

Finite Element Optimization Analysis of Heating Process of Nanopaper Enabled Composite Materials

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Abstract. The FLUENT finite element software is used to analyze the calculation area, thickness and shapes of nanopaper on the temperature field distribution of the composites with nanopaper during heating process. The average heat flux on the outer surface of the composites with pulse bending nanopaper with different calculation area has been analyzed. The heat flux along the nanopaper and the polymer surface decreases when the bending period of nanopaper increase under the same heating power. The highest temperature of the outer surface is higher when the flat nanopaper/polymer composites are heated to steady state, but the temperature distribution uniformity of the outer surface is better when the pulse bending nanopaper/polymer composites are heated to the steady state. Therefore, if the temperature is high in the actual working conditions, the flat nanopaper can be selected. If the actual working conditions have the demand for the uniformity of temperature distribution, it is more suitable to select the pulse bending nanopaper heating sheet.

1. Introduction

Carbon nanotubes (CNTs) have been used as reinforcement materials or functional agents for its excellent electrical and thermal properties, so CNTs have been used in high performance structural and multifunctional nanocomposites [1-4]. The nanopaper may exhibit a better thermal conducting performance not only in the plane but also more importantly along the plane and the thickness direction of nanopaper.

The FLUENT finite element software is used to analyze the calculation area, thickness and shapes of nanopaper on the temperature field distribution of the composites with nanopaper during heating process.

2. Results and discussion

Table 1 shows the average heat flux on the outer surface of the polymer composite with pulse bending nanopaper with different calculation area under the heating power of 0.6 w. Table 1 shows that the heat flux through the nanopaper and the polymer surface decreases with the increase of the bending period.

Table 1 Average thermal flow of different shape heating sheet nanocomposite with pulse heating sheet along external surface (W/m²)

Bending cycles	Nanopaper	Resin
1	1496.65	1284.06
3	501.08	575.38
5	356.33	311.68

Figure 1 shows the curve of maximum temperature of composites with pulse bending nanopaper of different thickness during heating process along the section $z=0$. During the first six minutes of heating, the highest temperature of composites with pulse bending nanopaper of 1.2 mm was always the highest. It is analyzed that the larger the thickness of the nanopaper is, the larger the proportion of the composite material is on the $z=0$ section, which leads to the higher thickness of the nanopaper in the first period of heating, and the higher the maximum temperature on the $z=0$ section. As the heating process continues, the temperature of the composites with pulse bending nanopaper of 0.4 mm gradually increase and become the highest among three different thickness nanopaper. It is considered that the smaller the thickness of the nanopaper is, the larger the unit volume heat source of the nanopaper is, which leads to the higher temperature on the $z=0$ section.

