

# IR heating of green wood while peeling.

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## Collaboration:

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## Plan

1. The project idea
2. Heating temperatures
3. Modelling principles
4. Thermal characterisation results
5. Future work

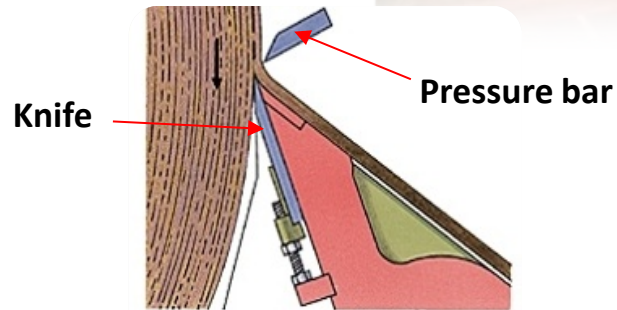
## 1.The project idea

# Peeling process: veneer production

Soaking



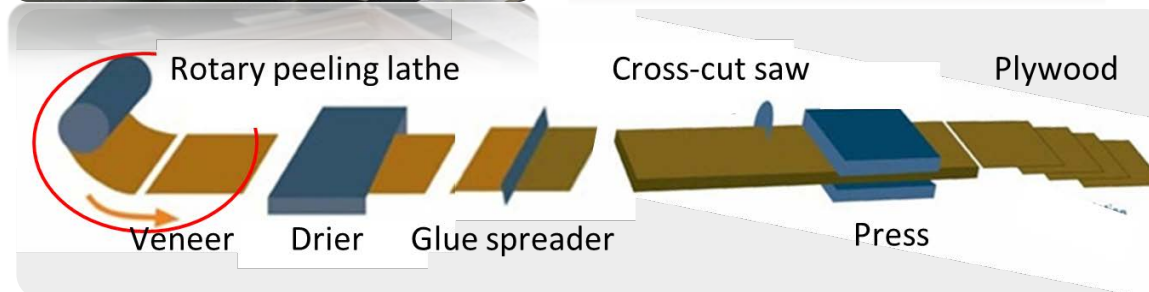
Peeling



Veneer



Plywood



Project Idea

Heating Temperatures

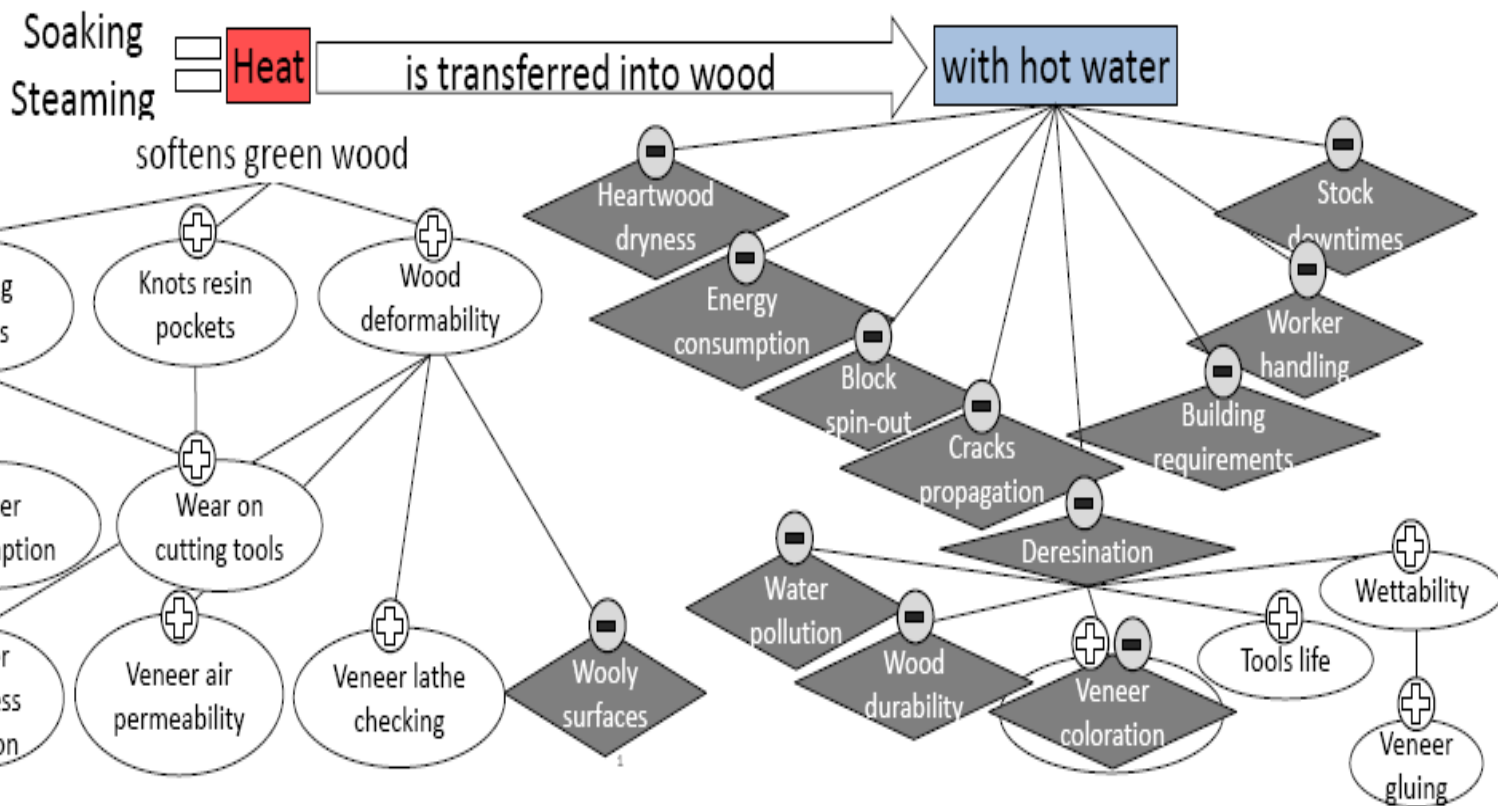
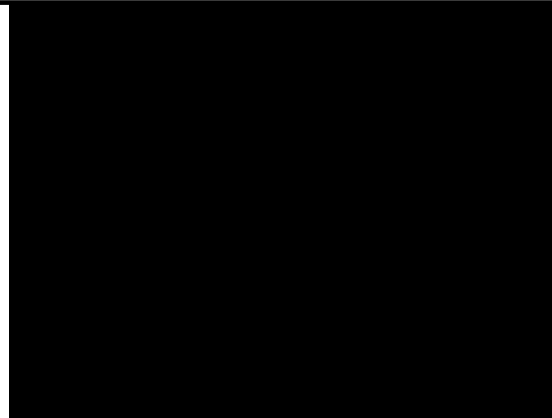
Modelling Results

Thermal Characterisation

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# Why soaking?



