

Is it necessary to perform a controlled cooling phase at the end of a conventional kiln drying process?

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Background

- **A conventional wood drying process performed in a batch kiln chamber, normally includes a controlled cooling phase**
 - **EMC is equal to the desired MC in the wood**
 - **Duration of 5-8 hours**
 - **The dry bulb temperature in the kiln is about 40 °C at the end**
- **Traditional arguments**
 - **Avoid undesired drying of the outer layer**
 - **Possible risk for cracks/micro cracks to form in the wood surface**
 - **Possible risk for new development of casehardening**
 - **Contribute to reduce the variation in MC**
- **It is, however, more and more important to reduce the drying costs**
 - **Is it possible to cut the controlled cooling phase?**
- **The aim of this investigation is therefore to**
 - **detect possible consequences of the drying stresses that can occur in the outer layer of sawn timber in cooling phases performed in various ways.**
 - **development of casehardening**
 - **possible cracks/micro cracks were**

Test material

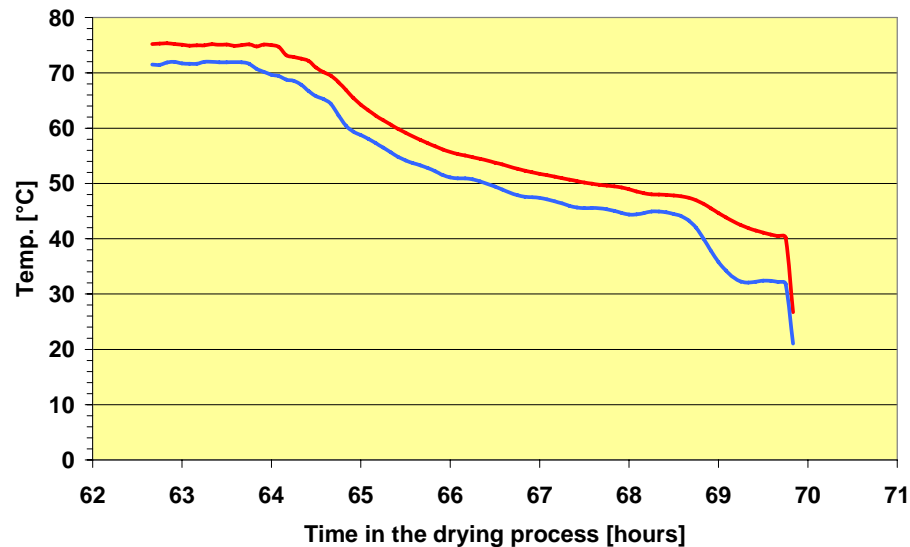
- **Norway spruce (*Picea abies*)**
- **Dimension 44 mm x 150 mm**
- **5 main planks with**
- **Cut into test pieces with a length of 1 m**
- **3 test runs are performed**
- **In each kiln run, one test piece from each main plank was used, i.e. five test pieces in each run**
- **2 test runs will be performed further**

Kiln drying

- **Laboratory kiln at Norsk Treteknisk Institutt**
- **Constant dry bulb temperature of 75 °C**
- **Decreasing wet bulb temperature**
- **Equalising phase of 24 hours**
- **Target MC in the three runs was**
 - 16 %
 - 14 %
 - 12 %

