# OPTIMIZATION AND SIMULATION OF MEMS BASED THERMAL SENSOR FOR PERFORMANCE OF TRANSFORMER OIL

Vijayalakshmi. V[1], Chandra Devi. K[1]
1. PSG College of Technology, Department of Biomedical Engineering, Coimbatore, Tamilnadu, India -641004.

**Introduction**:
A bimetallic strip based thermal sensor was designed to monitor the temperature rise in insulating oil which was used as coolant in transformers. It was designed with different shapes such as cylindrical and rectangle with different compositions such as Al/ High strength Steel Alloy and Fe/Cu which can withstand high temperatures, were analyzed for its displacement by changing its dimension and temperature by using COMSOL Multiphysics 4.4.

**Computational Methods**:
Using the Structural mechanics module, the bimetallic strip was simulated with the thermal stress physics in the 3D mode. When temperature changes it leads to expansion of material and amount of expansion is in linear relationship with coefficient of thermal expansion of that material which can be stated as:

$$\frac{\Delta L}{L} = \alpha_L \Delta T \quad \text{.....(1)}$$

Where, ΔL - Change in length after expansion
L - Original length before expansion
$\alpha_L$ - Coefficient of thermal expansion
ΔT - Difference in temperature

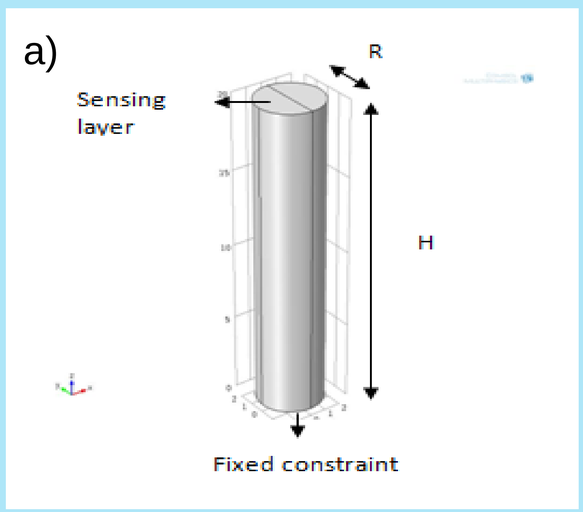



**Figure 1a**. 3D Cylindrical bimetallic strip

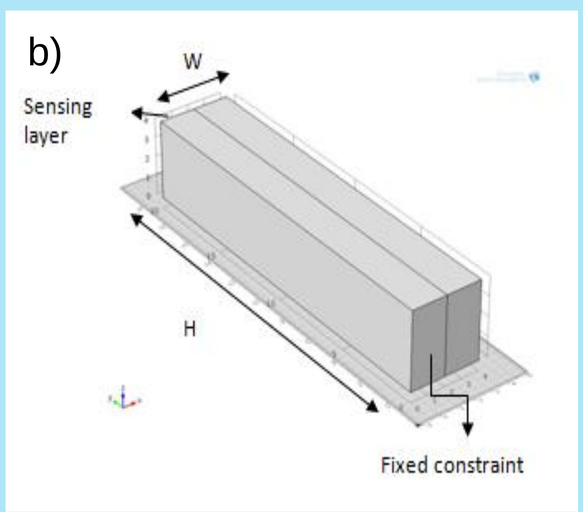



**Figure 1b**. 3D Rectangular bimetallic strip

Instead of using as single metal, bimetallic alloy increases its melting point greater than its individual melting point. The basic layout of the bimetallic strip was shown in Figure 1a and 1b.

The bimetallic strip was designed for two different geometries such as cylinder(C) and rectangle(R), analyzed with four different dimensions, two different alloy compositions and five different temperatures to optimize the best performance material and shape for sensing rise in transformer oil temperature.

**Results**:
The simulated results indicated that Al/ High strength steel alloy gave better displacement 0.7069 μm for cylindrical geometry and 0.6912 μm for rectangular geometry, shown in Figure 2 and 3. The graph was plotted as Temperature Vs Total displacement (Graph 1) and dimension Vs Total displacement (Graph 2).

