THERMAL MODELING ISSUES

Accuracy of Thermal Modeling Tools

William Maltz
Electronic Cooling Solutions Inc.

Overview

Reasons to use CFD for thermal design

- Availability of computing resources
- Accessibility of “user friendly” codes
- Difficulty in obtaining actual hardware
- Lack of resources required to build thermal or air flow impedance mockups
- The increasing need for up-front analysis

How accurate are models?

ECS assessment based on experience

- Modeling accuracy is dependent on several factors
  - Availability of information from the system and package designers.
  - Accuracy of power estimation and chip thermal data.
  - System design may go through several changes. It is often difficult to implement all these of changes in the model.
  - Limitations of CFD code used
  - Time constraints

Ways to increase accuracy

- Use of a Volumetric Flow Chamber to obtain boundary condition using experimental methods.
  - Total airflow through system
  - System impedance
  - Vent resistance
  - Fan or blower tray performance curve
  - Slot resistance
  - Other system resistances (Filters, EMI screens)
  - PSU airflow and resistance

Ways to increase accuracy

Chassis mounted to Volumetric Flow Chamber

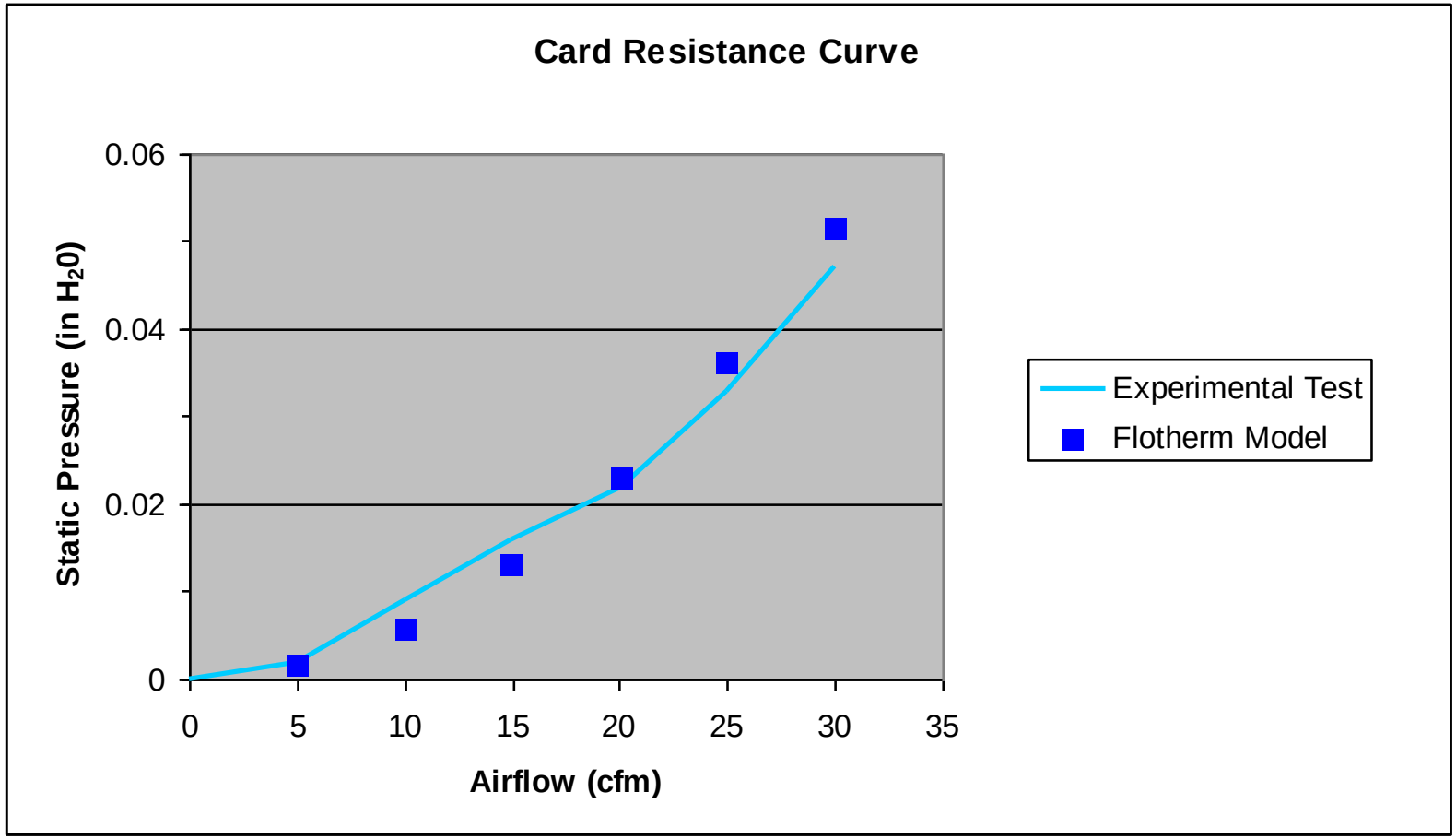
Ways to increase accuracy

Calibration of the Model

- It is important to understand the differences between the actual design and the model in order to do calibration
- Calibration is done by modifying the model to match experimental airflow results:
  - Vent resistance
  - Board Impedance
  - Adding detail that affect airflow results
- Use calibrated model to evaluate changes in the design using what if scenarios

Ways to increase accuracy

Comparison of experimental and modeling impedance data



Modeling vs. experimental results

Total airflow comparison

System	Model Cfm	Prototype Cfm	Percent Differences
Chassis 1	422	364	13.7%
Chassis 2	127	101	20.0%

Modeling vs. experimental results

Reasons why modeling data may not correlate with experimental data

- Component changes
  - Fans are different
  - Vents and filters resistance are not the same
- Cumulative discrepancies between the model and the design
  - Dimensions
  - Gaps
  - Leakage
- The design has changed significantly

Modeling vs. experimental results

