Modelling Of Current Density Distribution In Copper Wire And Frequency Dependence

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Abstract

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 as (Figure 1). Causes the resistance to increase, the conductor will heat up faster and its temperature will increases as the frequency increases for the same current.

USE OF COMSOL MULTIPHYSICS:

A magnetic field study was used to investigate the current distribution in 0.5mm and 0.63mm diameter wires. In this study, the skin depth was investigated when 1A sinusoidal wave pass through the wire of 0.5 mm and 0.63 mm diameter with copper electrical resistivity and relative permittivity are assigned. The simulation was done for different frequencies between 50Hz and 1MHz with 200 Hz 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.

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. Noticed that until 70 kHz, the current is uniform for all cross section of the 0.5mm wire and it starts increasing over the surface and at the same time, it is decreasing in the center. For 0.63mm wire, the current density starts to increase on the surface of the wire over its center at 42 kHz. Figures 4 show the current density distribution along the radius of the wires for frequencies 50Hz, 100Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz and 10 MHz for 0.5mm and 0.63mm wires.

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. This has been validated by the simulation Results and theoretical calculation. This also shows that the model developed is acceptable.

Reference

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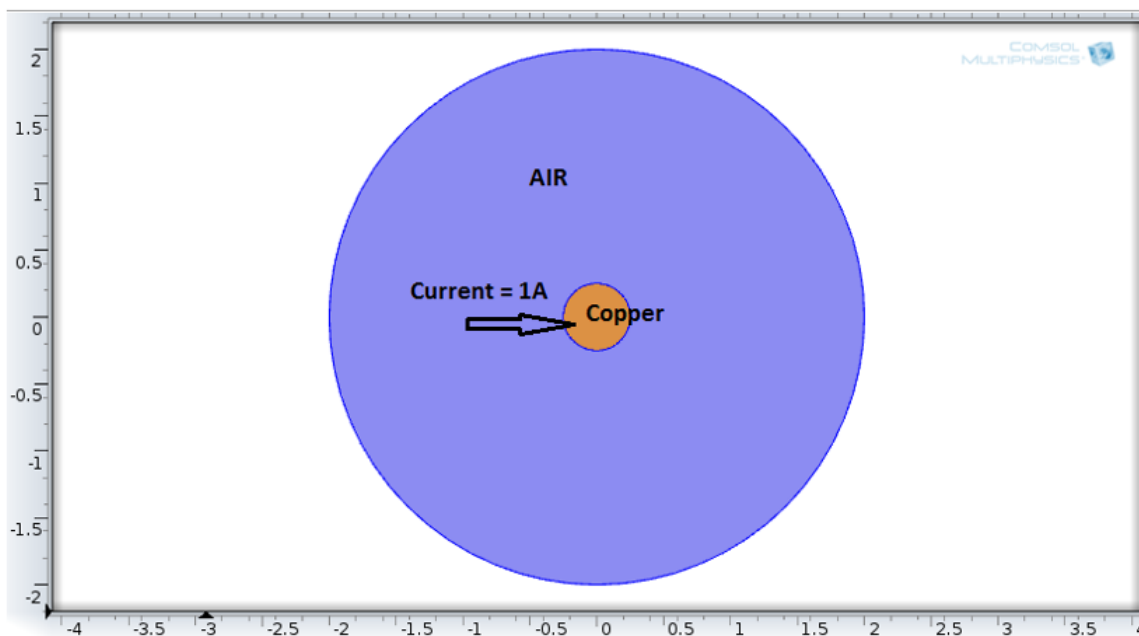
Figures used in the abstract
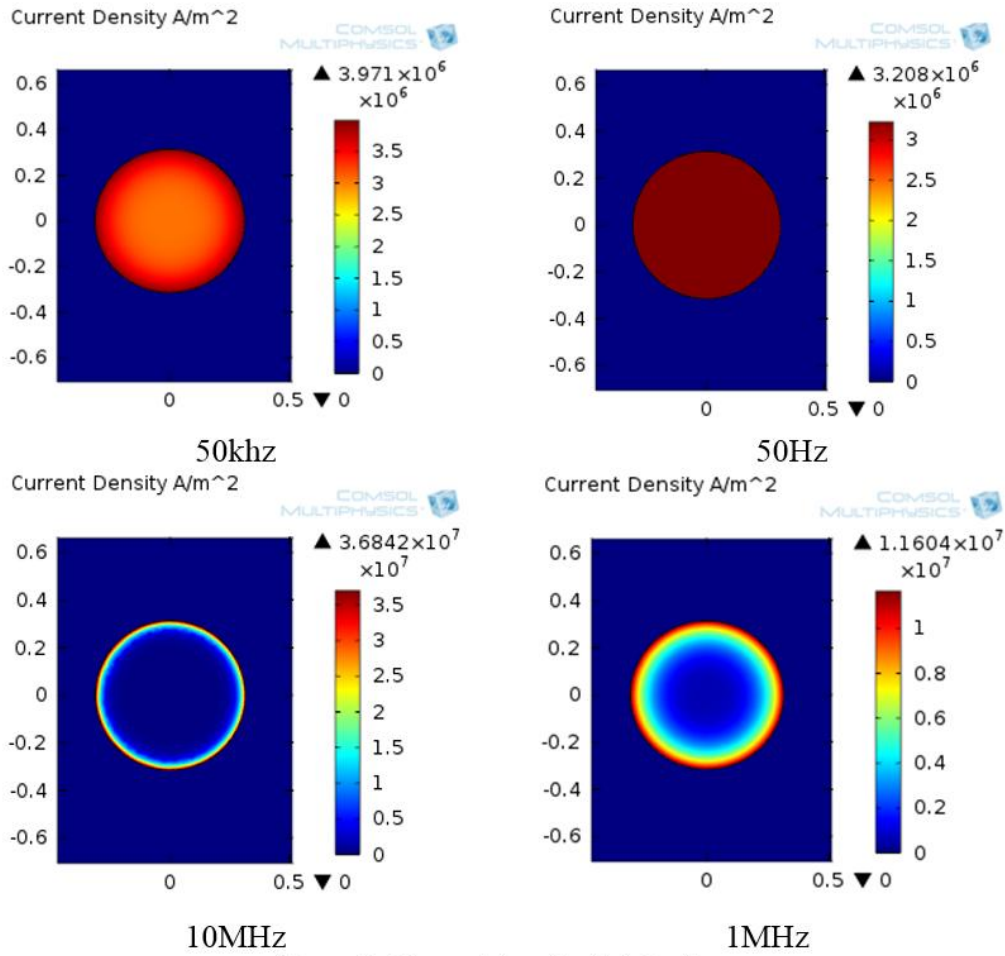

