

Thermal Interface Test Apparatus

Z. Sikand, A. Schissel, S. Meza

Northern Illinois University

590 Garden Road

Dekalb, IL 60115

Abstract- A device to study the effects of heat transfer across a thermal interface material that would simulate real life conditions. This device was designed to function as a test platform that would reduce time and cost of testing out different thermal interface materials that would ultimately go in and function within the Variable Frequency Drives that Danfoss manufactures. This device records all the data it collects and thus can be used to help make better models of what is happening inside of the device when in operation. This allows Danfoss to better simulate what is going on inside of their drive's and determine if maintenance must be done to the drive to continue its operation. This test apparatus will be used to test different thermal interface materials to help better understand their properties and performances in a more realistic sense and not just relying on the data sheets of the thermal interface materials for their data.

I. Introduction

Danfoss brought forth to the table a problem with heat management, specifically heat dissipation through a Thermal Interface Material (TIM). Danfoss has been having issues with their Variable Frequency Drives (VFDs) failing earlier than expected and they have deduced it is because the TIM material being used is not performing as expected. This is the primary motivation behind the project that Danfoss has proposed, how to measure the temperature difference across the TIM material.

II. Materials and Methods

The key components to the project that would resemble a VFD are the heat sink and more importantly the insulated gate bipolar transistor or IGBT for short. The IGBT is where a VFD gets its power from. The TIM material is between the IGBT and the heat sink. To be able to find the TIM materials thermal conductivity a temperature measurement must be taken across the TIM. To do this, J-type thermocouples were chosen. By setting up thermocouples on the IGBT and on the heat sink,

the temperature difference can be measured across the TIM. Finding this temperature difference allows us to find the thermal conductivity of the TIM.

Another section needed in this project is a cooling system. An effective cooling system is required because when powering an IGBT temperatures become extremely high. In order to be able to test multiple TIM materials effectively the system needs to be cooled as soon as possible so the next test can start. To meet these expectations a fan cowling was designed and 3D printed. Danfoss provided us with a fan that they currently use for cooling that has a high RPM. Another small task that had to be designed and 3D printed was a box for the top of the heat sink. The box was designed to help simulate how much space is within a VFD between an IGBT and its walls and how the heat will be contained within. This box more importantly covers the aspect of safety in the device, because the box will block any contact between a user and any person or bystander from the heat transfer from the IGBT to the heat sink. The box also allows for the small thermocouples to go into their respective spots across the IGBT and heat sink.

A final requirement from Danfoss was the device needed to have a GUI, a graphical user interface that would be used to control the device. This was done using the program called Processing because it allows for easy communication between the Arduino and the computer hooked up to the device. Using Processing, the user will use the GUI to talk back and forth with the Arduino to control the apparatus and show test results from the tests that are run.

III. Results

To gather the main data such as the temperatures and current measurements, 2 systems were developed. For the temperature, thermocouples connected to a serial hub then converted from a RS485 signal to a signal that an Arduino mega could read. Though mostly a coding endeavor, the final outcome was accurate and responsive temperature readings in real time when two thermocouples were placed in different temperature environments (I.e. ice water and boiling water). Scaling up was as simple as adding additional lines of identical code. For current measurements a transducer connected to the Arduino was tested. Functionality without having an actual 500-amp supply proved tricky initially, however a "trick" was worked by making several windings to

the transducer simulating high current using a standard lab bench supply. Several trials were run, and a curve was plotted that showed very close measurements to that of the data sheet, confirming system was functional.

In conjunction with a heat sink, a variable speed fan controlled via Arduino was used. The speed control was proved functional by coding implementation via a relay and its PWM pin. This allows the user to ramp up the fans or automatically run the fans while testing the user interface. Different speeds were tested and successfully adjusted remotely.

Unifying all the data and control was the coding behind this project. To ensure a user-friendly experience a user interface was developed to see the output data. Below in Figure 1, is an image of the completed GUI that allows for the user to interact and control the thermal test apparatus that was designed. Seen here is an example of thermocouple data and test stand control along with the ability to name tests and control the fans. This is only one of the many modular options a person running a test could display. Lastly, the mechanical layout created deemed the most efficient.

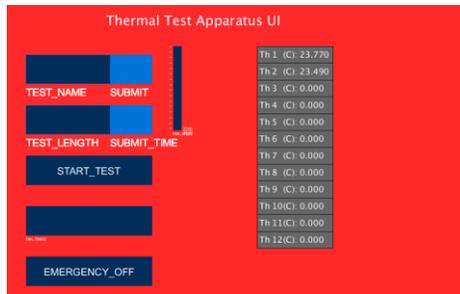


Figure 1: GUI for thermal test apparatus

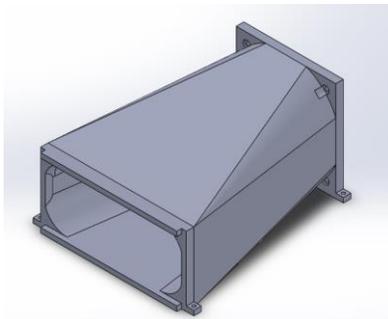


Figure 2: Isometric view of the designed fan cowling

In the image above is the picture of the designed fan cowling. It allows for the fan to be securely mounted into it. It was also made to fit flush

with the heat sink and the heat sink stands and most importantly to optimize the systems cooling. There are multiple pieces designed to be 3D printed for this project other than the cowling. The other 3D printed parts are the box on top of the heat sink, the stands that hold the heat sink, a fan guard to cover the fan, and another box to cover the current transducer. All things were designed to optimize the system and to make the system as safe as possible.

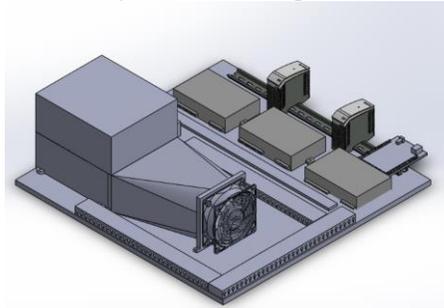


Figure 3: Isometric view of the designed apparatus

In Figure 3 above, this is the final agreed upon layout of the designed apparatus. This includes all of the components that are required for its operation. This design allows for easy ease of access to any of the components in case maintenance or changes needed to be made to the apparatus. Overall, the final design allowed for modular build that used off the shelf components that makes modification or replication of the device as simple as possible.

IV. Conclusion

Overall, this apparatus will allow Danfoss to save a lot of money when doing R&D and testing because of the time saving this device allows for. This will allow Danfoss to streamline its process of testing thermal interface materials and allow them to best choose a TIM that will serve their needs. With the data acquisition in the device, it will also allow Danfoss to improve the accuracy of their models of their products.

Acknowledgements

We would like to thank our advisor, Dr. Abdel-Motaleb, for his guidance throughout the project. We would also like thank our industry partner, Danfoss, especially Wesley Sedlacek and Matthew Gray for their massive support as we developed the project. A special thanks to Edward Miguel and Dr. Donald Zinger for their help in subsystem prototype testing and assistance optimizing the selection of parts.