Cooling phase *Type 1*

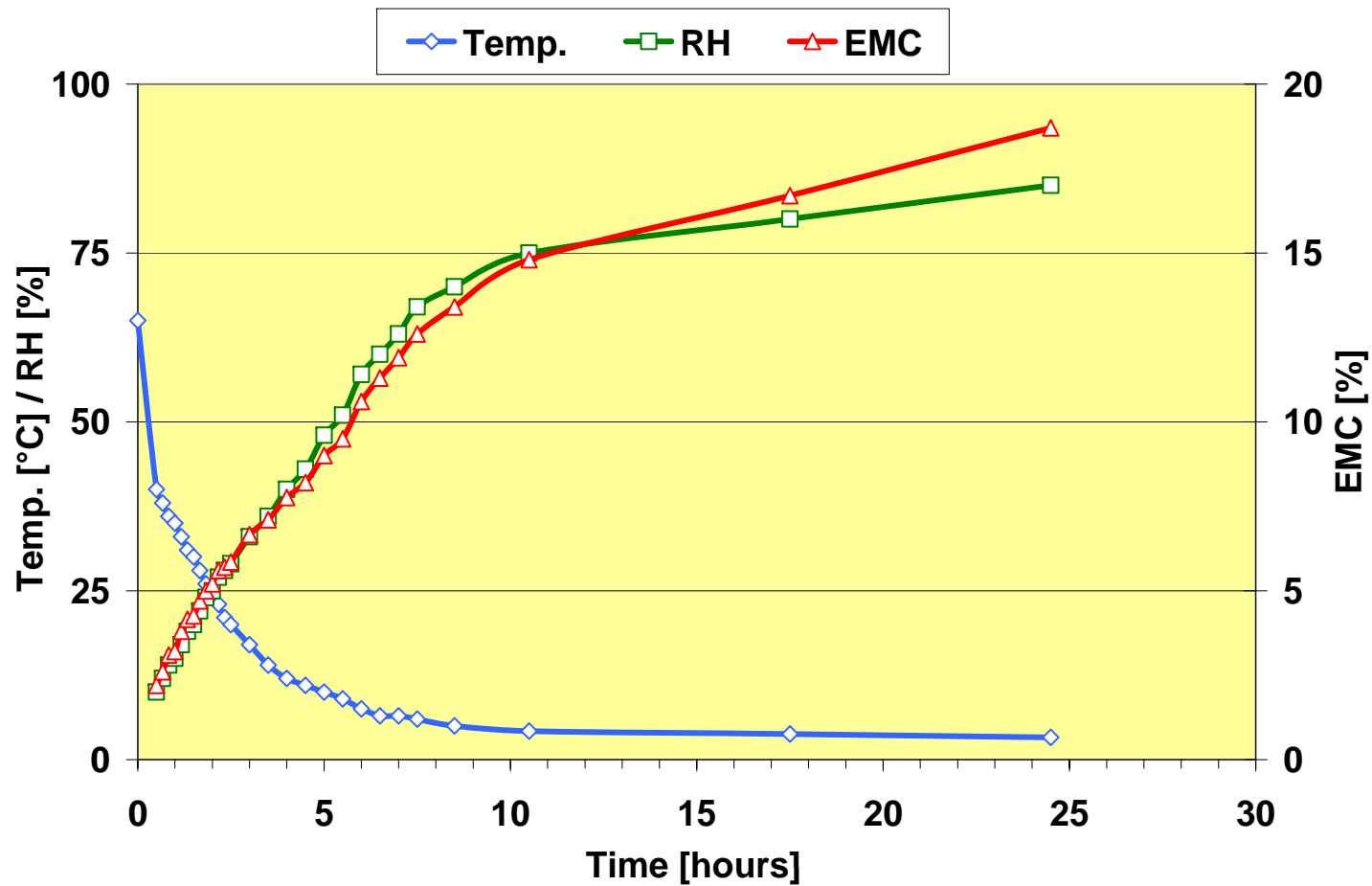
- **Traditional cooling phase in the kiln, down to about 40 °C.**
- **EMC that corresponds to the target MC**
- **After the controlled cooling phase, the test pieces were exposed to outdoor climate (temp.: 0-4 °C, RH: 75-90 %)**



Cooling phase *Type 2*

- **Conditions comparable to what is the situation in the middle of a package that is coming out into cold climate directly from the drying/equalising phase in the kiln**
- **Temperature and RH were measured in a timber package at a sawmill**
 - **Drying temperature of 70 °C**
 - **The timber was taken directly out into the cold climate without any cooling phase in the kiln**

Type 2 - climate in the middle of a package during cooling



Type 2

- **The sawn timber in the middle of the package is exposed to climatic conditions which will give a drying potential for several hours**
- **The length of this period will also depend on the wind conditions**
- **The sawn timber in the outer layer in the package will be exposed to the normal outdoor climate the whole time**
- **It will be a gradual change from these two conditions from the outer to the inner layer in the sawn timber packages**
- **In the experiments, a climate chamber was used to attain the climate shown in the figure**

