# Heat Transfer in Copper Using COMSOL Multiphysics

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## Abstract

This study aims to simulate the heat transfer process in copper. The software used is COMSOL. The simulation using COMSOL software took the least time. The simulation process displays the heat transfer model, including the temperature distribution from 275 to 316 K across the model, by solving the temperature equation $\rho Cpu.\ \tilde{\nabla}T + \tilde{\nabla}.\ q = Q + Qted$ for conductive heat transfer in COMSOL. Between simulation and measurement, the design is optimized based on the calculations. The parameters used are assumed and not too far from the actual parameters. The length and width of the model were chosen and the corresponding temperature was determined. This test was performed on copper as a better conductor of heat compared to other metals. Copper is highly ductile, thin, and lightweight, making it easy to mold it into a variety of sizes and shapes .

**Keywords:** copper, heating process .

**الملخص:**

تهدف هذه الدراسة إلى محاكاة عملية نقل الحرارة في النحاس. البرنامج المستخدم هو الكومسول. أتعرض عملية المحاكاة نموذج نقل الحرارة ، بما في ذلك توزيع درجة الحرارة من 275 إلى 316 كلفن من خلال حل معادلة العامة لنقل درجة الحرارة لنقل الحرارة للنحاس في برنامج ، تم تحسين التصميم بناء على الحسابات. اختيار طول وعرض النموذج وتم تحديد درجة الحرارة المقابلة. تم إجراء هذا الاختبار على النحاس كموصل أفضل للحرارة مقارنة بالمعادن الأخرى. النحاس شديد وخفيف الوزن.

**الكلمات المفتاحية:** نحاس, عملية التسخين

# INTRODUCTION

Unit heat transfer is a type of energy that moves within a system or from one system to another. This energy is stored in the atom and heat is immediately transferred to the other end (1). When a free electron in the lattice of a cooler atom collides with an ion at the hot end, it rapidly gains kinetic energy and accelerates towards the cold end. In this way, the heat is transmitted quickly and the temperature ranged from 275 to 316 K is used in this study. Heat transfer units describe the transfer of heat in systems where the thermal conductivity is constant or varies with temperature. There are many other reasons why copper conducts heat better than silver and other metals. Because they conduct heat and electricity very well and can be drawn into wires. They are also used in construction (roofs, plumbing, etc.) and industrial machinery (heat exchangers, etc.). Copper is highly ductile, thin, and lightweight, making it easy to form into a wide variety of sizes and shapes (2).

In this paper, we have considered describing research methodologies for COMSOL problems. This section also describes body heat transfer in this simulation. Simulation results and explanation of results using the program COMSOL Multiphysics.

## MATHEMATICAL MODELING

The effects of heat on copper are the quantities you want to calculate and analyze in this paper in accordance with this the equations are solved. Equations are accepted by the COMSOL Multiphysics program. The dimensional geometry of the block was as shown in Fig1.

