



Booklets

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Title: Thermal study of heat sink used in Peltier modules

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Editorial label MARVID: 607-8695
BMARVID Control Number: 2025-01
BMARVID Classification (2025): 121225-0001

RNA: 03-2010-032610115700-14

Pages: 11

SECIHTI classification:

Area: Engineering

Field: Engineering

Discipline: Mechanical Engineering

Subdiscipline: Thermal Engineering

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Introduction

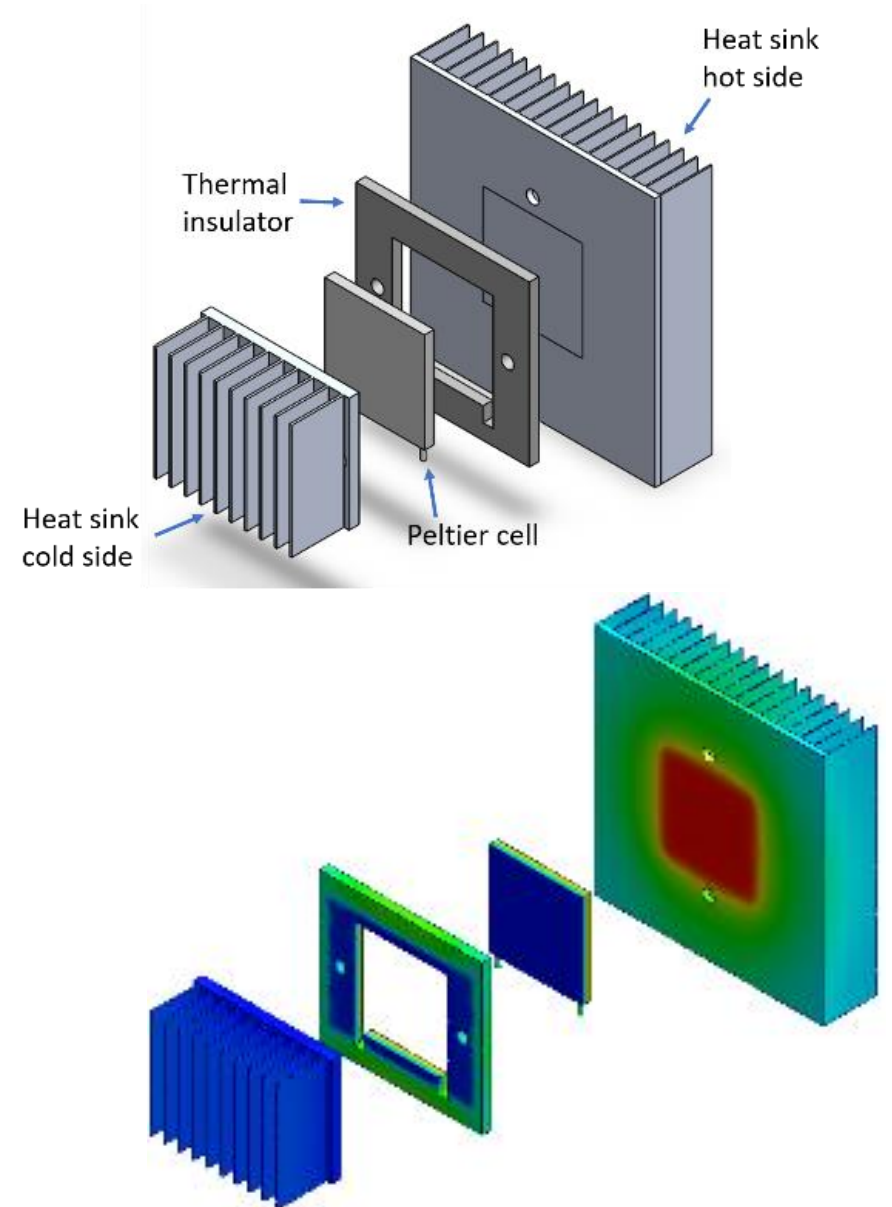
The introduction of thermoelectric modules (TEM) was mainly in the cooling of electronic devices for army and military technology. For the last ten years, the attention to others areas began, mainly for cooling and electric generation. Peltier cells for cooling have the advantage that can be used in small devices and due to noise produced is practically zero. ([Hájovský et al., 2016](#)). The efficiency or malfunctions of a TEM is related with the overload or strain ([Nasri et al., 2017](#)). Due to the thermal behaviour of the Peltier cell, heat sinks are used to regulate the temperature absorbing or dissipating heat from a fluid through the extended fins ([Korprasertsak and Leephakpreeda, 2017](#)

