IDENTIFYING FAULTS IN THE VARIABLE GEOMETRY SYSTEM OF A GAS TURBINE COMPRESSOR

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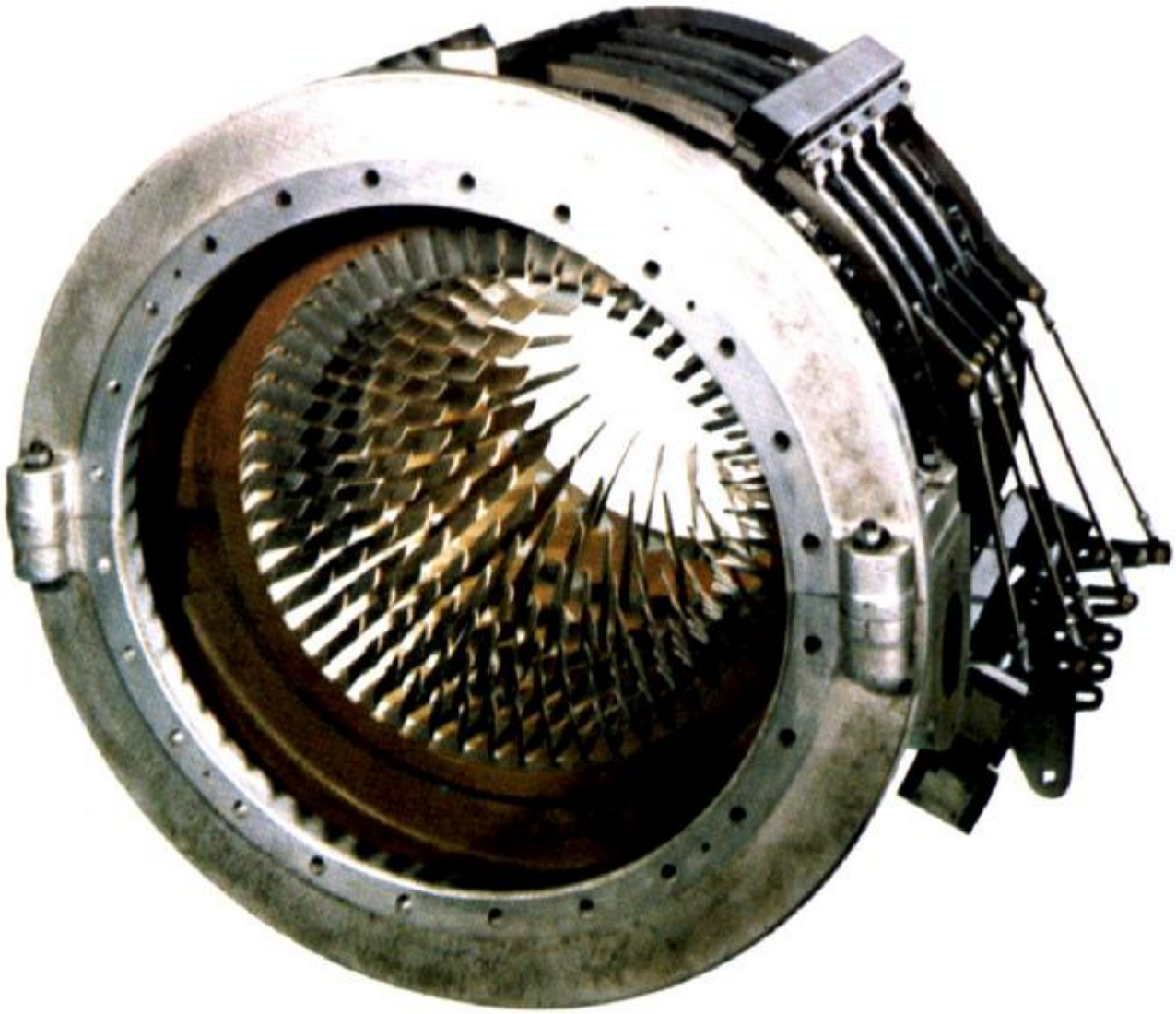
Identifying Faults in the Variable Geometry System of a Gas Turbine Compressor

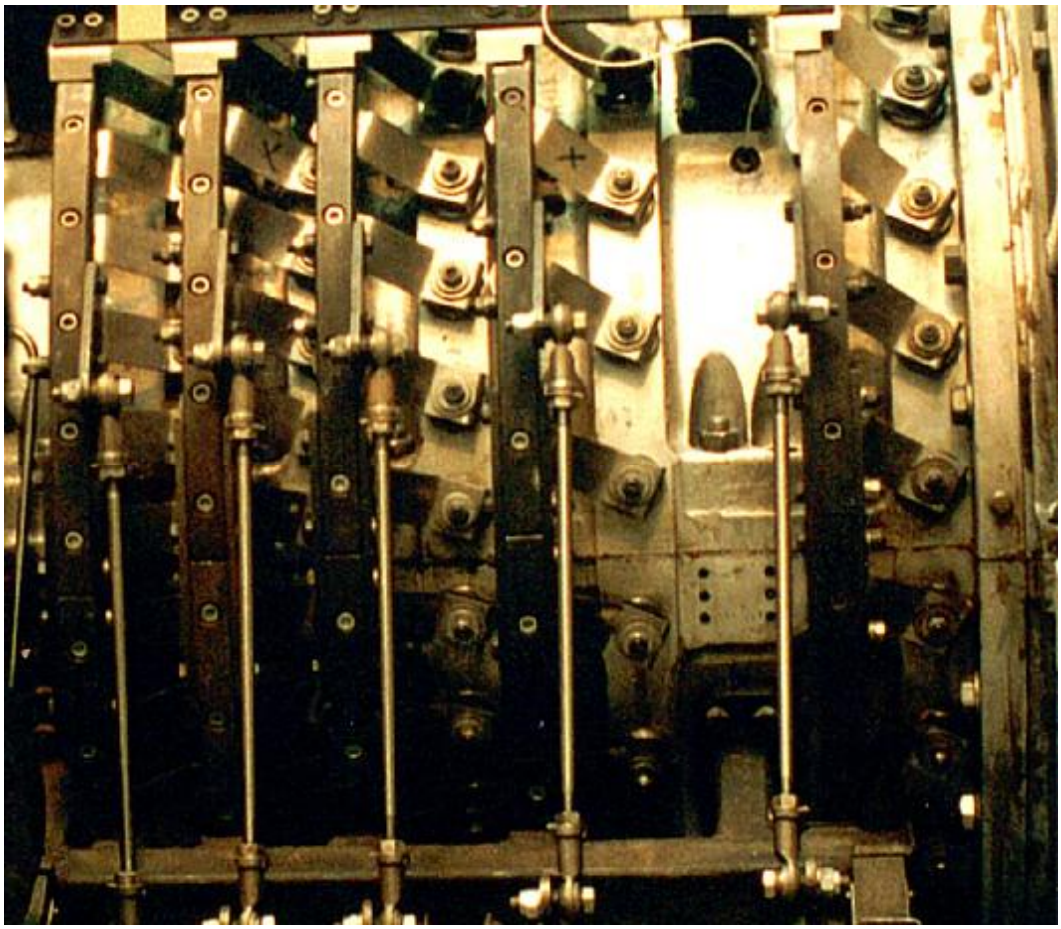
- Variable guide vane (VGV) system and related malfunctions
- A test program for VGV fault effects
- VGV faults impact on engine performance
- Analysis of fault effects with adaptive modelling
- Effect on EGT profiles
- Discussion-Conclusions

