Ballard Power Systems Inc.

Simulation Pinpoints Root Cause of Failure

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Ballard Power Systems Inc. designs, develops and manufactures zero-emission PEM fuel cell stacks. The company is working with leading automobile manufacturers to develop the next generation of engines that are more efficient and cleaner than internal combustion engines. Engines using Ballard® fuel cells can help manufacturers reach new environmental performance levels demanded for automotive power.

The Ballard MK9 series of cell voltage monitoring (CVM) systems are electronic devices used in automotive fuel cell stacks that monitor the voltages produced by cells during operation.

CVM chip solder joint failure can prompt a false failure signal to the vehicle control unit that subsequently can shut down the operation of the fuel cell and, possibly, the entire fuel cell engine. Improving CVM reliability means directly improving the entire fuel cell stack reliability. Therefore, addressing CVM solder joint failure is critical to improving fuel cell stack reliability

TECHNOLOGY USED

ANSYS® Multiphysics™

BUSINESS CHALLENGES

Thermal expansion of the PCB and potting material — which protects the CVM from the environment — can cause deflections that result in stress on the solder joints. The challenge was to concentrate on the CVM box and the PCB board inside to:

- Gain insight into the structural load on electronic components during thermal cycling
- Identify probable areas in which excessive stress could cause early CVM chip failure
- Identify potting material that avoids exerting thermal expansion stress on the CVM components

ENGINEERING SOLUTION

- High-stress areas and components were identified on the assembly model
- A thermal–structural coupled field analysis was conducted to calculate the stress on the solder joints from board deflections.
- Submodeling in ANSYS Multiphysics software was used to develop a finer mesh for the individual chip/solder joint detail analysis. Submodeling is effective in helping to calculate more accurate results in a specific region of interest.

BENEFITS / RESULTS ACHIEVED

- By using thermal–structural coupled field analysis and then creating a submodel of the worst CVM chip, Ballard pin pointed solder joint stress that was the primary cause of CVM solder joint failure and solved a major reliability problem
- Ballard selected new potting material with suitable coefficient of thermal expansion (CTE), eliminating stress components for the CVM chip and averting failures. The potting material was close to the PCB's CTE and eliminated "bulge" of other material tested. As a result, peak stress was reduced more than 3X, eliminating root cause of solder joint failure
- The process verified that CVMs potted with new material showed no sign of solder joint failure

COMPANY INFORMATION

Country: Canada

Industry: Power

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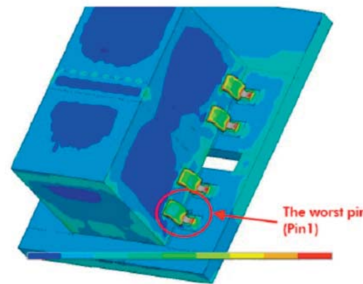
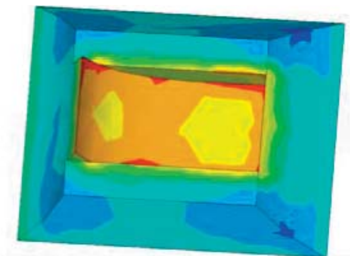
"ANSYS Multiphysics software was used to build an FEA model of Ballard MK9 series CVMs. The advanced submodeling technique provided by ANSYS allowed a quick turn-around analysis of several design iterations without sacrificing details (such as solder pads and leads) captured in the model."

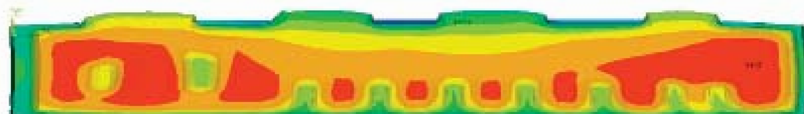
Kemal Ozgur
Automotive Alliance Group
Ballard Power Systems Inc.



CVM Chip Submodel



Solder Pad Submodel Stress



CVM Assembly Model Deflection Results

CASE STUDY

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