


TP 2023 -2024



Banc expérimental: Dot T. Kziarzk (2022)

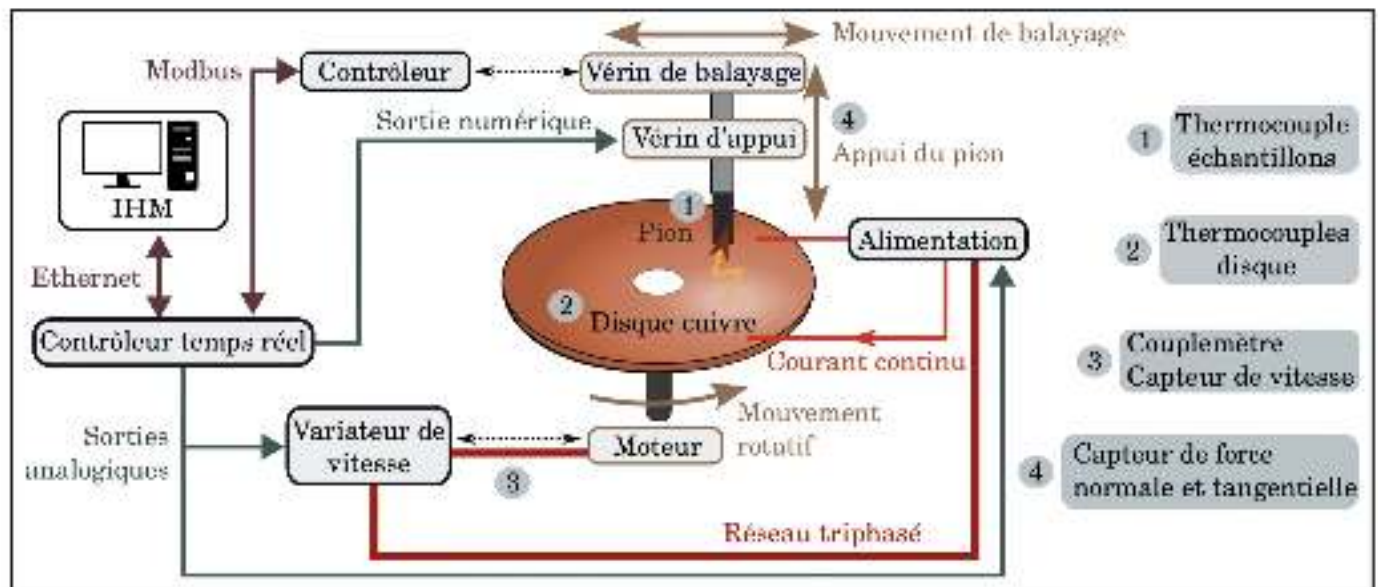


FIGURE 2.1 – Synoptique du banc d'essais.