Variable Guide Vane (VGV) System

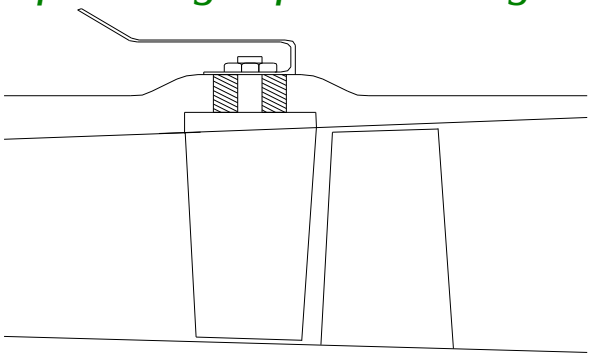


Variable Guide Vane (VGV) System

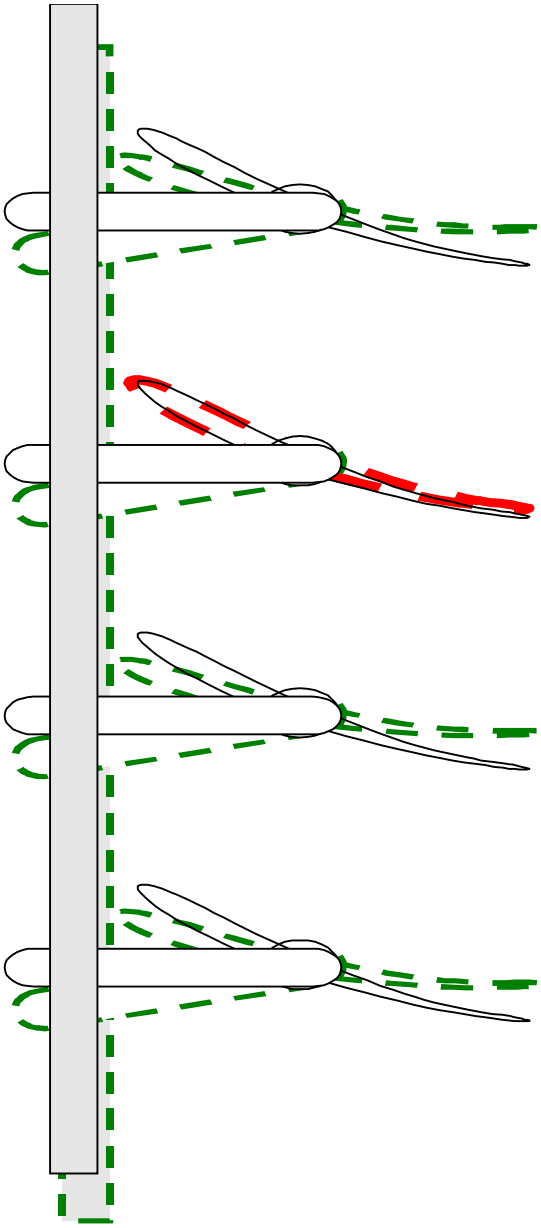
Controlling Mechanism on Compressor Casing