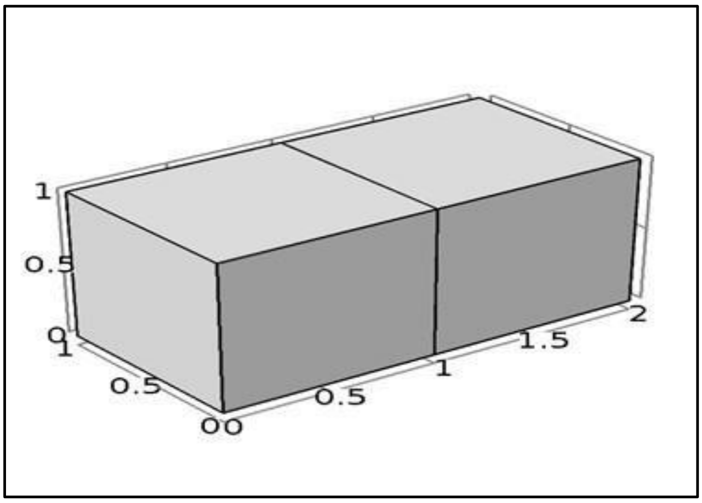


**Figure 1 (a)**. 3D geometry of block

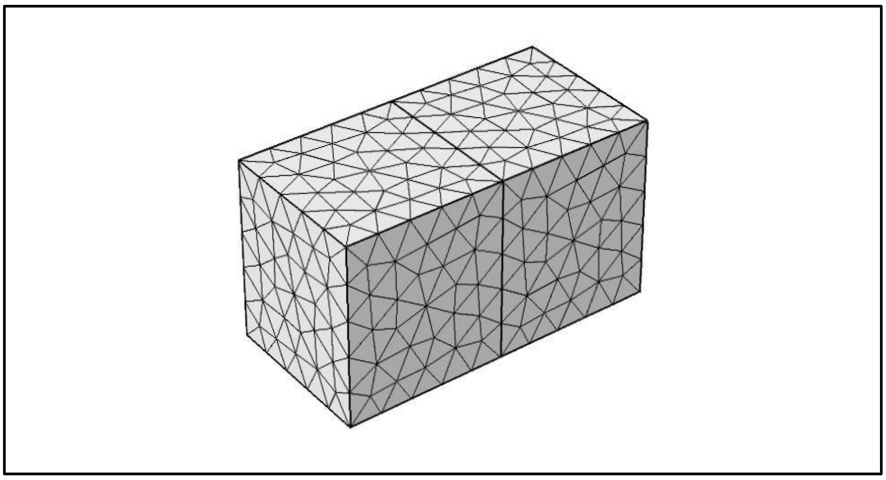

**Figure 1 (b).** Meshed block

**Heat balance in copper equation General heat transfer equation was used in this model (3).**

$$\rho Cpu.\ \tilde{\nabla} T + \tilde{\nabla}.\ q = Q + Qted \quad (1)$$

$$q = -k\nabla T \quad (2)$$

The different quantities involved here are recalled below:

$\rho$ is the density ($SI\ unit$: $kg/m3$)

$Cp$ is the specific heat capacity at constant stress ($SI\ unit$: $J/(kg \cdot K)$)

$T$ is the temperature ($SI\ unit$: $K$)

$utrans$ is the velocity vector of translational motion ($SI\ unit$: $m/s$)

$q$ is the heat flux by conduction ($SI\ unit$: $W/m2$)

$Q$ contains additional heat sources ($SI\ unit$: $W/m3$)

For a steady-state problem the temperature does not change with time and the terms with time derivatives disappear. The first term on the right-hand side of Equation 1 is the thermoelastic damping and accounts for thermoelastic effects in copper (4).

$$Qted = -\alpha T . \frac{dS}{dt} \quad (3)$$

It should be noted that the $d/dt$ operator is the material derivative, as described in the Time Derivative subsection of Material and Spatial Frames.

*Thermal Insulation*

Equation Thermal Insulation (5).

$$-n . q = 0 \quad (4)$$

## RESULTS

Basically, three significant values in each scenario were used to validate the simulations against the measurement results. Copper use in several areas is represented in this section of the form in the COMSOL program. This method allows very fast calculations, but its accuracy depends on heat transfer. Clearly indicates that the simulation was in good agreement with the heat transfer in copper.

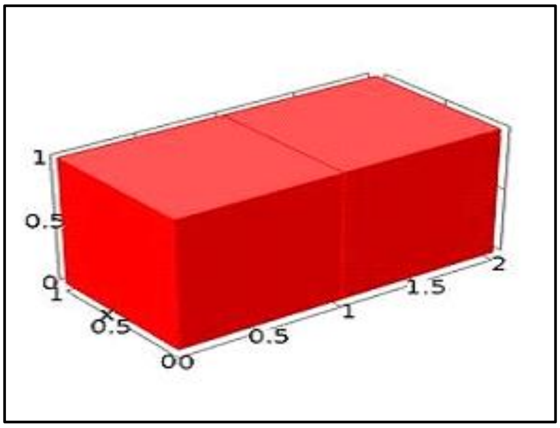

**Fig2 (a).** Data set: Study /Solution 1s

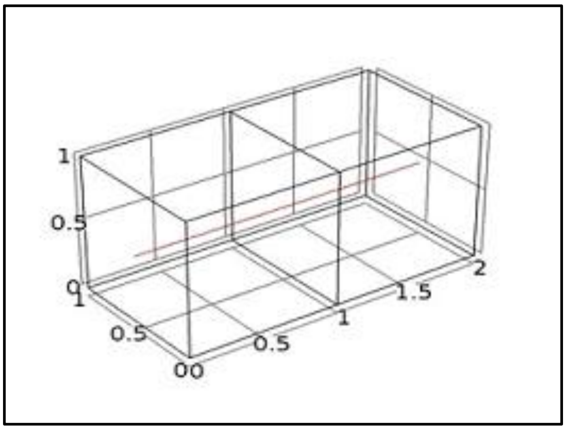

**Fig 2(b).** Data set: Cut Line 3D

The image above shows in fig 2(a,b) ,a solution to interrogate a dataset data set: Study solution and Cut Line 3D by temperature change during heat transfer in a copper block.