State of art

Author	Study	Parameters	Results
Ventola et al. (2016)	Experimental	V=5.6 to 13.9 m/s	Reduction of material up 53%
Abdelmohimen et al. (2021)	Simulation	Re=1333 to 5334	Parallel flow reduces the thermal resistance
Al-Luhaibi and Nazzal (2023)	Experimental	Fins with holes	Reduction of weight up 7.03%
Rodríguez-Muñoz et al. (2023)	Simulation	Shape of fins	Circular fins are the best configuration
Alomía (2025)	Simulation	Two materials	Ak 6061 T6 is the best option
Pupcevic et al. (2025)	Experimental	Natural convection	Optimal distance 5.26mm

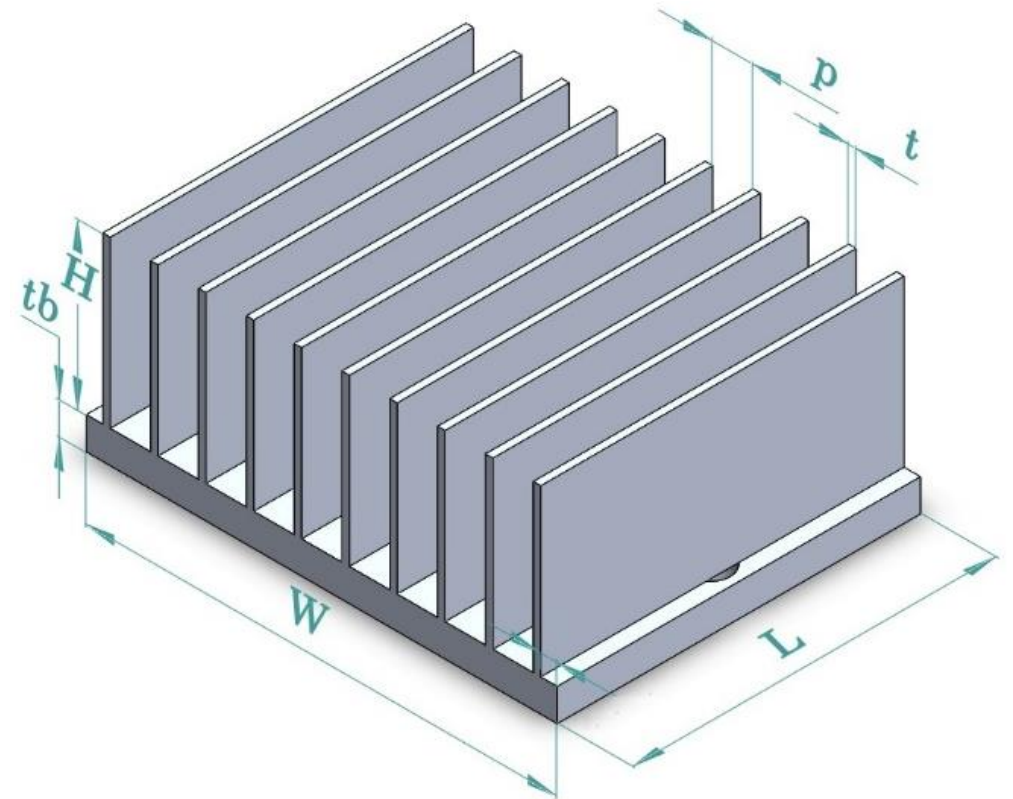
Methodology

The TEM analysed is based on a commercial aluminium model commonly used in thermoelectric application as it is shown in Figure 2. The TEM has an aluminium alloy heat sink on the cold side with a base of 60mm×46mm, a thermal insulation of 69mm×64mm×5mm, a Peltier cell with dimension of 40mm×40mm×4mm and an aluminium alloy heat sink on the hot side with a base of 100mm×100mm. The design includes parallel fins distributed along the base plate. The height of the heat sink is $H=20.83\text{mm}$ for the cold side, and $H=20.57$ for the hot side.