Schematic of a linkage of a variable geometry vane

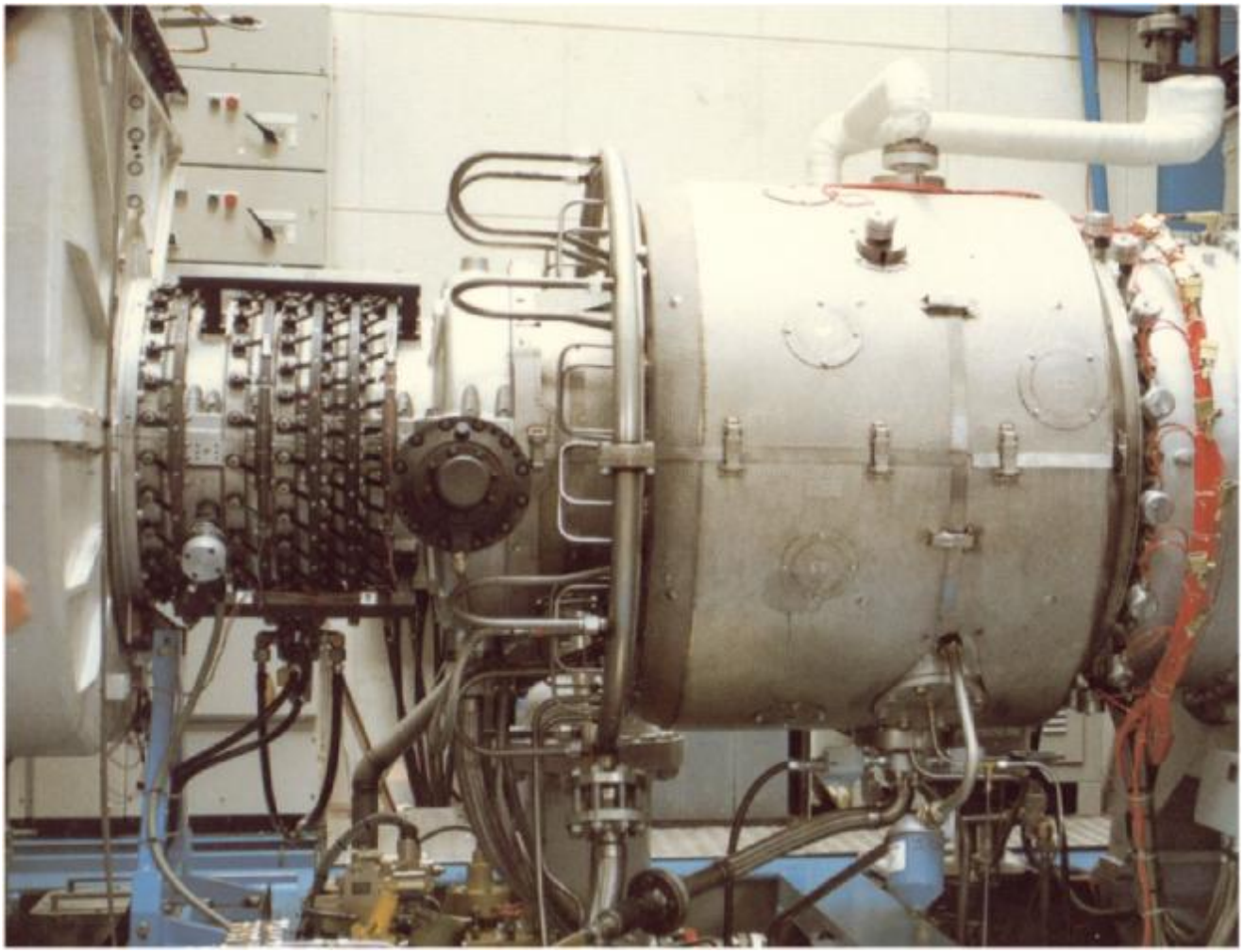


Schematic Representation Of Individual Vane Mistuning

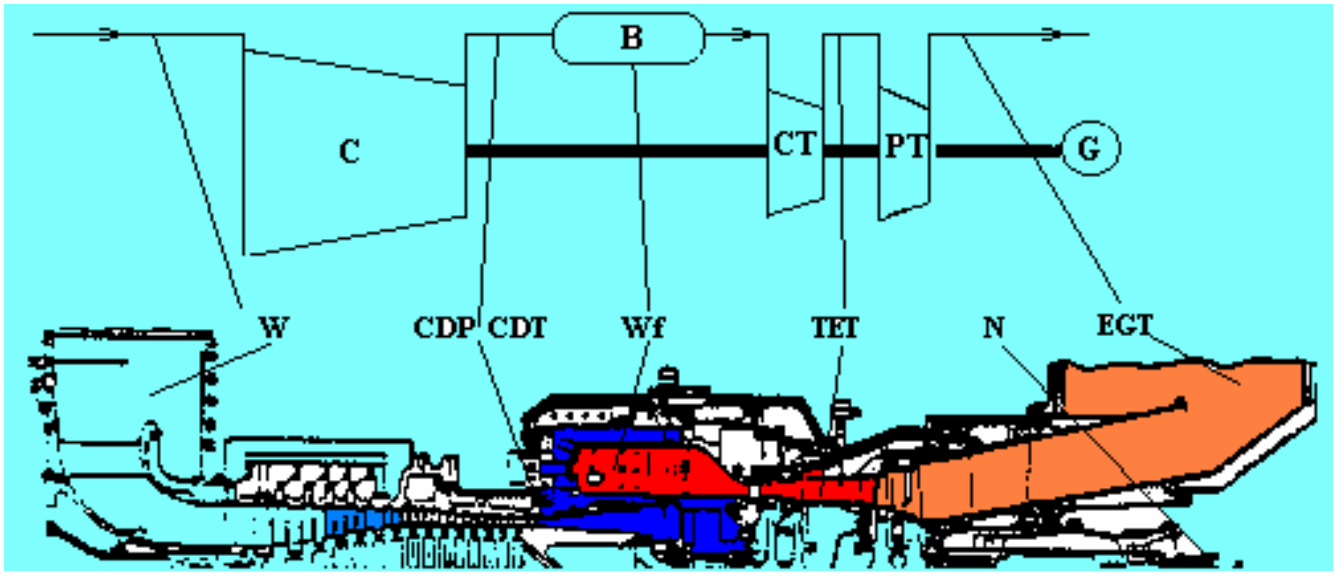


A Test Program for VGV Fault Effects

Test Engine: TORNADO



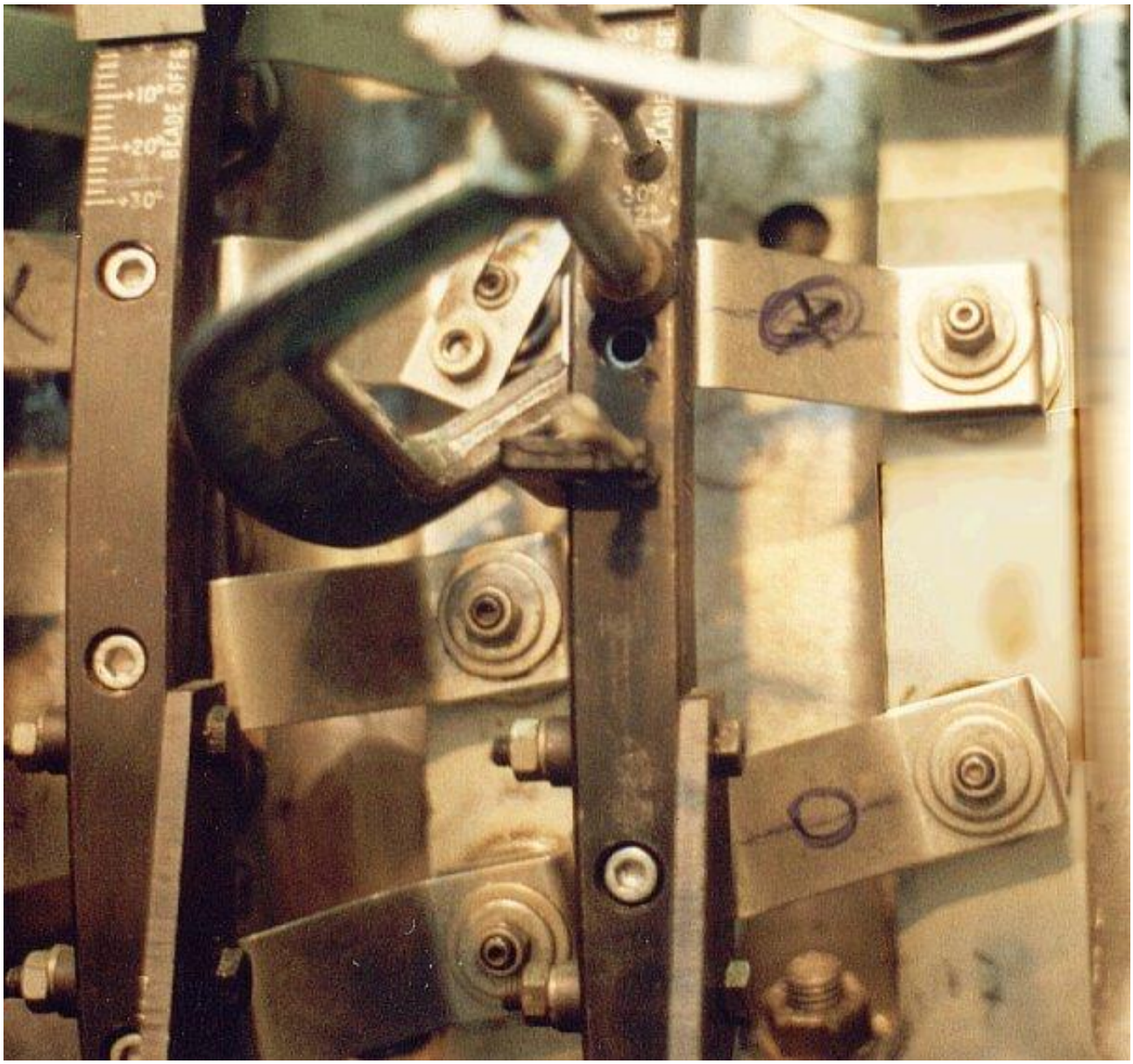
Engine Layout And Measured Quantities



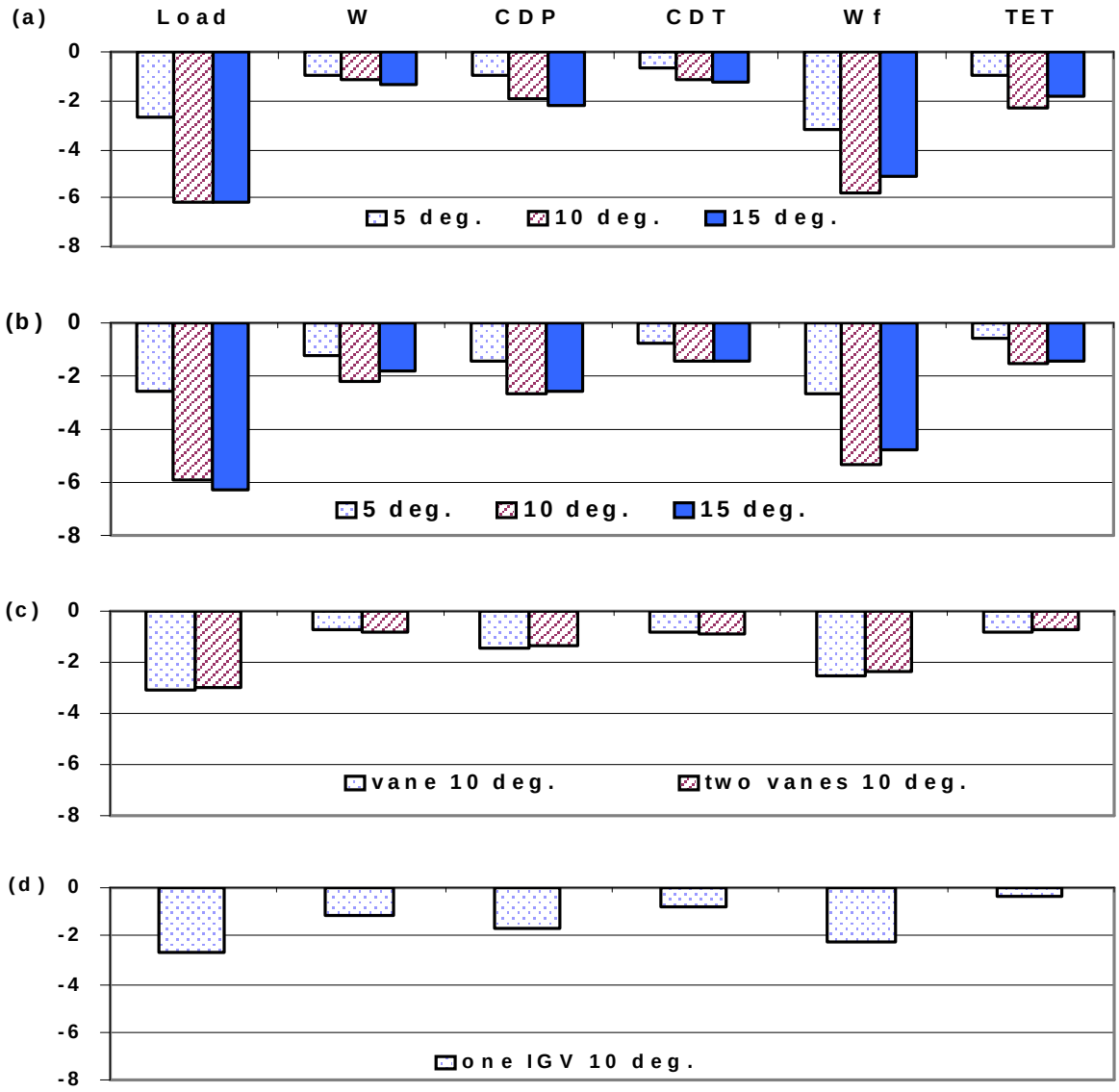
Implanted fault cases

- Different magnitude (severity: size, number of vanes)
- Different locations

Implanting Vane Mistuning



VGV Fault Effects On Engine Performance



a) Stage-1, one-vane faults, b) Stage-1, three vane faults, c) Stage-4 faults and d) IGV faults

