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SIMPLIFICATION OF A KIND OF COMPOSITE STRUCTURE

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ABSTRACT In this paper, the thermal simplification of surface of a satellite borne microwave antenna of a kind of sandwich composite of carbon fiber and Aluminum honeycomb is discussed. To this kind of composite it is needed to do some simplification when doing the thermal analysis. A uniform unit repeatedly was gotten and the equivalent thermal parameters such as thermal conductivity and heat capacity were computed. The influences of simplification methods to the thermal results and compute speed were contracted and discussed.

NOMENCLATURE

β = the angle from sunshine to the orbit surface
i = orbit inclination
δ_θ = solar declination
α_Ω = satellite right ascension of ascending node
α_θ = solar right ascension
S = the solar constant
α_s = solar absorptance
ε_h = hemispherical emissivity

INTRODUCITON

Satellite borne antennas are usually mounted on the outside of the satellites. The environment of them is more complex than those inner satellite borne equipments [e.g., Chen 2011]. The heat flow usually will changed much on orbit so the selection and design of satellite antenna is very important. A kind of sandwich composite of carbon fiber and Aluminum honeycomb is often used for satellite antennas because the light weight, strong strength and little thermal deformation. In this paper the simplification of this kind of sandwich composite of carbon fiber and Aluminum honeycomb is discussed. A uniform unit repeatedly was analyzed and gotten and the equivalent thermal parameters such as thermal

conductivity and heat capacity were computed. The influences of simplification methods to the thermal results and compute speed were contrasted and discussed.

MOTHEDS AND PROCESSES

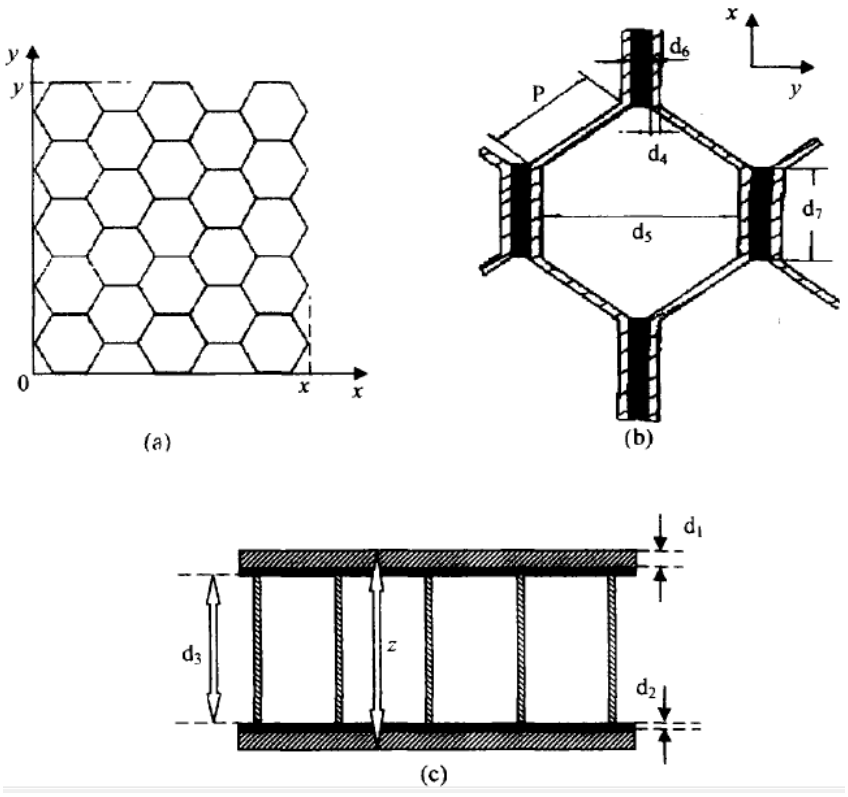
Computing Parameters The computing parameters used in this paper are shown in Table.1 .

Table 1
Thermal Physical Parameters of Materials

Material	k $[W/m°C]$	c_v $[J/Kg°C]$
Carbon fiber composite	45	600
Aluminum	121.4	920.9

Simplification method It is usually not good to build all details of the structure of this kind of honeycomb core panels because the antenna structure is usually of big size and complex, and that will use much more time to compute or even could not be computed. So the easy way of simplification is hoped for engineering application while the results is also kept well.

Firstly, suppose that the length is x, the breadth width is y, and the height is z as shown in Fig.1. [e.g.,Jia 2004]



Uniform and repeated unit is selected in order to analysis the equivalent thermal conduction. The equivalent thermal conduction of honey comb of three direction can be computed by referring with Eq. 1. Eq.2 and Eq.3. [e.g.,Jia 2004] And the equivalent density and the heat capacity could also be computed because the energy is balanced.

$$\lambda_{eff-x} = K_{eff-x} \cdot \frac{x}{y \cdot z} = \left[2\lambda_1 \cdot \frac{d_1 y}{x} + \frac{\lambda_2 N(d_3 d_4)}{l_x} + 2\lambda_3 \frac{d_2 y}{x} \right] \frac{x}{y \cdot z} \tag{1}$$

$$\lambda_{eff-y} = K_{eff-y} \cdot \frac{y}{x \cdot z} = \left[2\lambda_1 \cdot \frac{d_1 x}{y} + \frac{\lambda_2 (d_3 d_4) n}{2P \cdot N} + 2\lambda_3 \frac{d_2 x}{y} \right] \frac{y}{x \cdot z} \tag{2}$$

$$\lambda_{eff-z} = K_{eff-z} \cdot \frac{z}{6 \cdot \frac{1}{2} P^2 \sin(60^0)} = \left\{ \frac{2d_1}{\lambda_1 \left[6 \cdot \frac{1}{2} P^2 \sin(60^0) \right]} + \frac{d_3}{\lambda_2 (6Pd_4)} + \frac{2d_2}{\lambda_3 (6Pd_4)} \right\} \frac{z}{6 \cdot \frac{1}{2} P^2 \sin(60^0)} \tag{3}$$

Then an real example of satellite antenna [e.g., Chen 2015] is analysis and contrast with 5 kind simplification method shown as in Table.1 .