Cooling phase *Type 3*

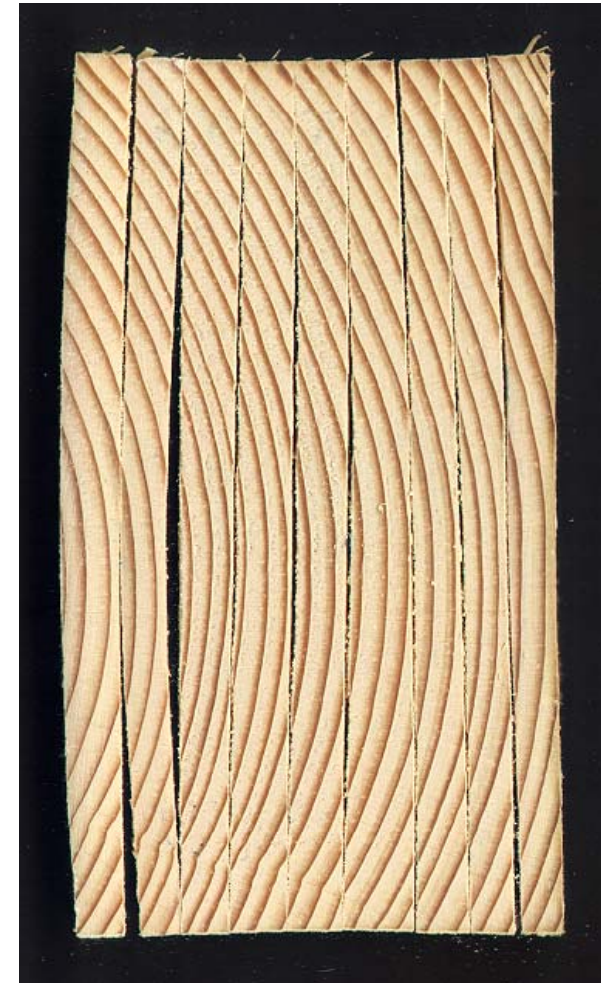
- **Directly into a freezer at -18 °C after the drying and equalising phase in the kiln**
- **This represents timber in the outer layer of sawn timber packages that are taken directly out into very cold climate, without any cooling phase in the kiln**

Cooling phase *Type 4*

- **Directly to outdoor climate**
- **The climate during the test days varied from 0-4 °C, and RH of 75-90 %**
- **This represents timber in the outer layer of sawn timber packages that are taken directly out into outdoor climate, without any extreme coldness, and without any cooling phase in the kiln**

Measurement of MC and casehardening

- **Casehardening**
 - **Two-cleave-method**
- **MC**
 - **Oven dry method**
- **Test piece cleaved into nine lamellae**
 - **MC gradient**
 - **Possible casehardening development**

