Simplified CFD Model Application Note

Description

This document describes the Simplified CFD (Computational Fluid Dynamics) Model provided by Toshiba Electronic Devices & Storage Corporation. In this document, CFD means three-dimensional thermal fluid analysis.

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1. Introduction

In recent years, the size reduction in electronic equipment, high-density mounting, and severe operating conditions such as high ambient temperatures have caused a variety of heat issues when selecting, placing electronic components to be used and designing boards.
Therefore, the importance of thermal design using cooling simulation with three forms of heat transfer: thermal conduction, thermal convection, and thermal radiation, is increasing.

Thermal models, such as the enclosure, the board, and the mounted components are required for cooling simulations. Toshiba Electronic Devices & Storage Corporation has created the Simplified CFD Model that is suitable for cooling simulations, focusing on MOSFET, and has started releasing this model. This Simplified CFD Model can be used with thermal fluid analysis tool to visualize three-dimensional behavior (temperature distribution and flow velocity).

This application note explains how to use the Simplified CFD Model and provides examples of cooling simulations.

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2. Download file

A ZIP format file containing the following two files is downloaded for each product.

Table 2.1 Download files

Content of the file	File format (extension)	Content
Simplified CFD Model	STEP (stp)	Three-dimensional models used in cooling simulations
Material properties	Text (txt)	List of adjusted material properties assigned to each component in cooling simulations

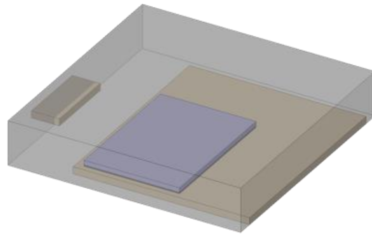

Figure 2.1 Simplified CFD Model
(Open with 3D CAD)

```
*************************************************************************************************
* (C) Copyright 2022 Toshiba Electronic Devices & Storage Corporation
* Date:          2022/09/27
* File Name:     TPH12008NH_CFD_rev1.txt
* Part Number:   TPH12008NH
* Adjusted Material Properties for Cooling Simulation:
* Component      Thermal Conductivity (W/mK)     Specific Heat (J/kgK)     Density (kg/m^3)
* Mold           0.8                             795                       1900
* E-pad          334.5                           369                       8302
* PinGS          334.5                           369                       8302
* SolderM        50.2                            197                       8500
* Chip           148.0                           705                       2330
*************************************************************************************************
```

Figure 2.2 Material property text
(Material property value list part)

The usage is described in Section 3. How to use .

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3. How to use

3.1. Instructions for use

The procedure for using the download file is as follows.

1. Download ZIP file and extract it to any folder.
2. Convert the Simplified CFD Model to a simulation model with the 3D CAD tool for thermal fluid analysis tool used.
3. Import the simulation model to thermal fluid analysis tool.
4. Assign the physical property values described in the material property text file to each component of the imported model.
5. Set on thermal fluid analysis tool, then run cooling simulation.

For information on using 3D CAD tool or thermal fluid analysis tool, please contact the tool vender.

3.2. Component structure of Simplified CFD Model and the method to assign material properties

Figure 3.1 shows the component structure of the Simplified CFD Model. Table 3.1 shows the meaning of abbreviations for the components. The abbreviations given to the components can be checked by opening the Simplified CFD Model using 3D CAD tool. For SOP Advance product shown below, it consists of five components (Mold, Chip, SolderM, PinGS, and E-pad).

