Twin-Driven Machine Condition Monitoring: A Literature Review’. In: *Journal of Sensors* 2022 (30th July 2022). Ed. by Xueliang Xiao, pp. 1–13. DOI: 10.1155/2022/6129995.