INVESTGATION OF TRANSIENT HEAT TRANSFER OF 3D BRAIDED COMPOSITES

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Summary In this paper a finite element modeling method based on nonhomogeneous elements is proposed for 3d braided composites. The representative volume element (RVE) model is built. The transient heat transfer behaviour of this composite is studied. With this method the finite element modeling process of the composite is simplified greatly and the problem can be solved efficiently.

INTRODUCTION

The 3d braided composites have better mechanical properties than those of traditional 2d composites laminates. The 3d braided composites have attractive prospects for the application[1]. In the past 30 years the research progress on the 3d braided composites developed rapidly. Many researchers devoted themselves to those composites and a lot of theoretical and experimental achievements were obtained. However, the numerical modeling methods of 3d braided composites were usually very complex and most of the researchers did not put their attention on the thermal problem of those composites. In this paper, an efficient FEM is proposed and the RVE of the composites is established to study the thermal properties of braided composites.

RVE AND NONHOMOGENEOUS FINITE METHOD

Nonhomogeneous finite method

In this paper the finite element method based on the nonhomogeneous elements is adopted. The finite element may include more than one material. This method is described as follows. The load-displacement equation of the static elastic problem can be expressed as

$$[\mathrm{K}][\delta]=\{R\} \tag{1}$$

where *[k]* is the stiffness matrix of the structure, *[δ]* is the nodal degree of the freedom and *{R}* is the total load of the structure. And *[k]* can be expressed as

$$[K] = \Sigma[K_f] + \Sigma[K_m] + \Sigma[K_{fm}] \tag{2}$$

where $[K_f]$ and $[K_m]$ represent the stiffness matrix of yarn element and matrix element and $[K_{fm}]$ are the mixed element. *{R}* can be expressed as

$$\{R\} = \sum_{k=1}^{n} \{R_e\}_k \tag{3}$$

where *{Re}* is the load of element, and n is the number of elements. The equation (2) shows that one element can comprise more than one type of material. When computing the stiffness matrix of the mixed element the material is distinguished by the Gauss integration points. For example a mixed finite element has 27 Gauss integration and the Young moduli and Poisson's rations of the 27 Gauss integration are different with the variation of their coordinates.

RVE

The 3d braided composite is different from the 4-directional ones. The RVE is built and shown in figure 1. In the RVE there are 5 longitudinal fiber bundles, 5 transverse fiber bundles and 25 vertical fiber bundles. The cross sections of the longitudinal and the transverse fiber bundles are rectangular. The cross sections of the vertical fiber bundles are circular. Both longitudinal and transverse fiber bundles are curving at some positions. The vertical fiber bundles are straight. This structure is reinforced with fiber bundles in three perpendicular directions and has good mechanical properties. And this type of braided composites is relatively easy to manufacture.

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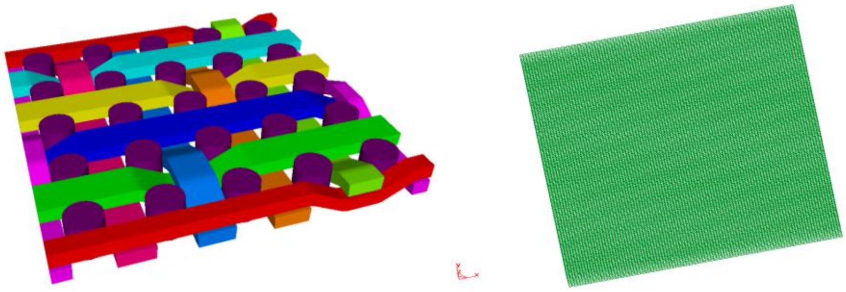

Figure 1 RVE of the 3d braided composite finite element model

RESULT AND DISCUSSION

The transient heat conduction problem of the braided composite is studied. The constituent properties and the thermodynamic properties are from Ref.[2]. The imposed temperature boundary condition is adopted in this calculation. In figure2 and figure3 the temperature and the heat flux distributions are shown. In figure2 the temperature is wavy in the heat transfer and it is different from the straight line form of the isotropic material. Form the figure3 it's known that the heat flux density distributions are heterogeneous and they are related to the fiber bundles of the composite.

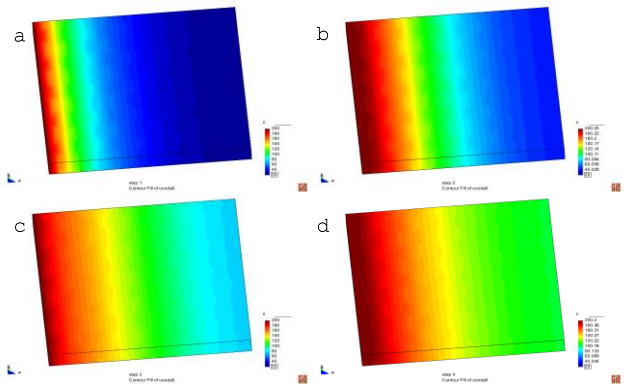

Figure.2 a),b),c),d) Distributions of the temperature when time=t_0, $2t_0$,3 t_0 and 4 t_0

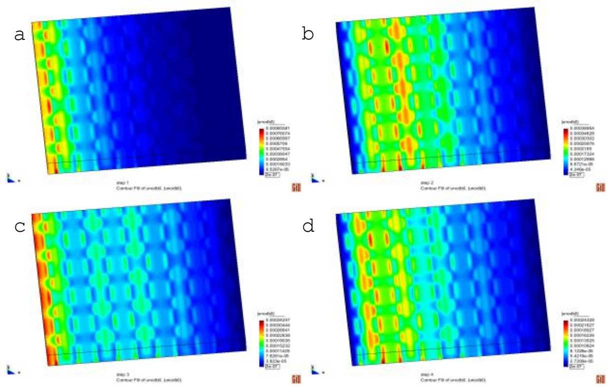

Figure.3 a),b),c),d) Distribution of the heat flux density when time= t_0, $2t_0$, 3 t_0 and 4 t_0

CONCLUSIONS

The nonhomogeneous finite element method is adopted in investigating the transient heat conduction problem of the braided composites. This method can conveniently deal with the materials which the mechanical properties are complicated. The result shows that the temperature and the heat flux density distributions are different from those of isotropic material and they are correlated with the structure of the composite.

Acknowledges

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