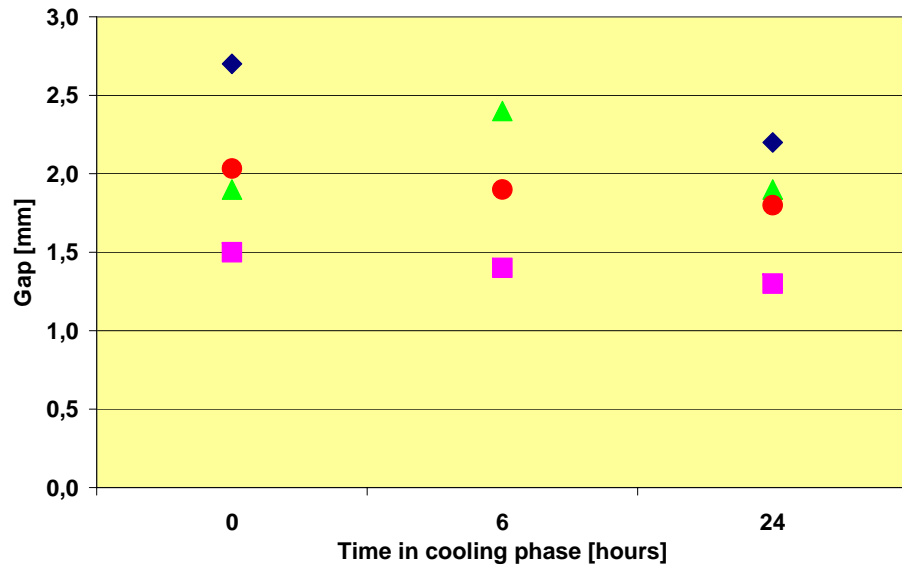


Detection of possible microcracks

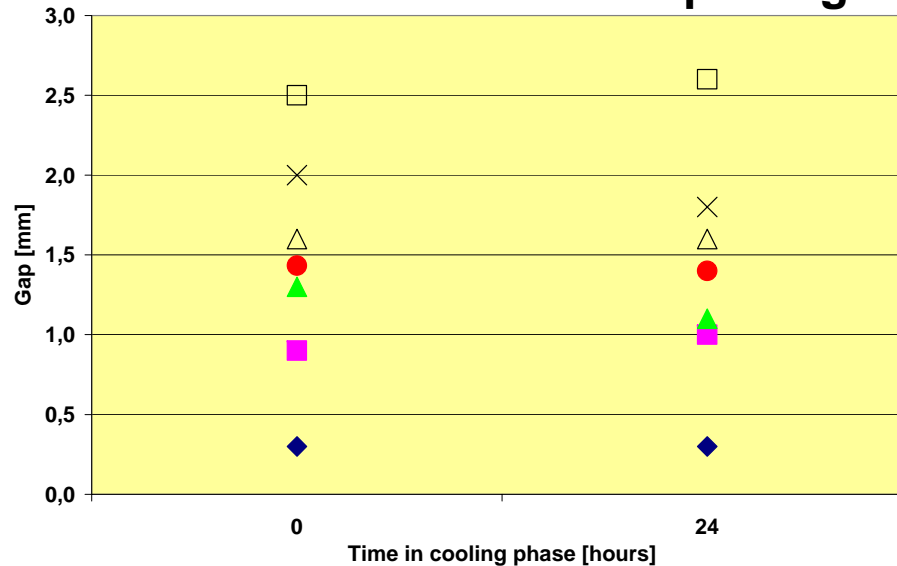
- **Macroscopic and microscopic methods**
- **A blue contrast fluid was introduced to the surface of the test pieces**
- **Layers of 0.5-1.0 mm were gradually removed from the surface by sanding, to see if some kind of micro cracks occurred**