# Alternative methods to heating wood prior to peeling avoiding soaking



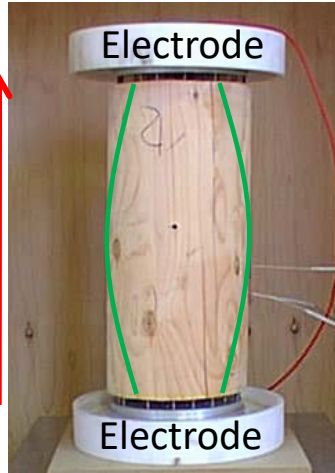
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Volume heating

Electric ohmic heating

Microwave heating

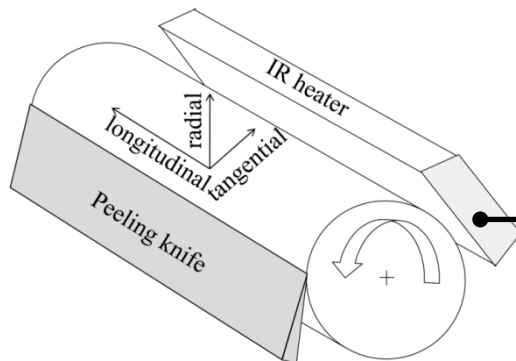
$U = 10 \text{ V/mm}$



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)



Infrared heater



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Project Idea

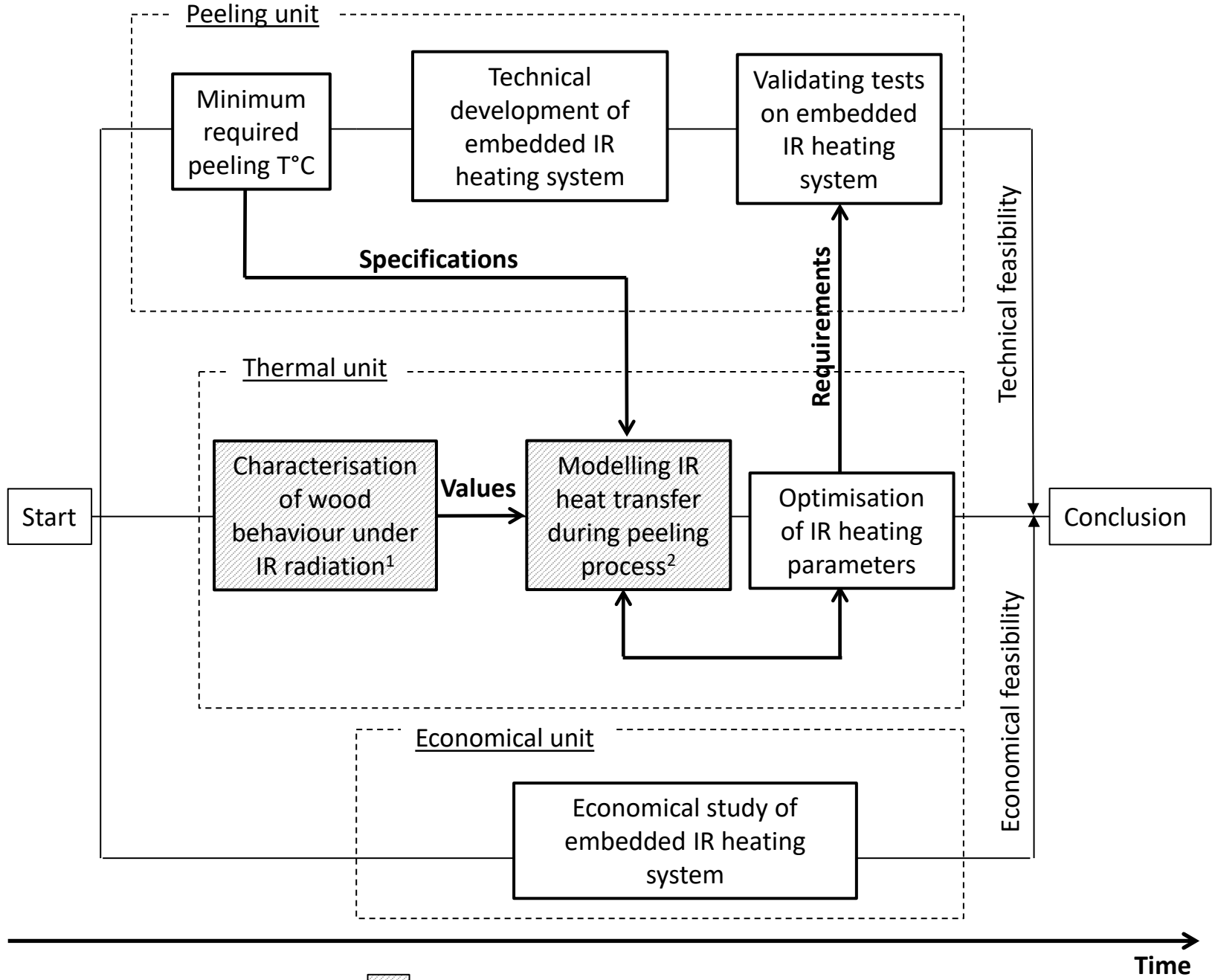
Heating Temperatures


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 Work in collaboration with : <sup>1</sup>Post-doc S. Ould Ahmedou  
<sup>2</sup>Master thesis G. Belluche

