Quality of Life and Management of Living Resources

Measures for improving quality and shape stability of sawn softwood timber during drying and under service conditions

“STRAIGHT”

Key Action 5: Sustainable agriculture, fisheries and forestry, and integrated development of rural areas including mountain areas

1st PROGRESS REPORT

0 – 6 Months

April 2002
Introduction

This progress report presents a short summary of the work undertaken by the various partners during the first six months of the project. On the whole the project has started very well and progress is well on schedule.
Workpackage number: 1. Acquisition of test material

| Start date: | Month 1 |
| Completion date: | Month 12 |
| Partner responsible: | BRE, CHA, ABT, VTT, CTBA, BFH |
| Person months per partner and total: | BRE(2), CHA(2), ABT(1), VTT(1), CTBA(1), BFH(1). Total(8) |

**Objectives**

- To provide matched constructional wood specimens to determine the improvement in drying distortion of spruce subjected to the 7 different drying approaches (described in workpackage 2), the growth characteristics and mechanical assessment (workpackage 3) and post drying assessment (workpackage 5)

**PROGRESS**

**BRE**: To date three packs of timber (50 x 100 mm spruce) have been sourced from UK sawmills and transported to two European research organisations. These have been dried using the novel methods described in workpackage 2.

**VTT**: Material (Spruce 50 x 100 mm, top diameter of logs max 160 mm) for two drying tests in tasks 2.1 and 2.2 is procured from Stora Enso Timber Kotka sawmill (SET).

Dried timber (Spruce 50 x 100 mm), which has been disqualified at the sawmill due excessive deformation was procured for pressurised steam treatments.

For further drying tests the material will be sorted after sawing at SET Kotka Sawmill.

**CTBA**: Attended the kick-off meeting, in which it was discussed about how material for each workpackage should be selected and sorted for testing in the novel and comparable conventional drying techniques. The material which will be dried by CTBA will be sent by BRE.

Each batch is composed of 72 pieces 4.80 m x 100 mm x 50 mm. When it arrives in CTBA each piece is cut into 2 samples 2 m long. It makes two packs 2 m long. Every other batten is transferred from one pack to the other to ensure an equal number of butt and top battens in each pack.

One pack of 72 pieces will be dried with high temperature in superheated steam. A conventional drying will be carried out with the other pack of 72 pieces.

In each drying, distortions, Moisture Content, final Moisture gradient, shrinkage, will be measured on 50 samples. The other 22 samples will be used for casehardening measurement, and will be cut each 20 cm to look for possible internal cracks.

**BFH**: Has communicated with the other partners regarding the acquisition of test material. After the kick-off meeting BFH has produced a guideline, describing the features of the test material.

With respect to WP 2.2, 2.3, 2.4, and 2.7 in which BFH is actively involved (experimental work) industrial partners have been contacted and the necessary rules for the provision of test material have been fixed.

According to the work plan the first delivery of test material will arrive in week 16.

First experimental work (not part of contract) on a very small scale (small lab kiln) has been carried out.
CHA: Over 100 small diameter logs from two very different stands were collected. All the logs were about 3 m in length. On these logs the diameter, ovality and the spiral grain angle under bark was measured. To determine the spiral grain angle on these trees an instrument S-GAG was used.

From one harvested stand about 20 logs were put aside. On these logs the spiral grain angle, diameter and ovality will be measured. It is assume that some of these logs will fulfil the requirements for sampling of logs for WP 2.5.
## Workpackage number: 2.1. High temperature drying

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<tr>
<td>Completion date:</td>
<td>Month 26</td>
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<tr>
<td>Partner responsible:</td>
<td>TNO, VTT, CTBA</td>
</tr>
<tr>
<td>Person months per partner and total:</td>
<td>TNO(9), VTT(3), CTBA(6). Total (18)</td>
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### Objectives
- To minimise distortion using optimised drying schedules with high temperature periods

### PROGRESS

**BRE:** Three parcels of freshly processed spruce have been sourced from UK sawmills and transported to research partners in Europe (CTBA & VTT). Other batches have been organised.

Two parcels consisting of 72 pieces of 50 x 100 x 4800 mm have been delivered to CTBA in France. One parcel has been dried using a temperature of 105°C, with applied top-load, plus associated conventional drying for comparative purposes. The second parcel will be dried in May.