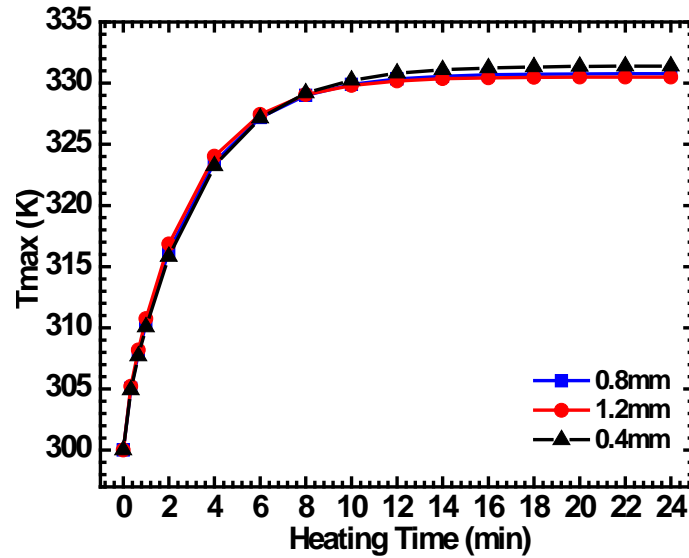
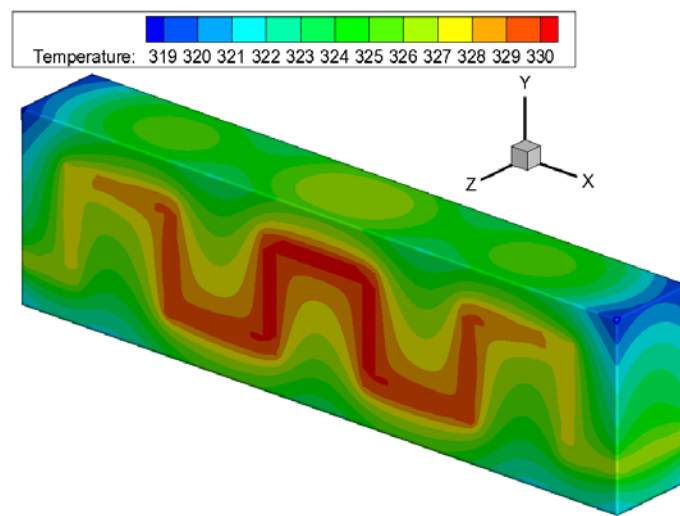
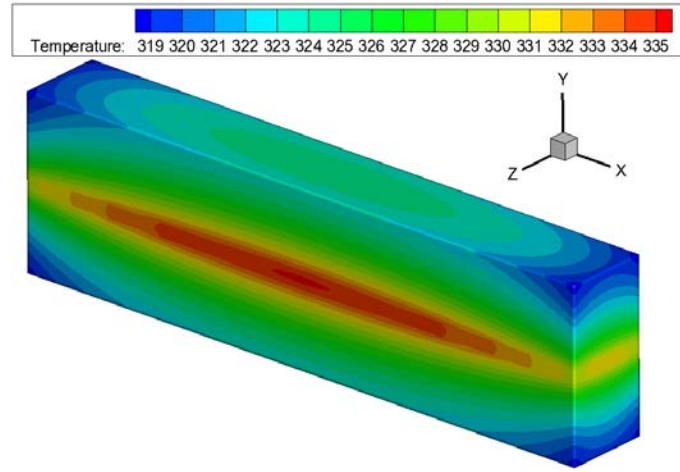


Fig. 1. Curve of maximum temperature of composites with pulse bending nanopaper of different thickness during heating process along the section $z=0$

As shown in Figure 2, the FLUENT finite element software is used to analyze the temperature field distribution of the outer surface of the composite material when the pulse bending and flat sheet /SMP matrix composites are heated to steady state.



