

Science & Technology Facilities Council



WARWICK

Imperial College

London



FETS RFQ Cold Model Cooling Tests 21st June 2011



by Ian Clark & Peter Savage







The manufactured baffles





Section view showing both baffle assemblies in place.





Cooling test procedure.

- 1. Stick thermocouples in positions shown using heat resistant tape.
- 2. Pass thermocouple wires out through one DN40KF port.
- 3. Close cold model ends with flanges to retain heat.
- 4. Wrap one heating tape (350W) around cold model.
- 5. Set LabVIEW program to read each thermocouple every minute (60,000ms) i.e. All thermocouples are read in 8 minute cycles.
- 6. Empty text file that stores data.
- 7. Close file.
- 8. Begin recording.
- 9. Switch on heating tape.
- 10. Monitor until steady state is reached (approximately 6 hours).
- 11.Stop recording.
- 12.Set LabVIEW program to read each thermocouple every 10 seconds (10,000ms)
 - i.e. All thermocouples are read in 80 second cycles.
- 13.Open data file and insert comment to separate data.
- 14.Close file.
- 15.Start recording.
- 16.Turn on water supply after approx 5 minutes.
- 17. Monitor until steady state is reached (approximately 30 minutes).
- 18.Measure flow rate using 4 litre jar.
- 19. Change data file name and save.



Test set-up.



Initial tests conducted using one (350W) heating tape and no foil insulation. For these conditions the copper will reach approximately 50^oC in 6 hours. Tests using two tapes and insulation to reach higher temperatures can be made.



8 Channel Thermocouple Data Logger



Saad provided us with an 8 channel thermocouple data logger and LabVIEW software to record the data. 2 channels were used to monitor inlet and outlet temperatures and 6 channels were used to measure the temperatures of the interior copper surfaces.



Test set-up showing inlet and outlet thermocouple positions



The inlet and outlet thermocouples were clamped beneath the jubilee clips that retain the inlet and outlet hoses.



Test 1





Measuring temperatures at the model centre along one cooled vane edge.



Test procedure.





Results for first 2 hours of cold model heating (before laptop crashed).



Series (thermocouple) data for numbers 2 to 7 overlay each other as does the data for thermocouples 1 and 8 (inlet and outlet).



After upgrading the laptop's cooling system it ran without crashing!



Slide 13 of 34



A snapshot of data from 115 to 120 minutes for thermocouples 2 thru to 7.



Slide 14 of 34



Data recording continued until a steady-state was reached (total time approx 6.5 hours)



Slide 15 of 34

Science & Technology (Asternology Facilities Council WARWICK Universidad Universidad Eukla Herrick

Then the cooling water supply was turned on (water temp = 22° C). The flow rate was measured to be 4 litres / 46 seconds = 5.2 litres / min



Slide 16 of 34



Test 2

Changes

•New thermocouple layout

•60,000 ms intervals for heat up stage - had too much data for Test 1

•10,000 ms intervals for cooling stage

•Take data for approx 5 minutes before switching on cooling

•Change inlet and outlet thermocouple positions to be avoid conduction



Test 2 – thermocouple positions.



Measuring temperatures longitudinally along one cooled vane edge.



Heating up for 6 hours.



Time (minutes)



Cooling down for 35 minutes. Flow rate = 5.2 litres/min



Slide 20 of 34



Cooling down from 4 to 7.5 minutes





Test 3

Changes •New thermocouple layout



Test 3 – thermocouple positions.





1 = Inlet8 = Outlet

Measuring temperatures at the centre around an un-cooled vane.



Heating up for 6 hours.



Slide 24 of 34



Cooling down for 35 minutes. Flow rate = 4.3 litres/min



Time (minutes)



Cooling down from 0 to 5.5 minutes



Slide 26 of 34



Test 4

Changes •Heating tape fitted inside cold model



Test 4 – thermocouple positions (same as test 3)





1 =Inlet 8 =Outlet

Measuring temperatures at the centre around an un-cooled vane.



Photo showing one 350W heating tape wrapped around 76mm diameter tube and inserted into one of the bores. End flanges are fitted during the cooling test.

Science & Technology

Facilities Council

Plan is to turn on heating and water. Starting with low flow rates and increasing at intervals.



Imperial College London



Internal heating, one 350W tape



Slide 30 of 34

Flow rates stated are the total i.e.for both channels combined.



Test 5

Changes

•Two heating tapes used – total power = 600W

•Slow flow control improved by using inline valve



Test 5 – thermocouple positions (same as test 3)





1 =Inlet 8 =Outlet

Measuring temperatures at the centre around an un-cooled vane.



Internal heating, two tapes, total power = 600W



Slide 33 of 34



Test 6

Changes

•Three heating tapes used – total power = 850W

•Thermocouples back in Position 1 (to allow room for the heating tapes)





Measuring temperatures at the model centre along one cooled vane edge.



Internal heating, three tapes, total power = 850W



Flow rates stated are the total i.e.for both channels combined. Lost first half an hour (approx) of data due to PC crash. Time (minutes)



END

