IR heating of green wood while peeling: a numerical model.

Collaboration:

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Plan:

1. The project idea
2. The model principles
3. The simulation results

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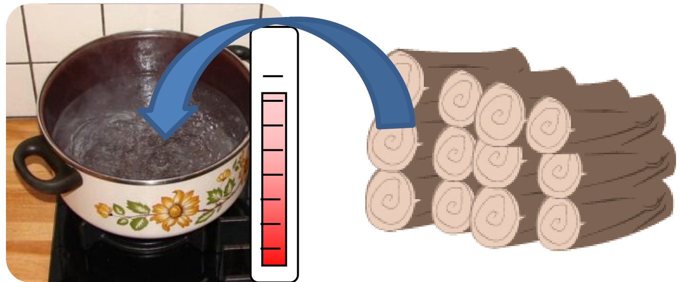
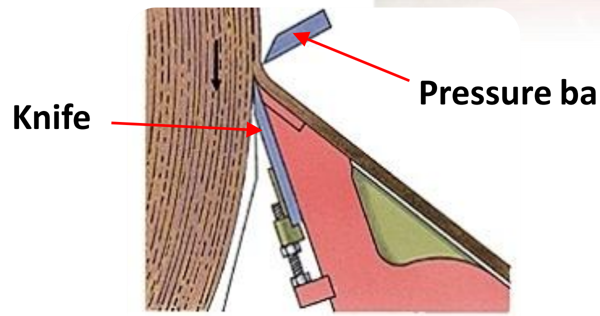
Peeling process: veneer production

Soaking

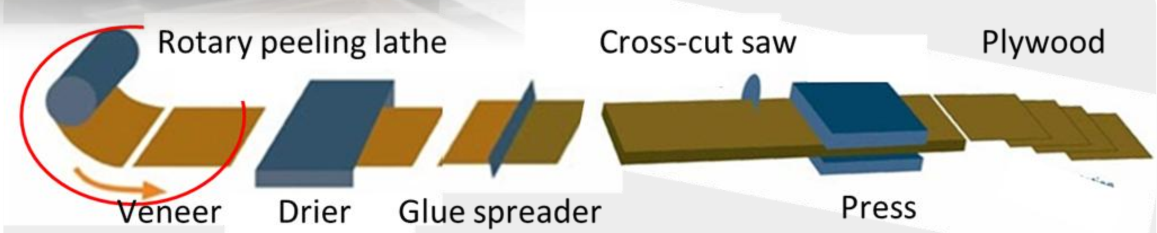


Peeling



Veneer

Plywood



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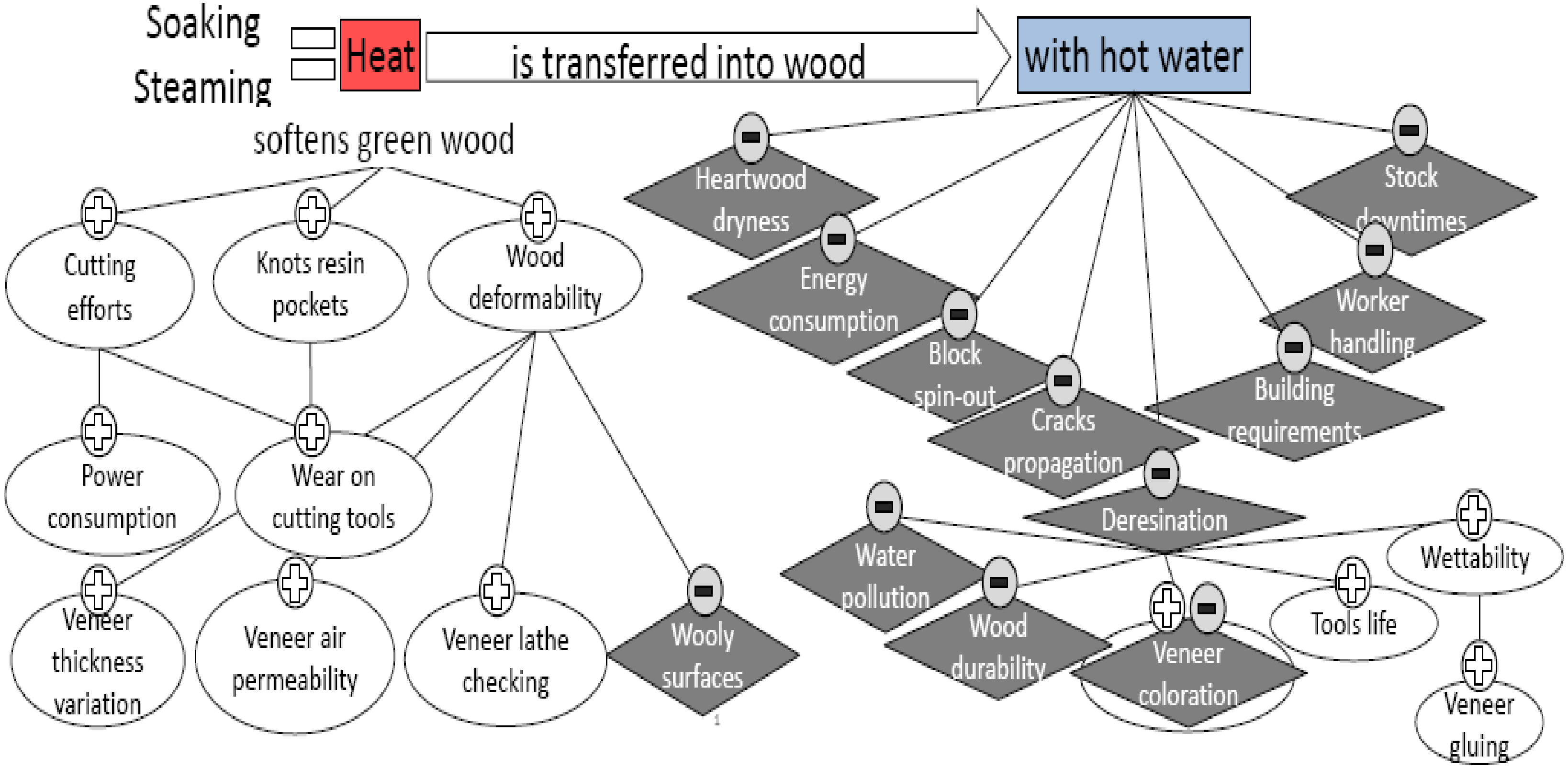
Why soaking?



