Modelling Of Current Density Distribution In Copper Wire And Frequency Dependence

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Introduction

The skin effect is described by the propensity of current density to be concentrated at the surface of a conductor at high frequency and to decrease exponentially toward the Centerline, which will decrease the effective cross sectional area of the conductor. Causes the resistance to increase, the conductor will heat up faster and its temperature will increases as the frequency increases for the same current.

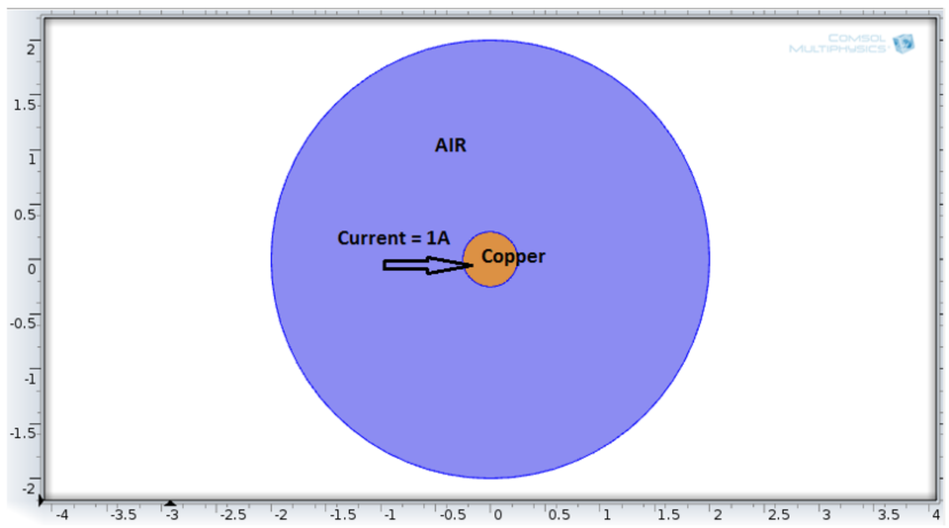

Figure 1. model geometry of copper conductor

COMSOL MULTIPHYSICS

A magnetic field study was used to investigate the current distribution in copper wires. In this study, the skin depth was investigated when 1A sinusoidal wave pass through the wire with copper electrical resistivity and relative permittivity are assigned. The simulation was done for different frequencies between 50Hz and 1MHz with 200Hz increment step. The current distribution was taken at the peak value of the sinusoidal wave. Figure 1 shows a two-dimensional (2D) model geometry for a copper wire surrounded by air.