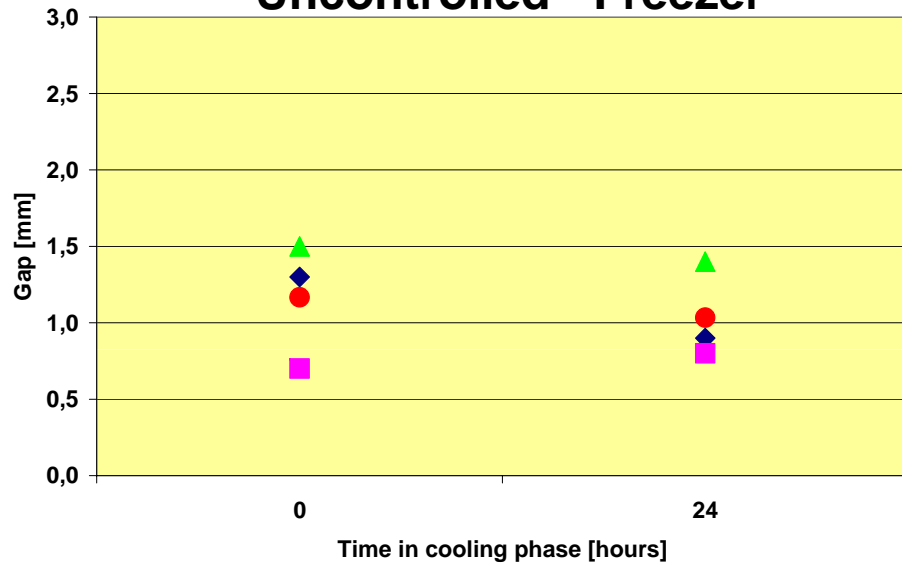
Controlled



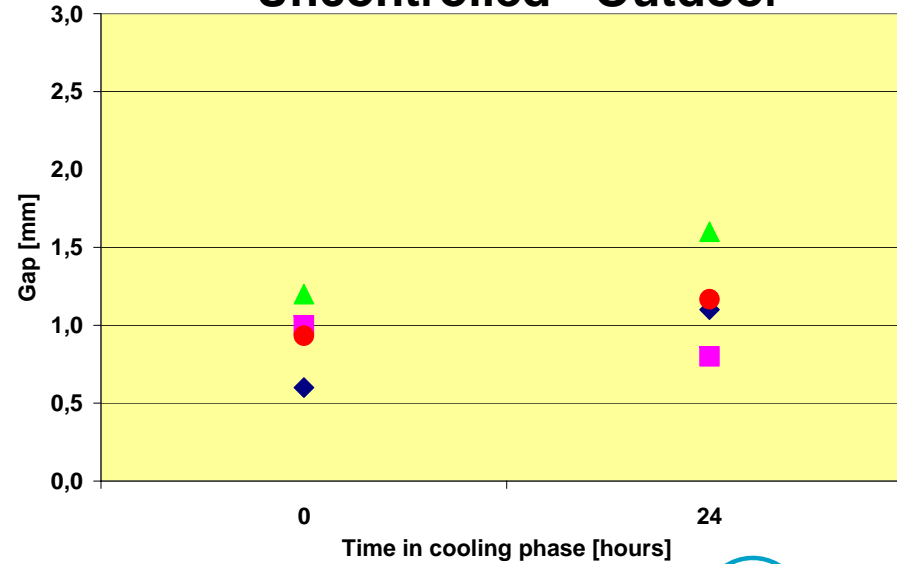
Uncontrolled – "In" the package



Uncontrolled - Freezer



Uncontrolled - Outdoor

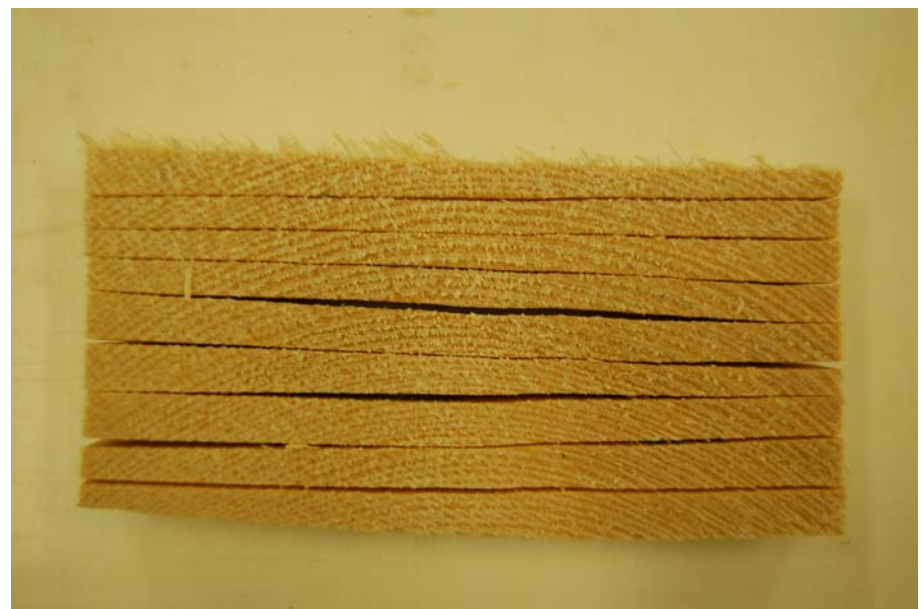
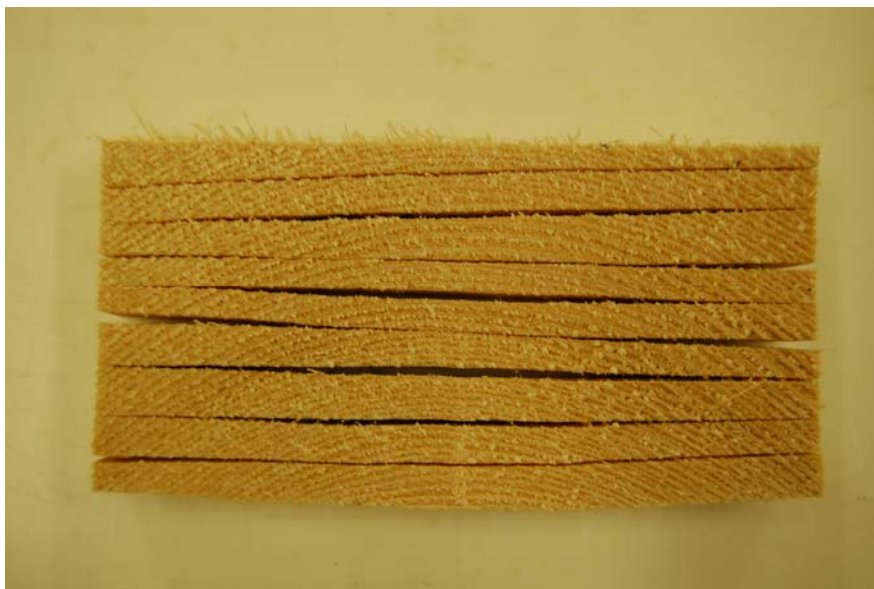