One parcel consisting of 140 pieces of 50 x 100 x 1200 mm has also been delivered to VTT in Finland. This parcel will be divided into four parallel groups of 35 pieces. Two parcels will be dried conventionally at 75°C, one loaded and one un-loaded and two dried using high temperature at 105°C, one loaded and one un-loaded.

**VTT:** Two pressurised steam treatments (method developed by New Zealand Forest Research) was performed in the laboratory with dry warped 38 x 100 mm Spruce timber. The procedure is presented in Annex 1.

In the laboratory one HT-drying trial was completed at 105 °C with and without top loading. One reference trial was also completed at 70 °C with and without top loading. Each long batten was cut in 4 samples. The samples were then divided systematically into 4 parallel groups.

**TNO:** Negotiations with the co-ordinator regarding taking over specific tasks from TNO Building research by TNO TPD are on-going.
- Proposal for Kiln Monitoring Measurements during trials for model development/validation and Energy monitoring
- Design new pilot kiln, which will be built by HB-Drying systems at their site in Almelo. The new kiln will be operational by the end of June 2002.
- Developing preliminary drying strategy for the HT-trials in pilot kiln.
- Allocation of an industrial saw mill for industrial HT- trials in The Netherlands
- Start first trials are scheduled for August 2002
- Delay due to organisational changes 6 months.

**CTBA:** One batten consignment, which was sent by BRE, has been received by CTBA.

It was composed of 72 battens 4.80 m x 100 mm x 50 mm. It has been cut into 5 parts : 2 parts 30 cm long at each end for initial Moisture Content, 1 middle part 20 cm long for initial Moisture Content and density 0%, and 2 parts 2 m long for dryings.

In each part 2 m long the every other batten has been transferred from one pack to the other to ensure an equal number of butt and top batten in each pack.
A high temperature in superheated steam has been carried out with the first pack. A conventional drying has been carried out with the second pack.

- **High temperature drying**
  Top load: 1580 kg = 880 kg/m²
  Air velocity through the pile: 5.8 m/s
  Warming up phase:
    Target Dry Bulb Temperature = Target Wet Bulb Temperature
    From 25°C to 100°C  4 hours
  Drying phase: DBT: 105°C  WBT: 100°C
  Equilibrium phase: DBT: 70°C  WBT: 66°C  5 hours.
  Drying time: 56 hours from 87.9% MC to 15.7% MC

- **Conventional drying**
  Air velocity through the pile: 2.9 m/s
  Warming up phase: 3 hours.
  Temperature: from 30°C to 50°C
  EMC: 16%
  Drying phase:
    Temperature from 60°C to 70°C
    EMC: from 16% to 6%
  Equilibrium phase: 5 hours
  Temperature: 70°C  EMC: from 10.5% to 14%
  Drying time: 183 hours from 81.9% MC to 12.4% MC

- **Drying quality** → See WP3: Drying quality assessment
Workpackage number: 2.2. Novel top loading

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<tr>
<td>Completion date:</td>
<td>Month 26</td>
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<tr>
<td>Partner responsible:</td>
<td>NTI, BRE, VTT, BFH</td>
</tr>
<tr>
<td>Person months per partner and total: NTI(10), BRE(3), VTT(3), BFH(3). Total (19)</td>
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Objectives

• To develop new approaches for top loading and determine their effects on the deformation of sawn timber during drying.
• To provide the basis for the design of commercial systems for top loading to reduce deformation during drying

PROGRESS

NTI has been in close contact with the two industrial partners for the planning of the industrial tests. A special jig in aluminium for measuring the warp over 2 m has been produced. The grain angle measuring device has been ordered from Chalmers. The first industrial test is planned to start week 15 at Begna Sawmill. The laboratory test equipment is ready with a pneumatic top loading device in our Brunner laboratory kiln, but the tests are delayed due to replacement of the control system, which has broken down.

A new pneumatic top loading system was constructed by VTT and installed on a Vanicek laboratory kiln. Top load can be adjusted to 0 - 16 kN. Stack width can be 50 - 90 cm and length 120 cm. In laboratory one HT-drying at 105 °C with and without top loading was performed and one reference drying at 70 °C with and without top loading were performed. The top loading was 5,2 kN / 70 x 120 cm (stickers 1 m apart).

Industrial tests at Stora Enso Timber ( Kotka Sawmill) have been planned. The fully automatic sorting line will sort out the problem test material. The aim is that Finnscan sorting device could divide the marked battens into 4 boxes.

