Optimizing Composite Repair by Tailored Heat Sources

The Joint Advanced Materials and Structures Center of Excellence

Inverse/Optimal Repair of Composites

- Goal: To minimize set up time and assure temperature control of repair site
- Objective: To design heat sources that achieve an isothermal state in the repair zone
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- Approach: An Inverse Analysis using Finite Elements, Proper Orthogonal Decomposition, Sparse Grids and Bayesian Inference
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FAA Sponsored Project Information

- A. Emery, K. Johnson, UW
- E. Casterline, C. Mays, J. Lombard, Heatcon
- Curtis Davies, David Westfield, FAA Technical Monitors

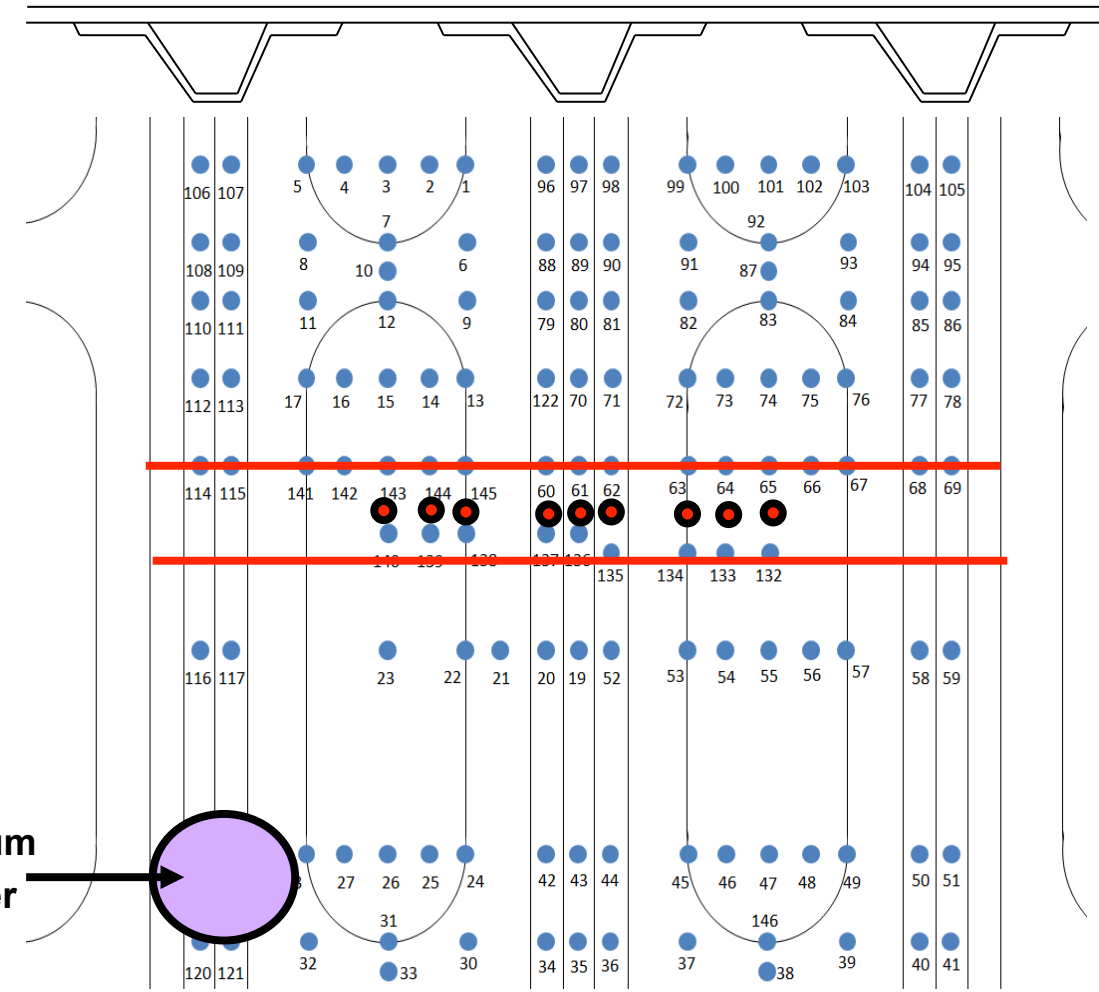
- Heatcon and Boeing

Goal

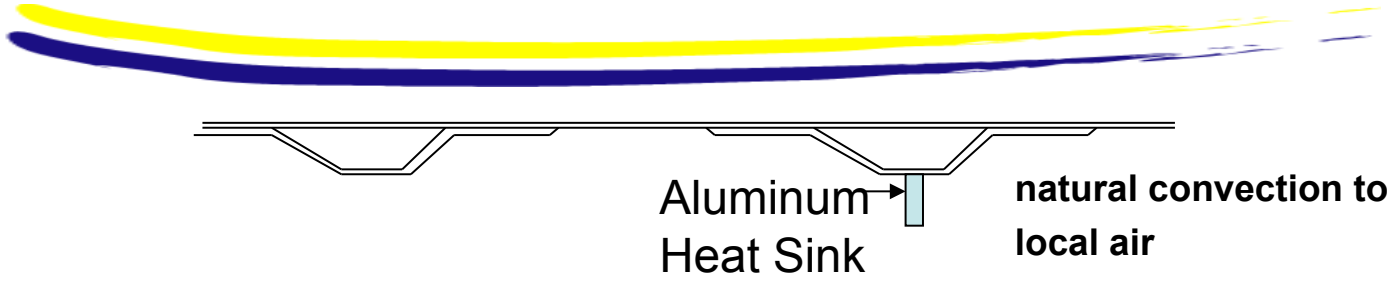
To specify the spatial distribution of heat flux
from a heating source (blanket)
to produce
a specified and constant temperature
throughout the cure zone