Results - Casehardening

- **The casehardening level during the cooling phases is quite stable for all the treatments**
- **None of the cooling phases differs from the other ones in a significant way concerning casehardening level.**

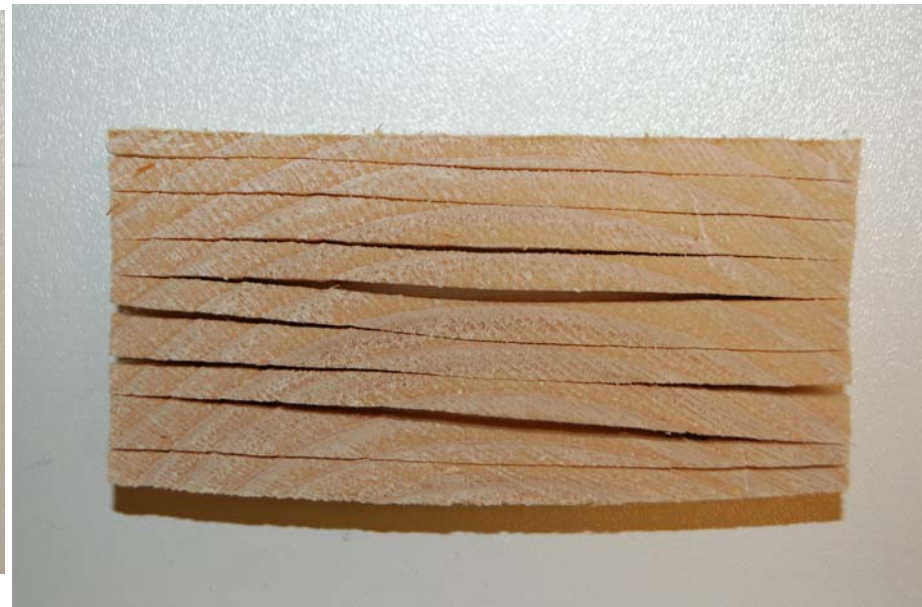
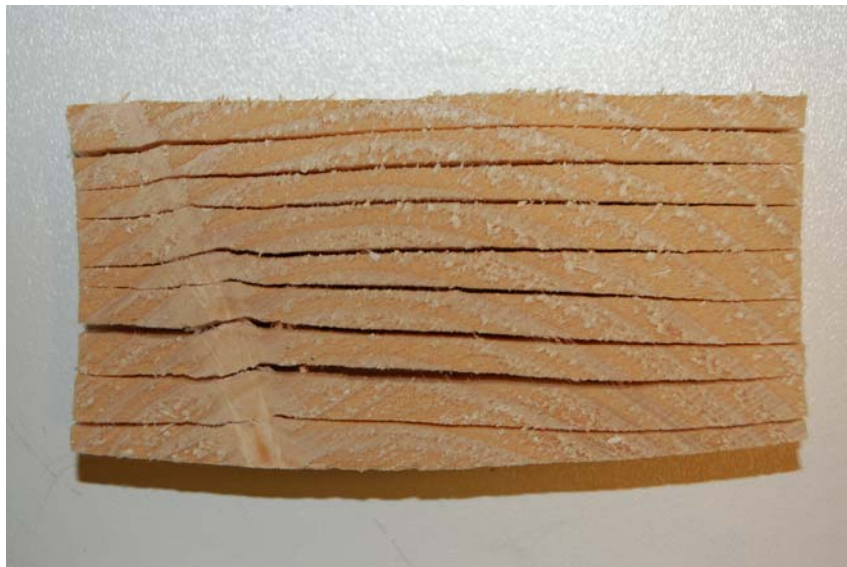
Run 1