Setting-Up An Adaptive Model For Fault Diagnosis

Compressor:

$$f_1 = q_c / q_{c,ref} \qquad f_2 = h_{pc} / h_{pc,ref}$$

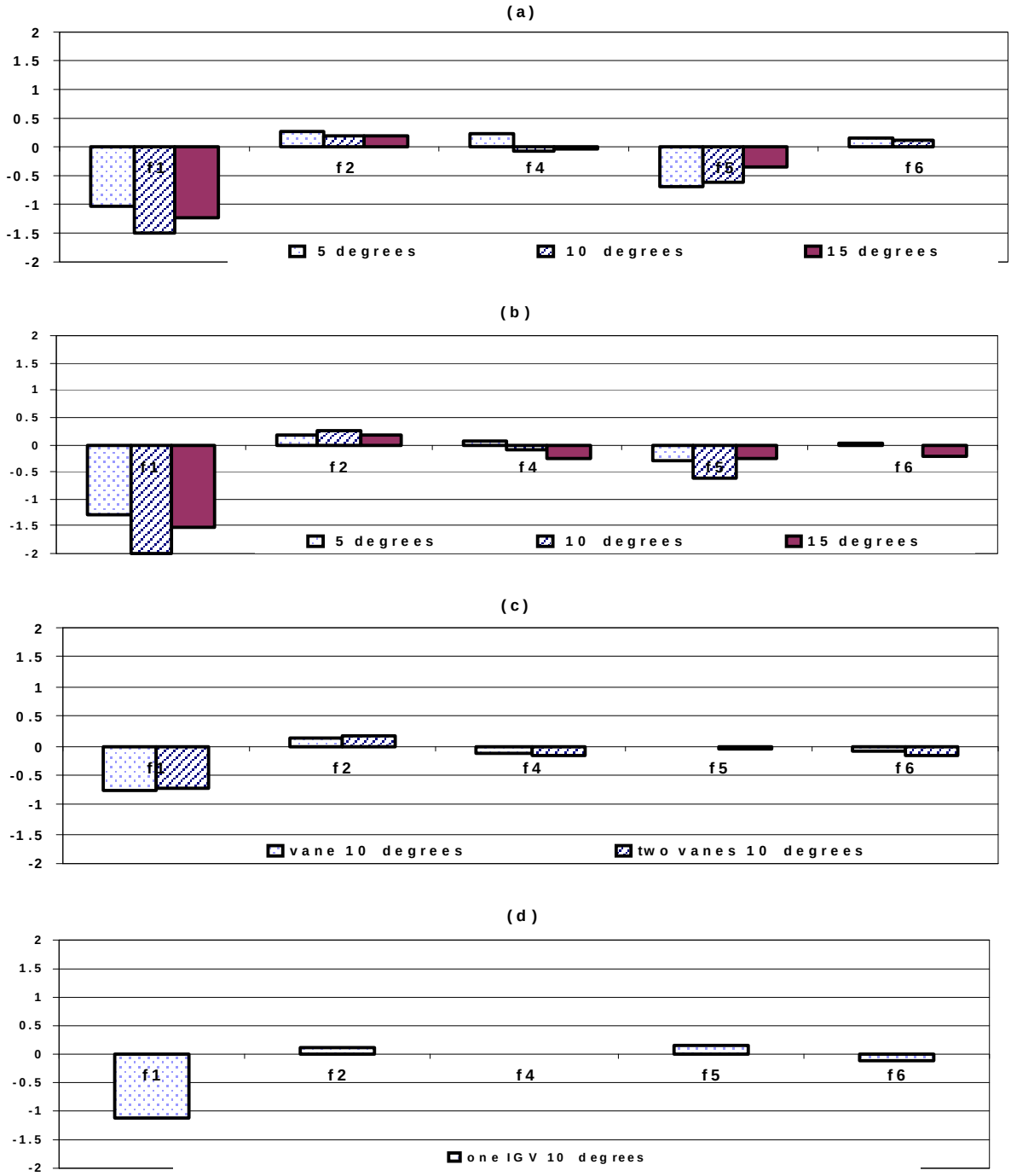
Burner:

$$f_3 = BPL / BPL_{ref} \qquad f_4 = h_b / h_{b,ref}$$

Turbine:

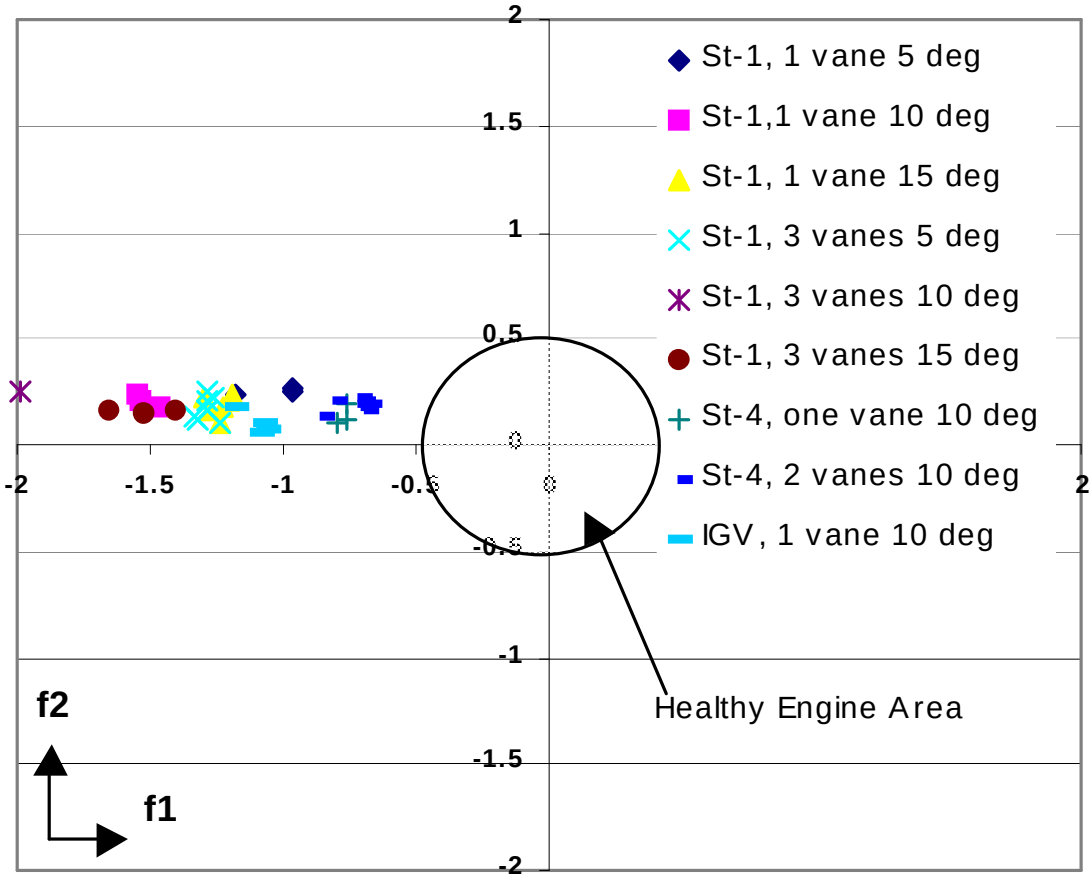
$$f_5 = q_T / q_{T,ref} \qquad f_6 = h_{is,T} / h_{is,T,ref}$$

