E-Cooling: Cooling Power Electronics at Room Level

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The conversion of electrical power with power electronics has become a key technology that enables many of today's innovations for electric vehicles as well as electricity production. Though the applications vary greatly there are two features they have in common: the electric components generate a significant amount of heat, and are trusted to operate reliably. A key factor in the reliability of electronics is the operating temperature. To maintain the operating temperature within specifications with a high heat dissipation, a proper thermal design must be developed.

Challenges

The market of inverter solutions for photovoltaic is growing. The Middle East, Africa and India are expected to massively invert in photovoltaic. In these regions, an average summer's day temperature of 50°C is usual. The customers require reliable inverters integrated in enclosures or containers without air conditioning. As the cooling air takes away the electrical losses, its temperature usually exceeds the environment temperature. Dust or sand entering the electric enclosures must also be avoided. Therefore, filters are necessary, despite large pressure losses.

E-Cooling, an engineering consultancy firm based in Germany, has expertise in the thermal design of Power Electronics, Transformers and Chokes at the component level or at room level where the computational domain enhances a complete enclosure, container or room. At room level, it must be ensured that the cooling path provides adequate airflow to all critical components.

Solution

E-Cooling performs thermal and airflow design with FloEFD® from Mentor Graphics. One of their recent designs involved the overall cooling of a 2.2 MW frequency converter enclosure. Such a frequency converter could be used for a wind power station to provide the grid with the correct