(a) pulse bending

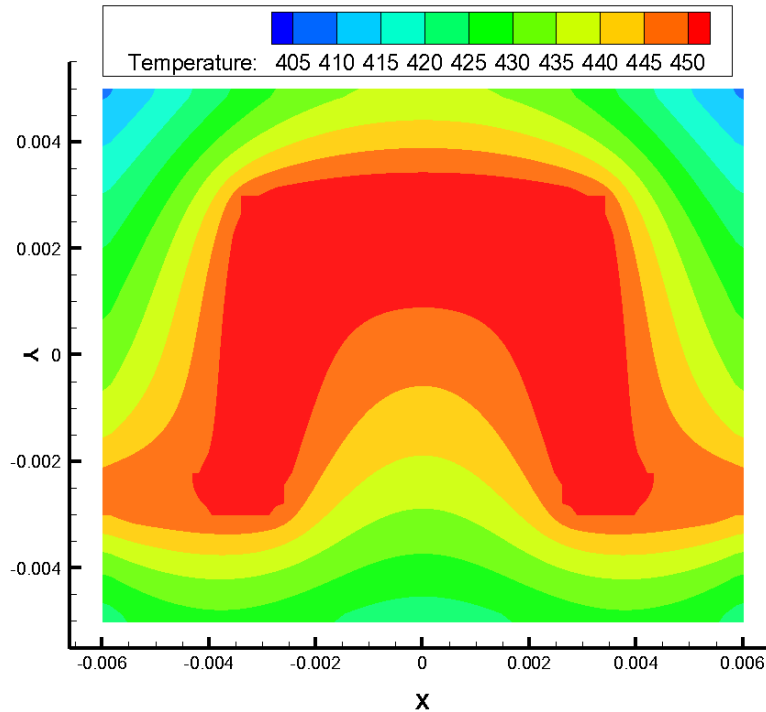


(b) flat

Fig. 2. Temperature distribution of of SMP composites reinforced by different shape nanopaper along the outside section

Figure 2 shows that the highest temperature of the outer surface is higher when the flat nanopaper/polymer matrix composites are heated to steady state, but the temperature distribution uniformity of the outer surface is better when the pulse bending nanopaper/polymer matrix composites are heated to the steady state. Therefore, if the temperature is high in the actual working conditions, the flat nanopaper can be selected. If the actual working conditions have the demand for the uniformity of temperature distribution, it is more suitable to select the pulse bending nanopaper heating sheet.

Figure 3 shows the temperature distribution of the polymer composite with pulse bending nanopaper with different calculation area along the section $z=0$ under the heating power of 0.6 w.



(a) 1A

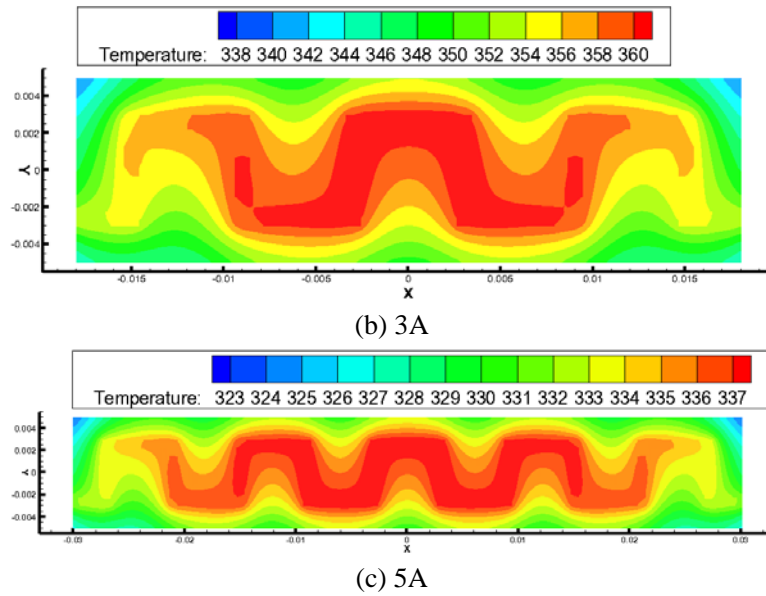


Fig. 3. Temperature distribution of composites with different bending cycles along the section $z=0$ under the heating power of 0.6 w

3. Summary

The FLUENT finite element software is used to analyze the calculation area, thickness and shapes of nanopaper on the temperature field distribution of the composites with nanopaper during heating process.

The average heat flux on the outer surface of the composites with pulse bending nanopaper with different calculation area under the heating power of 0.6 w have been analyzed. The heat flux along the nanopaper and the polymer surface decreases when the bending period of nanopaper increase under the same heating power.

The highest temperature of the outer surface is higher when the flat nanopaper/polymer matrix composites are heated to steady state, but the temperature distribution uniformity of the outer surface is better when the pulse bending nanopaper/polymer matrix composites are heated to the steady state. Therefore, if the temperature is high in the actual working conditions, the flat nanopaper can be selected. If the actual working conditions have the demand for the uniformity of temperature distribution, it is more suitable to select the pulse bending nanopaper heating sheet.

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