Multiphysics Modeling and Multilevel Optimization of Thermoelectric Generator for Waste Heat Recovery

Asutosh Prasad* and Raj CN Thiagarajan
*Corresponding author: ATOA Scientific Technologies Pvt Ltd, 204 Regent Prime, 48 Whitefield Main Road, Whitefield, Bengaluru 560066, India, www.atoa.com, corp.hq@atoa.com.

Introduction:- Waste heat is inevitable in any heat engine while producing mechanical work, which limits the system efficiency. Producing electricity from the waste heat using Optimized TEG Devices is a potential solution for energy industry. A TEG architecture is mentioned in below, which produces electricity from heat.

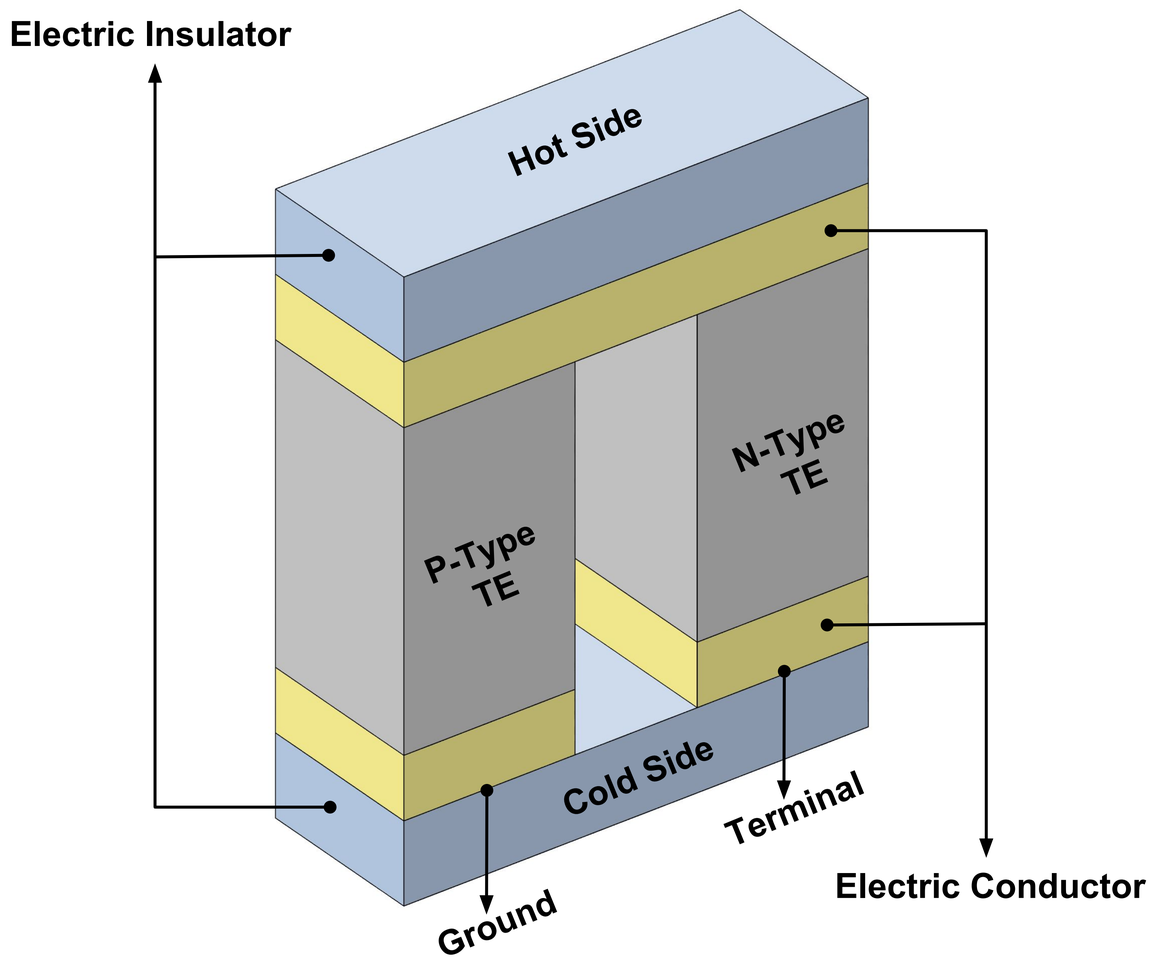

Fig 1. TEG Architecture

Computational Methods:- Multiphysics CAE Model of a Thermoelectric Generator is developed using COMSOL 5.2. The numerical problem is solved using Thermoelectric Effect Module in temperature gradients of 70^C, 170^C and 270^C. The governing equations are mentioned below.

(1) Heat Transfer in Solids

$$\rho C_p u.\nabla T + \nabla.q = Q + Q_{ted} \ , \ q = -k\nabla T$$

(2) Electric Currents

$$\nabla J = Q_j \ , \ J = \sigma E + J_e \ , \ E = -\nabla V$$

(3) Thermoelectric Effects

$$q = PJ \ , \ P = ST \ , \ J_e = -\sigma S\nabla T$$

Results:- The temperature distribution, generated voltage of unitcouple and module are plotted. Maximum power of 0.095W, 12.59W is produced at 300^C and equal value of internal electrical resistance and load resistance of 0.042Ω, 5.28Ω from unitcouple and module respectively.