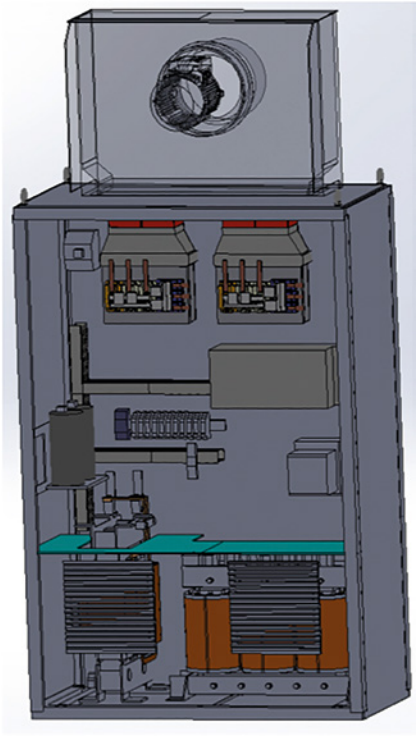

Figure 2. The enclosure with its electric components and fan

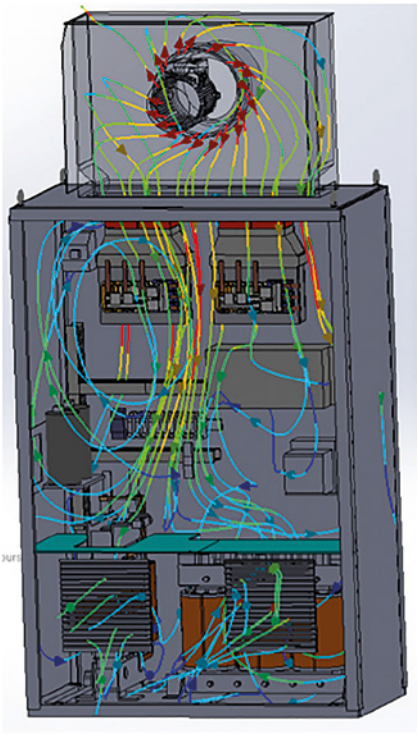

Figure 3. Streamlines starting from fan colored with the velocity

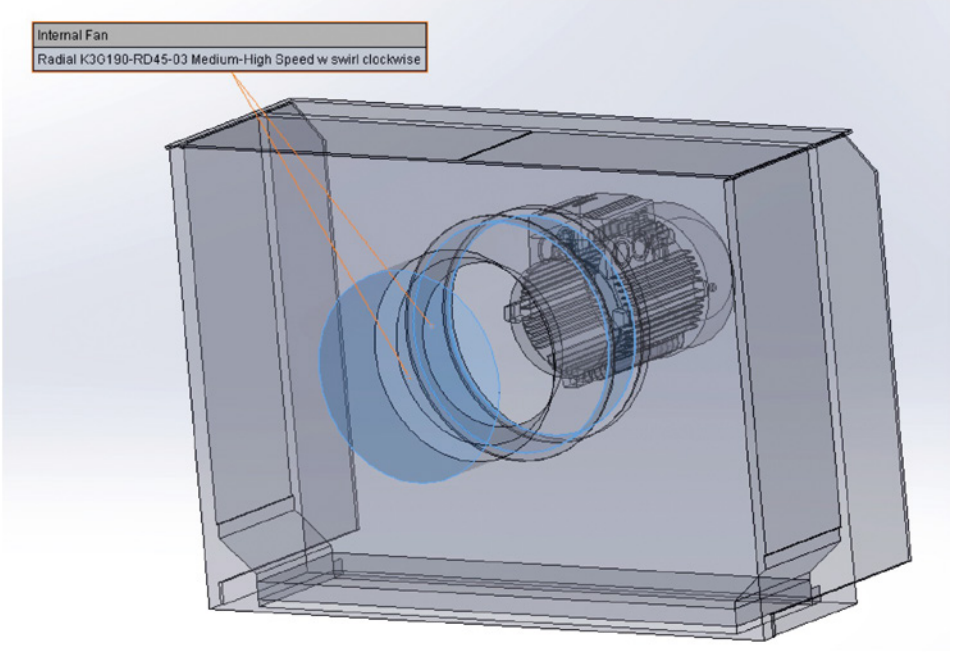

Figure 4. Frequency Converter Fans

frequency or for an electrical drive in order to control the rotation speed. This power is reached by two frequency converter boards, each has three IGBT power modules and two dedicated axial fans. Each board dissipates 1,350 Watts.

When integrating electronic systems into an enclosure, it is important to determine if there is enough airflow through all critical components. This requires the accurate representation of all the significant flow obstructions as well as the fans. Here each fan as well as the dust filter were modeled with characteristic performance curves (pressure vs. volume flow) provided by the manufacturers. With the analysis, E-Cooling is able to determine the flow distribution within the enclosure and make any design modifications to allow the neccesary airflow for each component, including the use of alternative fans.

In the lower portion of the enclosure the model detail was not compromised. A detailed representation of the choke and auxiliary transformer was included as well as the flow diaphragm flow upwards and the exhaust grid flow downwards. A critical aspect of the design is to ensure that a large amount of the flow is going through the tiny passages between the windings. This can only be realized by obstructing the flow with a diaphragm or inner walls.

Benefits

Designing airflow and cooling solutions at the room level for power electronics is essential for providing reliable products to the market. During a development project the electrical requirements and losses usually change and components are likely to be replaced. With FloEFD embedded in the MCAD program, the automatic Cartesian meshing, and the possibility to start a calculation with an initial field, E-Cooling can update the thermal and flow model very quickly to meet project datelines.

“The most viable method of airflow design prior to testing is with CFD simulation based design software such as FloEFD. FloEFD allows E-Cooling to quickly build and assess the viability of an airflow and thermal design.“ Karim Segond, Consulting Engineer, E-Cooling.

E-Cooling in Berlin is an engineering consultancy founded by Karim Segond. Their expertize lies in providing 3D thermal and flow analysis, enhancement and development supporting electronics, electric engines, and power electronics.