Uncontrolled - "In" the package



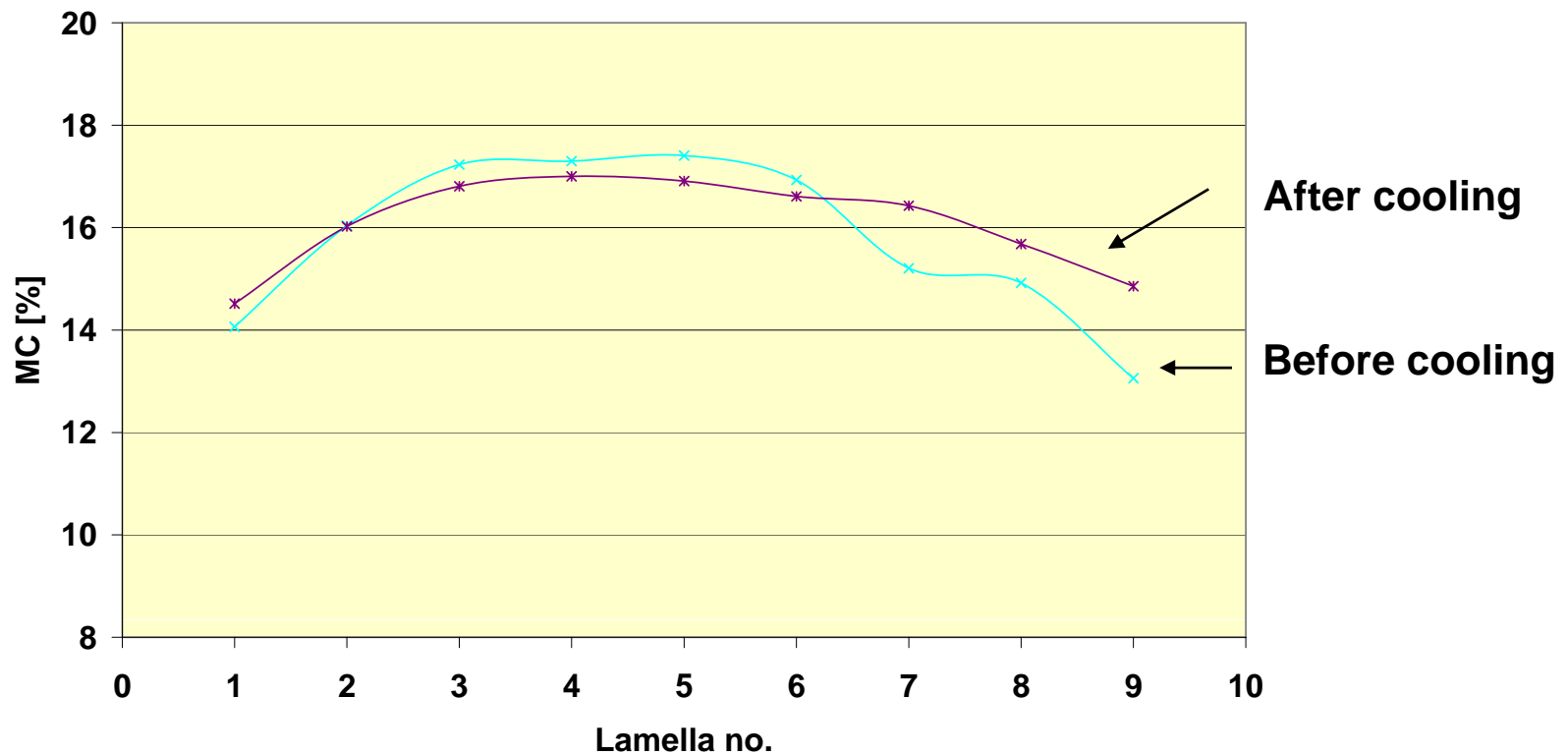
Run 2

Uncontrolled - "In" the package



Run 2

Uncontrolled - "In" the package



Results - Microcracks

- **It has not been possible to detect micro cracks in the test pieces**
- **Bigger cracks have not occurred either**

Conclusions

- **The casehardening level during the cooling phases is quite stable for all the treatments**
- **No cracks or micro cracks occurred**
- **Reservations must be taken concerning this conclusion**
 - **Only Norway spruce is included, and limited number of observations in the tests**
 - **Two more kiln runs will be performed in the project**
 - **The results are not yet verified by industrial tests**
 - **The possible positive effect of a controlled cooling process concerning equalising of the MC between planks/boards in a kiln is not investigated**
 - **Industrial tests have to be performed**

Acknowledgement

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 - **The Norwegian Kiln Drying Club**
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