with a minimum of pre-repair testing

New Thermocouple Placement

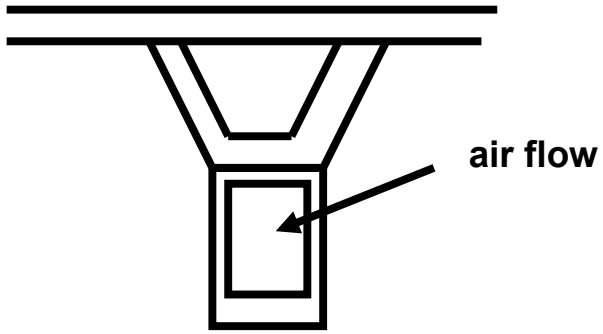


Adding a Heat Sink



This heat sink had little measurable effect

So we replaced it with a channel with air flowing at different rates

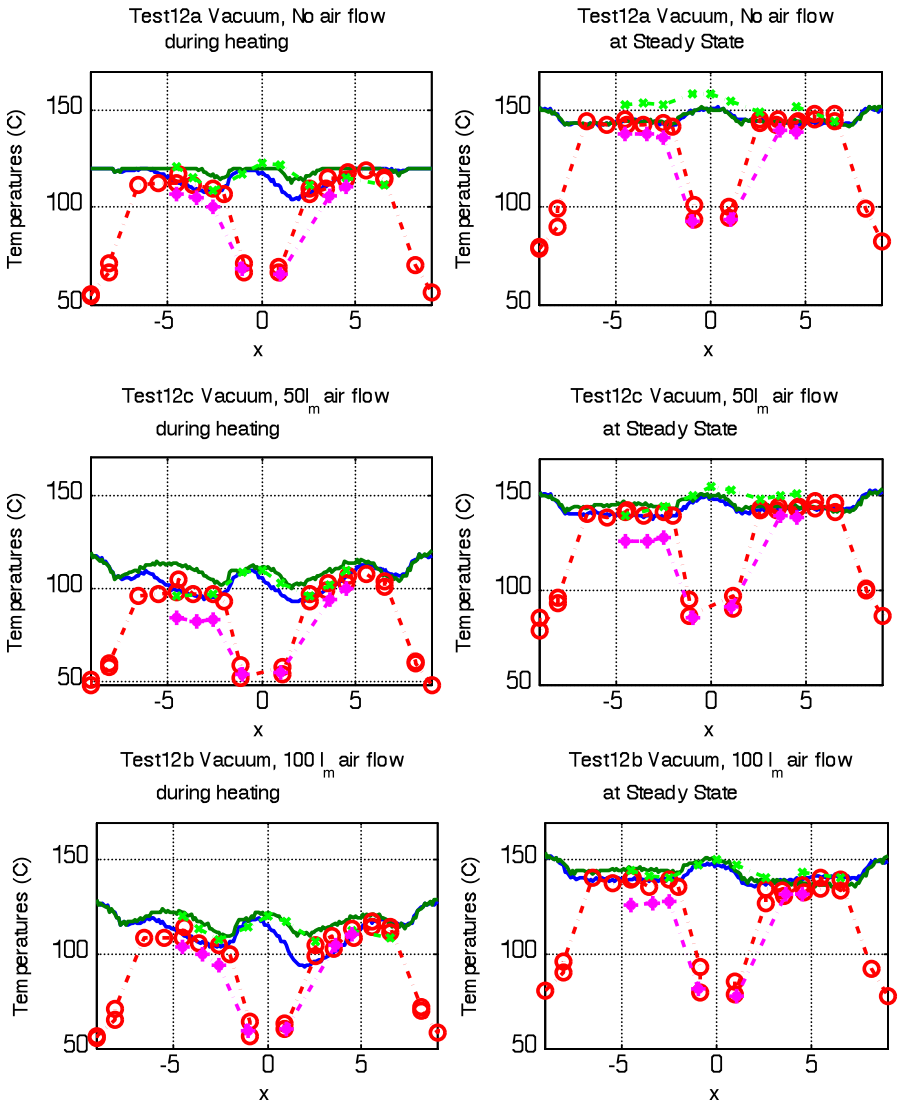


Adding Cooling Air

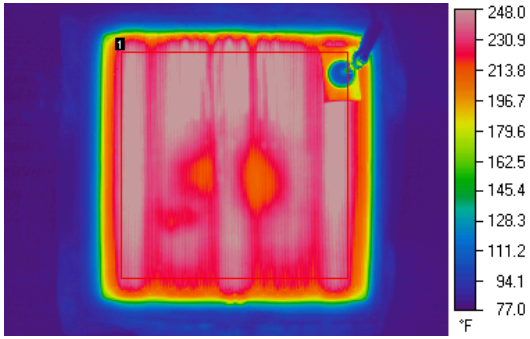