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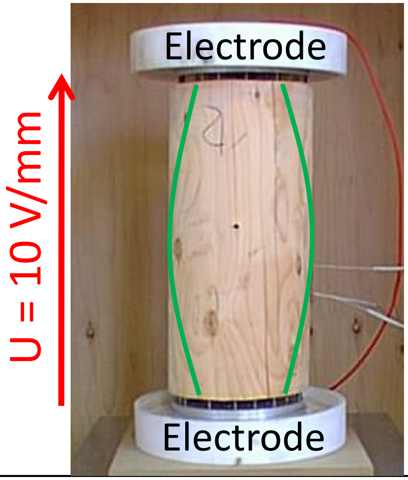
Alternative methods to heating wood prior to peeling avoiding soaking

Volume heating

Electric ohmic heating

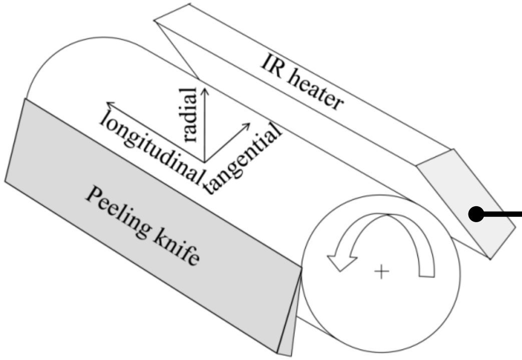


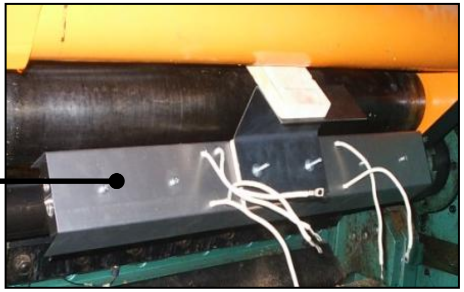
Microwave heating

Wood does not need to be cooked for a long duration nor at boiling temperatures
Cell wall has to be brought at the required medium range temperature

Surface heating

Infrared heating (IR)





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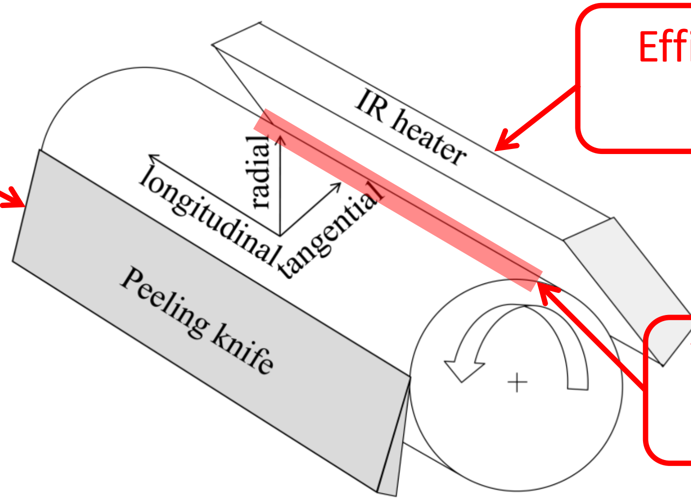
Modelling in-line IR surface heating: principle

Maximum cutting speed?

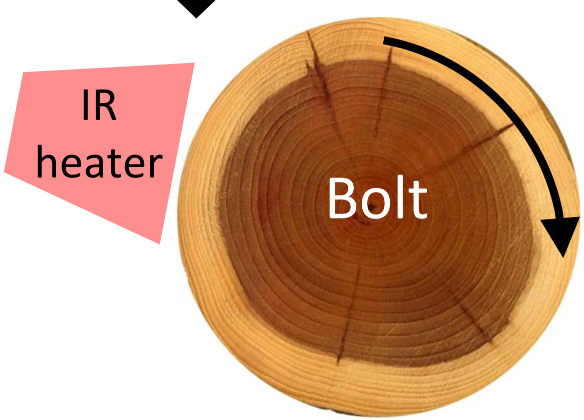


Efficient wavelengths?
Efficient power?

Without overheating bolt surface?

