Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 12-13, 2016

Thermal Flow and Structure Stability Analyses of High Power Waterload for 2450 MHz microwave applications

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1. Introduction

High power waterload is one of the important parts in the high power RF and microwave generator. The waterload absorbs RF power, converts it to thermal power, and increases the water temperature so that heat could be quickly removed by the water injection [1]. And it is installed on the end of transmission line and is used to absorb reflected RF power. High power waterload with cone-shaped quartz is designed for 10~30 kW power handling at 2450 MHz microwave system [2]. This study is focused on analyzing the internal flow dynamics in the waterload by changing the inlet and outlet locations and adding guide pipeline to the inlet [3]. The internal flow field simulation is done with CFX tool to compare the water flow velocity and temperature distributions in the waterload.

2. Thermal Fluid Flow and Structure Stability Analysis

2.1 Thermal fluid flow analysis using CFX

The waterload consists of WR340 rectangular waveguide with the cone-shaped quartz installed vertically and a tuning button at the bottom of the waveguide. Figure 1 shows volumetric heat generation from HFSS simulations and heat loss is concentrated at the bottom of the waterload. To model heat source and analyze the waterload, 10 kW heat source is applied at the bottom of the waterload as shown in Fig. 2. In the simulation mass flow rate of 20 liter/minute is applied at a static temperature of 25°C at inlet of waterload. Gravitational acceleration along the Y axis is also applied.

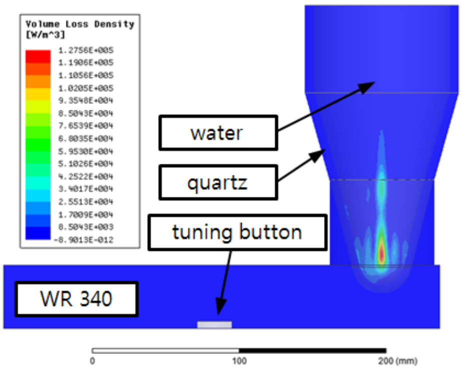

Fig. 1 Volume loss density of a 2450 MHz waterload obtained from HFSS simulations.

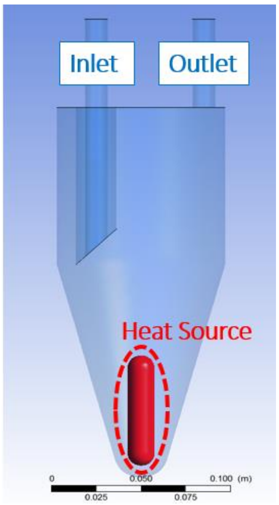

Fig. 2 Internal Flow filed of 2450 MHz waterload.

The inlet has been relocated to the position where the volumetric heat source could be detached from the wall by the guided flow along the wall surface. The wall flow, by increasing the flow velocity near the heat source, is expected to effectively lower the maximum water temperature while the installed guide pipeline has no interference with the RF.

When compared to the flow without the guide pipeline and the relocated inlet, new simulation results in Figs. 3 and 4 show lower maximum temperature by 45% and increased water flow velocity by 75% around the heat source.

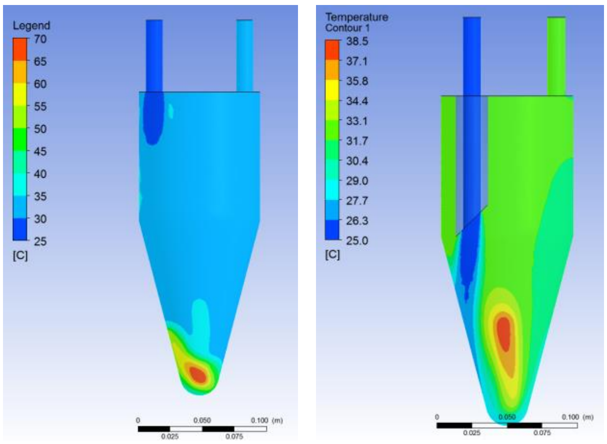

Fig. 3 Water temperature distributions of earlier (left) and new (right) simulations.

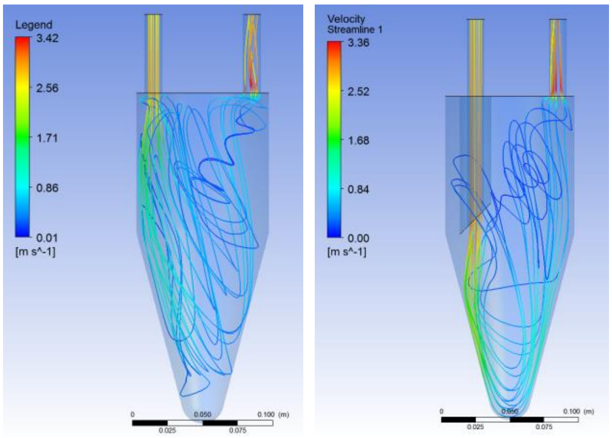

Fig. 4 Water streamlines of earlier (left) and new (right) simulations

2.2 Structure stability analysis using ANSYS Mechanical

Fig. 5 shows the inner pressure and temperature distributions on the waterload surface, calculated by CFX for the structural stability analysis with the bottom flange fixed. The temperature ranges from 25 to 33 ^{o}C while the internal pressure from 0 to 9 kPa. Fig. 6 shows the tensile yield stress of 48.3 MPa to the quartz, which is well above the structural stability limit of 10 MPa.

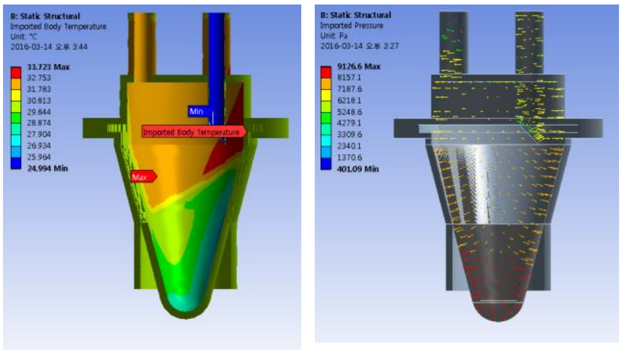

Fig. 5 Waterload surface temperature (left) and internal pressure (right) distributions

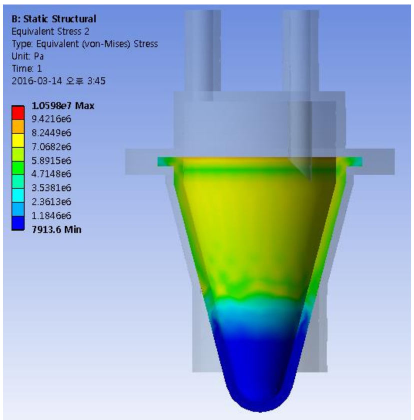

Fig. 6 Stress distribution on the waterload quartz

3. Conclusions

The thermal flow and structural stability analysis for the 2450 MHz waterload is done using ANSYS and the results are presented in this work. Relocation of the inlet and addition of the guide pipeline in the simulation shows a decrease in the localized maximum water temperature and increased water velocity around the heat source. It is also shown that the modified waterload is structurally more stable.

Acknowledgements

This work was supported by "The Project of Conversion by the Past R&D Results" through the Ministry of Trade, Industry and Energy (MOTIE) and the Korea Institute for the Advancement of Technology (KIAT) (N0001534, 2016).

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