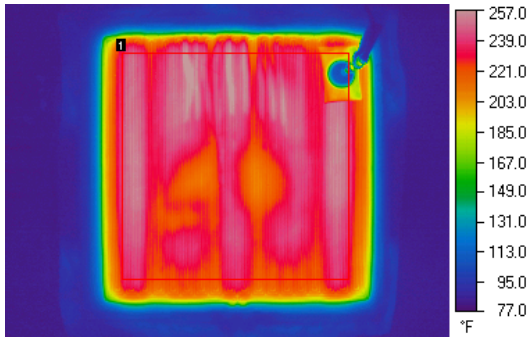
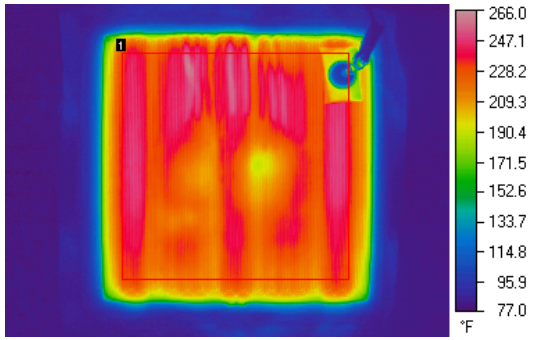
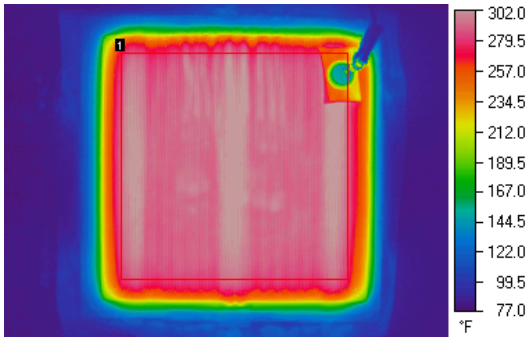
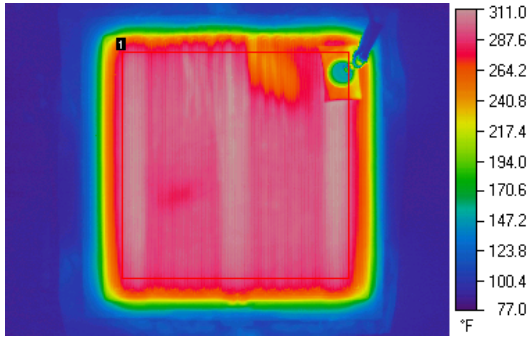
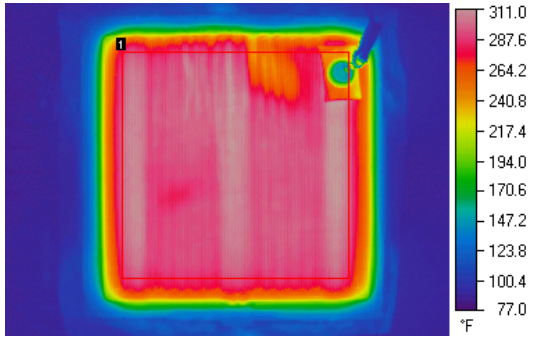
	h_{bottom} (w/m^2 C)	Blanket= 2 w/in^2
No air flow	6.9	
	8.5	
50 l/m	10.5	
	14.1*	0.8 w/in^2
100 l/m	11.9	
	15.9	1.6 w/in^2