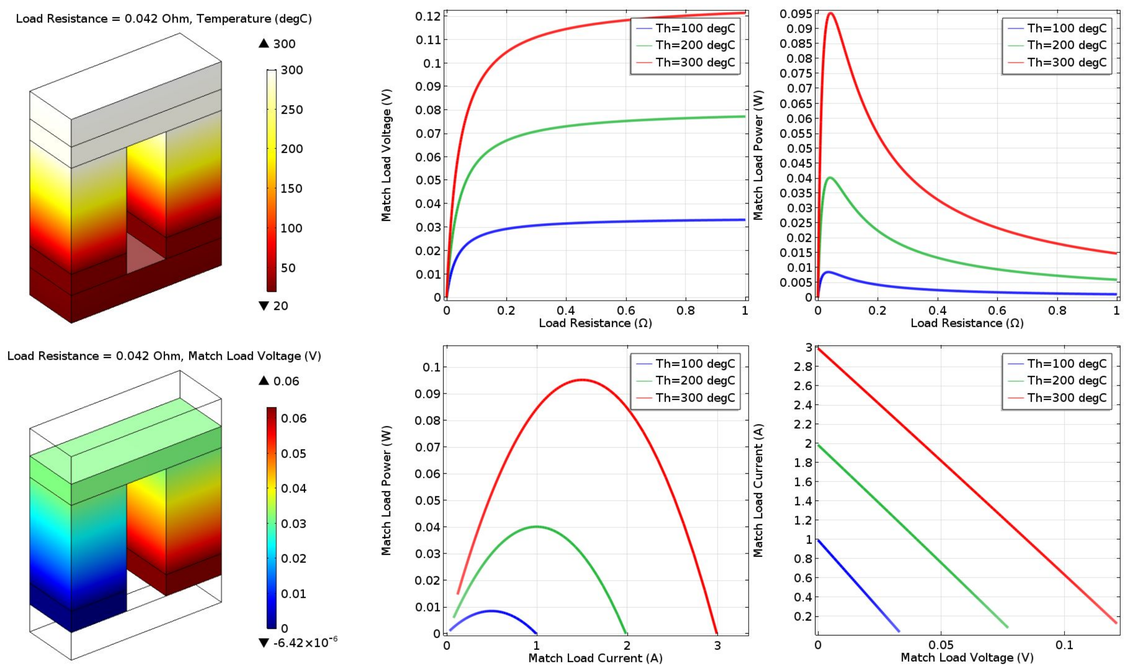

Fig 2:- 1.4mm*1.4mm*2.5mm Bi_2Te_3 Unitcouple Simulation

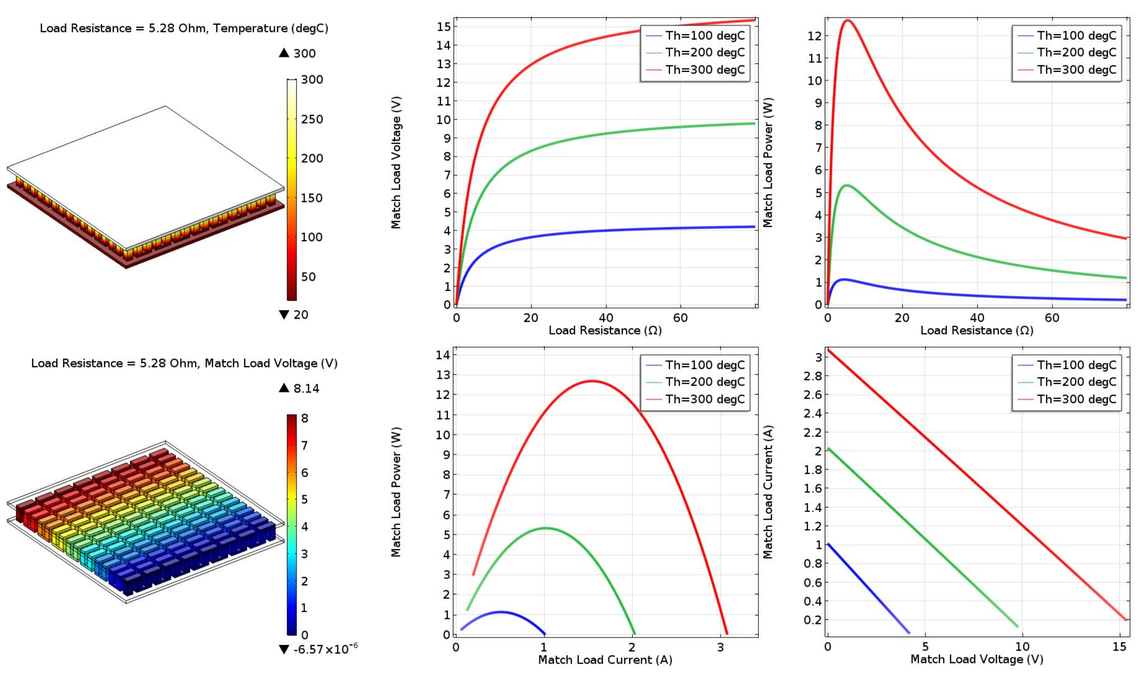

Fig 3:- 40mm*40mm*4.8mm Bi_2Te_3 TEG Module Simulation

Conclusions:- The performance of TEG Model is predicted numerically. The optimized multilevel TEG module shows potential in increasing waste heat recovery.

References:-

1.Thermoelectrics Design and Materials, HoSung Lee, John Wiley & Sons, 2016.
2.Introduction to Thermoelectricity, H.Julian Goldsmid, Springer Science .