The answer here:

By numerical modelling of IR heating while peeling



Equations solver Comsol Multiphysics®

Procedure implemented under MatLab®

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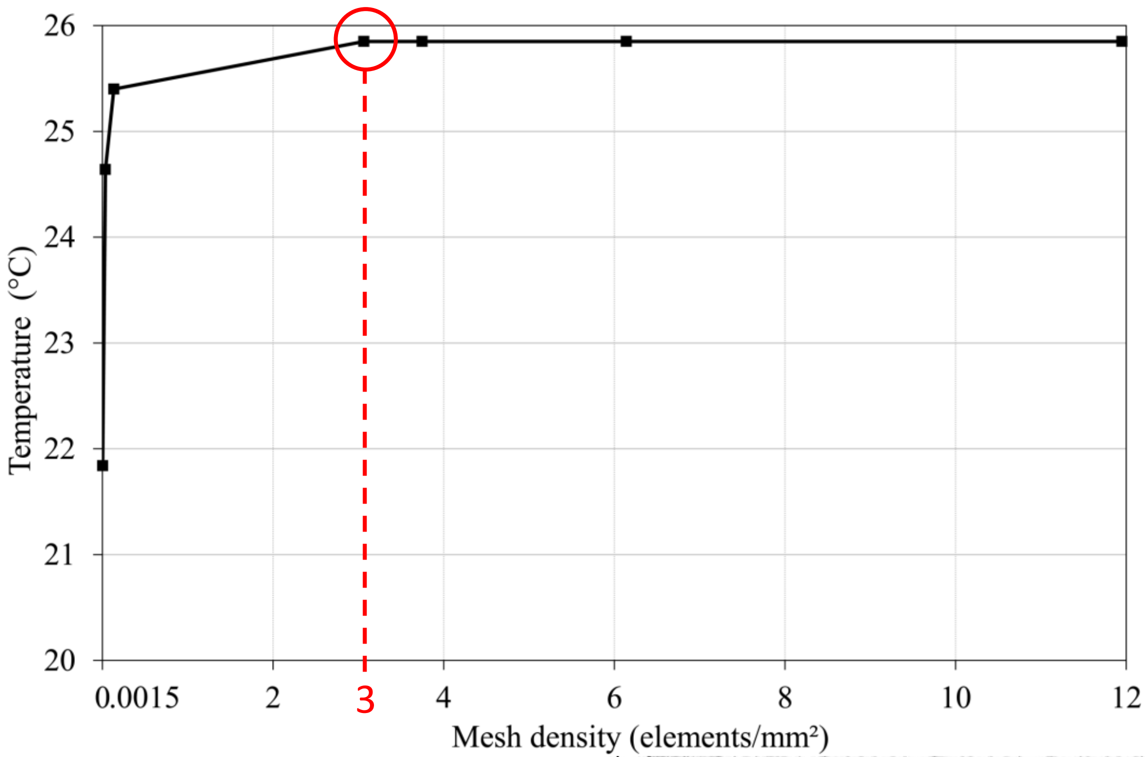
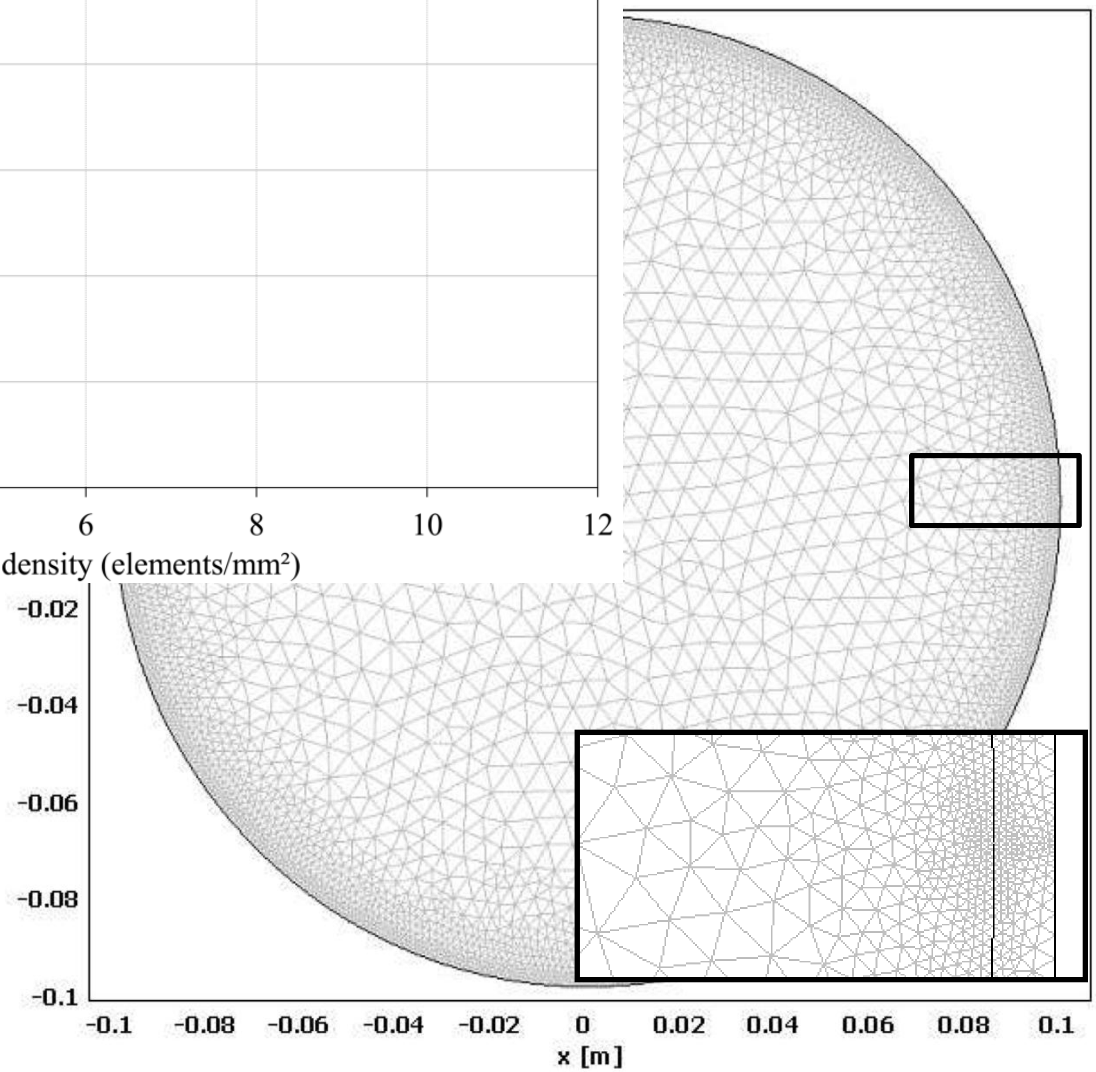
Methodology: meshing and sensitivity analysis





