How small can you go?

A detailed CFD study to optimize the design of multiple compact heatsinks in the mobile communication module of radio access stations

By Seung-Hyun Jeong, Hangang University

Mobile cellular phone subscriptions hit the six billion mark worldwide in 2011 [1], resulting in an increased demand for base stations. This in turn drives the need to build even smaller, more compact stations which are unobtrusive. Under these circumstances more compact heatsinks become critical to keeping component temperatures below threshold levels for optimal electronics performance. A 2010 study [2] conducted by engineers at the Hanyang University in Seoul addressed this issue using the market leading FloTHERM™ electronics cooling simulation tool from Mentor Graphics. It was used in association with a new process integration and design optimization (PIDO) tool, PIAnO™, from PIDOTECH Inc. in Korea [3]. Their detailed CFD study looked to optimize the design of multiple compact heatsinks in the mobile communication module of these radio access stations (Figure 1) which enable subscribers’ wireless internet connections while on the move.

The compact heatsinks integrate into the front and rear housing of the radio access station. This makes them thermally stable over a wide range of ambient temperatures and they operate with only natural air convection currents to cool the electronics. Natural convection is preferable because of its silent operating mode as opposed to the alternative of fan cooling. The challenge posed by the researchers in this multivariable design project was to find the optimal heights, thicknesses and base thicknesses of the heat sinks, as well as the gap between the sun-shield and the heat sink in the front of the station (Figure 2).

The ultimate goal is to minimize the volume of the system while satisfying the constraints on the junction temperatures of 12 key components in the system (Figure 3).

FloTHERM® CFD simulations (Figure 4) obtained the temperature distribution in the unit for extreme operating conditions. PIAnO was employed to execute an array of CFD simulations needed for a Design of Experiment and to automate the procedure for the multivariable design scenario. In order to obtain an approximate optimal design solution, the thermal analysis results were obtained at 54 experimental sampling points.
points. These points were specified by an orthogonal array L54(21 x 325) and then full quadratic polynomial regression models were built to approximate temperatures at the 12 important locations. Design optimization was performed using the approximate models.

This design optimization study with PIAnO and FloTHERM resulted in a reduction of volume of the base station unit by 41.9% while satisfying all the design constraints (Figure 5). The approximate optimum temperature values were also measured and found to be almost the same as those obtained by the FloTHERM simulation at the optimal design point, confirming the validity of this design approach.

References:

For more information on PIDOTECH Inc. and PIAnO: www.pidotech.com/en/product/PIAnO

### Boundary Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Ambient Temperature</td>
<td>50°C</td>
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<tr>
<td>Altitude</td>
<td>1,800m</td>
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<tr>
<td>Solar Load Heat Flux</td>
<td>753W/m²</td>
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<tr>
<td>Related Standards</td>
<td>Telcordia GR-63-CORE</td>
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</tbody>
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Figure 3. Radio access station FloTHERM geometries and the 12 key component junction temperatures monitored in the parametric simulations

Figure 4. Boundary conditions & typical FloTHERM calculation of the base station box

Figure 5. Difference between initial and optimal design of the base station box for the 12 key junction temperatures
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