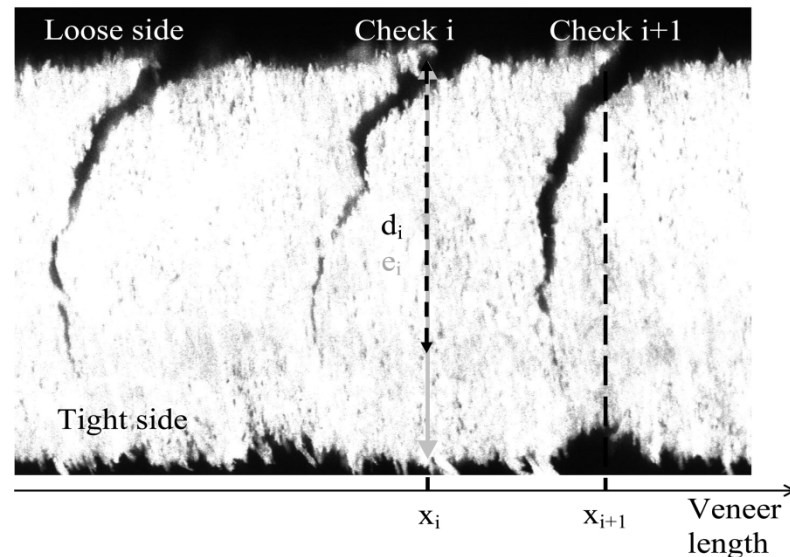
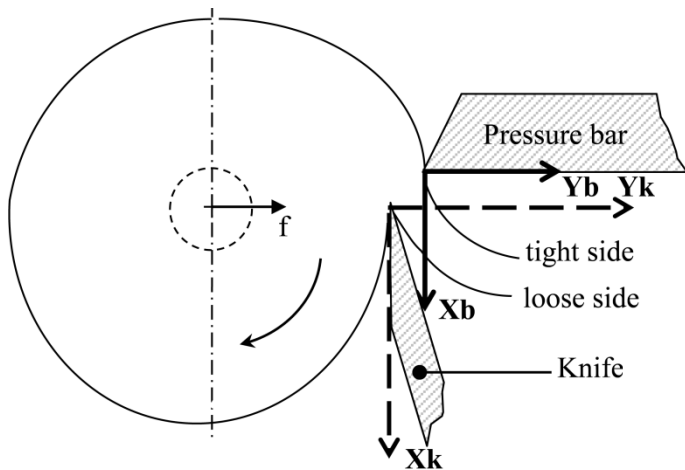
## 2. Heating Temperatures



# Results summary



- No interest in heating up to 70°C
- With heating temperatures:
  - Cutting efforts start to decrease
  - Lathe checkings are less deep and closer
  - Minor thickness variation
- Already at 50°C, positive effects of heating ensure efficient peeling process.



- Project Idea
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- Modelling Results
- Thermal Characterisation
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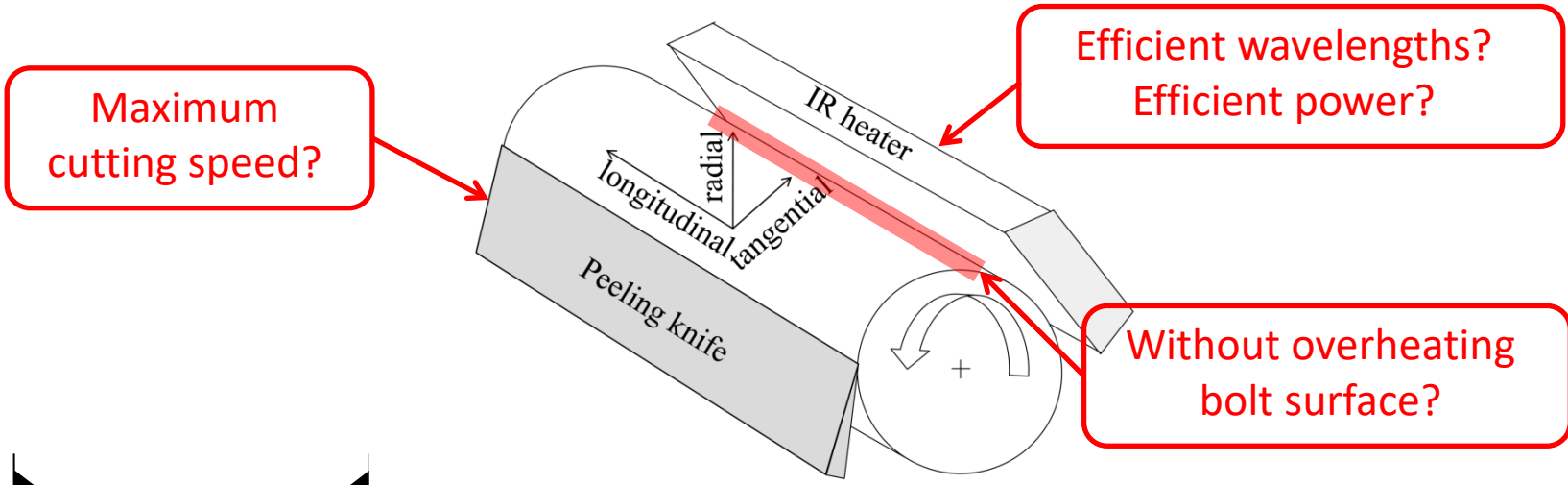


## 3. Modelling results

# Modelling in-line IR surface heating: principle

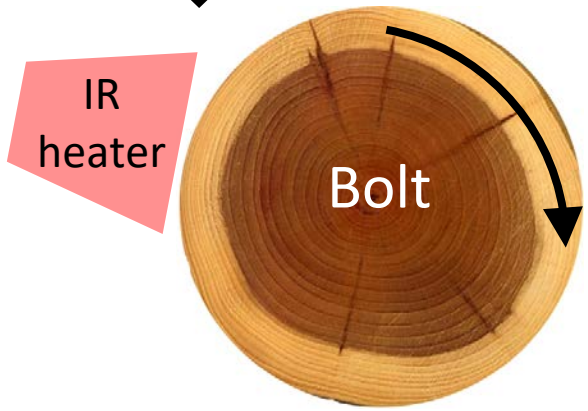


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**The answer here:**

By numerical modelling of IR heating while peeling



Equations solver Comsol Multiphysics®  
Procedure implemented under MatLab®

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- Heating Temperatures
- Modelling Results
- Thermal Characterisation
- Future Work