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Heat transfer equations

(1) $$\rho Cp \frac{\partial T}{\partial t} = \nabla (k \nabla T)$$

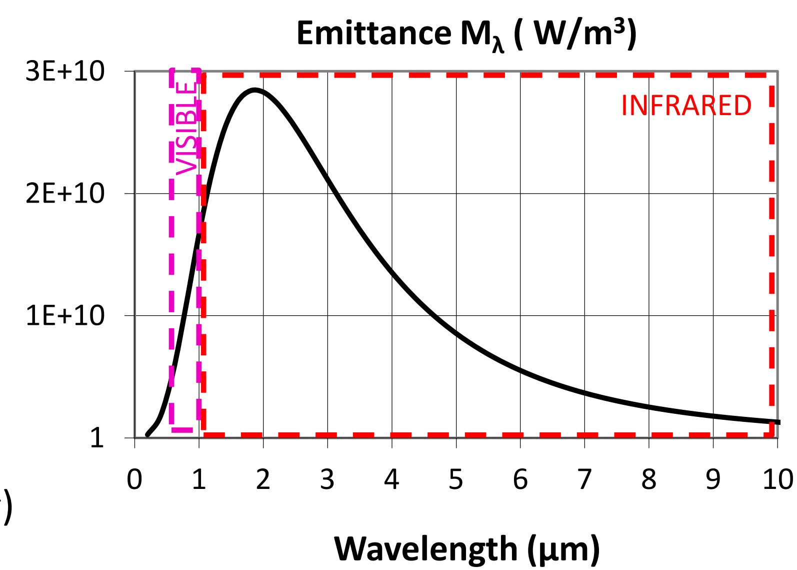
(2) $$Q_{rad} = h(T_{ext} - T) + \varepsilon\sigma(T_{ext}^4 - T^4)$$

ρ	wood density ($kg.m^{-3}$)
Cp	heat capacity of the wood ($J.kg^{-1}.K^{-1}$)
T	bolt temperature (K)
k	conductivity of wood ($W.m^{-1}.K^{-1}$)
Q_{rad}	external IR heat source
h	heat transfer coefficient ($W.m^{-2}.K^{-1}$)
T_{ext}	external IR source temperature (K)

$$M_\lambda = \frac{2\pi . c^2 . \lambda^5}{e^{\frac{h.c}{\lambda.k.T}} \quad 1}$$

Planck's law

ε	wood emissivity (no dimension)
σ	Stefan-Boltzmann constant ($W.m^{-2}.K^{-4}$)



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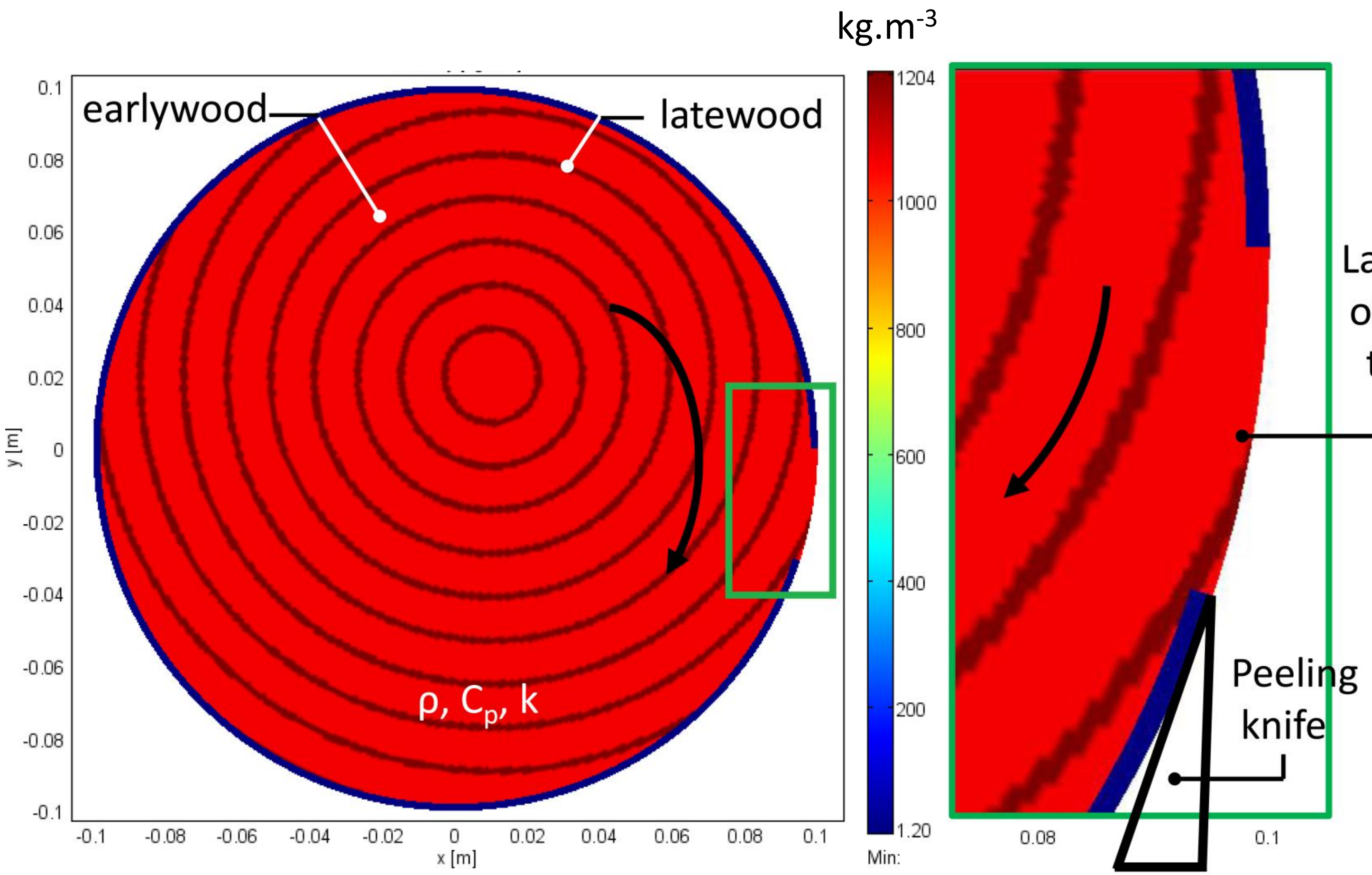
Subdomain settings



