Tree Power

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ABSTRACT.

Key words:

Introduction

Literature review:

1 Assumptions

With these assumptions, the DE problem reduces to 1D.

1. We assume all trees we consider are roughly the same. That means same height, same radius
2. With the previous assumption, we place all devices at the same height, and same depth

2 To do

1. (DISCUSSION ITEM) Understand the hardware more: which equations to use, heat? thermoelectric? both?
2. (ACTION ITEM) Write code (Matlab/Python) to solve equations (equations see next section). ref: http://www.claudiobellei.com/2016/11/10/crank-nicolson/

   http://www.claudiobellei.com/2016/10/15/explicit-parabolic/
3. Verify the assumptions.
   (a) With vertical drilling and data collection, find the best height. Call h_0
   (b) With horizontal drilling and data collection, find the best depth. Call r_0

   With the assumption that we have found the "best" height and radius (best: highest voltage, most activities, depending on the device??), we simplify the problem into a 1D problem.
4. Find appropriate parameters in DE. For now, we take simple ones. ISSUE: if real parameters are small, might cause unexpected numerical errors

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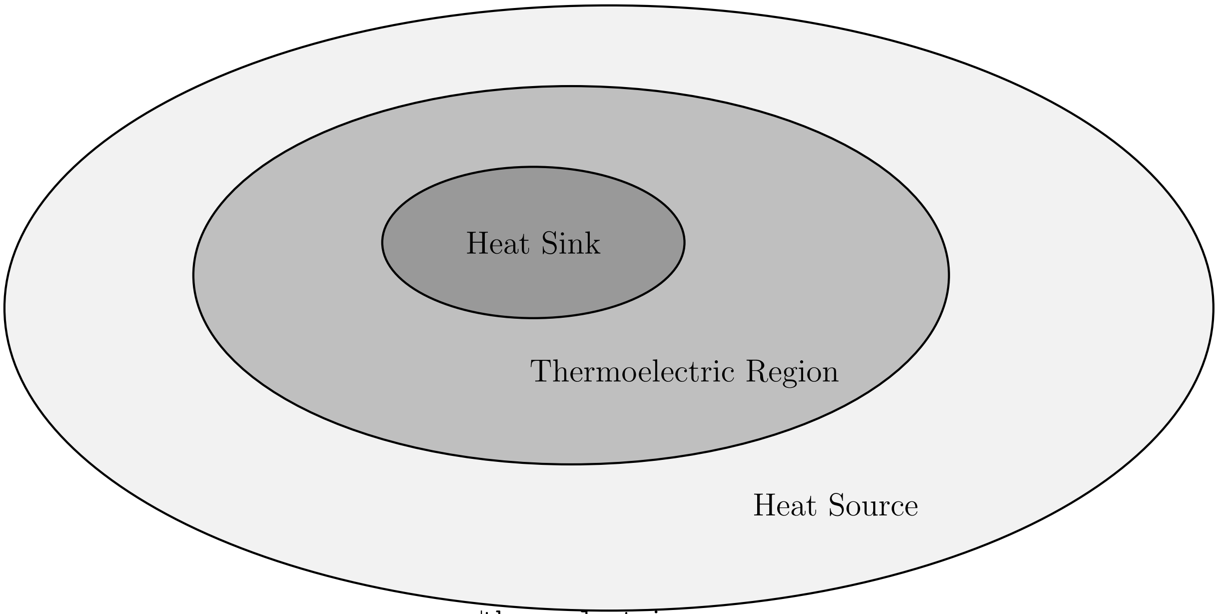
3 Differential Equations



We modify the equations from thermoelectric [1], to radial equations. Heat source and thermoelectric material in Fig.2 thermoelectric [1] is now along the radius r. (ASK ABOUT HARDWARE. Fig.1, and Fig.2. from ref)

Heat sink and resource for region R are governed by the heat equation

$$\rho_R \, C_{vR} \, \frac{\partial T}{\partial t} = \nabla \cdot (k_R \nabla T), \tag{1}$$ heat

here, T is the temperature, t time, ρ_R the density for region R, C_{vR} specific heat, k_R is the thermal conductivity.

The middle layer is the thermoelectric region, governed by

$$\rho_m \, C_{vm} \, \frac{\partial T}{\partial t} = \sigma \mathbf{E} \cdot \mathbf{E} - \sigma \cdot \alpha \mathbf{E} \cdot \nabla T + \nabla \cdot [(k_m + \sigma \alpha^2 T)\nabla T - \sigma \alpha T \mathbf{E}], \tag{2}$$ elec

$$\frac{\partial \rho}{\partial t} = \nabla \cdot (-\sigma \mathbf{E} + \sigma \alpha \nabla T). \tag{3}$$ chargede

Here $\mathbf{E}$ is the electric field, ρ the charge density, σ the electric conductivity, and α the Seebeck coefficient (with temp dependence $\alpha = \alpha(T)$. Need curve fitting to decide).

DO NOT KNOW ANY PARAMETERS

3.1 Reduction to 1D problem

Based on our assumptions, we reduce spatial dependence to only on radius r:

$$\rho_R \, C_{vR} \, \frac{\partial T}{\partial t} = \frac{\partial}{\partial r}\Big(k_R \frac{\partial T}{\partial r}\Big), \tag{4}$$ heat1d

$$\rho_m \, C_{vm} \, \frac{\partial T}{\partial t} = \sigma E^2 - \sigma \alpha E \cdot \frac{\partial T}{\partial r} + \frac{\partial}{\partial r}[(k_m + \sigma \alpha^2 T)\frac{\partial T}{\partial r} - \sigma \alpha T E], \tag{5}$$ elec1d

$$\epsilon \frac{\partial E}{\partial t} = J_0 - \sigma E + \sigma \alpha \frac{\partial T}{\partial r}. \tag{6}$$ chargede

Here chargedensity1d (6) is the result of integrating chargedensity (3), and J_0 a constant.

3.2 Radial boundary conditions

From outside inwards, the boundary conditions are:

- Outside: tree bark has T_{amb}.
- Between Heat Source and Thermoelectric region, a voltage V_0 is generated, heat flux and temperature??
- section A. in Yan paper

Reference BAD FORMAT. FOR convience only

lectric 1. Time-Dependent Finite-Volume Model of Thermoelectric Devices, Yan. D. et al, IEEE, Transactions on industry applications, Vol. 50, No.1, Jan/Feb 2014

mit 2. MIT notes online