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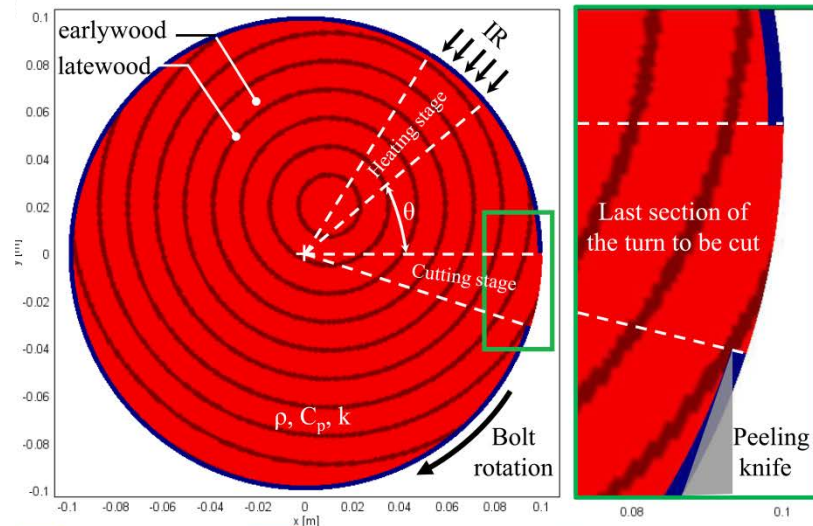
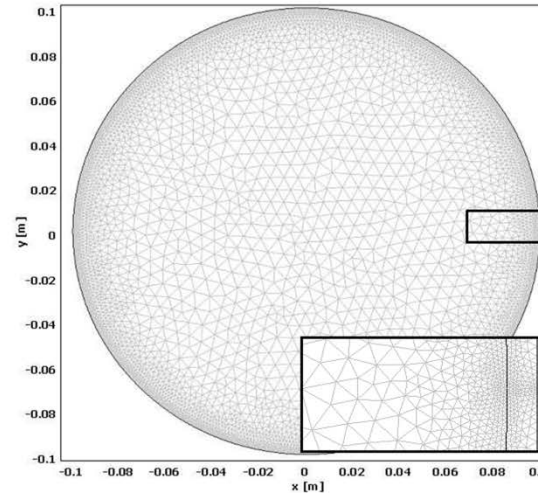
# Methodology: meshing and equations



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

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



1.2 kg/m<sup>3</sup> (air)    900 kg/m<sup>3</sup> (earlywood)    1200 kg/m<sup>3</sup> (latewood)

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- ρ wood density (kg.m<sup>-3</sup>)
- Cp heat capacity of the wood (J.kg<sup>-1</sup>.K<sup>-1</sup>)
- T bolt temperature (K)
- k conductivity of wood (W.m<sup>-1</sup>.K<sup>-1</sup>)
- Q<sub>rad</sub> external IR heat source
- h heat transfer coefficient (W.m<sup>-2</sup>.K<sup>-1</sup>)
- T<sub>ext</sub> external IR source temperature (K)

# Simulation results



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Project Idea

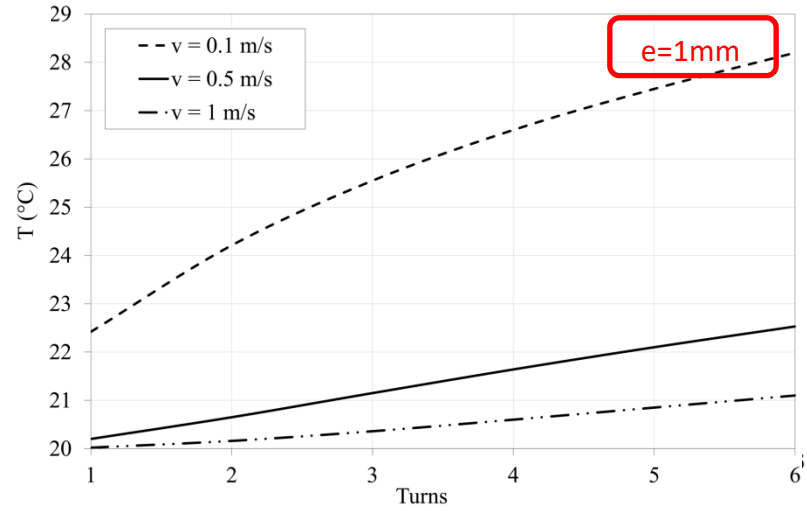
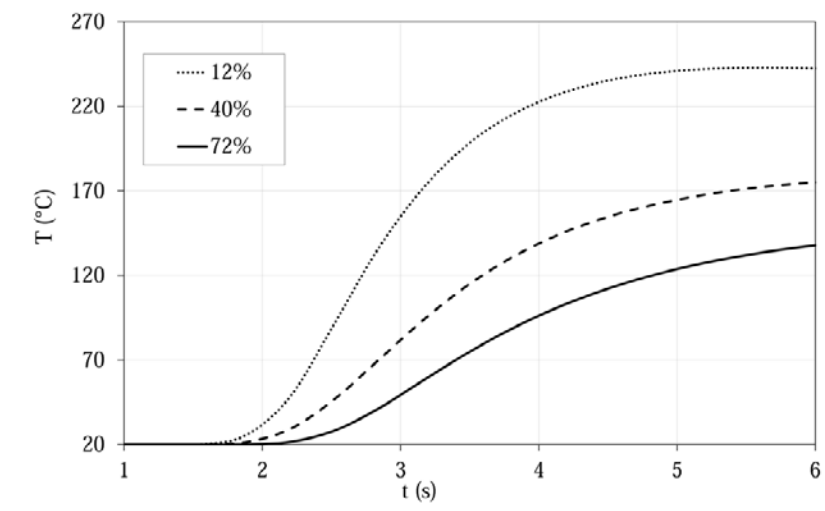
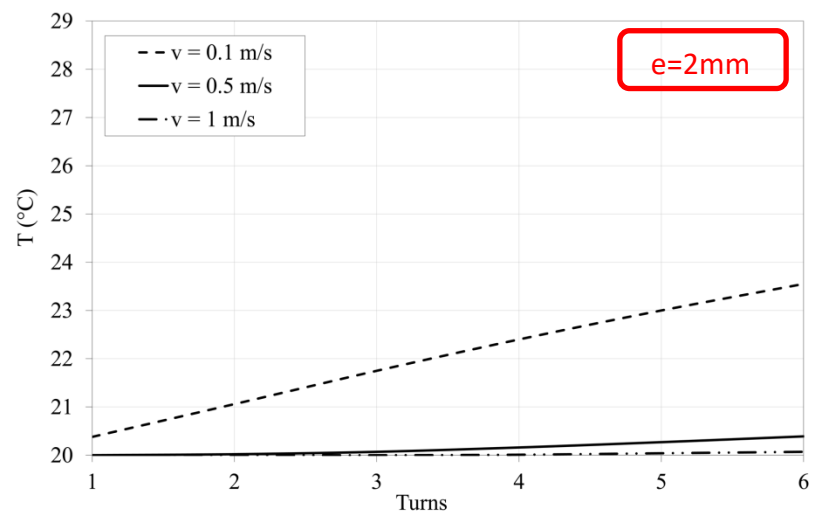
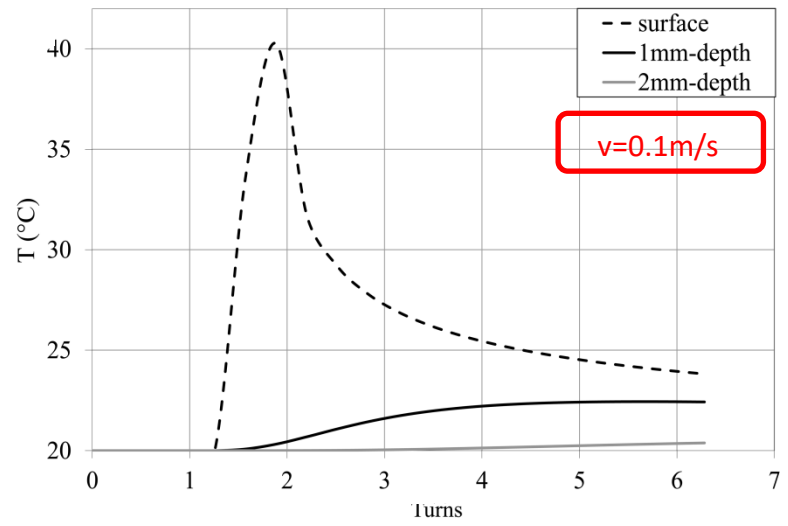
Heating Temperatures