Methodology

Side	L	W	tb	N	H	T	p
C1	46	60	4.06	10	20.83	0.94	5.08
C2				13			3.81
C3				17			2.54
C4				27			1.27
H1	100	100	2.29	17	20.57	0.94	5.08
H2				21			3.81
H3				28			2.54
H4				44			1.27



Methodology

$$\nabla \cdot (k\nabla T) + \dot{q} = 0$$

Where k is the thermal conductivity ($\text{W/m}\cdot\text{K}$) and \dot{q} is the volumetric heat generation (W/m^3). Due to the heat sink does not include internal source, then $\dot{q} = 0$.

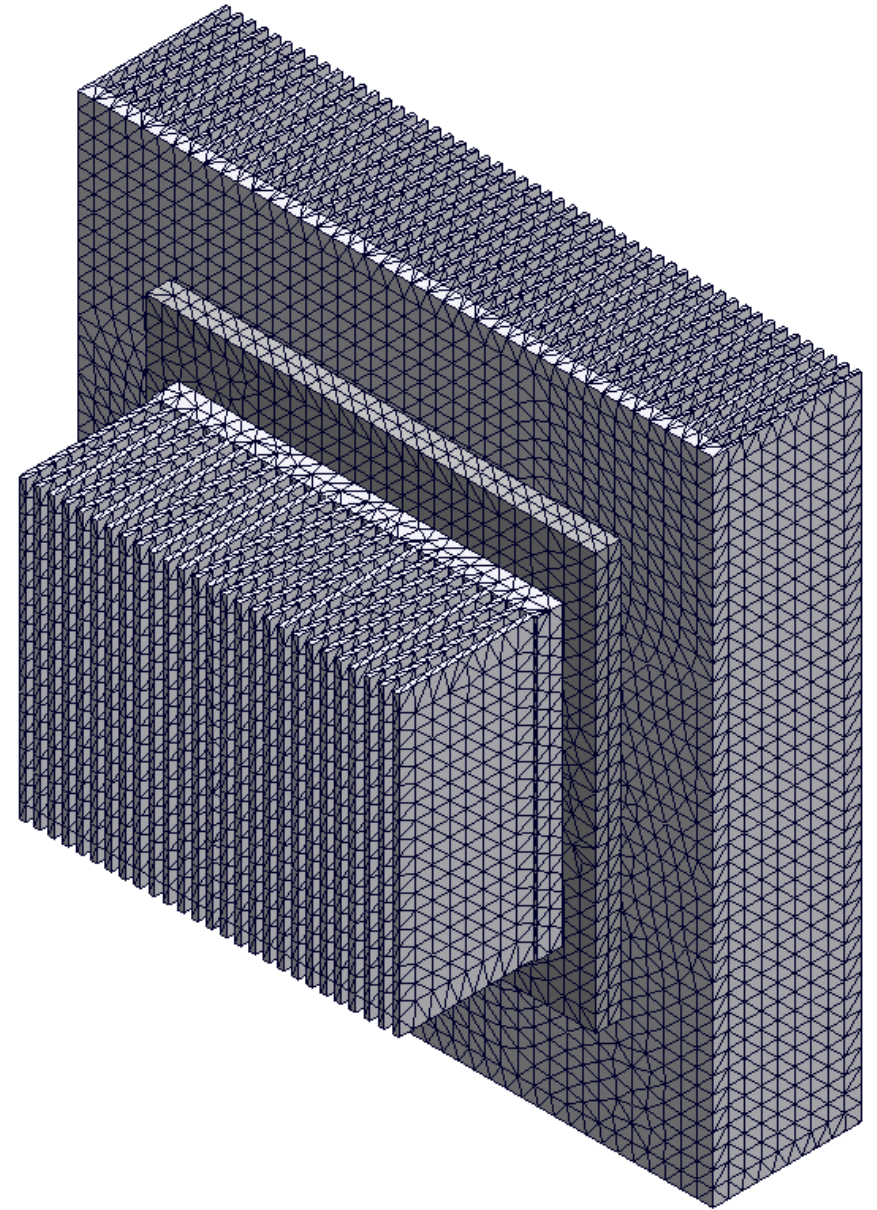
$$\dot{q}_{\text{convection}} = h(T_s - T_\infty)$$