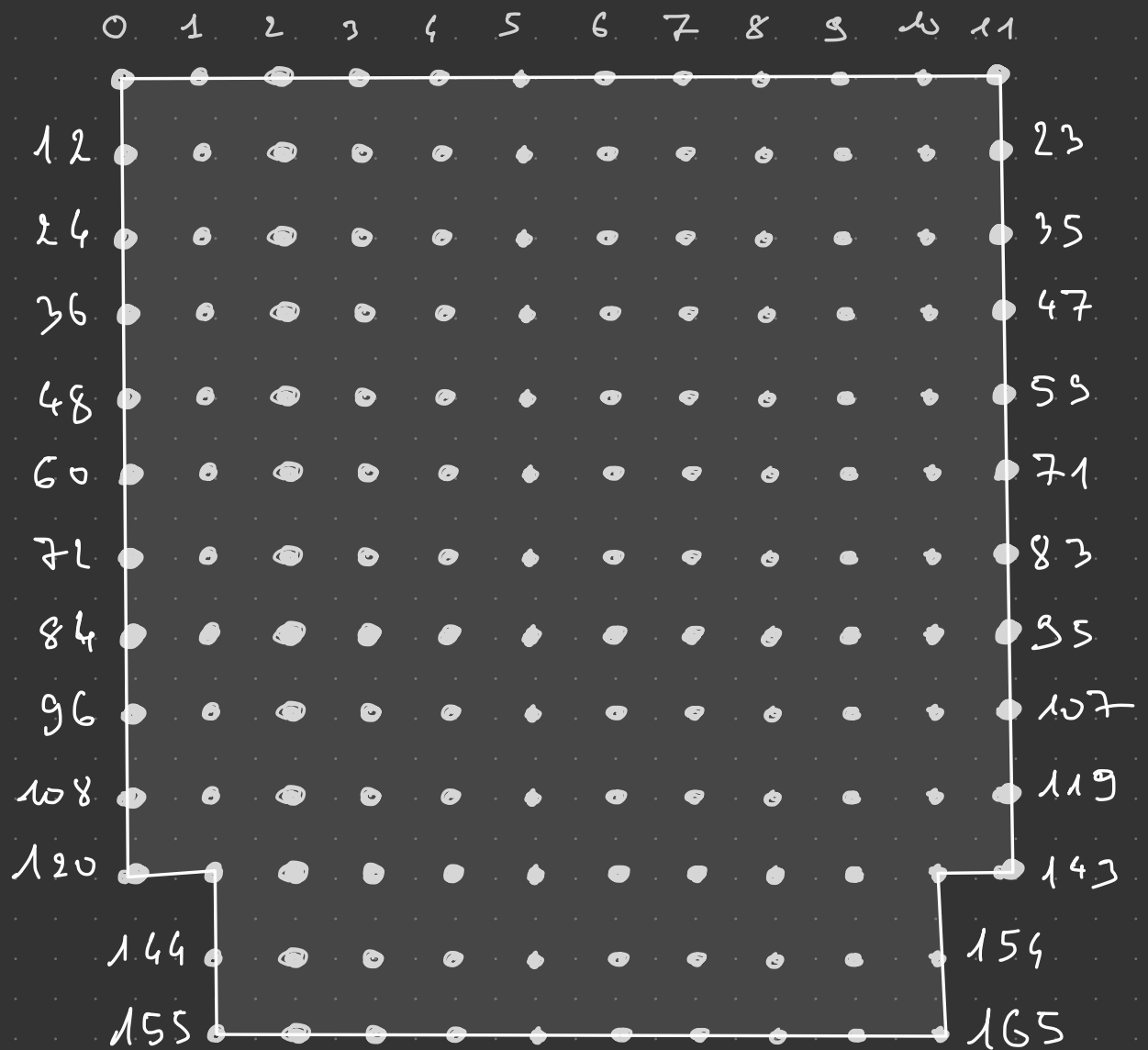
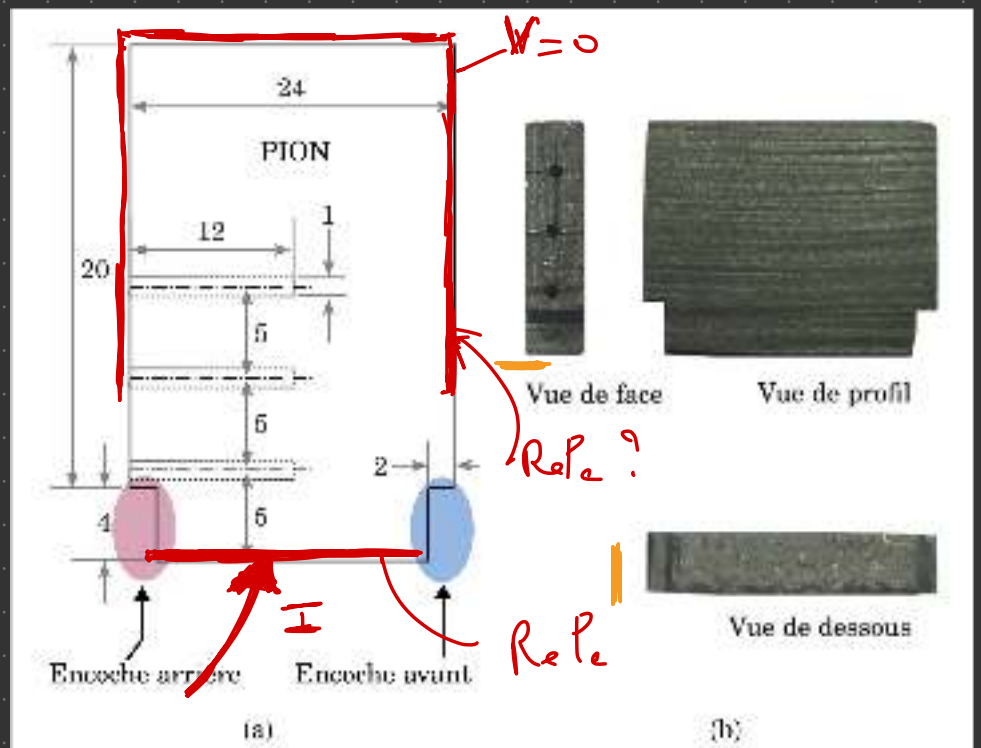
- Etude de l'usure électrique / thermique d'un pion en carbone
- Obtention du champ de température (T) et de potentiel (V) en régime transitoire
- Méthodologie
 - ① Géométrie → maels et indices
 - ② Pb électrique
 - ③ Pb Thermique
 - ④ Pb couplé ?