BRE: At the present time no actual work on novel top loading has been undertaken. Although, in anticipation of beginning work on this workpackage, BRE is in the process of having a new experimental conventional over-head fan wood drying kiln installed. The kiln will be able to operate at temperatures up to 95°C and will have variable air-flow control. It is hoped that the installation will be completed by the end of May when we plan to dry our first packs of UK grown spruce under this workpackage. These parcels of timber will be sorted into two packs of battens, those containing the pith and those cut further from the pith. Four trials are planned using temperatures up to 80°C, steam conditioning and various constant top loads.

BFH: In later stages of the experimental work BFH will carry out top loading drying experiments in conjunction with other treatments. Within the first 6 months, the following activities have been undertaken.
1) Several interviews with saw mills regarding their experience and practice with top-loading. Result: Top-loading is not widely used in Germany.
2) Inspection of different materials for producing top load for lab application. Size and weight must be manageable under lab conditions.
3) Development of time schedule for test runs, consultations with sawmills regarding timely delivery of fresh test material.
Workpackage number: 2.3. Oscillating drying schedules

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<td>BFH</td>
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<td>Person months per partner and total:</td>
<td>BFH(7), TNO(2). Total (9)</td>
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**Objectives**
- To reduce drying induced deformation by facilitating internal mechano-sorptive creep effects generated through oscillating drying schedules

**PROGRESS**

**BFH**: After major repair works in the laboratories of BFH (roof construction) during the recent 4 months, all labs and kilns can now be used again.

With respect to oscillating drying schedule treatment of timber the following activities have been undertaken during the first 6 months:
1) Search for sawmills which are able and willing to deliver test material according to the specific requirements of the STRAIGHT project at a reasonable cost (test material can not be used anymore after test, due to short length of pieces). 2 sawmills have been allocated, one close by, the other in 350 km distance.
2) Negotiations with co-ordinator regarding taking over of tasks from partner TNO.
3) Drafting of a preliminary time schedule for the test runs. Due to re-distribution of work, revision and alteration of work programme and time schedule.
4) Additional staff (young scientist, technical assistance and student worker) sought and contracted.
5) Start of first test runs are scheduled for April/may 2002.

**BFH**: Has analysed the drying conditions in industrial kilns which are run by a large Spruce sawmill. The conditions were analysed with respect to cyclic oscillations of climate conditions. It was found that, in industrial scale kilns, cyclic oscillations of climate conditions are much more pronounced than in the previous laboratory tests. Over long periods of the drying time, conditions exist in parts of the kiln load, where virtually no drying takes place. This type information is needed to fix the conditions for the experimental drying tests aiming at reduction of deformations and a reduction of drying time.

The first experimental tests in a small lab kiln have been carried out (not part of the contract). Pilot-scale tests (in 1-2 m³ kiln) will start in week 16.
Workpackage number: 2.4. Twisted pack drying

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<td>Person months per partner and total:</td>
<td>ABT(6), BRE(1). Total (7)</td>
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**Objectives**

- To minimise twist during drying of softwood by putting the drying package on a to the left warped basement in the kiln. The basement shall be twisted in the opposite direction to the natural twist occurring in spruce during drying (twist to the right)

**PROGRESS**

**ABT:** A test frame of stainless steel has been built. This frame is a fixture for the test boards and is placed into the kiln. The boards can be reverse twisted at different angles. In the frame there are gauges, which can also measure the twist force. After calibrating and adjusting the system, 12 test runs in a laboratory kiln have been planned. Parameters which influence the reversed twist force have been checked. Both low (70°C) and high (105°C) temperatures have been tested. All these tests are pre-tests for Wp 2.4 and Wp 2.7. Quite new physical effects have been found. Predicting formulas have been developed. Schedules are being built up for the industry tests and will show the right reverse twist for the packages needed in a dry kiln.
Workpackage number: 2.5. Pre-sorting

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**Objectives**
- To pre-sort the quality of logs in terms of spiral growth, age/diameter ratio, ovality and taper and to separate out logs prone to distort for either rejection or for special drying treatment
- To pre-sort timber battens on the basis of moisture content and density before drying to improve drying economics and constancy of moisture content and distortion after drying.

**PROGRESS**

**BFH:** Talk with industrial softwood sawmills in Germany has been carried out in order to examine the chances for pre-sorting prior to drying. For all those sawmills which cut sawn timber to order, pre-sorting is not a feasible option, but those companies that produce standard dimension stock, pre-sorting sounds interesting.

Contacts to these companies have intensified together with Brookhuis Electronics. The first tests will start in April. A test programme is currently being elaborated.