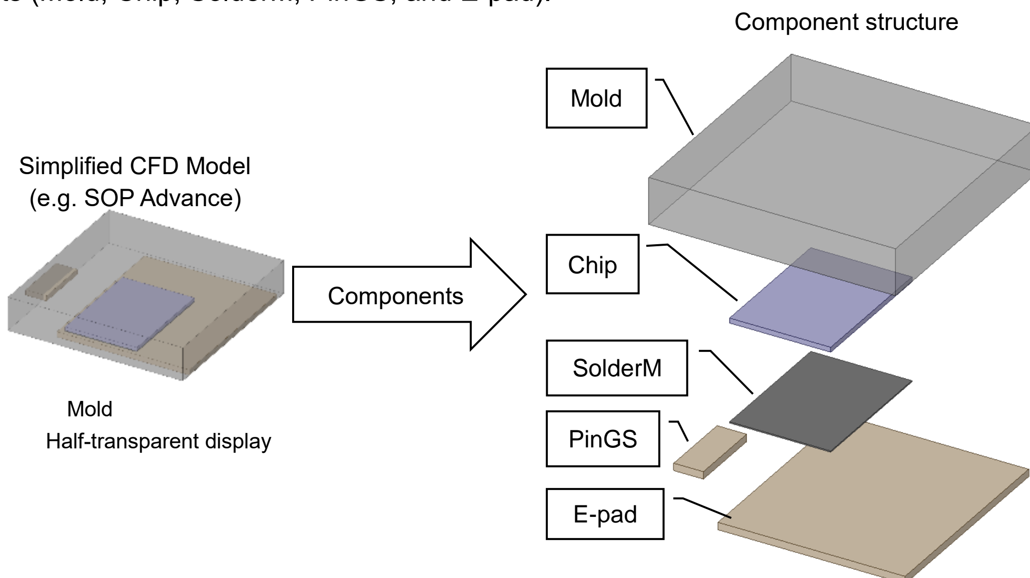

Figure 3.1 Component structure of Simplified CFD Model

Table 3.1 Meaning of abbreviations for components31

Abbreviation of component	Meaning
Mold	Molding
Chip	Semiconductor chip
SolderM	Solder for mounting semiconductor chip
PinGS	Gate and source pin (common block)
E-pad	Drain pad exposed at the bottom of the package

These abbreviations are the same as the components abbreviations in the material property text file shown in Figure 3.2.

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Figure 3.2 shows an example of the contents of the material property text file for each component.
In cooling simulation, the material properties of each component listed in the file are assigned on thermal fluid analysis tool.

Simplified CFD (Computational Fluid Dynamics) Model File
(1)
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(2)
Operation of this model has been verified only on the ICEPAK

Precautionary statement in the Simplified CFD Model

```
************************************************************************************************
*  (C) Copyright 2022 Toshiba Electronic Devices & Storage Corporation
*  Date:            2022/09/27
*  File Name:       TPH12008NH_CFD_rev1.txt
*  Part Number:     TPH12008NH
*  Adjusted Material Properties for Cooling Simulation:
*  Component Thermal Conductivity (W/mK)  Specific Heat (J/kgK)  Density (kg/m^3)
*  Mold      0.8                           795                    1900
*  E-pad     334.5                         369                    8302
*  PinGS     334.5                         369                    8302
*  SolderM   50.2                          197                    8500
*  Chip      148.0                         705                    2330
************************************************************************************************
```

Description
・・・Items of physical properties
・・・Physical properties of Mold
・・・Physical properties of E-pad
・・・Physical properties of PinGS
・・・Physical properties of SolderM
・・・Physical properties of Chip

Material properties list

Figure 3.2　Example of material property text file

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4. Simulation example of Simplified CFD Model

4.1. Cooling simulation

Thermal analysis methods used in thermal designs are broadly categorized into two methods: using a simplified model converting heat-flow paths to an electric circuit network, and using a three-dimensional model generated based on device geometry by CFD. While the former considers only one-dimensional behavior in SPICE simulations, the latter calculates the three-dimensional behavior of the fluid so that the temperature distribution and heat flow can be visualized and checked, including the inside that cannot be seen by actual devices. Section 4.2 shows an example of cooling simulation using the Simplified CFD Model.

4.2. Cooling simulation examples

This example shows a simulation of a board model assuming an inverter circuit. Figure 4.1 shows the model used for cooling simulation. The Simplified CFD Models of six MOSFETs are mounted on the board with heatsink. This section explains how to visualize the temperature distribution and heat flow using cooling simulation results in this model.

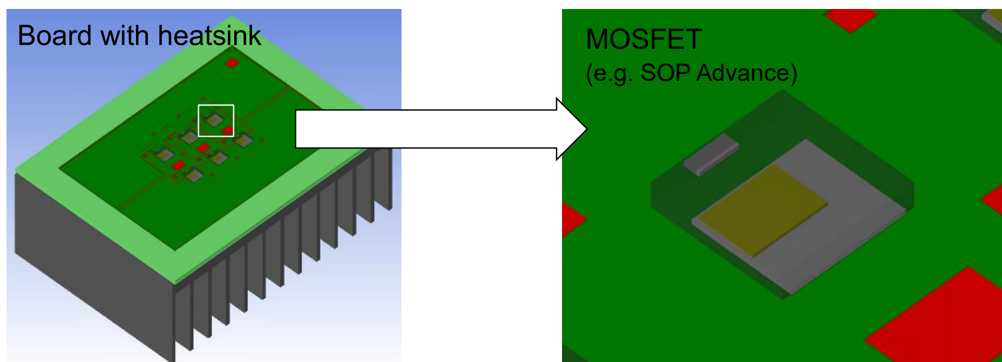

Figure 4.1 Simulation model example

Figure 4.2 shows the temperature distribution on the model surface that shows heat spread to the board or heatsink as MOSFET temperature rises. In addition, thermal fluid analysis tool display setting allows checking the temperature inside the device, such as a chip, that cannot be seen in the actual set. On the board, the temperature inside the board (Cu layers and Vias) as shown in Figure 4.3 can be checked.