$$\dot{q}_{\text{radiation}} = \varepsilon\sigma(T_s^4 - T_\infty^4)$$

Where h is the convective heat transfer coefficient ($\text{W/m}^2\cdot\text{K}$) ranging from natural convection ($5 \text{ W/m}^2\cdot\text{K}$) to forced convection ($200 \text{ W/m}^2\cdot\text{K}$), T_s is the surface temperature, T_∞ is the temperature of the fluid (air), ε is the emissivity of the surface (it was considered for this study $\varepsilon=0.85$), σ is the Stefan-Boltzmann constant ($5.67\times 10^{-8} \text{ W/m}^2\cdot\text{K}^4$). It was considered constant thermophysical properties.

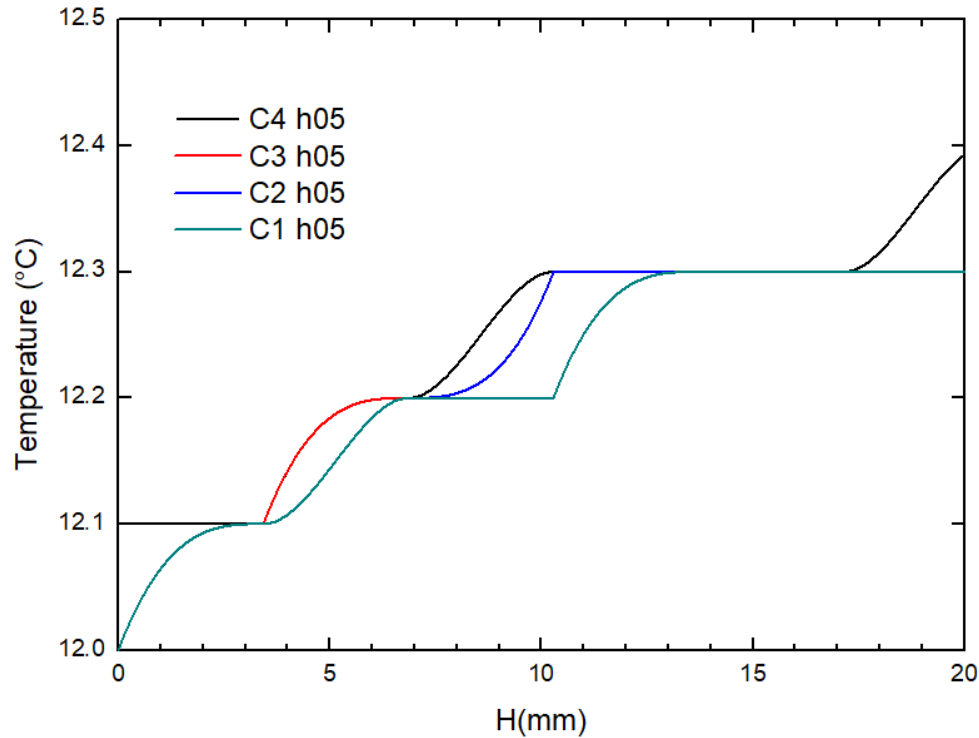
Methodology

The steady state thermal simulation was done using Solid Works software. The governing equation are solved by the Finite Element. Mesh independence was verified by refining the grid until it was a difference on the temperature less than 1%. A fine standard grid with a tolerance of 0.125mm with 16 Jacobian point was used.