geometrie

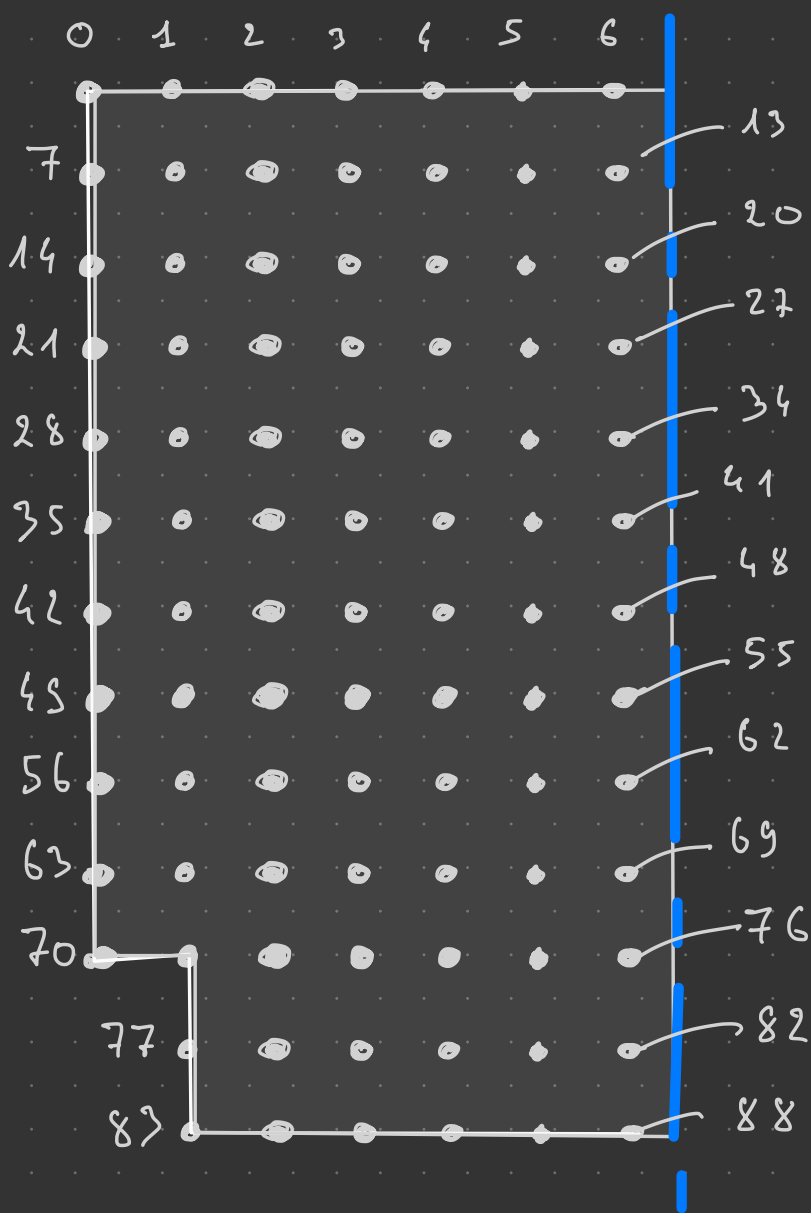
2D

$$\Delta x = \Delta y = 2 \text{ mm}$$

$$e = 5 \text{ mm}$$



Utilisation Symétrie

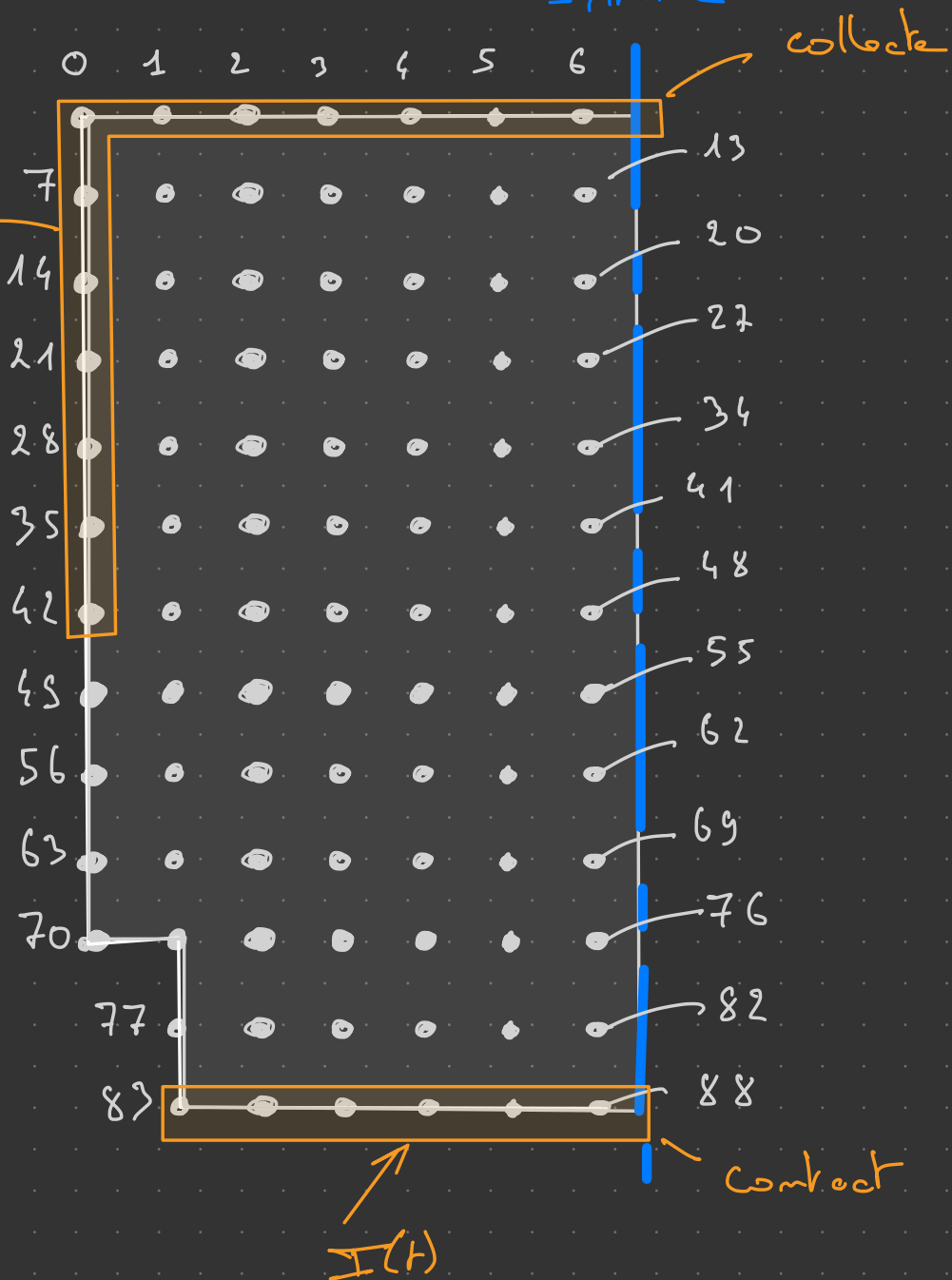


Pb Elec

→ Régime Permanent des E_2 carbone.

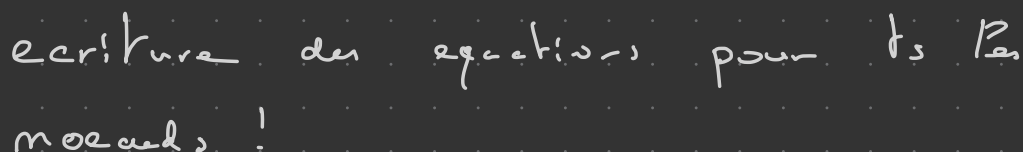
Symétrie

$V=0$



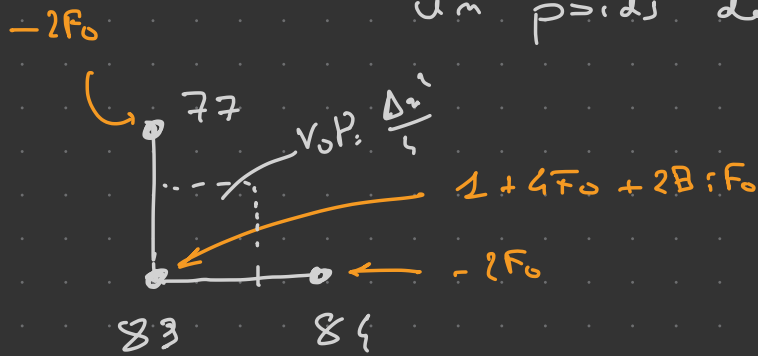
type de nœuds

- centraux
- symétrie Δ volume ?
- contact
- en coque
- collecte

$$\frac{1}{s} (t) \quad ?$$


détail des équations

modèle (83) par symétrie identique à (77) avec
un poids double sur (77)