* Common colors denote the results from the same tests

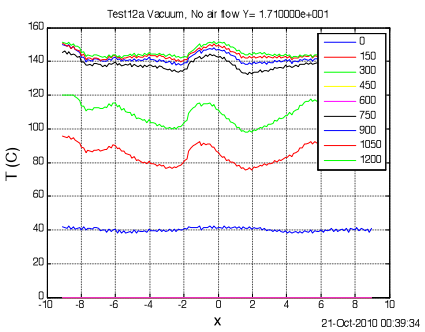
Behavior of Temperatures

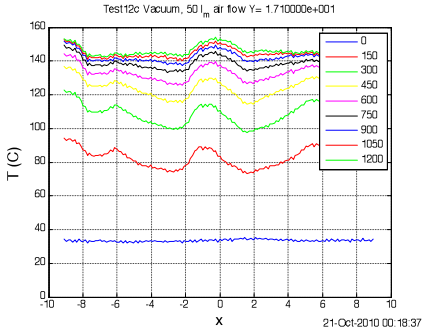


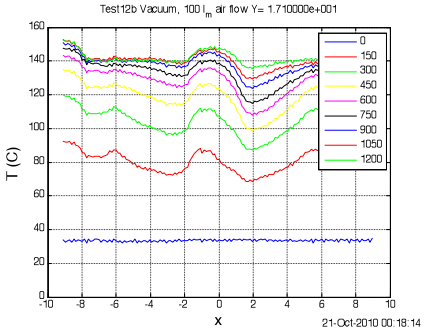
Thermograms at early times

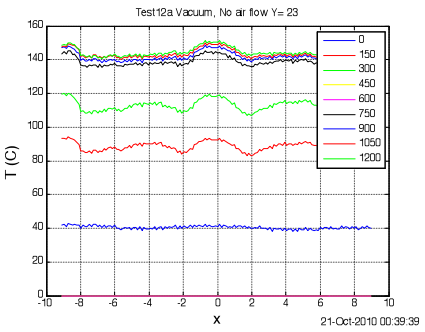
No Air Flow	50 l/m 0.8 w/in^2	100 l/m 1.6 w/in^2	
			Early Time
			Steady State