Each Finite Element is parametered with wood physical properties, taking into account natural defects (knots, rays, off-centered pith)

Continuous peeling with a circle trajectory

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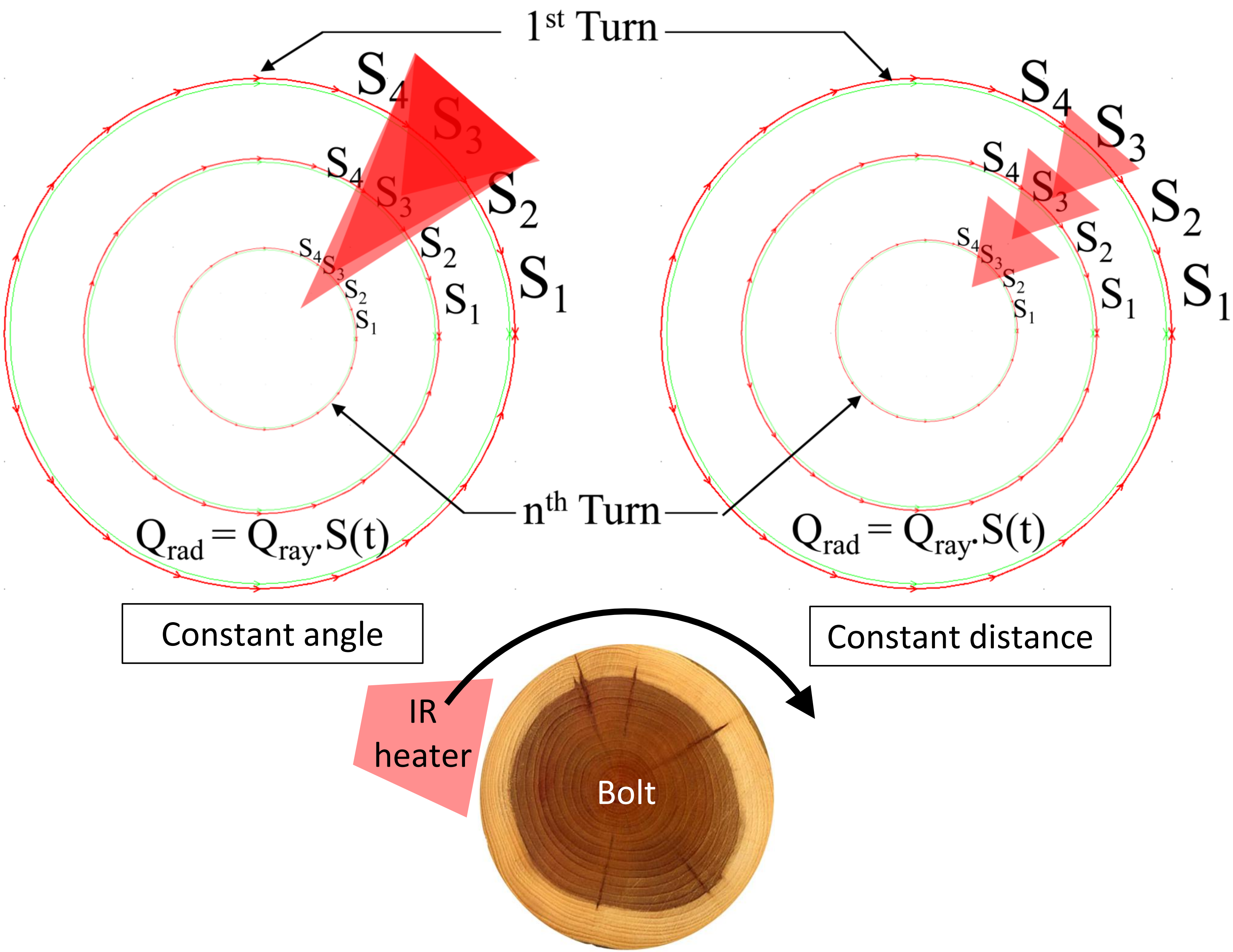
Boundary conditions