$$Q_J: \text{W/m}^3$$

$$q_c: \text{W/m}^2$$

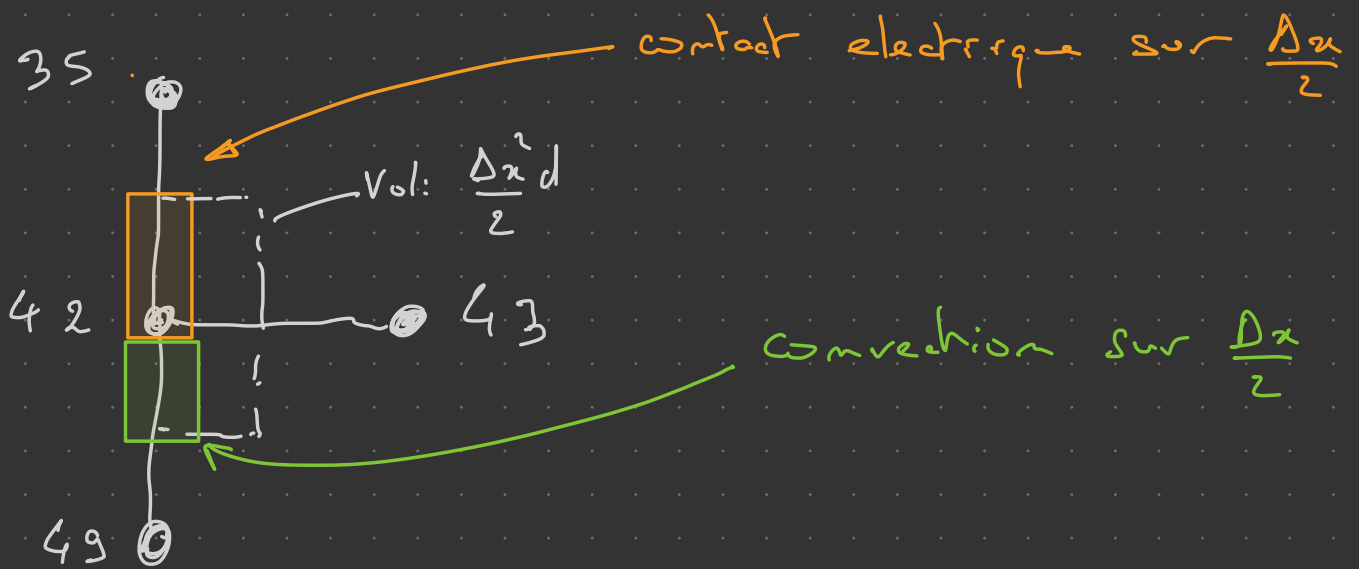
Vérification (83)

$$Q_J \times \frac{\Delta x^2}{4} + h \frac{\Delta x}{2} (T_{83}^* - T_\infty) - \left\{ -k \frac{\Delta x}{2} \left(\frac{T_{84}^* - T_{83}^*}{\Delta x} \right) - k \frac{\Delta x}{2} \left(\frac{T_{77}^* - T_{83}^*}{\Delta x} \right) \right\} + q_c \frac{\Delta x}{2} = \rho \frac{\Delta x^2}{4} c_p \frac{T_{83}^* - T_{83}}{\Delta t}$$

$$\left[\frac{Q_J \Delta t}{\rho c_p} + 2BiFo (T_{83}^* - T_\infty) + 2F_0 (T_{84}^* - T_{83}^*) + 2F_0 (T_{77}^* - T_{83}^*) + \frac{2q_c \Delta t}{\rho c_p \Delta x} \right] = T_{83}^* - T_{83}$$

idem 84/85...88

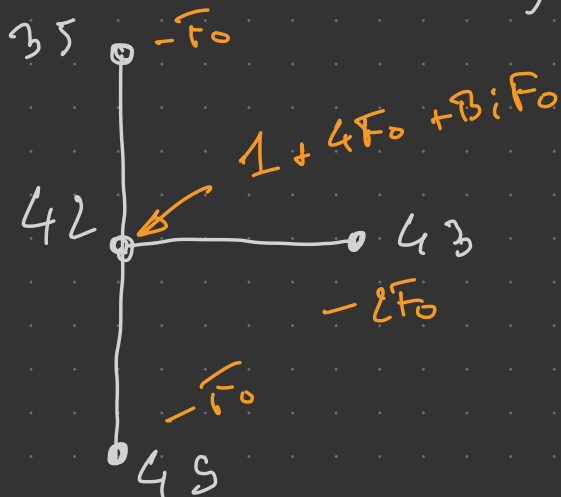
modél (42)



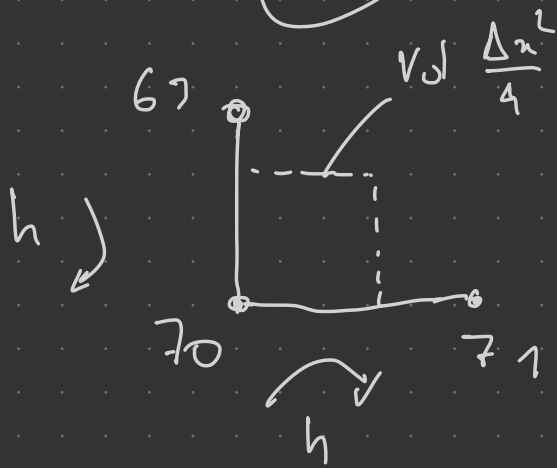
$$\begin{aligned}
 & -k \frac{\Delta x}{2} (T_{42}^* - T_{45}^*) + Q_J \frac{\Delta x}{2} + q_c \frac{\Delta x}{2} \\
 & - h \frac{\Delta x}{2} (T_{42}^* - T_\infty) - \left\{ -k \frac{\Delta x}{2} (T_{43}^* - T_{42}^*) \right. \\
 & \left. - k \frac{\Delta x}{2} (T_{35}^* - T_{42}^*) \right\} = \rho C_p \frac{\Delta x^2}{2} \frac{(T_{42}^* - T_{42})}{\Delta t}
 \end{aligned}$$