Modification Factors Percentage Deviations

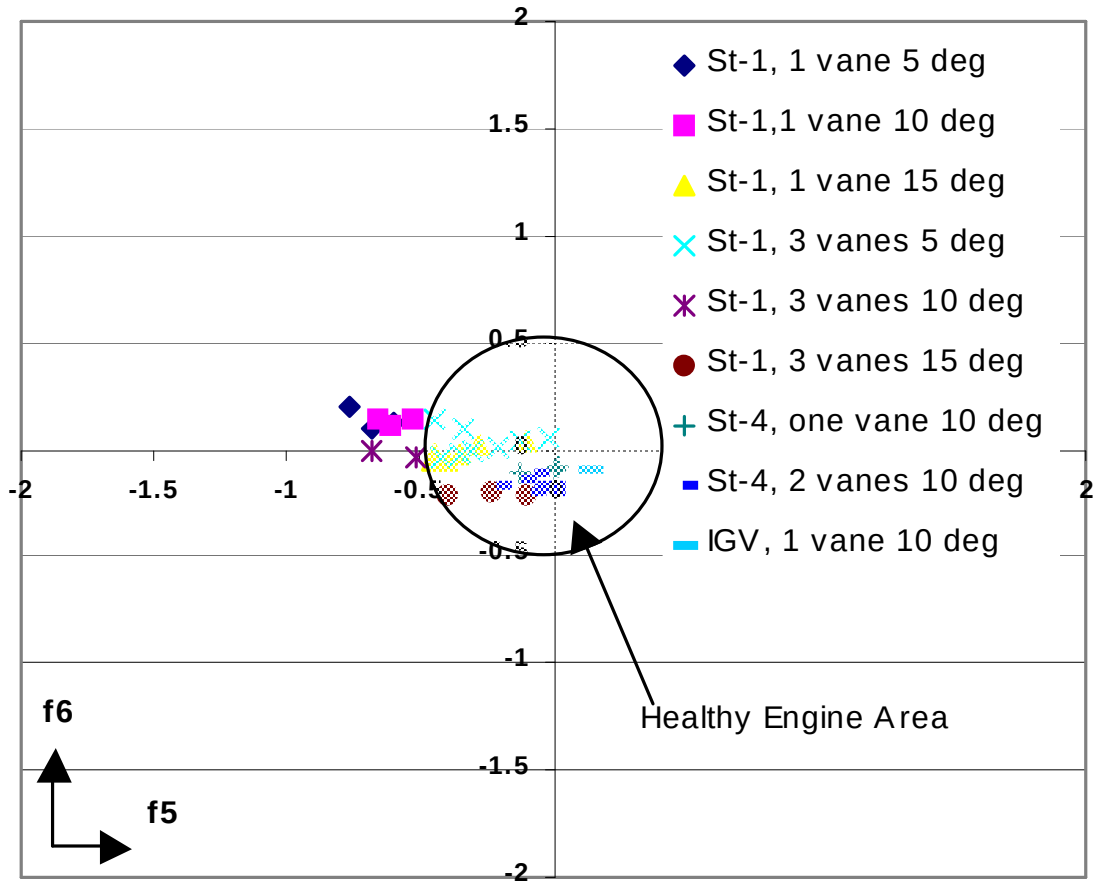


a) Stage-1, one-vane faults, b) Stage-1, three vane faults, c) Stage-4 faults and d)IGV faults