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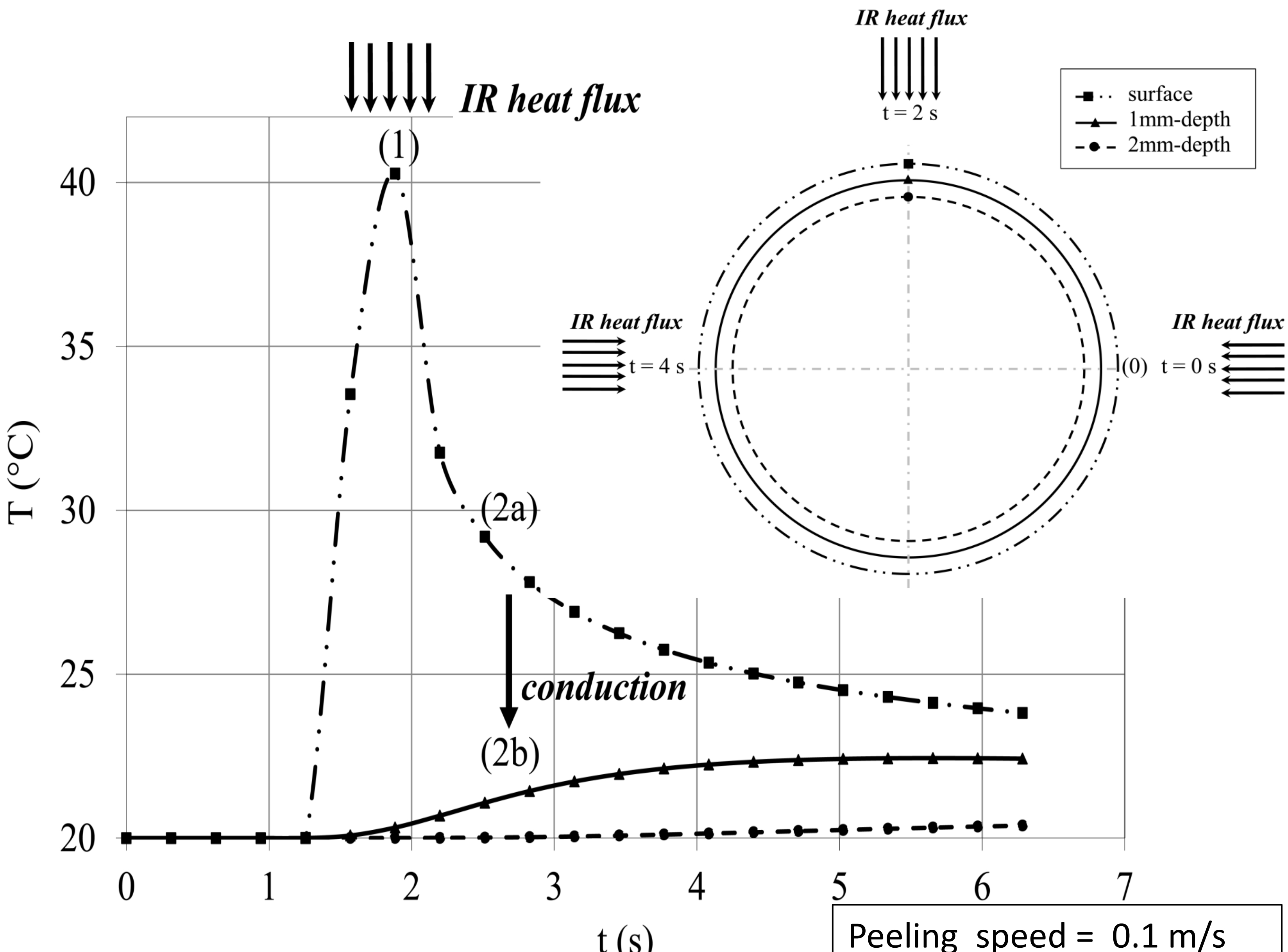
Temporal evolution of temperature within the bolt during one turn



Peeling speed = 0.1 m/s

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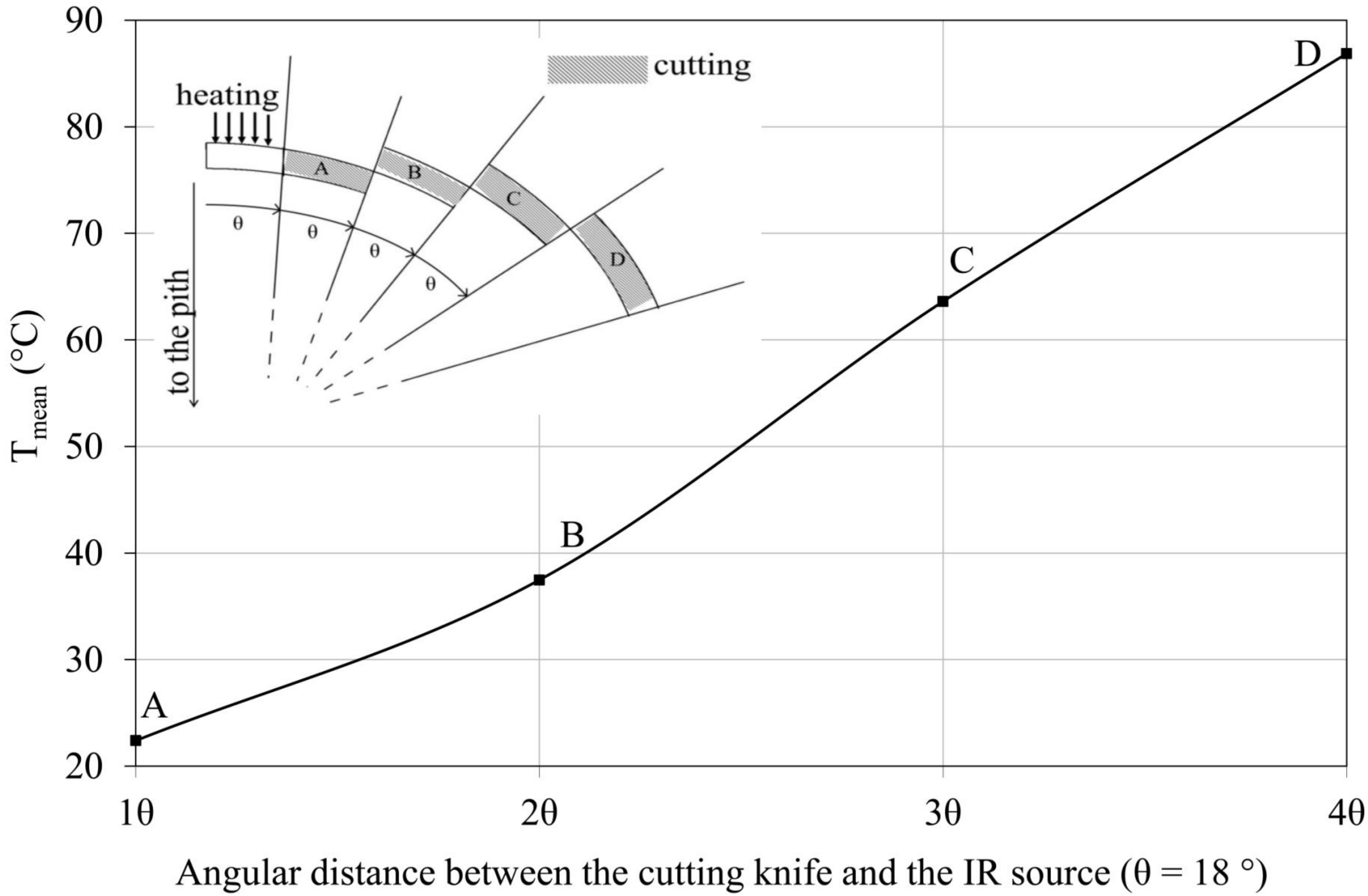
Influence of the distance between the knife and the IR source