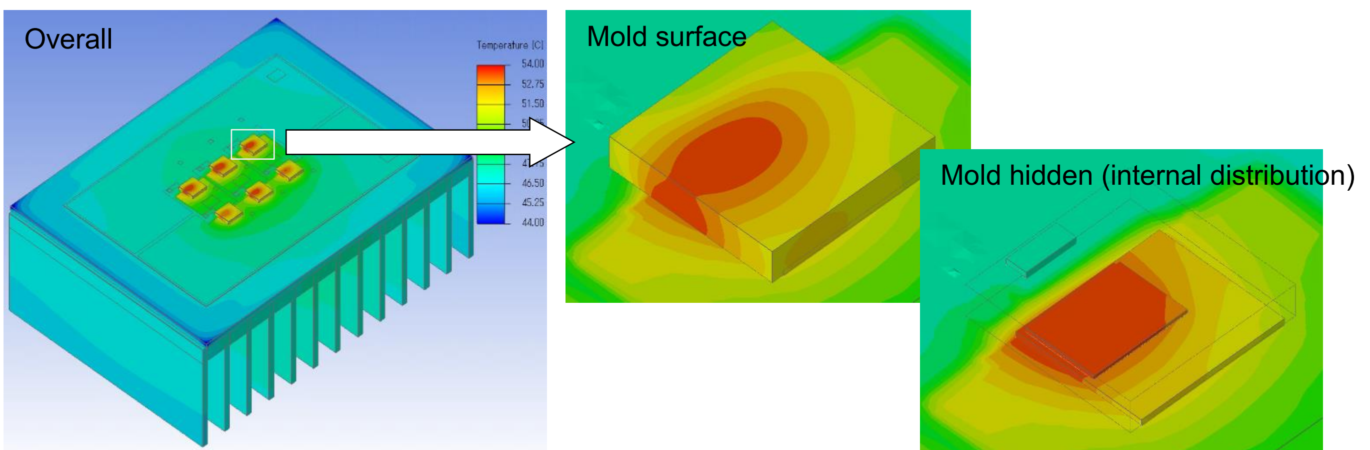

Figure 4.2 Surface temperature distribution (overall, mold surface and inside)

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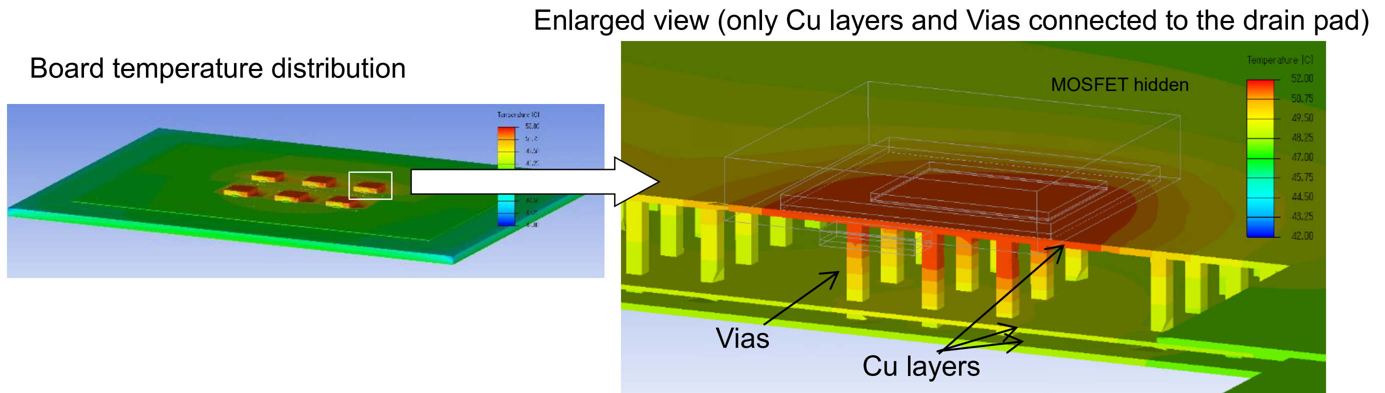

Figure 4.3 Temperature distributions inside the board (Cu Layers, Vias)

Figure 4.4 shows the temperature distribution of the cross section including the area around the board. This result allows checking the spread of heat on the heatsink and seeing how much heat is dissipated.