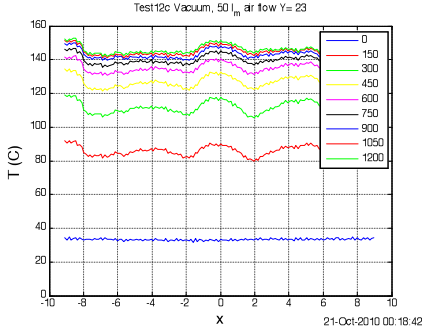
Time Histories of Thermograms

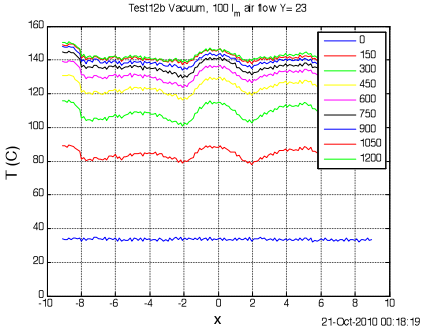






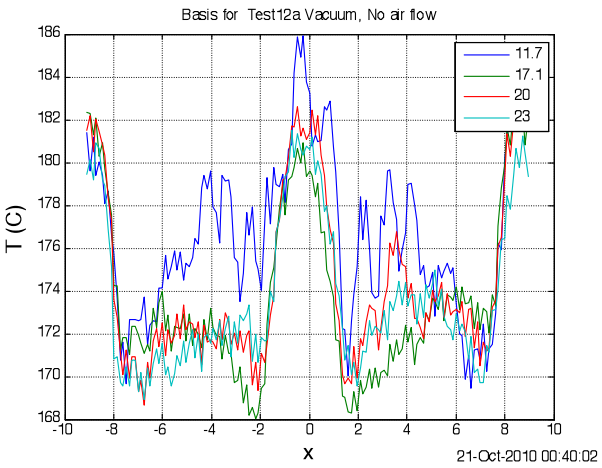


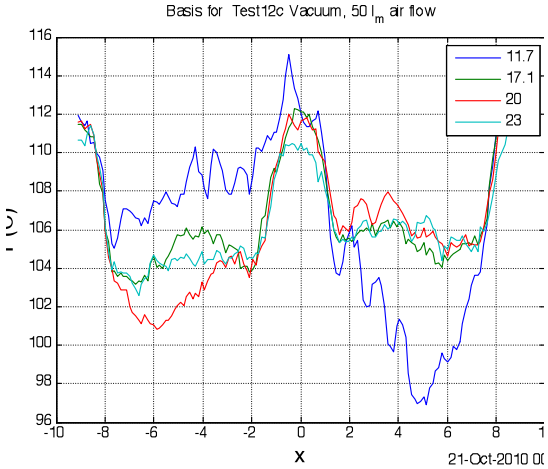


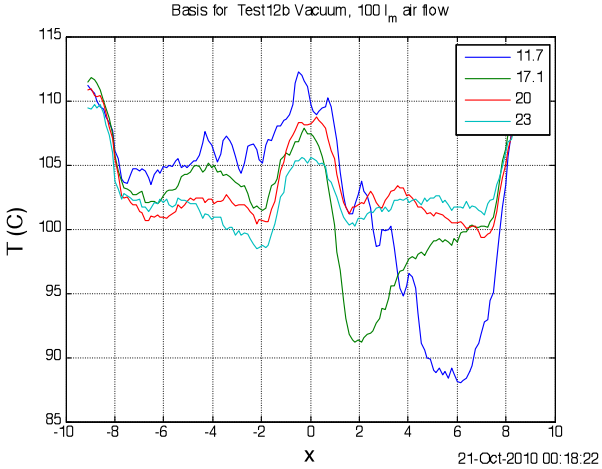


No Air Flow **50 l/m, 0.8 w/in^2** **100 l/m, 1.6 w/in^2**

Basic Thermogram Patterns







No Air Flow

50 l/m, 0.8 w/in^2

100 l/m, 1.6 w/in^2

Conclusions

A) Estimating back side heat transfer using surface thermograms depends very strongly on material properties and the magnitude of the heat flows.

B) The basic patterns of the surface temperature as measured by the thermograms shows promise in detecting backside heat flows.

C) Relating the characteristics of the thermograms to the magnitude of the heat flows is currently being studied—experimentally and through simulation