Heat energy transfer to space via graphene: Heat transfer analysis

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Abstract
The idea of transferring heat via graphene is analysed with respect to altitude in COMSOL Multiphysics and results have been documented in this paper.

Keywords
Graphene, Heat transfer, 2d analysis, COMSOL, Space.

Introduction
Graphene has been renowned as a wonder material and the author have tried to test this in heat transfer in solids (ht) module of COMSOL Multiphysics.

The properties used are:
i) Thermal conductivity: 3080-5150 W/mK [1] (for this analysis ~ 4000)

ii) Density: close to that of crystalline graphite ~ 2.267 g/cm^3

iii) Heat capacity: 0.643-2.10 J/g.K ~ 1.4 J/gK [2]

It should be kept in mind that the analysis depends on the properties chosen, and not the actual graphene sheets.

Design and analysis
Three designs have been made to test with convective heat flux of 5 W/m^2K in 2d with dimensions 1 x 1 mm, 1 x 10 mm and 1 x 100 mm.
Figure 1 and 2 show the results for 1 x 1 mm graphene strip with left side given 500K temperature with convective heat flux as mentioned earlier.
Figure 3 and 4 depicts analysis results with 1 x 10 mm strip and here the decline of temperature is evident unlike 1 x 1 mm.

iii)
Figure 5 and 6 illustrates the results achieved with 1 x 100 mm dimensions and it is worth noting that the contour plots 20 lines within the 100 mm boundary so at the mark 100mm from temperature source <497.48 K temp is there, the plot shows 497.48 K at around 85mm.

The next part requires dimensions equivalent to the sorts of space elevators with dimensions of 1 x 500000000 mm (500km) but due to the limitations of the software and authors skills 1 x 1000 and 10000 mm have been achieved to be further plotted for a coarse estimation.

i) x 1000

![Figure 7 & 8](image)

Figure 7 & 8 plots show a drop of about 133 K.

i) x 10000 mm

![Figure 9](image)
Here, figure 10 shows the drop of over 300k due to applied natural convection (convective heat flux of 5 W/m^2K) which suggests the lower part of the graphene cable, if made, must have insulation!

**Conclusion**

<table>
<thead>
<tr>
<th>Mm</th>
<th>K</th>
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<tbody>
<tr>
<td>1</td>
<td>500</td>
</tr>
<tr>
<td>10</td>
<td>499.97</td>
</tr>
<tr>
<td>100</td>
<td>497.48</td>
</tr>
<tr>
<td>1000</td>
<td>377.88</td>
</tr>
<tr>
<td>10000</td>
<td>298.32</td>
</tr>
</tbody>
</table>

With above data at hand linear regression gives following output:
And nonlinear regression gives:
With coefficient of determination ~ 0.99 as shown below in figure 13.

Thus, heavy insulation at the lower end is a necessity which can be achieved with other wonder materials like sorbothane and/or aerogel.
References

[1] “Experimental review of graphene” Daniel R. Cooper, Benjamin D’Anjou, Nageswara Ghattamaneni, Benjamin Harack, Michael Hilke, Alexandre Horth, Norberto Majlis, Mathieu Massicotte, Leron Vandsburger, Eric Whiteway, and Victor Yu, McGill University, Montreal, Canada, H3A 2T8