[

$$\begin{aligned}
 & -Fo (T_{42}^* - T_{49}^*) + \frac{J_E \Delta t}{\rho C_p} + \frac{q_c \Delta t}{\rho C_p \Delta x} \\
 & - Bi Fo (T_{42}^* - T_\infty) + 2Fo (T_{43}^* - T_{42}^*) \\
 & + Fo (T_{35}^* - T_{42}^*) = T_{42}^* - T_{42}
 \end{aligned}$$

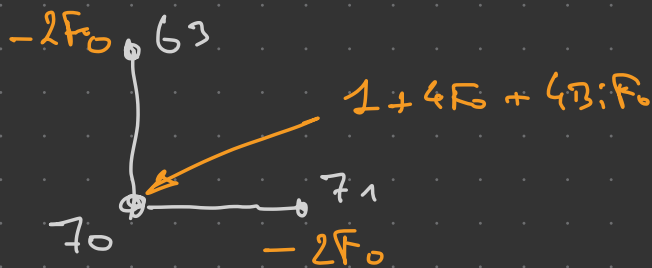


Note and (70)

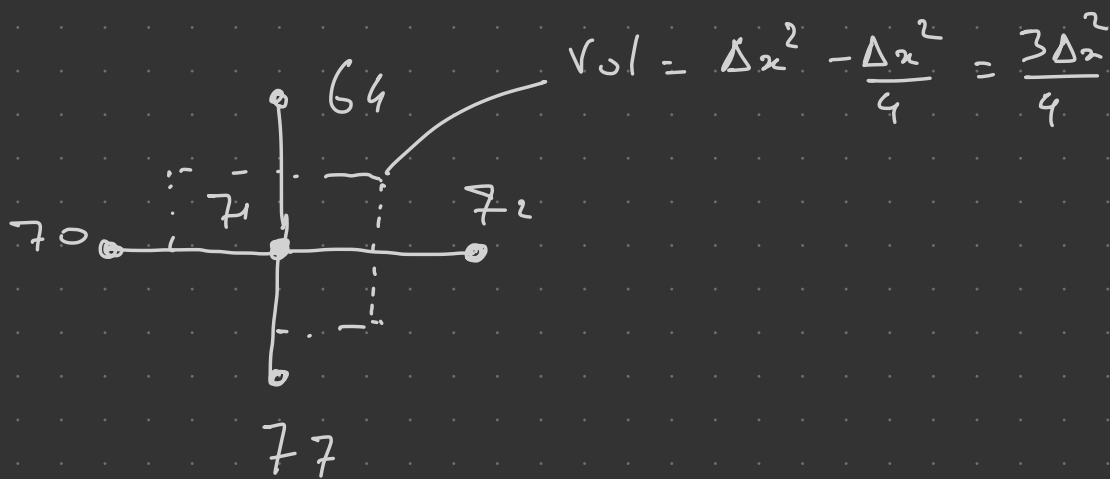


$$Q_5 \frac{\Delta x^2}{4} - h \cancel{\rho} \times \frac{\Delta x}{2} d (\overline{T}_{70}^* - T_\infty) - \left\{ \right. \\ \left. - h \frac{\Delta x}{2} d (\overline{T}_{63}^* - \overline{T}_{70}^*) - Q \frac{\Delta x}{2} d (\overline{T}_{71}^* - \overline{T}_{70}^*) \right\} = \\ \rho C_p \frac{\Delta x^2}{4} \frac{(\overline{T}_{70}^* - T_{70})}{\Delta t}$$

$$\frac{Q_5 \Delta t}{\rho C_p} - 4 Bi F_0 (\overline{T}_{70}^* - T_\infty) + 2 F_0 (\overline{T}_{63}^* - \overline{T}_{70}^*) \\ + 2 F_0 (\overline{T}_{71}^* - \overline{T}_{70}^*) = \overline{T}_{70}^* - T_{70}$$



mod (71)

