

THERMAL ANALYSIS OF COPPER AND CHROMIUM ALLOY, COPPER AND ALUMINIUM SOLAR ABSORBER

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Abstract

In the solar chimney solar collector plates are used for heating up the ambient air. Increase in the temperature of the air inside the chimney increases the efficiency. Thus the solar absorber selected plays an important role in the efficiency of the solar chimney. In this paper the heat transfer analysis is done for solar absorbers like aluminium, copper and copper chromium alloy using ANSYS. The fluid dynamics analysis helps us to select the optimum solar absorber. The analysis of various solar collector plates, the nodal temperature of the copper chromium plate is compared with the copper and aluminium plates. The heat transfer and thermal conductivity of the copper chromium plate is compared with copper and aluminium plates

I. INTRODUCTION

The solar collecting material used in this solar chimney is copper and chromium alloy. Copper and Chromium is a heat treatable alloy offering good electrical conductivity, resistance to softening at elevated temperatures and good strength and hardness[1]. This combination of alloy absorbs more solar energy when compare with other materials. It is also preferred for resistance welding electrode materials for a variety of applications. Nominally composed of 99.1% copper and 0.9% chromium, this heat treatable alloy can be brought to its softest condition by annealing it at 1000°C (1850°F) for one-half hour at temperature, then rapidly quenching it in water[3]. In this annealed condition, the alloy is ductile and easily formed, and has an electrical conductivity of about 40% IACS and its chemical composition is Cu:98.80-99.40%, Cr:0.60 – 1.20 %.

TABLE 1
MECHANICAL PROPERTIES OF COPPER
-CHROMIUM

Hardness	Rockwell B Scales	70
Tensile Strength	N/mm ²	482.633
Yield strength	N/mm ²	379.211
Elongation	cm	4.2

TABLE 2
PHYSICAL PROPERTIES OF COPPER
-CHROMIUM

Thermal Conductivity	W/m.K	26.97
Specific Heat	J/Kg.K	376.8
Density	Kg/m ³	5.14
Modulus of Elasticity	N/mm ²	117210.90

II. THERMAL ANALYSIS FOR COPPER CHROMIUM PLATE

Thermal analysis is a general term used to describe analyses where the results quantities include stresses and strains. It is also known as thermal analysis. The properties of the copper plate is taken as follows: Thermal conductivity is 187 W/mk, Specific heat is 0.095 KJ/Kgk, Density is 0.321 kg/m³ [6]. The Mesh Size that is the number of element divisions is 0.1".