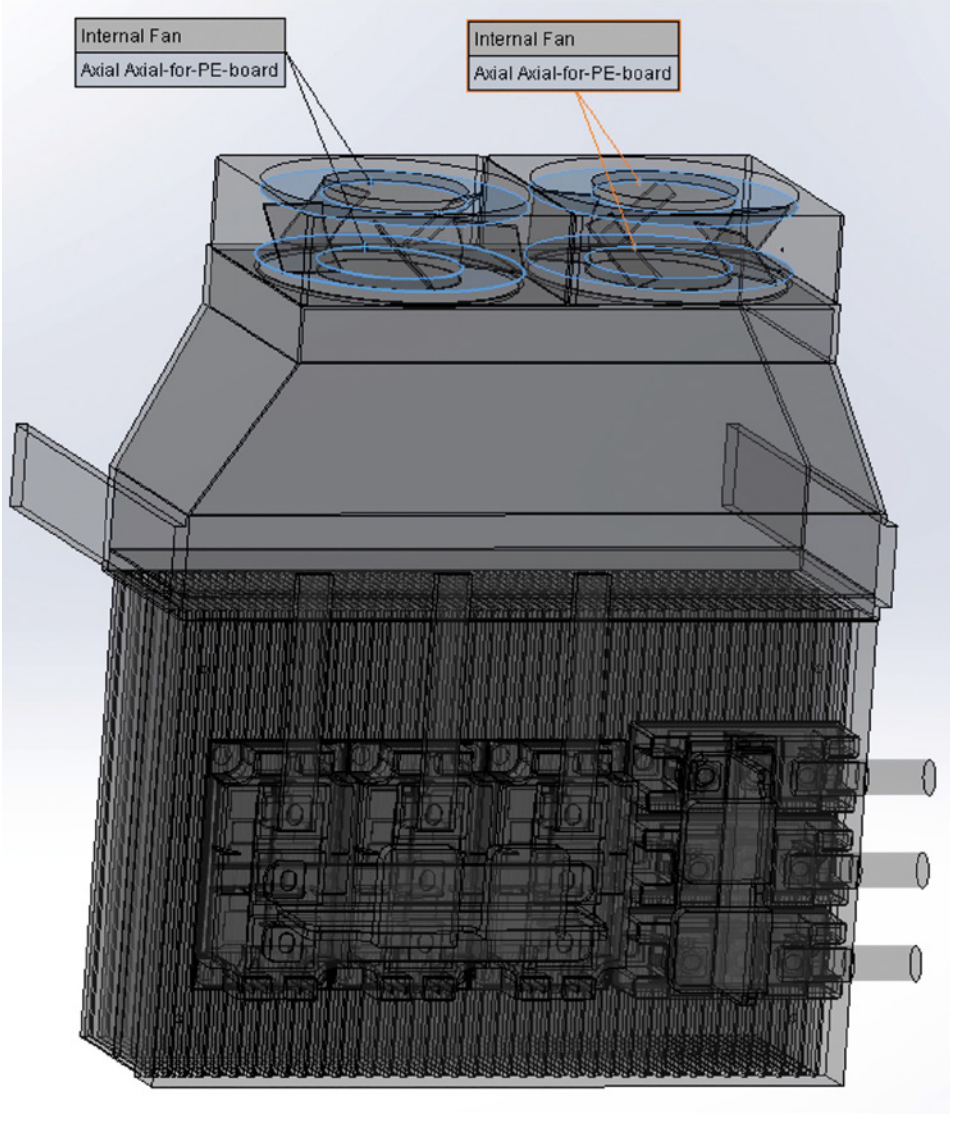

Figure 5. Enclosure Fan

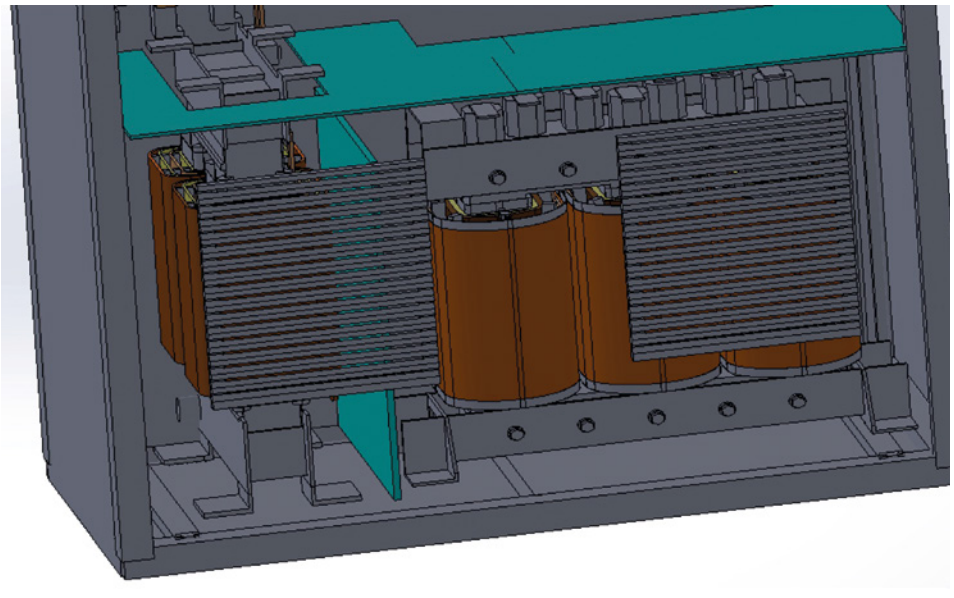

Figure 6. Lower portion of the enclosure