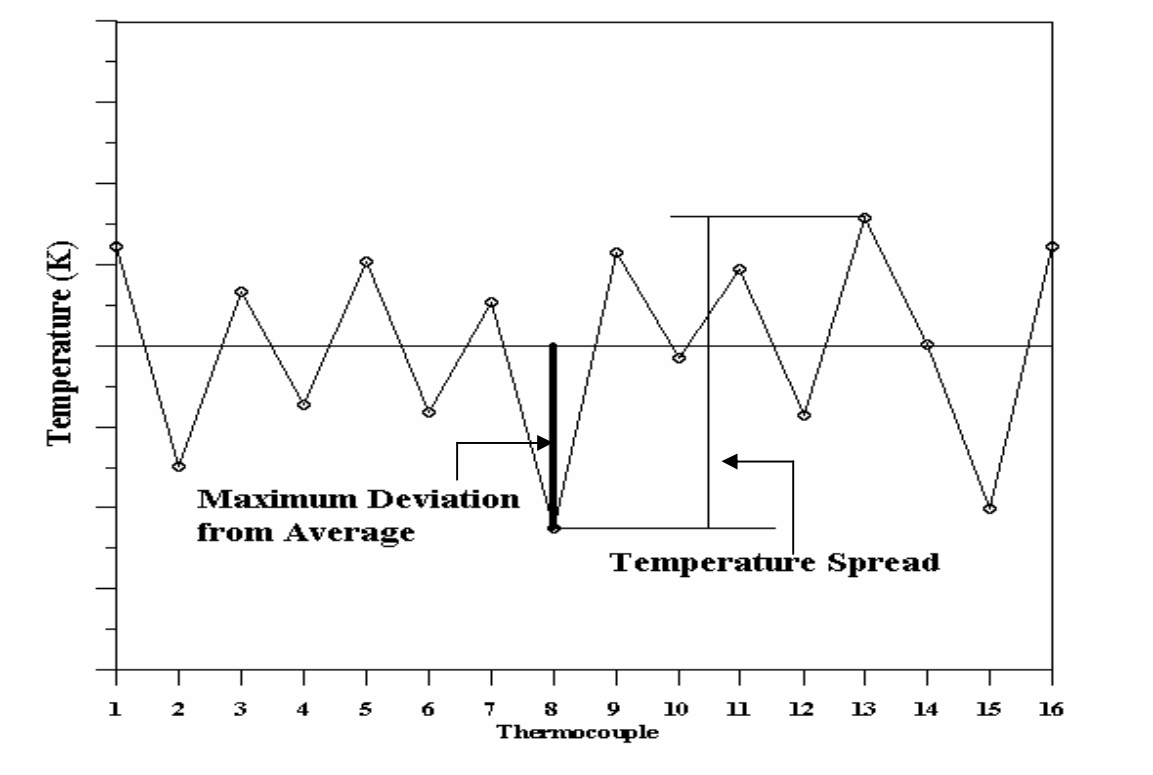
Compressor Diagnostic Plane



Turbine Diagnostic Plane



Exhaust Temperature Distributions



$$dT_i = T_i - T_{i,ref}$$

$$dT_i^r = dT_i \frac{|dT_i|}{dT_s} \frac{1}{dT_{av}}$$

$$dT_{av} = \frac{\sum_{i=1}^{N} | dT_i |}{N}$$

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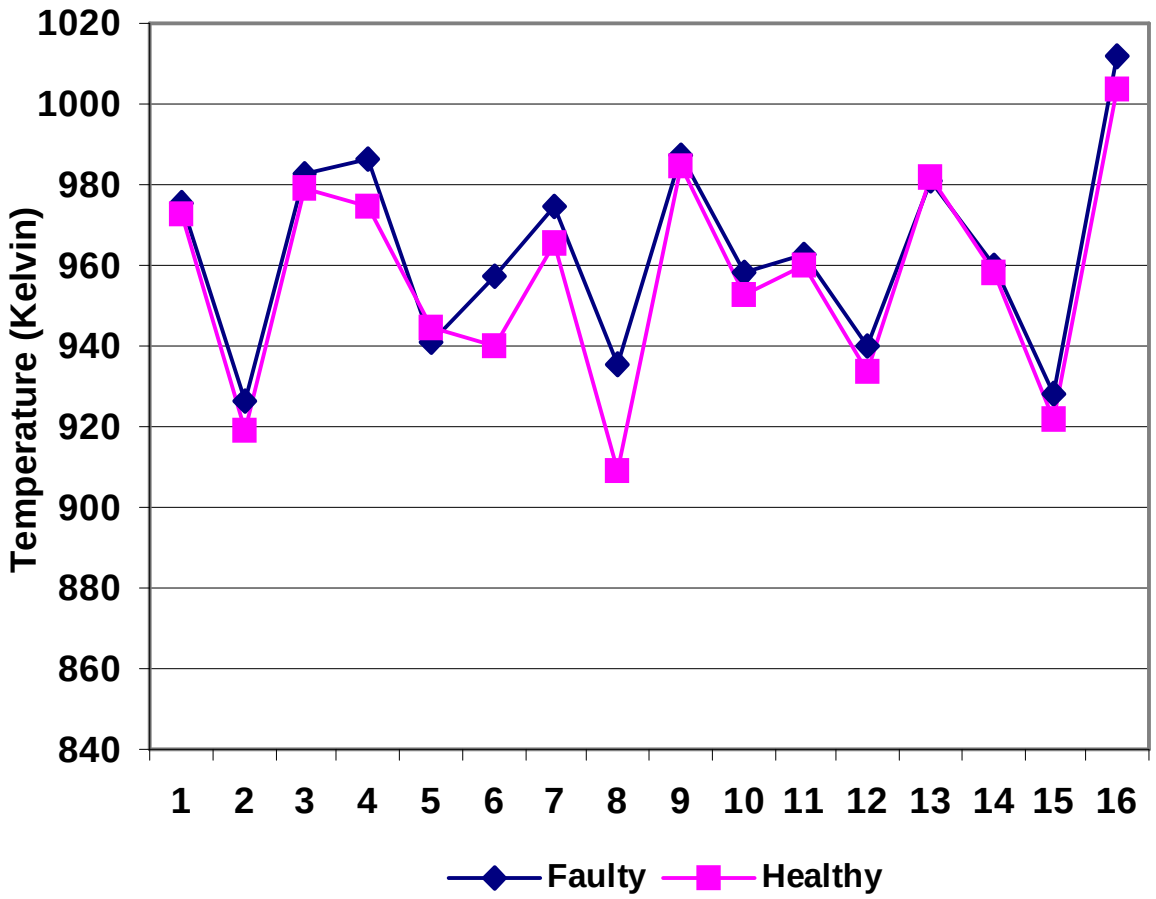
Temperature Pattern At Core Turbine Outlet For Two Cases



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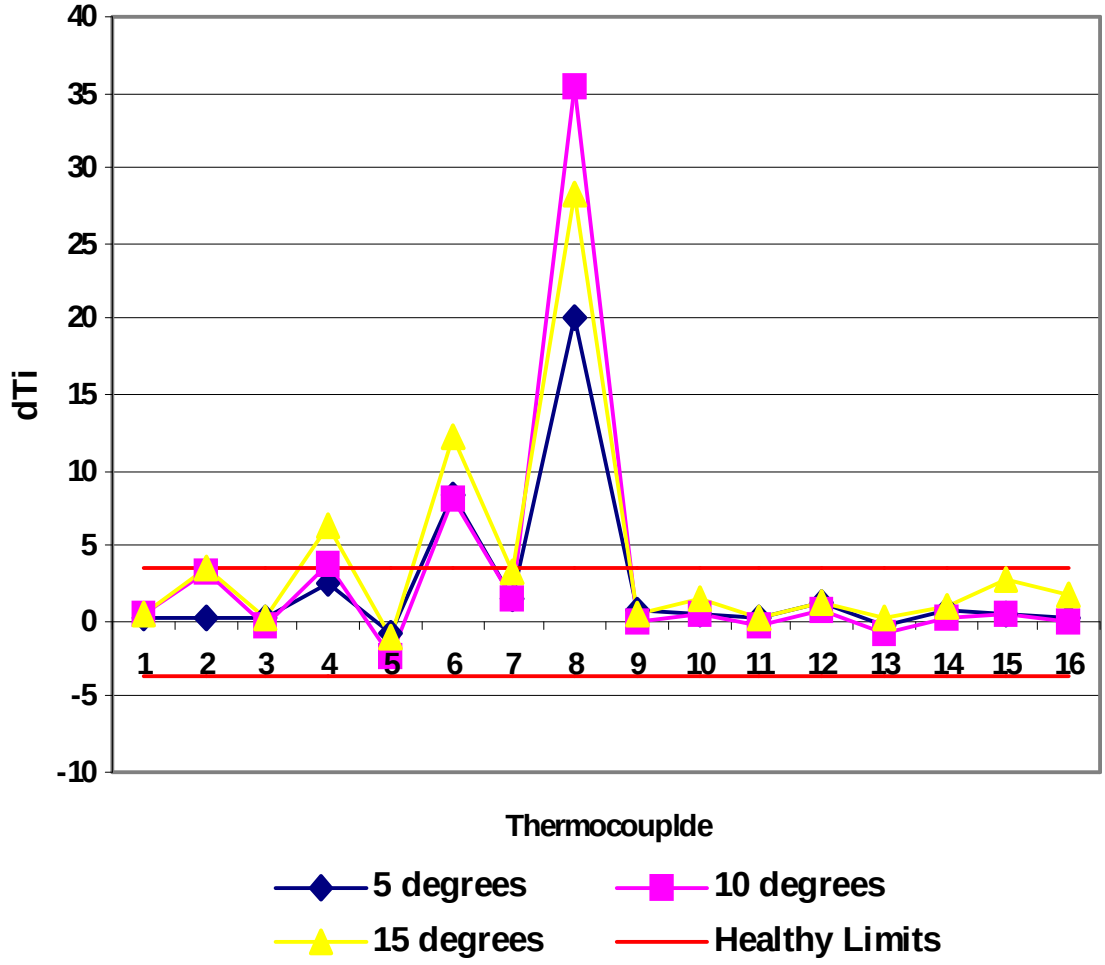
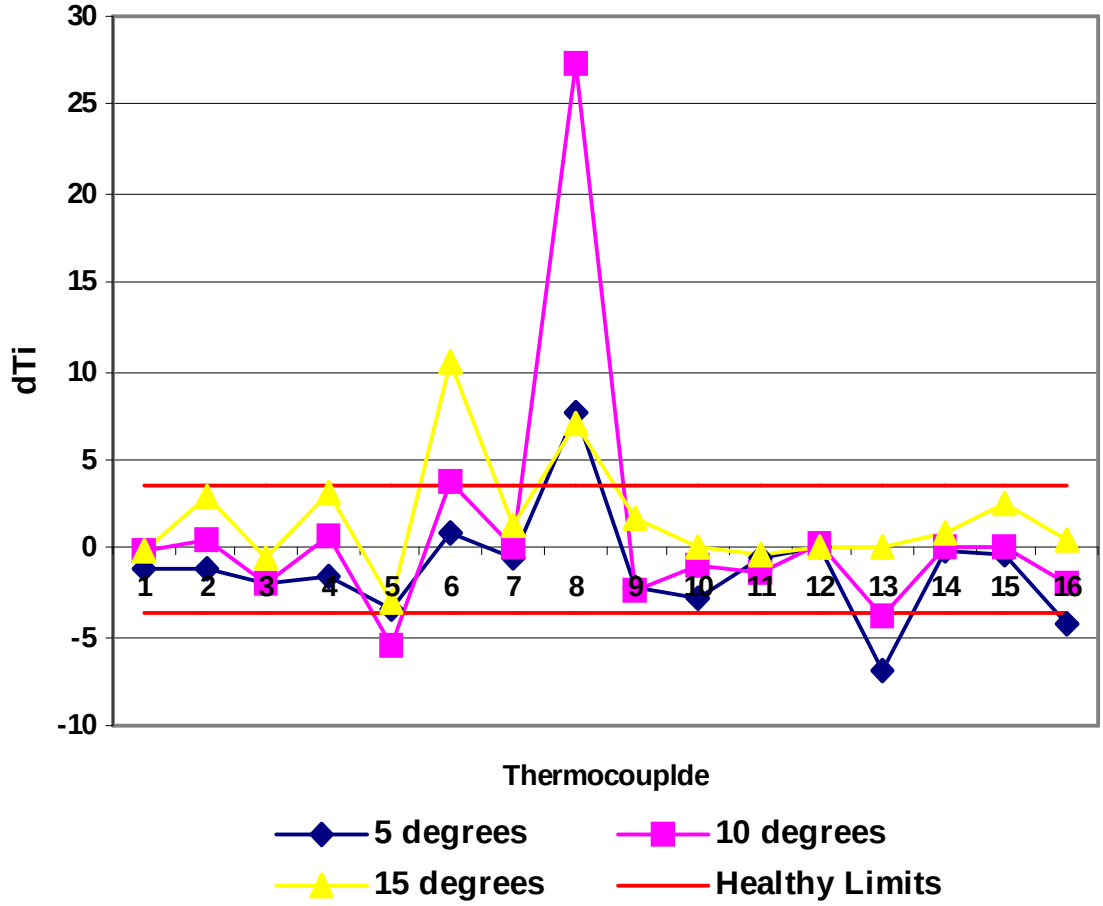
Reduced Temperature Deviations