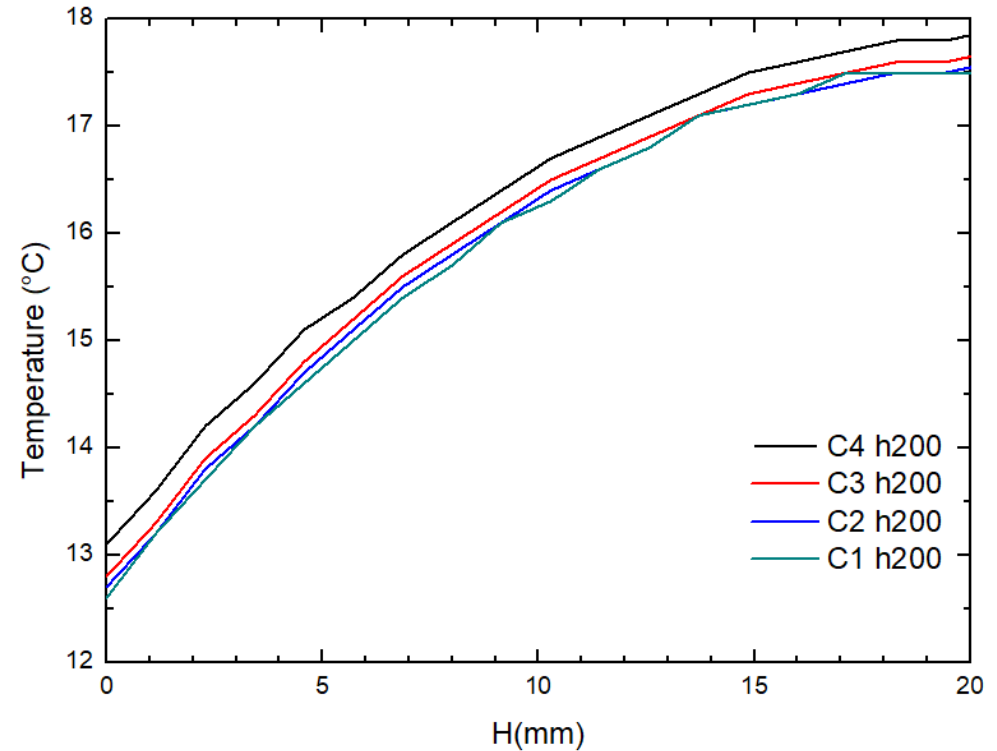


Results

Effect of spacing at the cold side



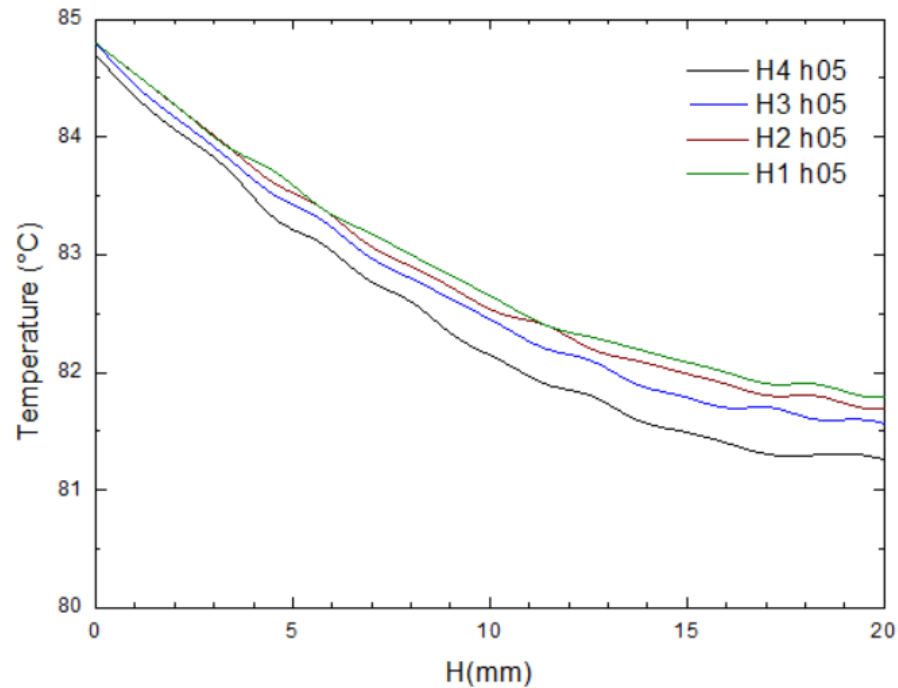
Temperature profile for the case of $h=5$ W/m²·K and the four cases of p at the cold side of the TEM