Modelling Results

Thermal Characterisation

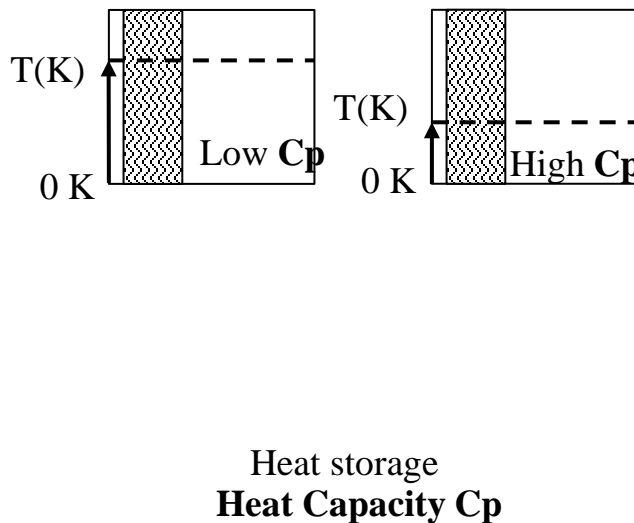
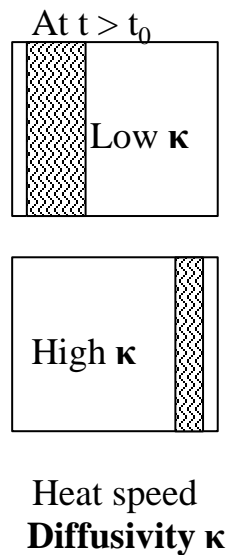
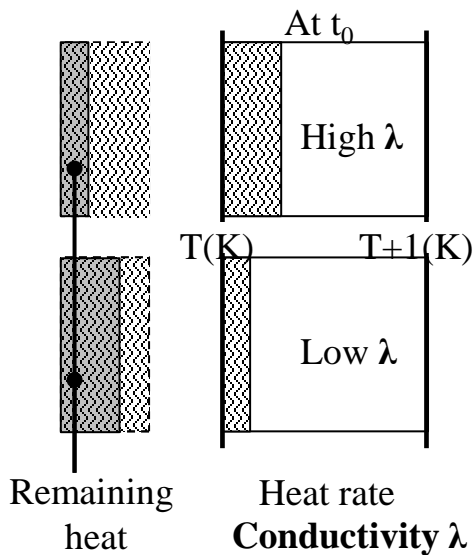
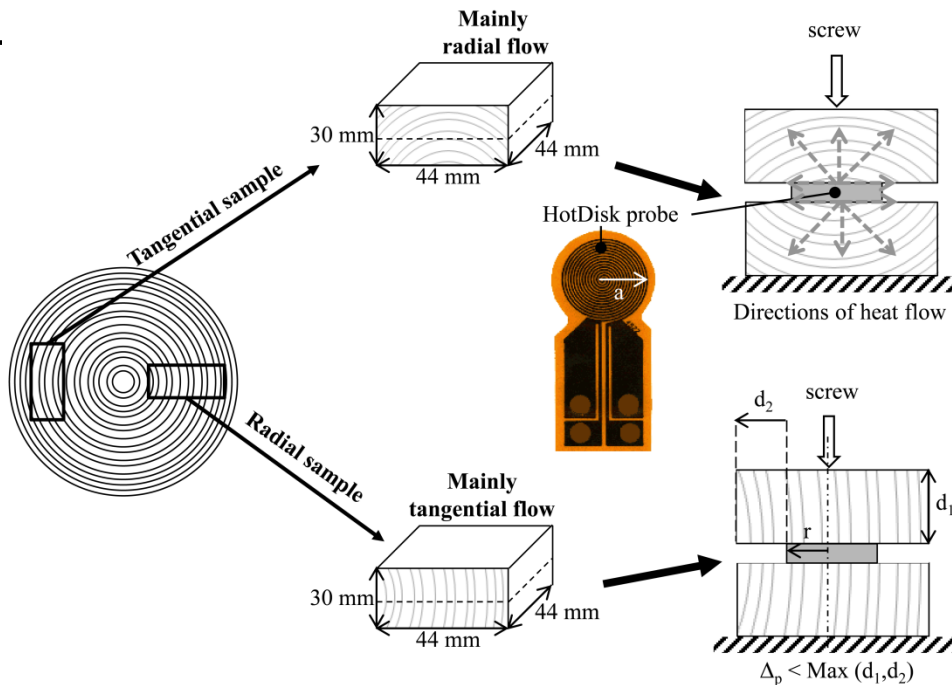
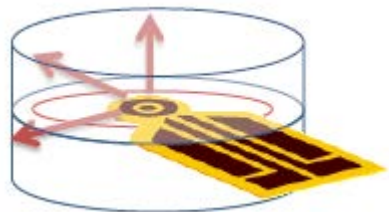
Future Work