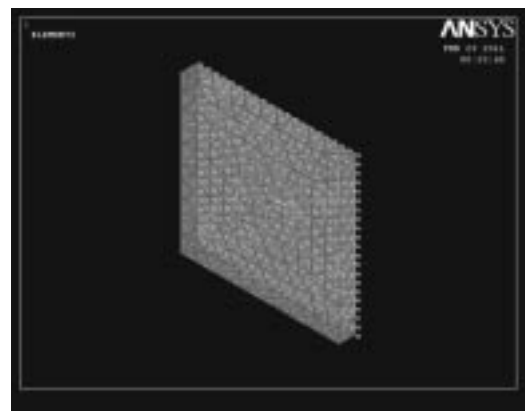


Fig.1. Solution of Temperature Model for Cu-Cr Plate

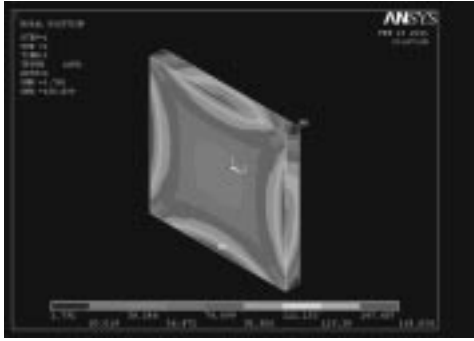


Fig. 2. Nodal Temperature For Cu-Cr Plate

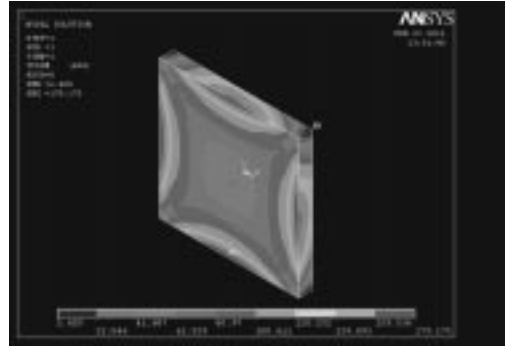


Fig. 5. Nodal Temperature For Cu Plate

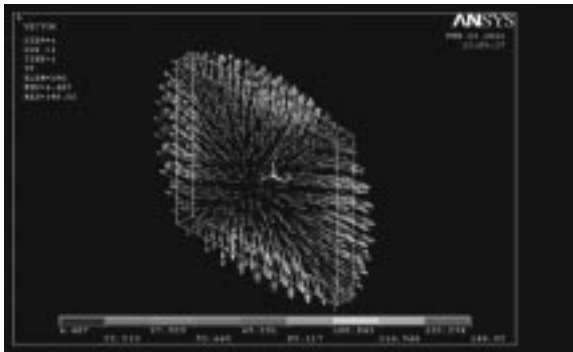


Fig. 3. Vector Plot Heat Transfer for Cu-Cr Plate

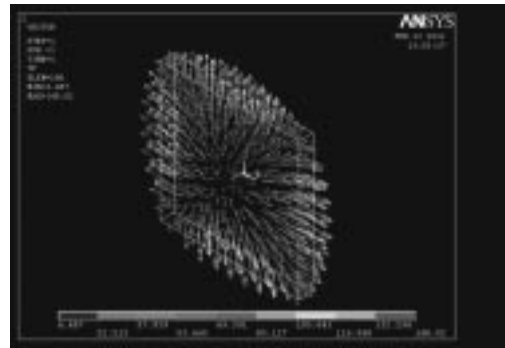


Fig. 6. Vector Plot Heat Transfer For Cu Plate

The thermal analysis of the copper chromium alloy is shown in the figure.1, 2 & 3 from this we can resolve that the maximum nodal temperature of copper chromium alloy is 180°C and the heat transfer is about 150°C

III. THERMAL ANALYSIS FOR COPPER PLATE

The properties of the copper plate is taken as follows: Thermal conductivity is 231 W/k, Specific heat is 0.095 KJ/Kgk, Density is 0.095 kg/m³. [8]. The Mesh Size that is the number of element divisions is 0.1".

The thermal analysis of the copper is shown in the figure. 4, 5 & 6 from this we can resolve that the maximum nodal temperature of copper is 165°C and the heat transfer is about 135°C.

IV. THERMAL ANALYSIS FOR ALUMINIUM PLATE.

The properties of the aluminium plate is taken as follows: Thermal conductivity is 136 W/mk, Specific heat is 0.098 KJ/Kgk, Density is 0.24 kg/m³. The Mesh Size that is the number of element divisions is 0.1".