IR source temperature T_{ext} = 2500°C
peeling speed v = 0.3 m/s

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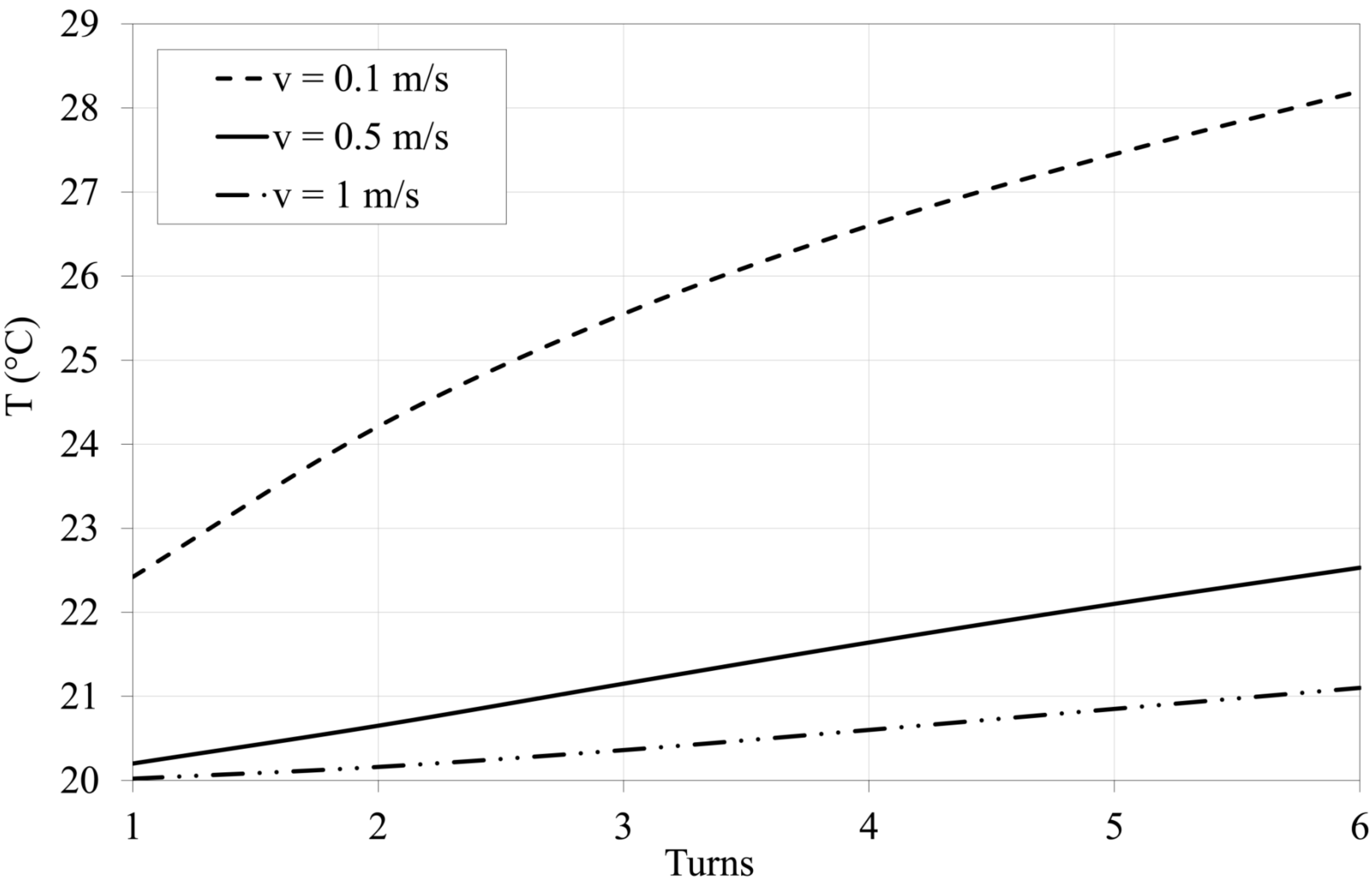
Influence of peeling speeds and peeling thickness