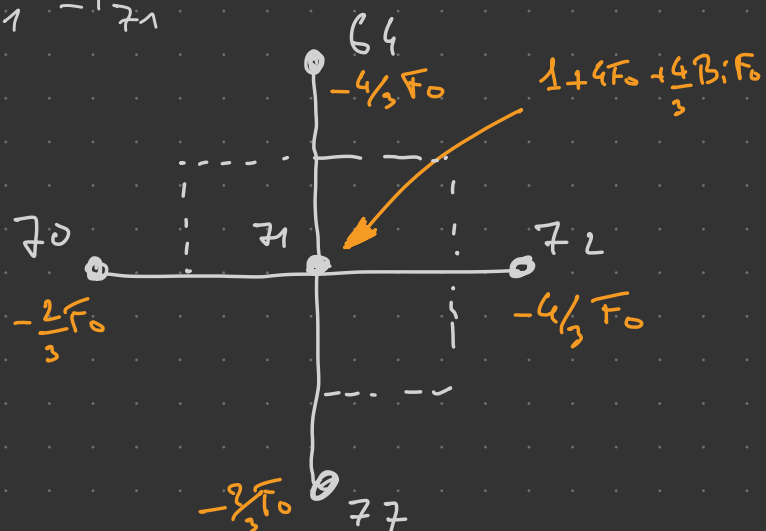


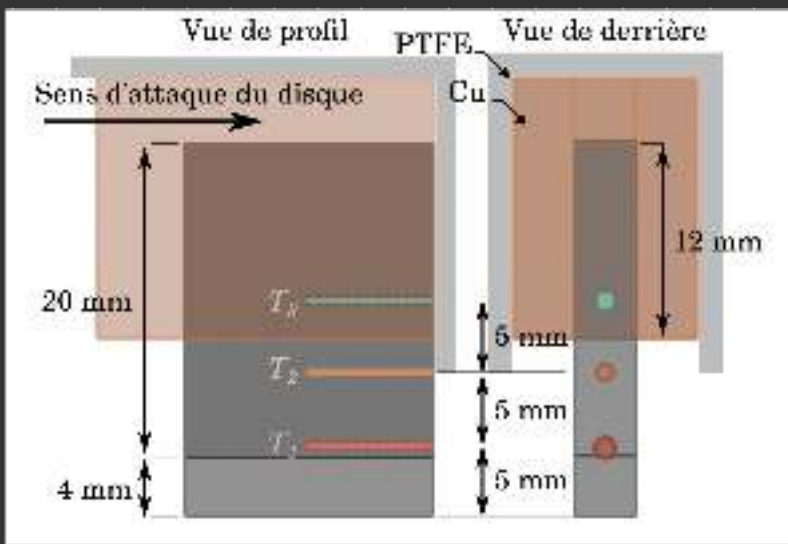
$$Q_5 \frac{3\Delta x^2}{4} d - R \frac{\Delta x}{2} d \left(\frac{T_{71}^* - T_{70}^*}{\Delta x} \right) - R \frac{\Delta x}{2} d \left(\frac{T_{71}^* - T_{77}^*}{\Delta x} \right) - 2h \frac{\Delta x}{2} d (T_{71}^* - T_\infty) - \left\{ -R \frac{\Delta x}{2} d \left(\frac{T_{64}^* - T_{71}^*}{\Delta x} \right) - R \frac{\Delta x}{2} d \left(\frac{T_{72}^* - T_{71}^*}{\Delta x} \right) \right\} = \rho C_p \frac{3\Delta x^2}{4} d \frac{(T_{71}^* - T_{71}^*)}{\Delta t}$$

$$\frac{Q_5 \Delta t}{\rho C_p} - \frac{2F_0}{3} (T_{71}^* - T_{70}^*) - \frac{2F_0}{3} (T_{71}^* - T_{77}^*)$$

$$- \frac{4}{3} Bi F_0 (T_{71}^* - T_\infty) + \frac{4}{3} F_0 (T_{64}^* - T_{71}^*)$$

$$+ \frac{4}{3} F_0 (T_{72}^* - T_{71}^*) = T_{71}^* - T_{71}^*$$





implantations
des
Thermocouples

Résultats en régime dynamique

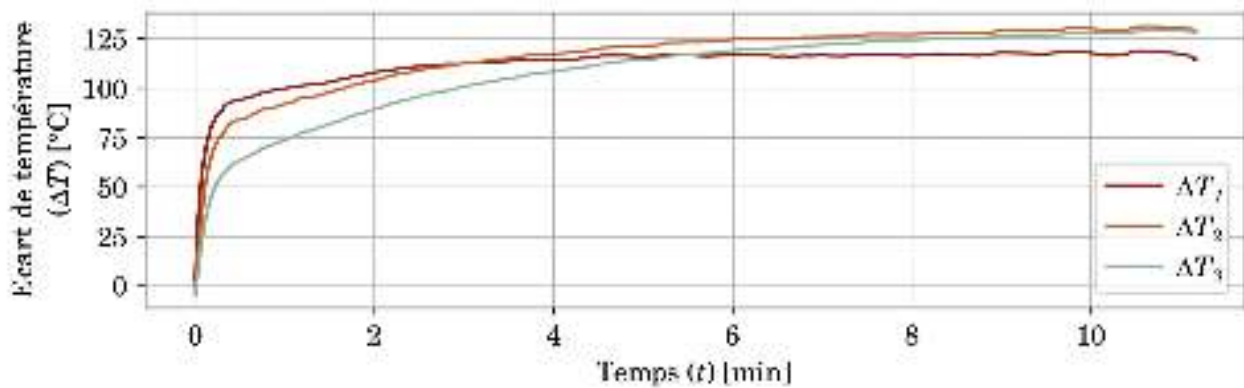


FIGURE 4.14 – Variation des écarts de température en fonction du temps (Nuance B, $I=200$ A, $v_t=30$ km·h⁻¹ et $F_N=70$ N).

