Modelling and simulation of assembled components of an integrated diffusion method

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ABSTRACT – This paper presents the modelling and simulation of modified microwave oven in order to improve the curing process of silver nanoparticles (AgNPs). The models of component are developed by using CATIA design part and finite element analysis is performed by using Analysis System (ANSYS). The force acting on the model is represented by ultrasonic transducer that is placed on top of microwave oven. Static structural analysis is used to show the equivalent stress and total deformation of the microwave oven structure. The results show bending effect on the microwave oven when the load is applied and require extra structural support.

1. INTRODUCTION

Microwave oven is known to speed up the process of heating the foods. Generally, microwaves are produced in a magnetron which it feeds by way of a waveguide into the cooking chamber. The strong interaction between electric fields of the waves and nearly free electrons of the metal causes microwave absorption become more effective. However, a few factors cause the heating temperatures inside the food become non uniform such as the location of microwave waveguide, composition of food, geometry and placement of food.

Ultrasonic is the sound wave that consists of frequencies bands above edible range of about 20,000 Hz. Basically, ultrasonic waves are produced by magneto-stiction generator or oscillator and piezoelectric generator or oscillator. Ultrasonic welding involves the joining process of metals together by using ultrasound which known as future-oriented process. The materials used such as metal is placed under low pressure and high-frequency mechanical vibrations. It creates excellent physical properties of a permanent, solid and metallurgical pure joint without thermally stressing the components.

Heating rod is a heating element which changes the electricity into heat via the resistive process. In this study, the problems of existing microwave oven are investigated to prove its capability in curing the conductive inks such as silver nanoparticles (AgNPs). The innovation of novel diffusion method involves microwave oven that combines with ultrasonic transducer and heating rod.

The purpose of this study is to develop a model of microwave oven and simulate the effects of design modification. The model is developed by using CATIA part design and simulated by using computational software, ANSYS.

2. RESEARCH METHODOLOGY

2.1 Modelling of microwave

To produce the model of microwave oven, ultrasonic transducer, heating rod for this project, the parts were sketched in CATIA V5R20 by using part design. The dimension of each part was included in order to draw the model in accordance with the desired size. The sample of the dimension procedure is shown in Figure 2.1.

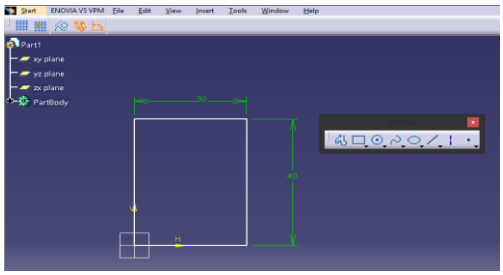
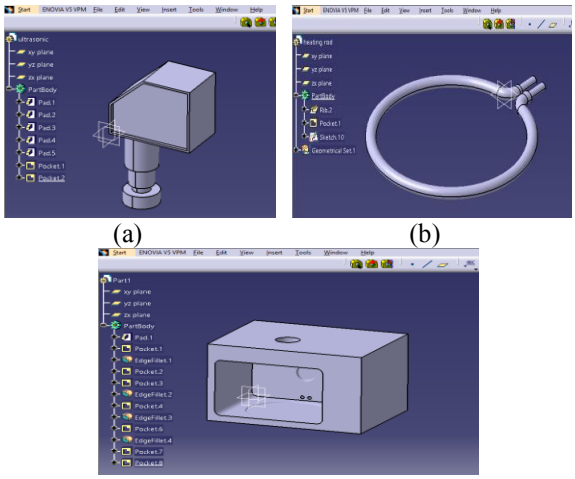


Figure 2.1 Sample of the dimension

Firstly, the rectangular profile was sketched by considering the shape of microwave oven. Then, pad in sketch-based features was used to make it in 3-Dimensional form. Figure 2.2 below shows the sketch modelling of ultrasonic transducer, heating rod and microwave oven in CATIA part design.



(a) (b)

(c)

Figure 2.2 Integrated system (a) ultrasonic transducer, (b) heating rod and (c) microwave oven

2.2 Simulation on microwave

To analyze the microwave oven, the computational software which known as Analysis System (ANSYS) version 18.2 was used in this project. The static structural analysis was conducted to simulate the force and stress on microwave oven when ultrasonic transducer and heating rod were inserted into it. Figure 2.3 shows the tetrahedral volume elements of mesh of microwave oven before constructing the static structural analysis.