Figure 1: Model geometry of copper conductor

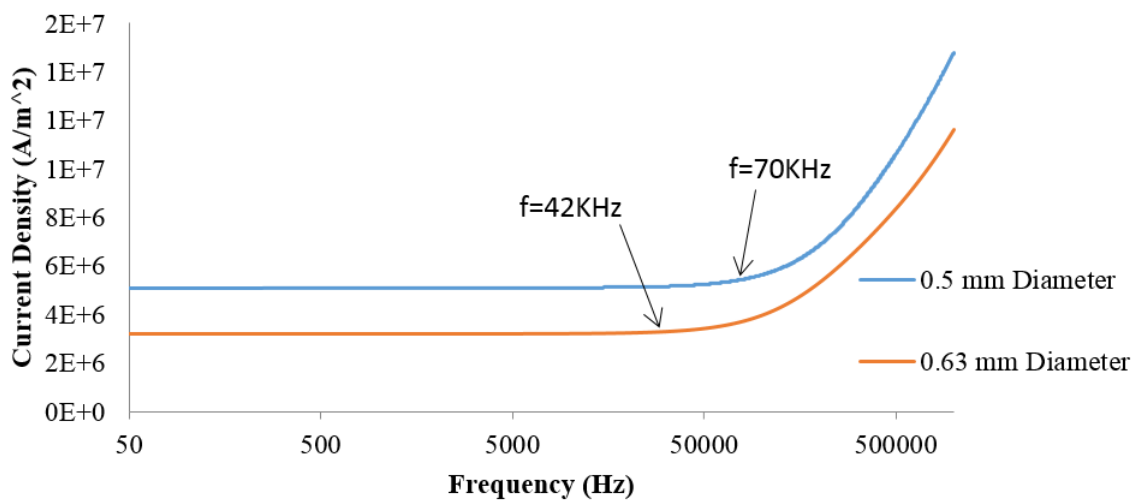Figure 2: Current density distribution

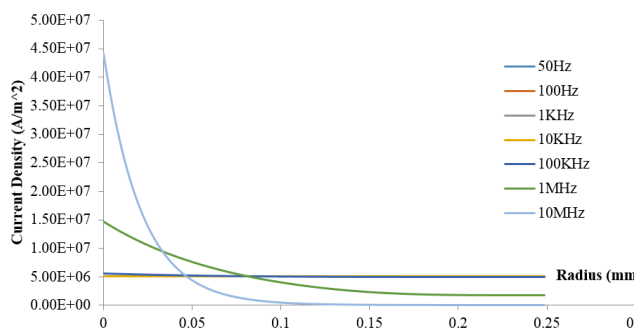Figure 3: Maximum current density for 50Hz to 1MHz

Figure 4.a: Current density distribution vs. distance from the wire center for 0.5mm wire
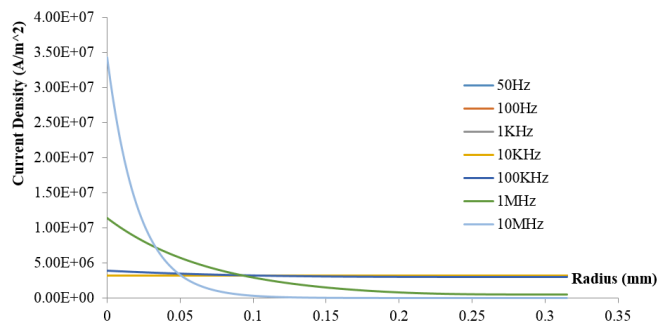

Figure 4.b: Current density distribution vs. distance from the wire center for 0.63mm wire

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