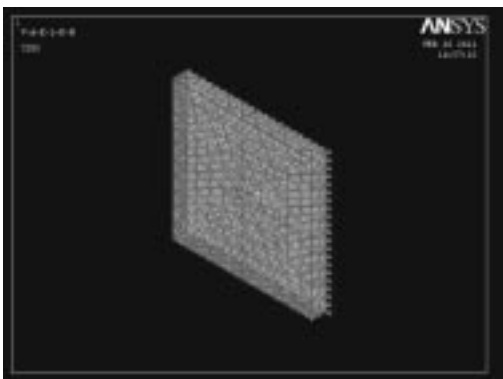


Fig.4. Solution of Temperature Model For Cu Plate

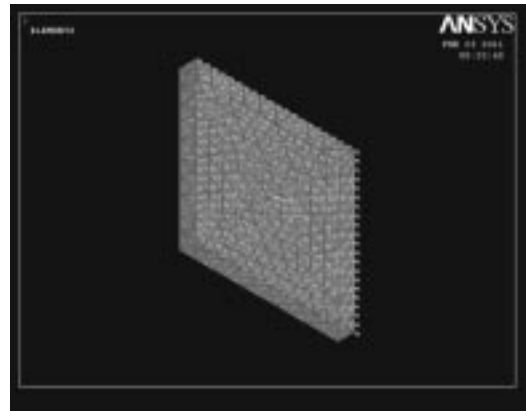


Fig.7.Solution of Temperature Model For Al Plate

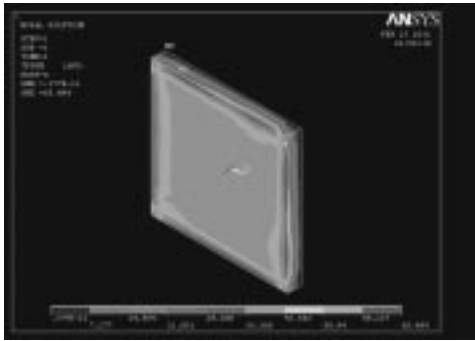


Fig. 8. Nodal Temperature for Al Plate

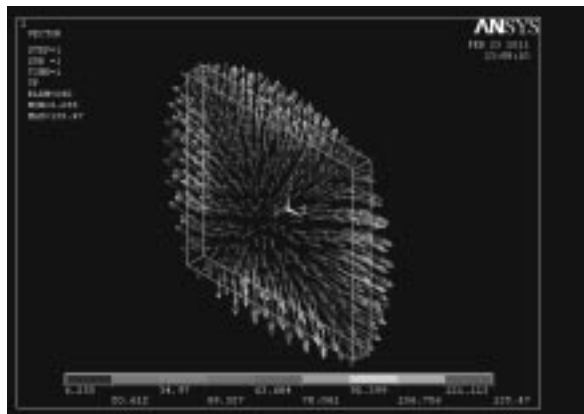


Fig. 9. Vector Plot Heat Transfer For Al Plate

The thermal analysis of the aluminium is shown in the figure 7, 8 & 9 from this we can resolve that the maximum nodal temperature of aluminium is 65°C and the heat transfer is about 40°C.

TABLE 3
Comparison of Analysis off Various Solar Collector Plates

	Nodal temperature (°C)	Vector temperature (°C)
Copper chromium	179.175	148.02
COPPER	165.834	135.47
ALUMINIUM	65.494	40.839

The figure.10. and the table.III shows the comparison of analysis of various solar collector plates. The nodal temperature of the copper chromium plate is very higher when compare with the copper and aluminium plates.

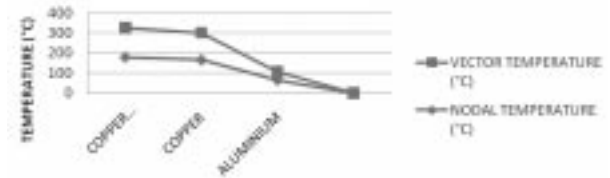


Fig.10.Comparison Of Analysis Of Various Solar Collector Plates

Nodal Temperature

$$= (\text{Cu} - \text{Cr } (179.175^\circ\text{C}) > \text{Cu } (165.834^\circ\text{C}) > \text{Al } (65.494^\circ\text{C}))$$

The heat transfer in the copper chromium plate is very high and its thermal conductivity is more when compare with copper and aluminium plates

Heat Transfer

$$= \text{Cu} - \text{Cr } (148.02^\circ\text{C}) > \text{Cu } (135.47^\circ\text{C}) > \text{Al } (40.839^\circ\text{C})$$

When Comparing the nodal temperature and heat transfer of the three plates the copper chromium plate has higher heat transferring capacity and thermal conductivity. So we selected the copper chromium plate as the solar collector or solar absorber for the solar chimney.

V. RESULT AND CONCLUSION

When comparing the analysis of various solar collector plates, the nodal temperature of the copper chromium plate is very higher when compare with the copper and aluminium plates. The thermal analysis of the copper chromium alloy is shown in the figure.1, 2 & 3 from this we can resolve that the maximum nodal temperature of copper chromium alloy is 180°C and the heat transfer is about 150°C. The thermal analysis of the copper is shown in the figure.4, 5 & 6 from this we can resolve that the maximum nodal temperature of copper is 165°C and the heat transfer is about 135°C. The thermal analysis of the aluminium is shown in the figure.7, 8 & 9 from this we can resolve that the maximum nodal temperature of aluminium is 65°C and the heat transfer is about 40°C.

Nodal Temperature of Cu-Cr alloy is 179.175°C which is greater than that of copper and aluminium.

The heat transfer in the copper chromium plate is very high and its thermal conductivity is more when

compare with copper and aluminium plates. The Heat Transfer of Cu-Cr is 148.02°C which is greater than that of copper and aluminium. So we selected the copper chromium plate as the solar collector or solar absorber for the solar chimney design.

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