Air Temperature Comparison Data for a 2U Chassis

	Experiment	Model	Difference (%)
Channel 1	49.9	63.8	27.9
Channel 2	49.0	60.5	23.3
Channel 3	49.0	56.8	15.8
Channel 4	48.8	55.6	14.0
Channel 5	50.7	55.6	9.8
Channel 6	51.1	55.0	7.7
Channel 7	53.0	52.5	1.1
Channel 8	46.8	49.7	6.0
Channel 9	52.5	53.2	1.4
Channel 10	52.1	49.1	5.8
Channel 11	52.4	49.9	4.8
Channel 12	52.8	50.0	5.3
Channel 13	54.0	48.9	9.4
Channel 14	50.6	49.2	2.9
Channel 15	51.2	49.4	3.6
Channel 16	51.0	50.2	1.7
Channel 17	49.9	48.5	2.8

Modeling vs. experimental results

Air temperature comparison of a 2U chassis

- The air temperature was measured in the middle of the channel with a thermocouple.
- In the model, the air temperature was obtained from a region located in the middle of the channel. The average temperature of the air flowing through the region was reported.

Velocity data issues

- Background
  - Commercial velocity probes measure the air velocity indirectly. Sensor are typically calibrated in a laminar chamber.
  - Velocity values can be easily extracted from a CFD model. In order to extract a more useful value a region perpendicular to the airflow direction is often used.

Velocity data issues

- Resolution and accuracy of each technique
  - Velocity probes are sensitive to orientation and location. Unless significant time is spent on the setup, it is difficult to get good repeatability
  - CFD: We use a defined region and we extract the average air speed flowing through that region. The data extracted is difficult to correlate with experimental data.

Velocity data issues

Comparison of data for a Board Level Model: Experimental results were used to apply to the board level model the appropriate flow rate

	Velocity Comparison (LFM)								
	TP1	**TP2**	**TP3**	**TP4**	**TP5**	**TP6**	**TP7**	**TP8**	**TP9**
Test	504	269	122	217	150	105	204	136	365
Model	514	228	202	223	142	130	205	122	132

– A qualitative evaluation of air velocity data is useful.
– The model can be use to identify re-circulation, low velocities zones, and evaluate airflow distribution across the board.

Conclusions

- More reliance on modeling will occur in the future
- More work is needed in order to increase awareness of both the value and limitations of modeling
- A combination of modeling and experimental methods is recommended