Pq inversion de τ ?

Valeur de T pour $\neq I$

| I [A] | Avec convection | | | | Convection limitée | | | |
|---------|-------------------|-------------------|-------------------|------------|--------------------|-------------------|-------------------|------------|
| | ΔT_1 [°C] | ΔT_2 [°C] | ΔT_3 [°C] | T_d [°C] | ΔT_1 [°C] | ΔT_2 [°C] | ΔT_3 [°C] | T_d [°C] |
| 0 | 5,7 | 2,8 | 0,6 | 27,0 | 4,0 | -1,1 | -4,0 | 47,3 |
| 50 | 15,9 | 12,0 | 5,9 | 37,0 | 12,1 | 9,2 | 5,5 | 46,8 |
| 100 | 43,2 | 40,0 | 32,9 | 43,5 | 36,4 | 37,9 | 35,7 | 46,3 |
| 150 | 81,1 | 84,5 | 76,2 | 46,5 | 75,2 | 81,3 | 79,4 | 46,2 |
| 175 | 88,0 | 95,1 | 91,8 | 47,6 | 97,9 | 109,7 | 108,6 | 45,0 |
| 200 | 113,2 | 121,1 | 119,0 | 48,9 | 118,0 | 130,2 | 127,8 | 43,6 |

TABLEAU 4.11 – Écarts de température mesurés pour différents courants et extraits de la figure 4.13 (Nuance B, $v_f=30 \text{ km}\cdot\text{h}^{-1}$ et $F_N=70 \text{ N}$).

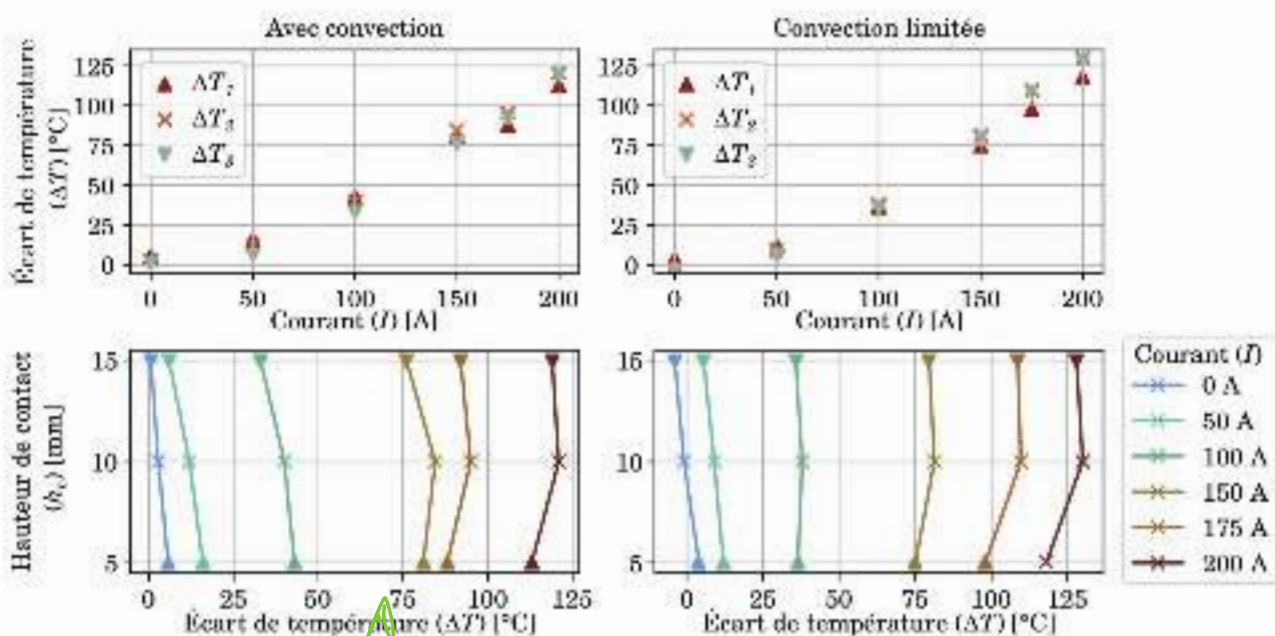


FIGURE 4.13 – Évolution de la température en fonction du courant injecté et de la hauteur des thermocouples par rapport au contact h_c (Nuance B, $v_f=30 \text{ km}\cdot\text{h}^{-1}$ et $F_N=70 \text{ N}$).

inversion ?
impossible ?