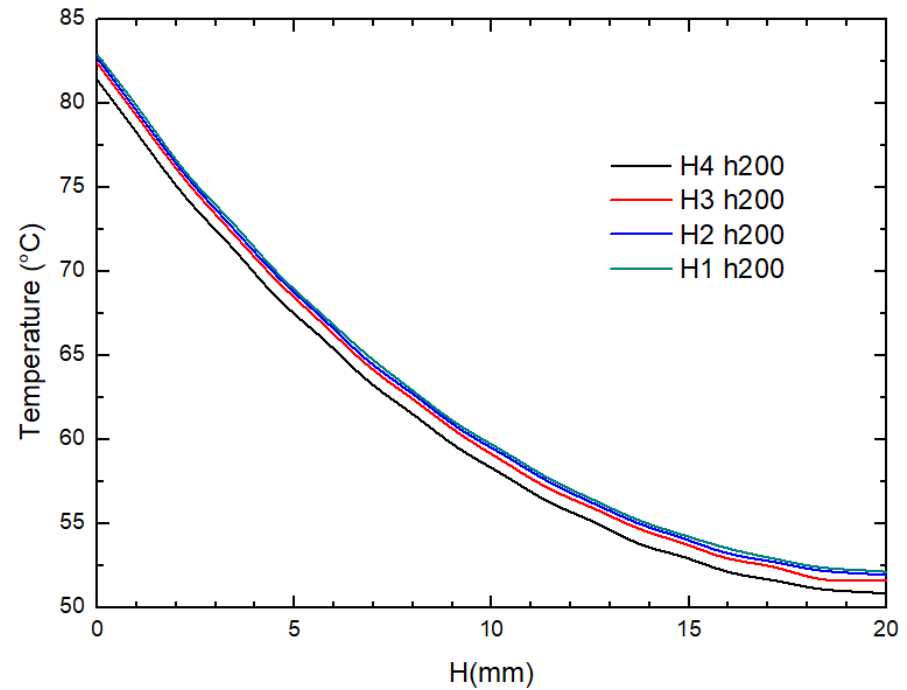
Temperature profile for the case of $h=200$ W/m²·K and the four cases of p at the cold side of the TEM

Results

Effect of spacing at the hot side



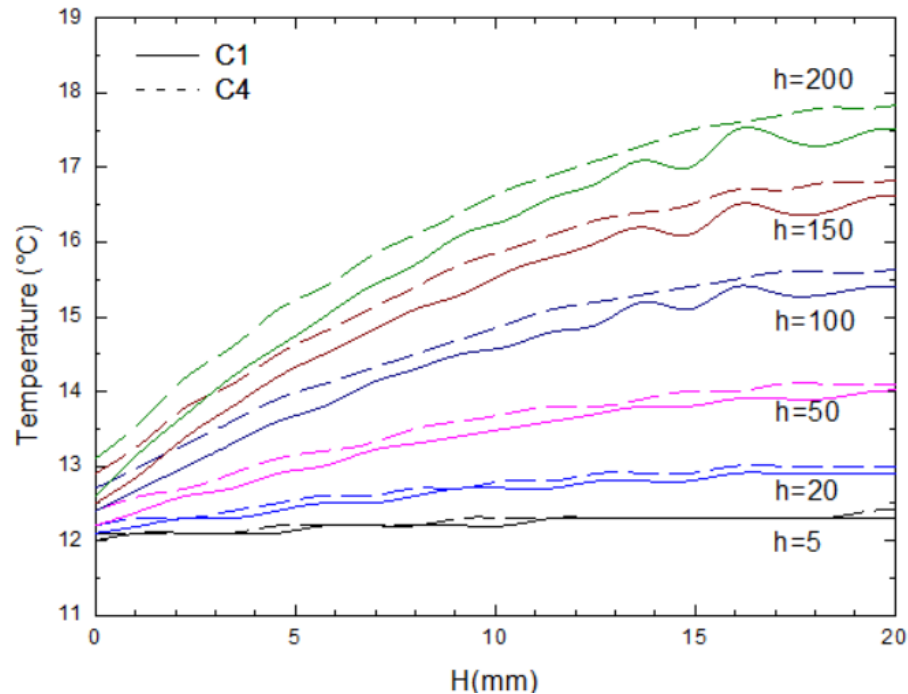
Temperature profile for the case of $h=5 \text{ W/m}^2 \cdot \text{K}$ and the four cases of p at the hot side of the TEM