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## 3. Thermal characterisation

# The transient HotDisk method



Project Idea

Heating Temperatures

Modelling Results

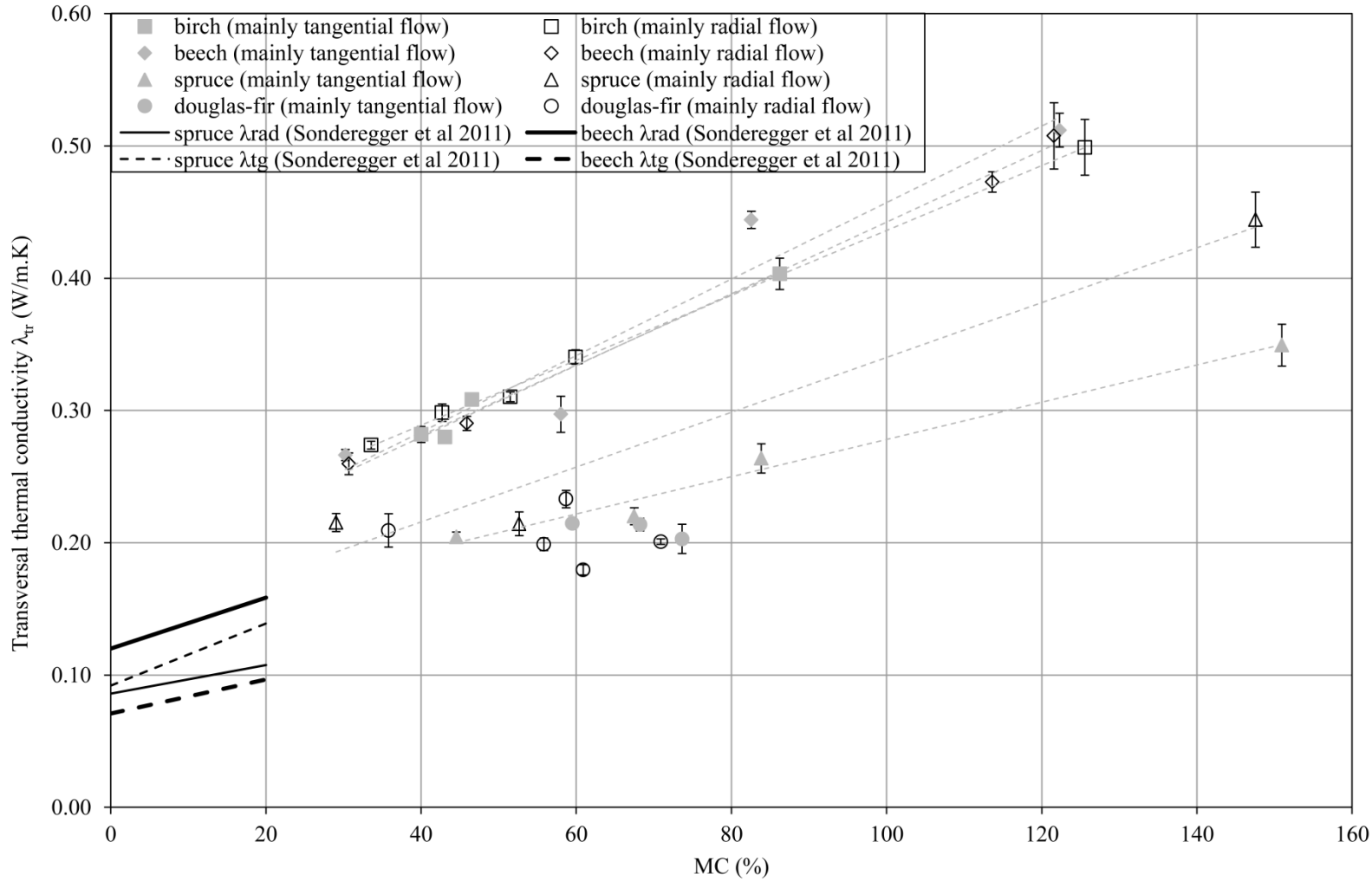
Thermal Characterisation

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# Transversal conductivity



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Heating Temperatures

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Thermal Characterisation

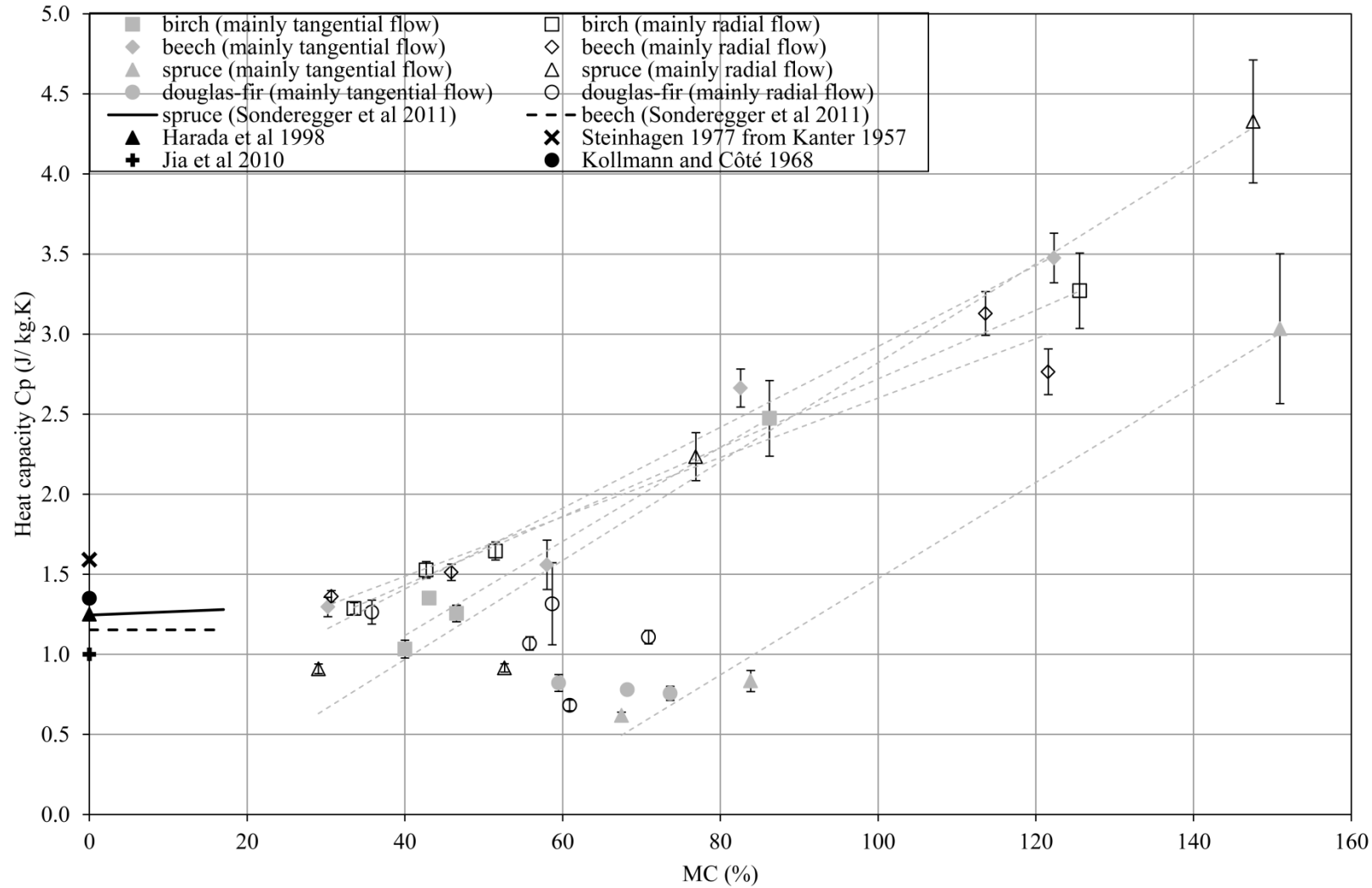
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# Heat capacity