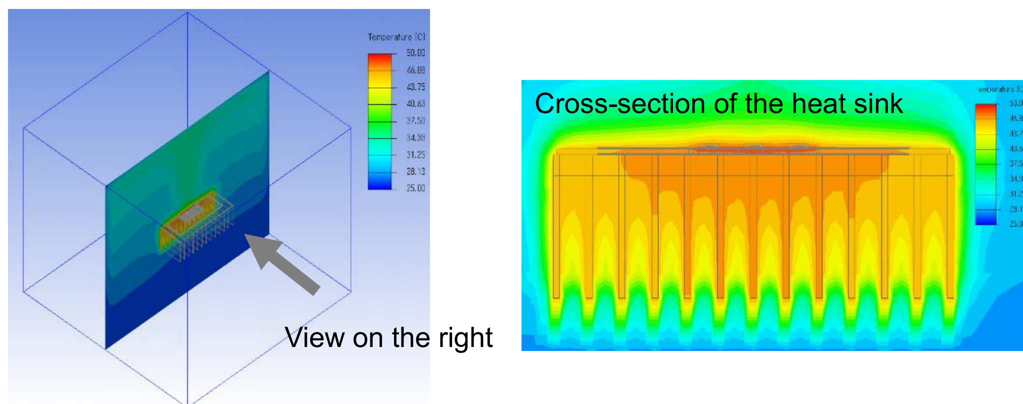

Figure 4.4 Cross-sectional temperature distribution

Figure 4.5 shows the air velocity and heat flow in the chamber set during the analysis.

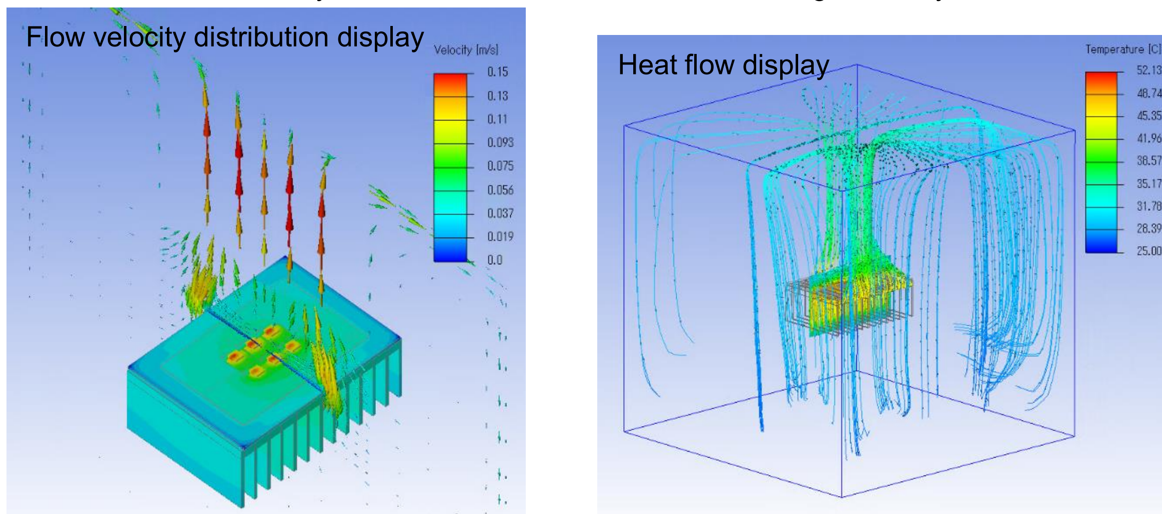

Figure 4.5 Fluid display around the board (flow velocity and heat-flow path in the chamber)

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5. Summary

This document explains how to use the Simplified CFD Model and examples of its use. Toshiba Electronic Devices & Storage Corporation has released some of our Simplified CFD Models on website since October 2022, and continues to add them. They can be downloaded from the parametric search page or from each product page.
Various application notes for thermal designs are also available on our website. Please use them together.

Finding Simplified CFD Models (MOSFET parametric search) → Click Here

Application Notes for thermal design → Click Here

Document Title

- Hints and Tips for Thermal design for Discrete Semiconductor Devices
- Hints and Tips for Thermal design for Discrete Semiconductor Devices _part2
- Hints and Tips for Thermal design for Discrete Semiconductor Devices _part3
- Quick Reference Guide of Thermal Design for Power Semiconductor SMD type
- Quick Reference Guide of Thermal Design for Power Semiconductor SMD type: Part 2

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