Three vanes of stage-1 mistuned



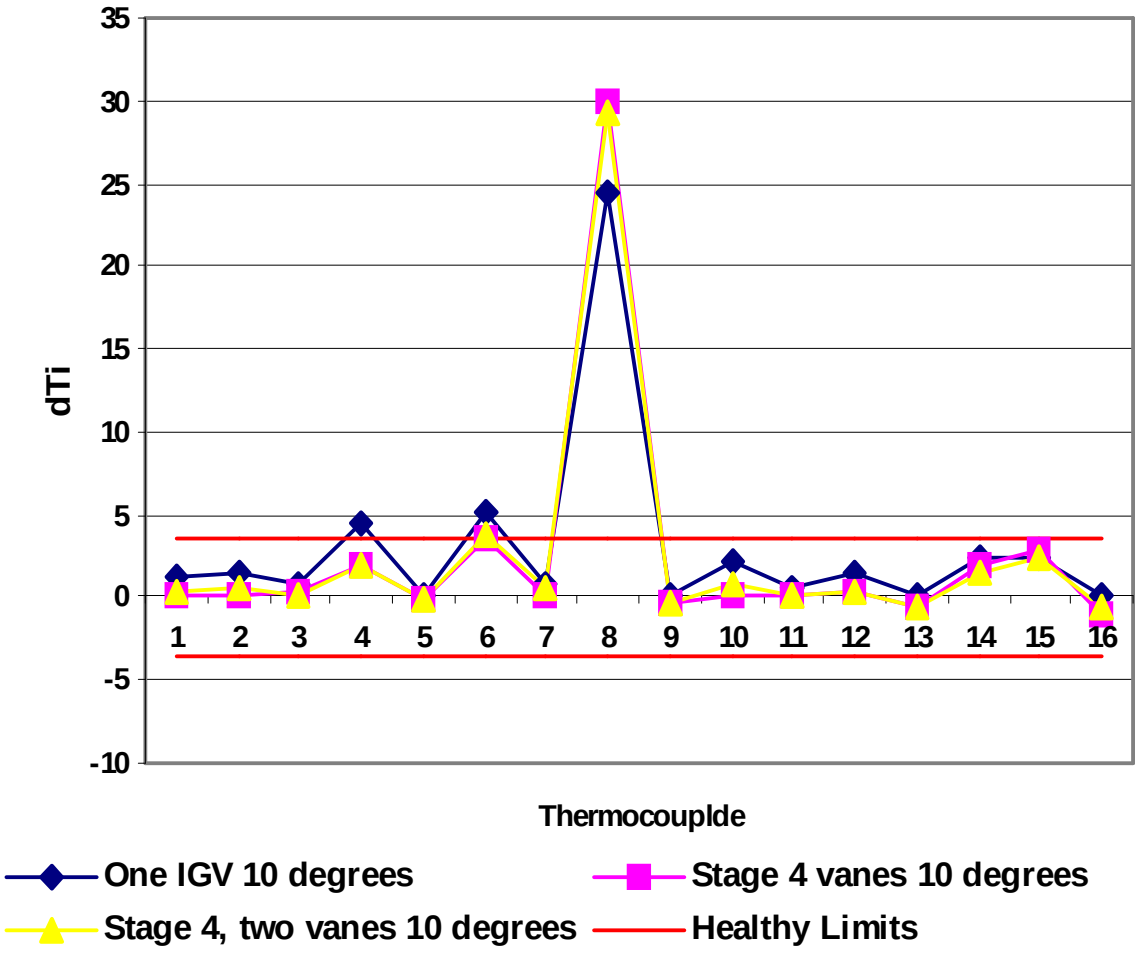
Reduced Temperature Deviations

One vane of first stage mistuned

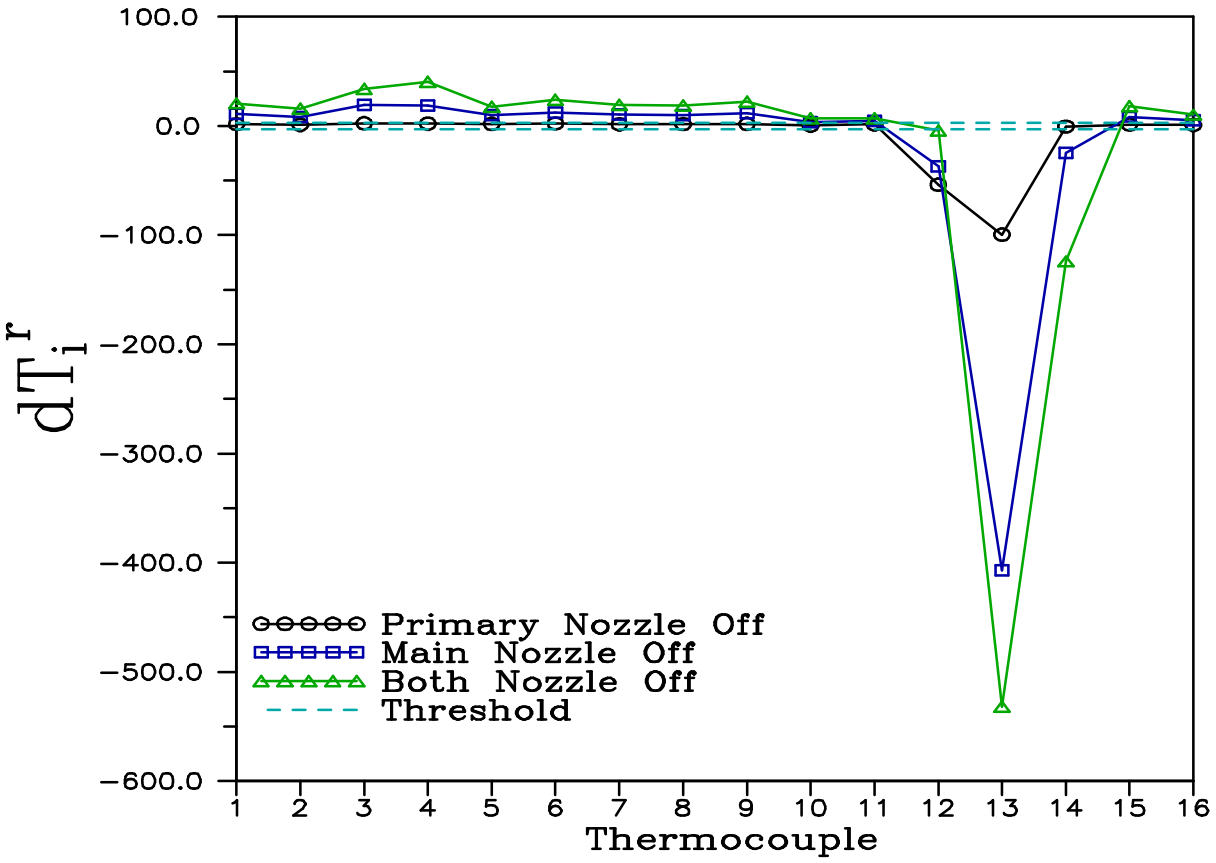


Reduced Temperature Deviations

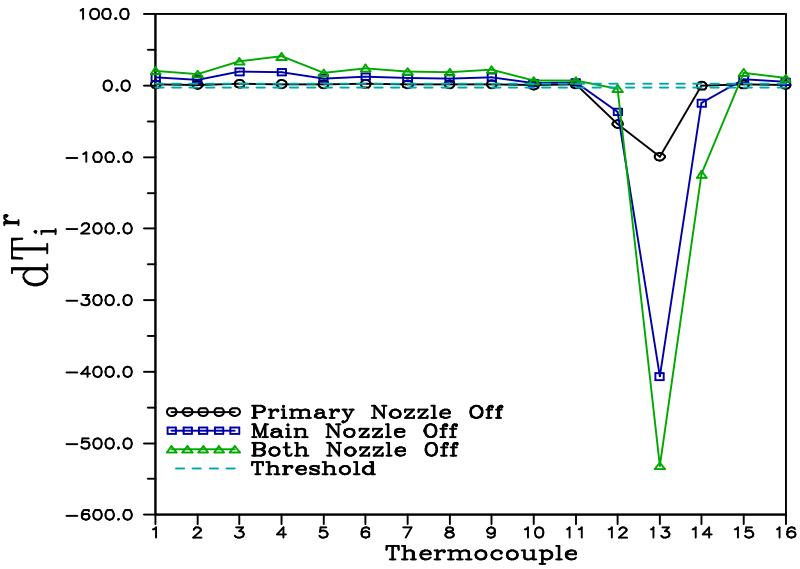
Different cases of mistuned vanes



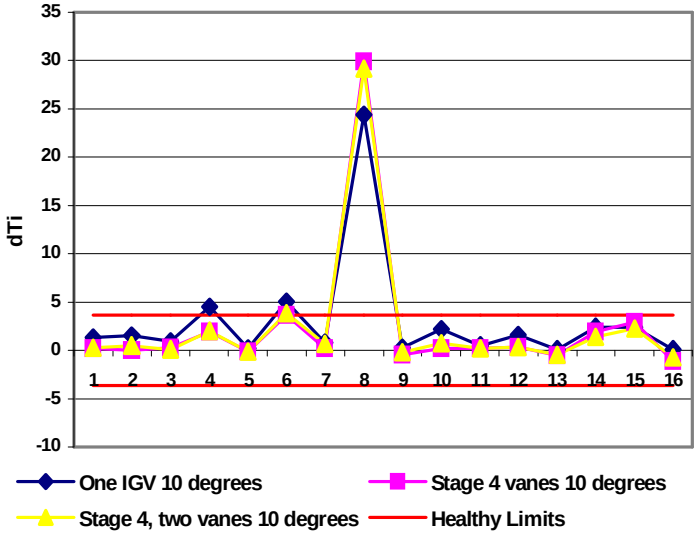
Reduced Temperature Deviations For Burner Faults (Tsalavoutas Et Al, 1996)



Comparison Of Reduced Temperature Patterns

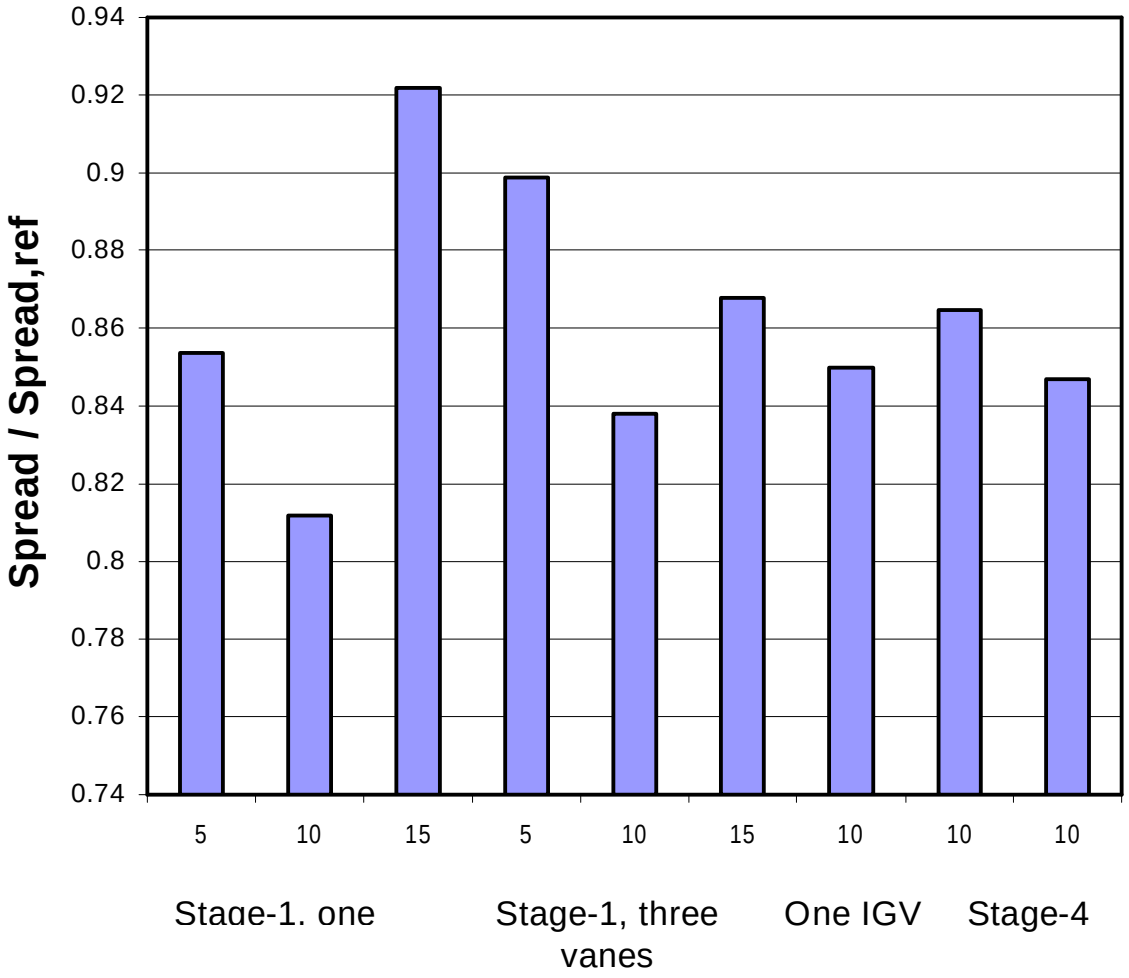


Burner Faults



VGV faults