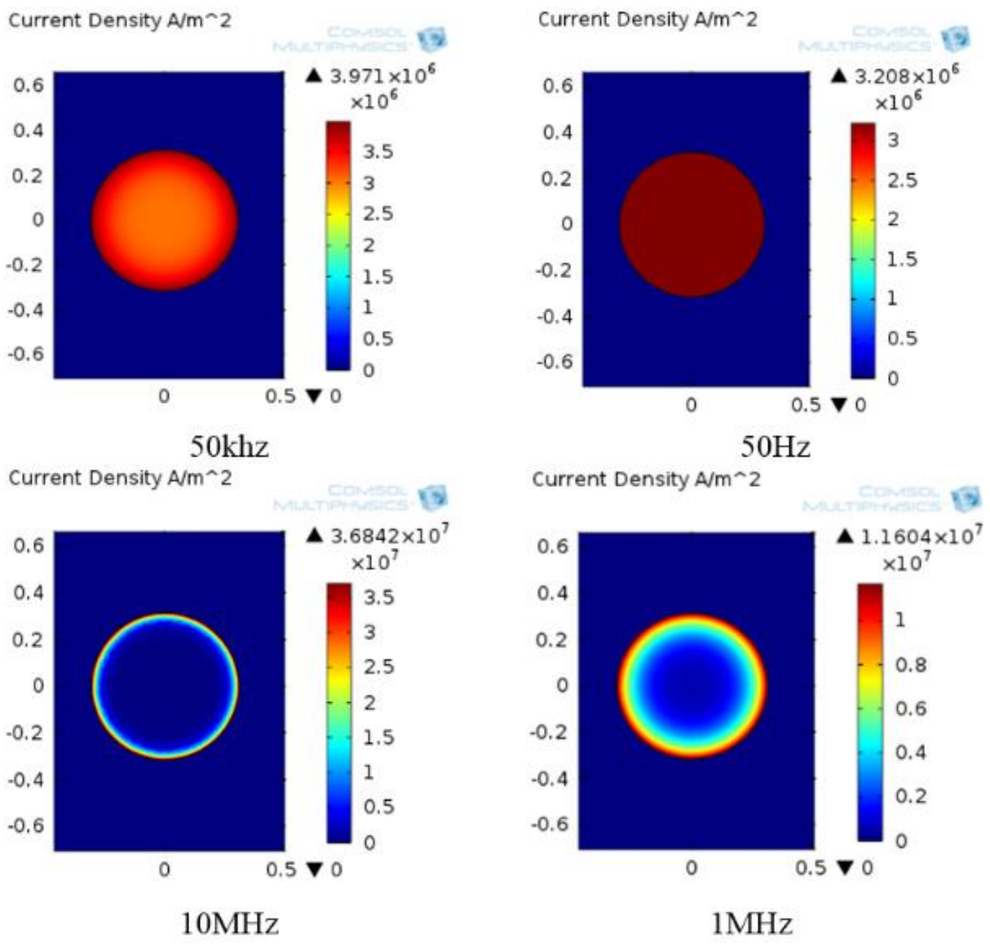

Figure 2 Current density distribution

Results

Figure 2 presents the current density distribution along the cross section of the wire for frequencis of 50Hz, 50kHz, 1Mhz and 10MHz. At 50Hz, the wire has uniform current distribution, then the current density increases gradually at the surface due to increasing of the frequency and concentrating of the current at 10 MHz is in 20µm of the wire. Figure 3 shows the comparison between the current density of outer surface of the wire with respect to current density at center and the operating frequency of the sinusoidal wave. Figures 4 show the current density distribution along the radius of the wires .

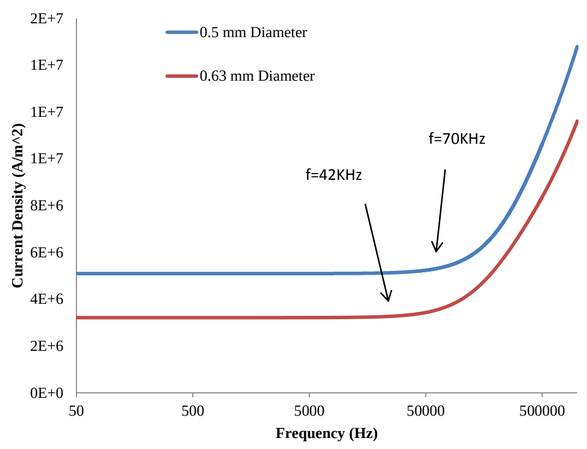

Figure 3. current density for 50Hz to 1MHz

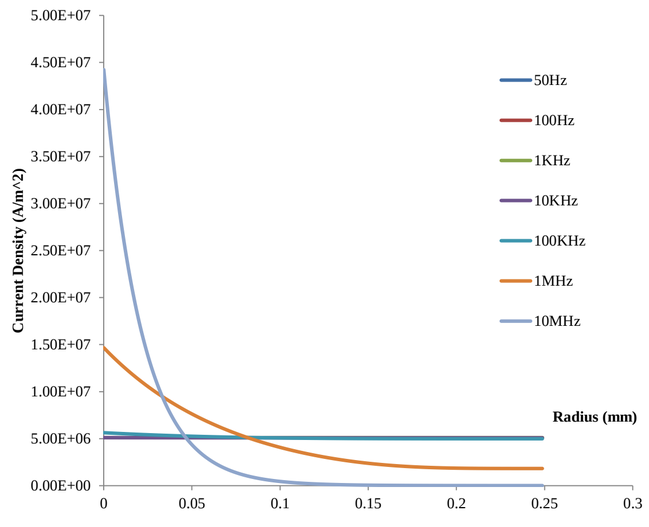

Figure 4. current density over wire section

Conclusion

From the results obtained, at the frequency of 50 Hz, for 0.5mm and 0.63 mm wire, the skin effect has no effect on the resistance of the wire because e the current density is uniform over the cross section and the effective area is same as cross sectional area of the Wire. However, at high frequencies more than 20 kHz, the skin depth start to have major effect on the resistance and current capacity of the wires..

References

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