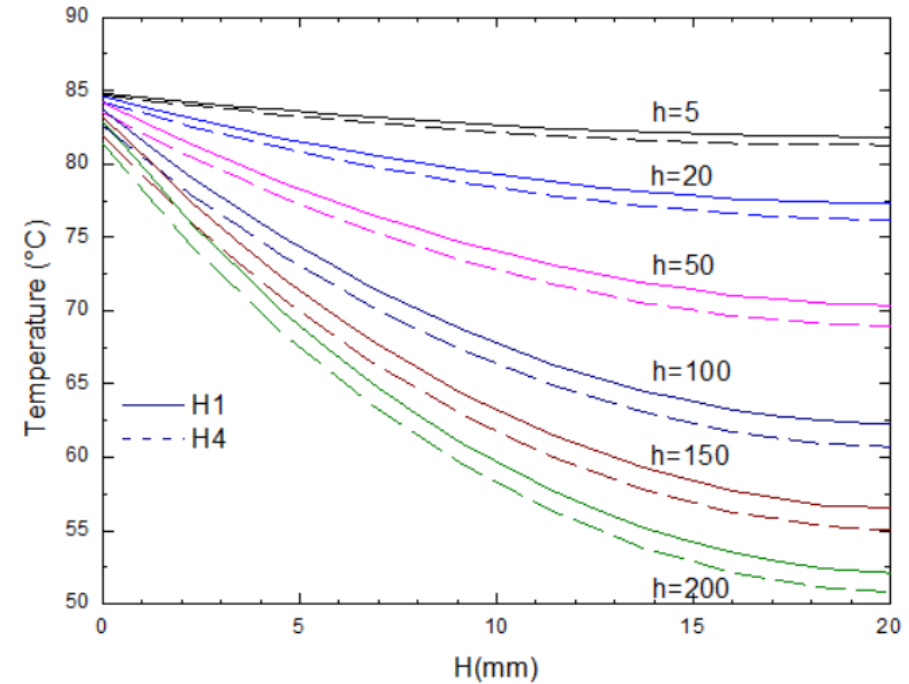
Temperature profile for the case of $h=200 \text{ W/m}^2 \cdot \text{K}$ and the four cases of p at the hot side of the TEM

Results

Effect of convective heat transfer coefficient



Temperature profile at the cold side for cases C1 and C4 with the variation of the convective heat transfer



Temperature profile at the hot side for cases C1 and C4 with the variation of the convective heat transfer

Conclusions

1. At the cold side of the TEM, for $h=5 \text{ W/m}^2\cdot\text{K}$, there is not significant difference with the number of fins used, the maximum difference of temperature was 0.3°C .
2. At the cold side for $h=200 \text{ W/m}^2\cdot\text{K}$, the C4 can increase the temperature of the heat sink because it has more area of heat transfer.
3. At the hot side, the temperature decreases as increases the number of fins 0.6°C for $h=5 \text{ W/m}^2\cdot\text{K}$. The temperature decreases from 84.8°C at the base of the heat sink to 81.2°C at the end of the fin.
4. When $h=200 \text{ W/m}^2\cdot\text{K}$, the temperature decreases from 82.4°C to 50.7°C at the end of the fin.
5. The selection of the heat sink on the cold side depends on the application to select the adequate number of fins.

The results are in agreement with studies reported in the literature, so the geometry and convective heat transfer plays an important role in the heat dissipation at the hot side in contrast with the cold side that remains almost at the same temperature.

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