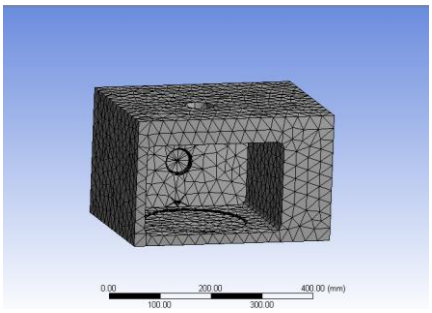


Figure 2.3 Finite element mesh for static structural of microwave oven with ultrasonic transducer and heating rod in ANSYS.

3. RESULTS AND DISCUSSION

In this section, results of modelling and simulation were discussed in detail. The separated parts of microwave oven, ultrasonic transducer and heating rod were assembled together to form one complete model. The process of assemble was done in 'Assembly Design' workbench. Ultrasonic transducer and heating rod were inserted into a microwave oven as shown in Figure 3.1.

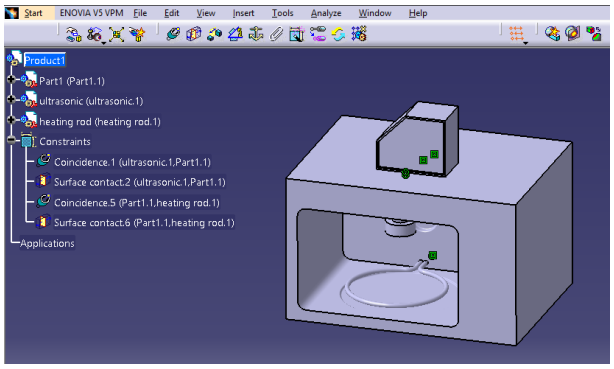


Figure 3.1 Assembly of microwave oven, ultrasonic transducer and heating rod in CATIA.

After assembly process was completed, it then simulated in ANSYS. Fixed support was set at the bottom of the microwave oven and the direction of force was facing downward. The force was represented as a load when the ultrasonic transducer was placed on top of microwave oven. Figure 3.2 shows the results of equivalent stress.

In addition, Figure 3.3 shows the results of total deformation when the distributed force of 45.5 N was applied on top of the microwave oven. There was a bending at the top center of the microwave oven which may lead to the failure of holding the load. Hence, an additional support was needed to support the top of the microwave oven from destruction due to excessive load.

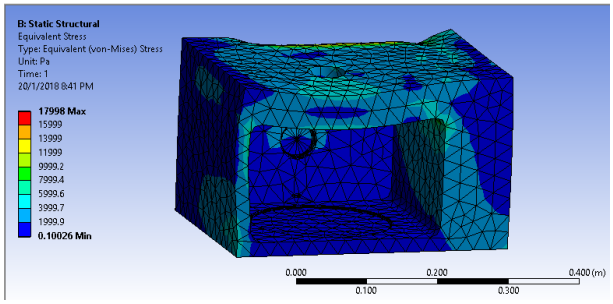


Figure 3.2 Equivalent stress on the microwave.

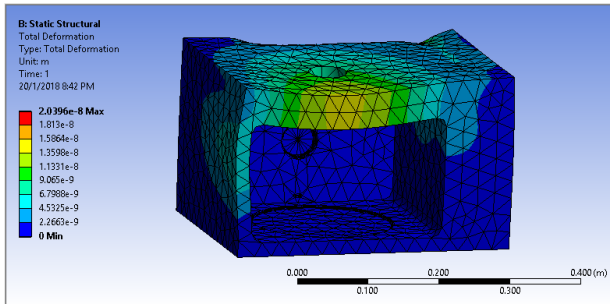


Figure 3.3 Total deformation on the microwave.

4. SUMMARY

This study was performed to create a model and analyse it by using simulation method of microwave oven equipped with ultrasonic transducer and heating rod. CATIA V5R20 was used to assemble these three parts by inserting ultrasonic transducer and heating rod into microwave oven. Then, the analysis was performed by using ANSYS version 18.2 to simulate the structural static strength of microwave oven with ultrasonic transducer and heating rod. Results showed the bending effect on the microwave oven when load was applied, thus required extra support to avoid the destruction of the microwave oven structure.

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