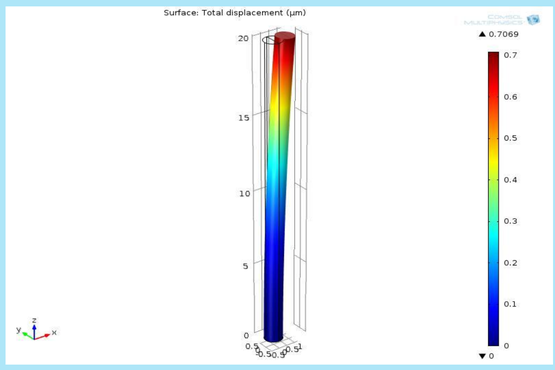



**Figure 2**. Total Displacement Cylindrical geometry

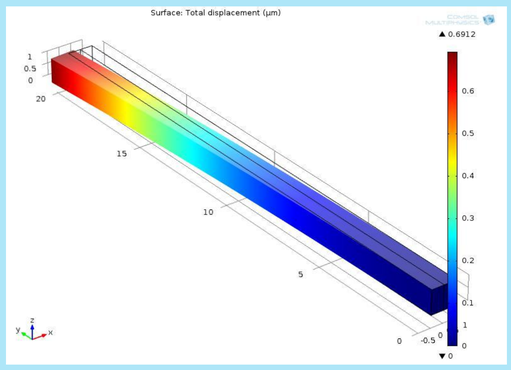
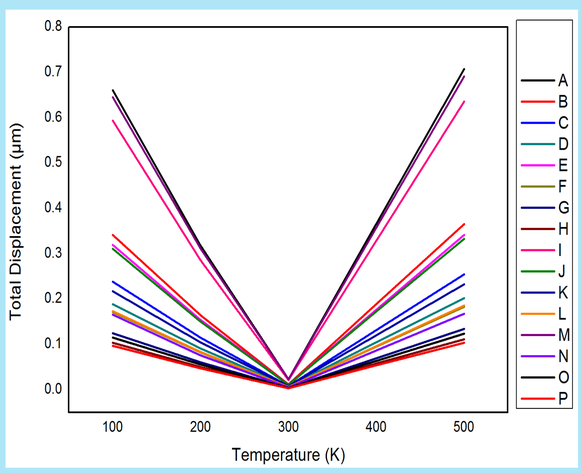
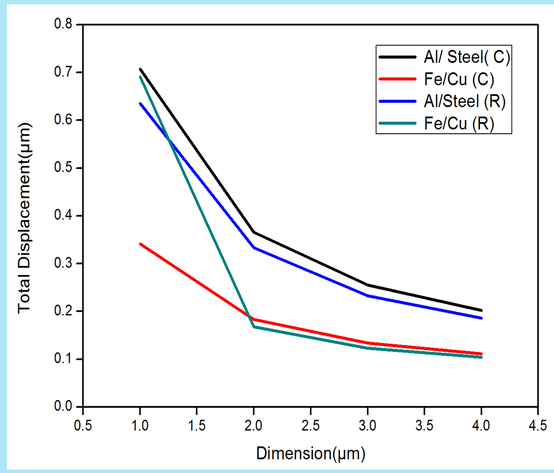



**Figure 3**. Total Displacement Rectangular geometry




**Graph 1**. Temperature Vs Total Displacement for Cylindrical(C) and rectangular (R) geometry




**Graph 2**. Dimension Vs Total Displacement for Cylindrical(C) and rectangular (R) geometry

A- Al/Steel (C), R-0.5 μm B- Al/Steel (C), R-1 μm C- Al/Steel (C), R-1.5 μm
D- Al/Steel (C), R- 2 μm E- Fe/ Cu (C), R-0.5 μm F- Fe/ Cu (C), R-1 μm
G- Fe/ Cu (C), R-1.5 μm H- Fe/ Cu (C), R-2 μm I- Al/Steel (R), W-1 μm
J- Al/Steel (R), W- 2 μm K- Al/Steel (R), W- 3 μm L- Al/Steel (R), W- 4 μm
M- Fe/ Cu (R), W- 1 μm N- Fe/ Cu (R), W- 2 μm O- Fe/ Cu (R), W-3 μm
P - Fe/ Cu (R), W- 4 μm

**Conclusions**:
Thus the bimetallic strip based thermal sensor was designed for better performance of transformer oil monitoring. The best suitable material was obtained as Al/ High strength steel alloy for cylindrical geometry with minimum radial dimension and for rectangular geometry Al/ High strength steel alloy for width >1 μm and Fe/Cu for width <1 μm.

**References**:
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2.Michael Ertl et al., Investigation of load noise generation of large power transformer by means of coupled 3D FEM Analysis. The International Journal for Computation and Mathematics in Electrical and Electronic Engineering Vol 26(3); 2012.

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