The basis condition of the antenna is as following [e.g., Chen 2015] and Fig 2: The diameter of the parabolic antenna is 1.3 meters, made of the kind of multi-interlayer honeycomb structure which is made up of 0.5mm thick fibre composite layer skins top and bottom with a 20mm aluminium honeycomb core 4mm*0.05mm. The supporting bracket of the antenna is a 600 mm diameter aluminium bracket with thickness 6mm and height 88mm, and is mounted on the satellite mounted board thermal insulated. The height from bracket to edge of antenna surface is 230mm. The supporting rods of feed component is made of glass cloth of 2mm thickness. And the feed component is aluminium. The total height of the antenna is 634mm. In order to decrease the absorption of sun and increase the heat radiation, a kind of white paint is sprayed on the front-side of the parabolic surface. And in order to help resist the drastic changed outside thermal flow, multi-layer insulation (MLI) component is covered on the back-side of the parabolic surface, the bracket, the feed component and the outside of the wave guide.

The orbit is the sun synchronous orbit and the front-side of the parabolic surface faces to the earth. The orbit height is 964 Km. The orbit inclination degree is 99.34° . The orbit eccentricity is 0. The orbit period is 104.5min. And the descending time is 6:00±15min.

Only compute the typical time of low temperature case, date of which is October 15.

Table 2
Five kinds of Simplification

No.	Equivalent width [mm]	Equivalent thermal conductivity $[W/m°C]$	Single layer or Two layers	Weather consider honey comb	Equivalent Thermal Capability $[J/Kg°C]$	Equivalent density $[Kg/m^3]$
1	21	3	Single	Yes	728	126.7
2	1	63	Single	Yes	728	2660
3	1	45	Single	No	600	1600
4	0.5 for each layer	45	Two layers (kz=2.3)	Only consider the thermal conductivity of z	600	1600
5	0.5 for each layer	63	Two layers (kz=2.3)	Yes	728	2660

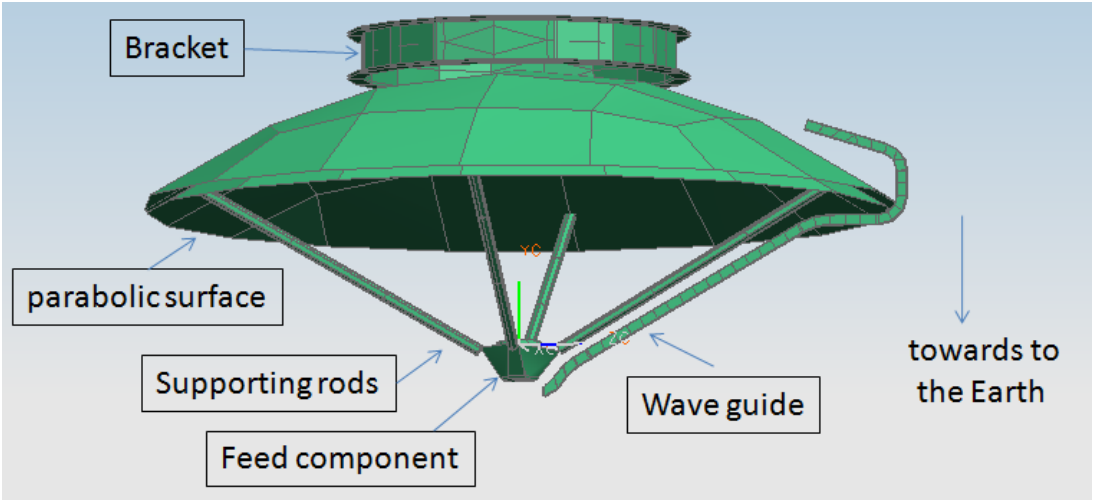


Figure 2. Finite model of the antenna

RESULTS AND DISCUSSION

Thermal Results of Stability Analysis The results is shown in Table 3. From the result it can be seen that the stability temperature is same. The compute time is almost same. And the transient temperature have some difference but is very little.

Table 3
Result of Five kinds of Simplification

No.	Temperature of Antenna Parabolic surface on stability analysis [℃]	Time of compute for stability analysis [s]	Temperature of Antenna Parabolic surface on transient analysis [℃]
1	-34 ~ -27	283	-36 ~ -18
2	-34 ~ -27	282	-36 ~ -18
3	-34 ~ -27	282	-36 ~ -17
4	-34 ~ -27	284	-37 ~ -16
5	-35 ~ -27	298	-36 ~ -18

Discussions The compute speed is almost same and the temperature is almost in accordance with each other.

CONCLUSION

Five kind simplification methods of a kind of sandwich composite of carbon fiber and Aluminum honeycomb are discussed in this paper. The difference in the speed and the temperature results for these five simplification methods are all acceptable in engineering application.

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