**Plot Groups**

COMSOL generates several plots, which are graphs of the heat transfer in copper process's results. These findings are divided into sections below.

**Temperature (Ht)**

Final drawing duration, temperature 275-315 K, lift simulation process in 3D mode shown below red denotes areas with low temperatures, while white denotes areas with high temperatures. This is the last stage of Duration. As shown in the figure below, the temperature distribution showed a wide spread across the copper mass in fig 3.

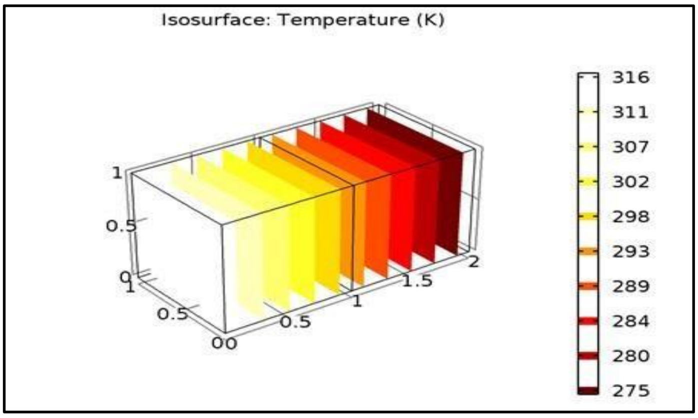


**Fig3**.Temperature (K) Max/Min Volume: Temperature (degC)

## 3.2-ISOTHERMAL CONTOURS (HT)

This section shows Isothermal Contours in the temperature distribution through heat transfer, which is the same as for the other parts. It was also shown that the red flakes represent high temperatures while the blue lines represent low temperatures. The temperatures are shown in the chart below.

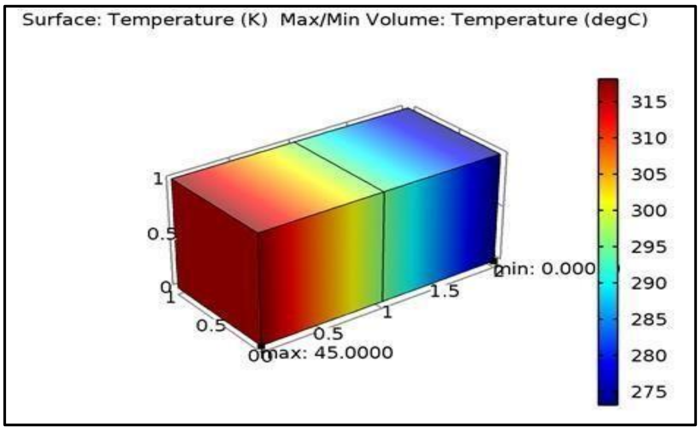


**Fig4.**Isosurface: Temperature (K)

### 3.4- 1D PLOT GROUP

This graph shows the relationship between arc length and temperature, which was linear.

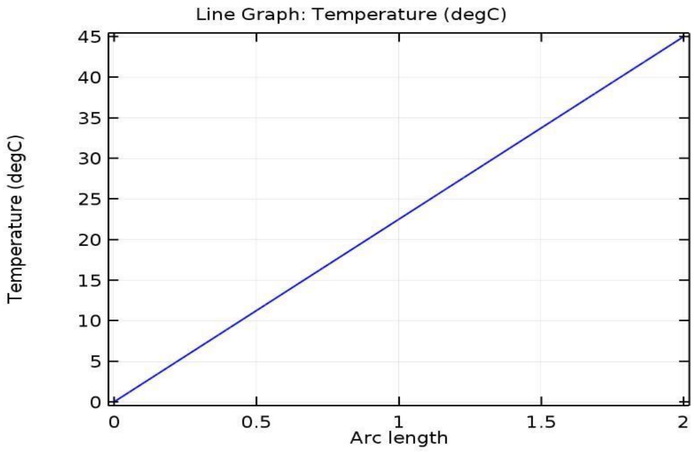


**Fig 5**. Line Graph: Temperature (degC)

## CONCLUSION

This study aims to simulate the heat transfer process in copper. The software used is COMSOL. A 3D finite element model of the heat transfer process was developed using COMSOL. The model's predictions were validated using empirical measurement. The simulation process displays the heat transfer model, including the temperature distribution from 275 to 316 K across the model over time, by solving the temperature equation for heat transfer by conduction. This test was performed on copper as a better conductor of heat compared to other metals. Copper is highly ductile, thin, and lightweight, making it easy to model into a variety of shapes.

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