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Project Idea

Heating Temperatures

Modelling Results

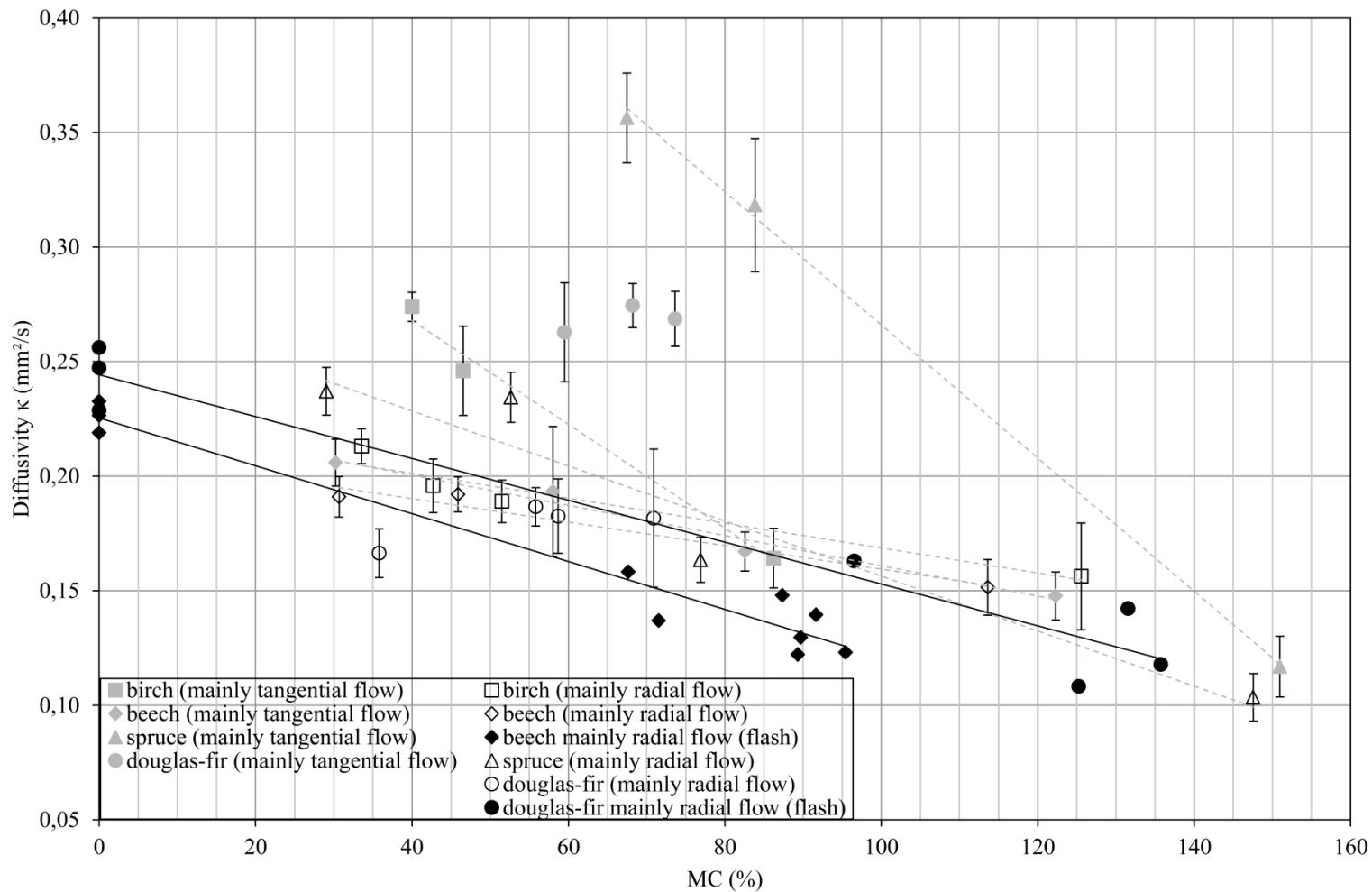
Thermal Characterisation

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# Diffusivity



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Modelling Results

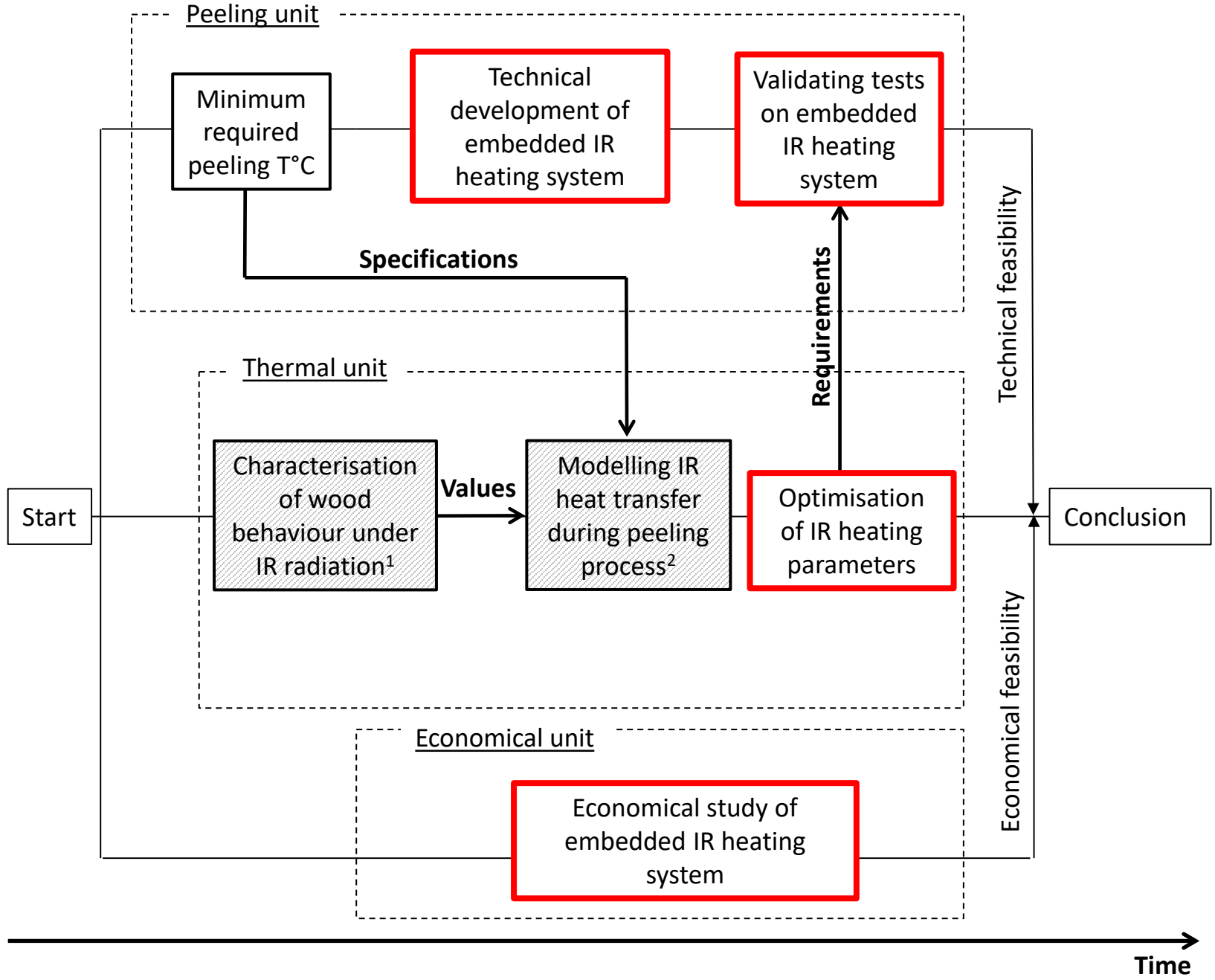
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## 4. Future Work



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Heating Temperatures

Modelling Results

Thermal Characterisation

Future Work

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Time

## FUTURE WORK

### To integrate in the model:

- green wood thermal properties :  $C_p$ ,  $k = f(MC)$ 
  - > with transient HotDisk® method (TREFLE, Bordeaux)
  - > should speed up heat penetration
- green wood optical properties : emissivity, transmittivity, absorptivity =  $f(\lambda)$ 
  - > modifying model's equations with IR volumic Beer- Lamberts absorption law (CNRS, Orléans)



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

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

> 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

### To study the economical feasibility of the project

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Project Idea

Heating  
Temperatures

Modelling  
Results

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Characterisation

Future Work

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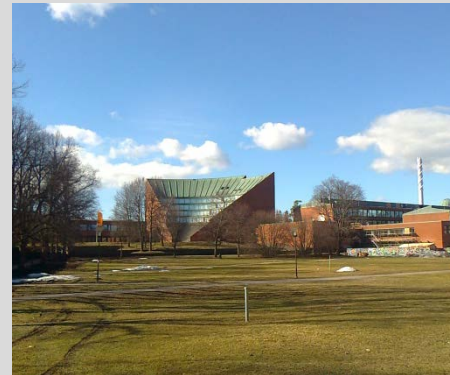
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Thank you for your attention



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