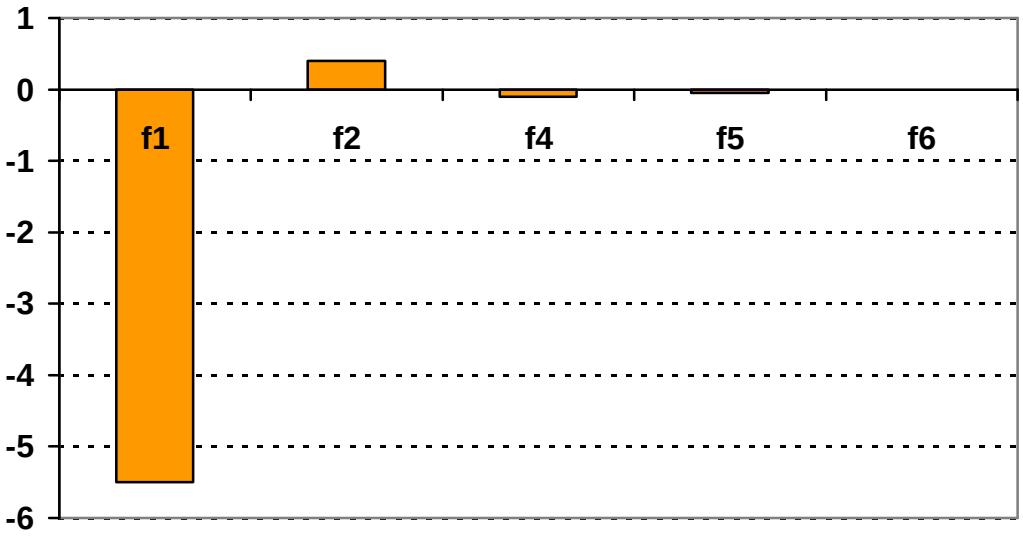
Temperature Spread for the Examined Cases



Diagnostic Observations

Particular features of VGV faults

- *Mainly f_1 reduction*
- *Effect on EGT profile*
- *Mis-rigging no effect on EGT*



IGV +6 Degrees misrigging

VGV faults also produce acoustic signatures

Conclusions

- Individual VGV faults have an effect on performance
- Adaptive modelling provides component oriented (localized) information
- EGT patterns are influenced by individual VGV faults (distinguishable on reduced temperature patterns)