IR source temperature T_{ext} = 500°C
Peeling thickness **e = 1 mm**

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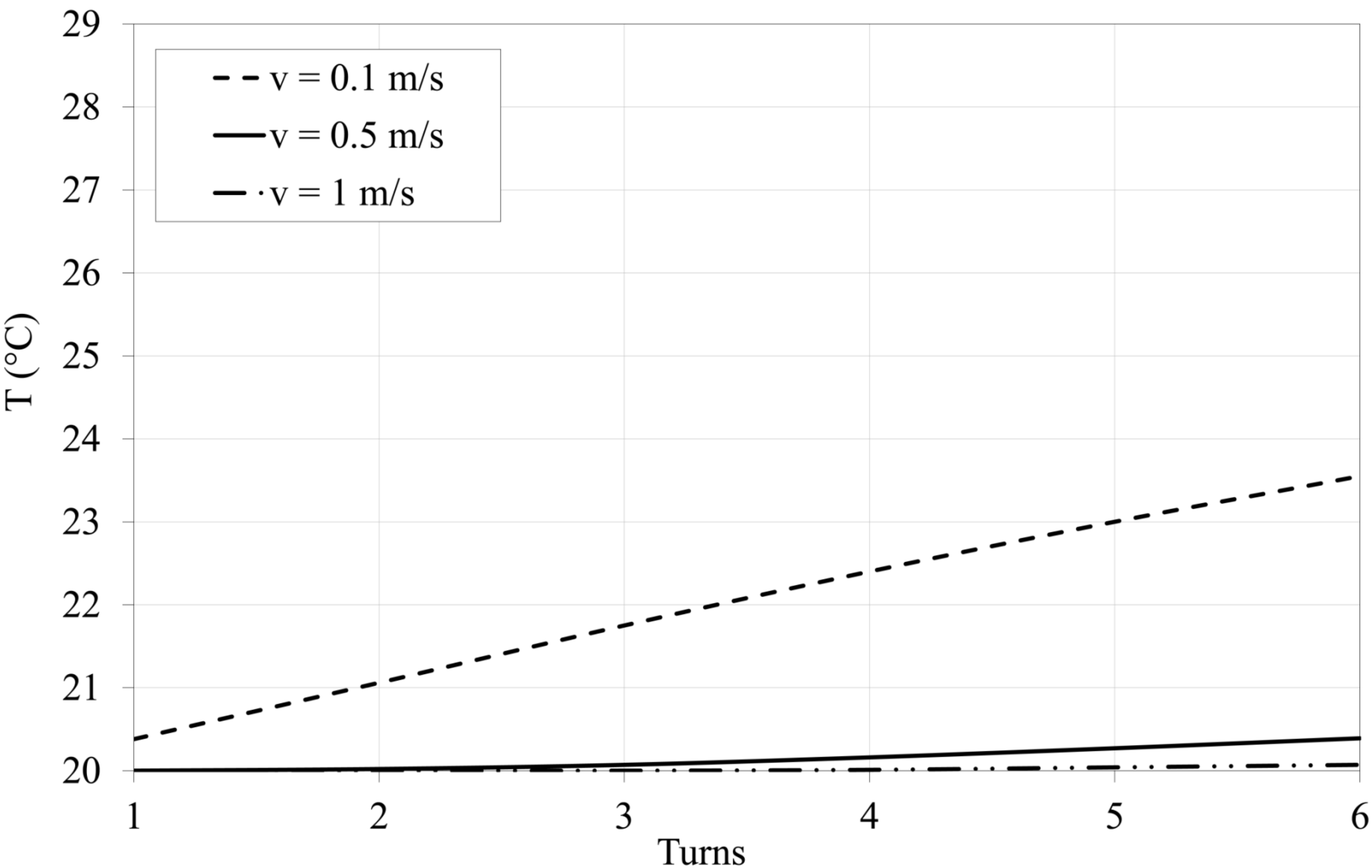
Influence of peeling speeds and peeling thickness



IR source temperature T_{ext} = 500°C
Peeling thickness **e = 2 mm**

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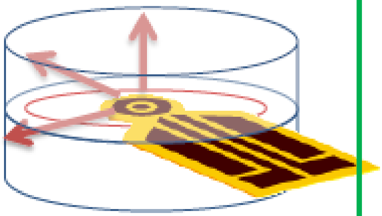
FUTURE WORK

To integrate in the model:



- green wood thermal properties : Cp, k = f(MC)
  > with transient HotDisk®method (TREFLE, Bordeaux)
  > should speed up heat penetration

- green wood optical properties : emissivity, transmittivity, absorptivity = f(λ)
  > modifying model's equations with IR volumic Beer- Lamberts absorption law(CNRS, Orléans)

(1) $\rho C_p \frac{\partial T}{\partial t} = \nabla(k \nabla T) + \beta I_0 e^{-\beta r}$ with $I_0 = \sigma T_{ext}^4$ and $\beta = \frac{4\pi\kappa}{\lambda}$

(2) $Q_{rad} = h(T_{ext} - T) - \varepsilon\sigma T^4$

> should deepen radiation penetration

To experimentally validate the model

- to establish it as an essential decision-making tool to design in-line IR heating system directly embedded on the cutting machine

CONCLUSIONS SO FAR ON THE OPTIMUM CONFIGURATION

To locate IR source as far as possible from the knife

Thank you for your attention

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