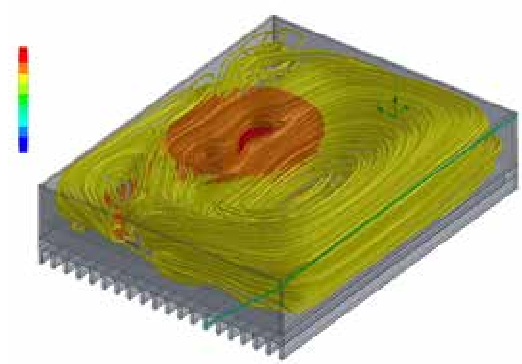
Beat the Heat:
Thermal Engineering Solutions for Rugged Computing

For industries that require on-field computing for rugged operations in diverse, potentially harsh, environments, temperature poses a barrier. Computers must be able to withstand extreme operating temperatures. Since external thermal conditions cannot be controlled, engineers must design devices with minimal heat production. The following white paper discusses the thermal design strategies of thermal simulation, structural conception, component choice and circuit placement.



Challenges

When placing a computer in the field, uncontrollable circumstances, such as climate and process, pose the biggest challenges. Consider fracking as an illustration. This industry maintains active sites in climates with frequent temperature extremes. These climates include places like North Dakota, where record temperatures have dropped as low as -59 °C and climbed as high as 49 °C. The process of extraction exposes fracking rigs to intense heat too. Consequently, ambient temperatures for technology could exceed 49 °C.

Other points of difficulty include size and maintenance limitations. Continuing with fracking as an example, which demands travel along sites, rigs and their equipment must be optimized for size and portability. Space onboard is tight and airflow is at a minimum. Natural heat mitigation, such as heat dissipation via airflow, may not be available. Fracking equipment on rigs must also have shock resistance, which limits options and adds an element of difficulty to part selection and layout. Components such as fans, which take up valuable space and break easily, may be ruled out.

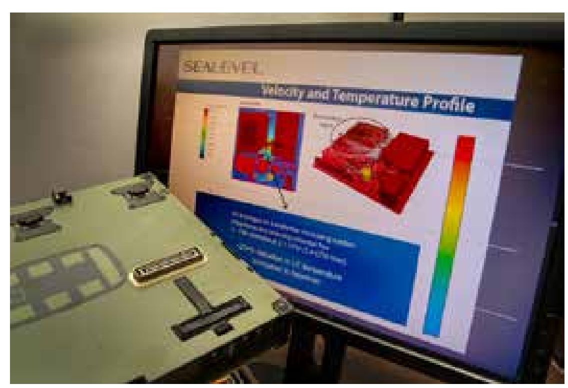
Engineers must also account for possible manufacturing errors, depending on the solutions used. Minimizing the likelihood of these errors is a priority. They can cause failures or inhibit the product from functioning properly.

Method

With these challenges present, thermal solutions optimize the controllable aspects of heat generation and dissipation. Given the complexity of thermal design — and the cost associated with high-tech rugged materials — a primary tool is simulation, which can help optimize structural design, component choice and circuit placement solutions without expensive prototyping. In-house simulation may be an option; however, many design firms need a third-party simulation provider. Investigate possible one-stop shops: companies who can provide thermal simulation and design solutions, offer machining knowledge and manufacture at affordable rates. Consider using multiple simulation providers to ensure consistent results.

It may be helpful for your team to visit on-site, but it is not necessary. The thermal simulation depends on parameters that a client can provide. Parameters will include the upper and lower ambient temperature absolutes, airflow rates and space limitations. Collect or find the thermal qualities of components and materials; they are key to understanding the heat production and dissipation in a device. Testing that data will provide an ideal shape and material selection.

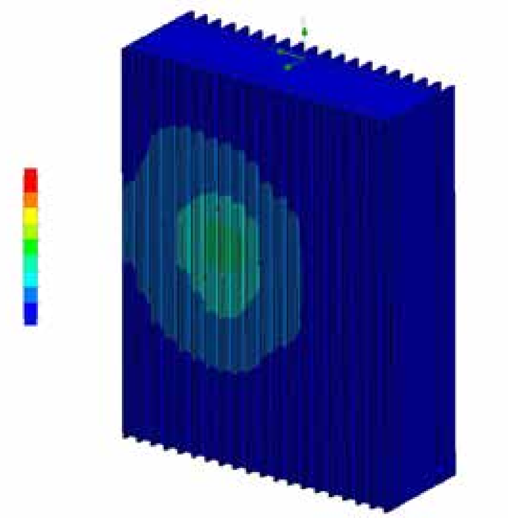
Once simulations are complete and the appropriate components and materials are chosen, the next steps before manufacturing are component placement and product testing. This can be done partially in simulation, but primarily in prototyping. Components must be placed strategically such that heat producing components do not share proximity, creating "hot-spots." In testing, establish the upper and lower limits of the device.



Solutions

A key solution is using efficient, low-heat electronics. When selecting components, ensure that individual operating temperatures meet the temperature range requirements. Indicators of their durability are the material specifications and thermal characteristics. Other things to consider are the inconsistences between and in components — which include integrated circuits, inductors and mechanical parts — because they will affect the thermomechanical design.

Optimize component conduction by incorporating fine surface finishes. The connections will be more efficient, reducing undirected thermal energy from remaining within the computer. A flexible solution for smoothing out inconsistencies is a thermal interface material (TIM), which minimizes random thermal loss and promotes heat flow. TIMs use known thermal conduction characteristics to fill in gaps. A key electronic component in a ruggedized industrial computer is the power supply. Ensure a stable, low-heat connection that will not erratically radiate heat. The goal is to utilize electronics that withstand heat, efficiently supply and direct power, and give off minimal thermal energy. Furthermore, be strategic about circuit placement and design. Reduce the proximity between heat-producing components to avoid "hot spots."



Finally, assemble the exterior body from the smallest number of pieces possible. An enclosure with minimal locking points reduces thermal resistance which improves heat conduction, allowing the energy to efficiently escape the system. Using a ram extrusion process, create a bottom encasing and top enclosure from a solid block of a suitable material. Black anodized aluminum alloy promotes heat radiation, allowing thermal energy to escape the computer's system into the external environment; it also resists shock and vibration. This machining process will enable atypical body designs, such as structural appendages that can be used to draw heat away from components.

One format is a series of fins on the top and bottom of the device. Another solution may be rods extending from the top. When deciding on exterior features, simulate optimized heights and distances on these appendages to maximize heat dissipation, even with low air flow. Simulation may recommend different heights for each side of the device. This disparity is influenced by component location. If the bottom of the computer contains more heat-producing components, the extensions protruding from that side may be longer.

Solutions

With the right structure, electronics and strategic circuit placements, a device can meet the operational temperature requirements necessary. Depending on its application, a device may not need to optimize its thermal capacity using all techniques. Each strategy will have a substantial effect on mitigating thermal conditions and can be done independently. If portability or zero-maintenance are not concerns, internal fans may be a cheaper solution for a product. Likewise if a device will not experience intense shock or vibration: a solid-block body may not be necessary.