The material origination from the first industrial pre-sorting tests will hopefully be provided to BFH for drying tests. The problem is that the industrial counterpart is located approx. 1200 km away from Hamburg.

**CHA:** No progress as yet.
Workpackage number: 2.6. Green gluing

| Start date: | Month 7 |
| Completion date: | Month 26 |
| Partner responsible: | BRE |
| Person months per partner and total: | BRE(6). Total (6) |

**Objectives**

- To reduce the distortion (particularly twist) during drying of battens containing juvenile wood by reengineering by face jointing with green (moisture insensitive) gluing.

**PROGRESS**

**BRE:** Initial work in this workpackage has centered on investigating the best method of re-orientation of boxed pith battens after being split down their length. 78 spruce boxed pith battens were selected for trial. These were cross-cut to provide test and control material. Nine different orientations were assessed, with battens being bonded whilst ‘green’ and then dried commercially to approximately 18%. Results have indicated that the best orientation to use when re-engineering boxed pith pieces is back to back (battens cut length ways and turned over before bonding).

Further work in this task will now concentrate on testing a greater number of battens in the selected orientation, with the possibility of including some work on the re-engineering of falling boards.
Workpackage number: 2.7. New conditioning techniques

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<td>Person months per partner and total:</td>
<td>ABT(8), BRE(2), BFH(1). Total (11)</td>
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**Objectives**
- To minimise distortion during drying by inducing stress relaxation in timber battens by new conditioning phases during kiln drying schedules.

**PROGRESS**

**BFH**: has undertaken no activities up to now.

**ABT**: See workpackage 2.4
Workpackage number: 3. Drying quality assessment

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<td>BFH, All except BRO</td>
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**Objectives**

- To assess the quality of timber dried by each of the novel processes described in workpackage 2
- To determine the optimum processes for producing timber with minimum distortion after drying.

**PROGRESS**

**VTT:** According the plan from NTI, a new deformation measurement device is being built. A new case hardening measuring device also being built.

**CTBA:**

One drying test has been performed. It is composed of one high temperature drying and one conventional drying run. The pieces are 2 m x 100 mm x 50 mm.

- High Temperature Drying in superheated steam.
  - Top load : 880 kg/m²  DBT : 105°C  WBT : 100°C
  - Available results :
    - Drying time : 56 hours from 87.9% MC to 15.7% MC.
    - Final MC
      - Average : 15.7%  Std : 6.6%
      - Final Moisture Gradient : 5.8%
    - Surface cracks on 3 samples (on 50)
    - Final distortions (average)
      - Bow : 3.1 mm
      - Spring : 3.1 mm
      - Cup : 0.7 mm
      - Twist : 5.1 mm
      - Casehardening : 1.3 mm
    - Internal cracks
      - 9 samples without cracks (on 22)
      - 13 samples with collapse cracks in early wood.
- Conventional drying
  - Available results :
    - Drying time : 183 hours from 81.9% MC to 12.4% MC.
    - Final MC
      - Average : 12.4%  Std : 2.3%
      - Final Moisture Gradient : 2.7%
    - Surface cracks on 2 samples (on 50)
    - Final distortions (average)
      - Bow : 3.1 mm
      - Spring : 4.4 mm
      - Cup : 0.6 mm
      - Twist : 8.4 mm
      - Casehardening : 0.7 mm
    - Internal cracks
      - 19 samples without cracks (on 20)
      - 1 sample with collapse cracks in early wood.
CTBA: In conclusion, we can resume the results as follows:

- Short drying time in case of High temperature drying.
- Final MC not so homogeneous with HTD than with Conventional drying.
- Lower distortions with HTD than with conventional drying.
- Important collapse with HTD

For the next High Temperature Drying it is foreseen to use high temperature only below the Fibre Saturation Point. But in this case there is a risk of shrinkage cracks.

BFH: As decided during the kick-off meeting, BFH has produced a guideline for carrying out the drying quality assessment tests throughout the project. All partners have been informed on how to carry out the measurement in order to get comparable results.

BFH has installed a separate PC on which all relevant data originating from the project will be collected and stored. The spreadsheet, which should be used by all partners for providing drying quality data, has been designed and circulated to all partners. The data base formed on the basis of these spreadsheets will be open to all partners in the consortium and will form the basis for subsequent evaluation of the efficiency of the different treatments (WP2.1 - WP 2.7)
Workpackage number: 4. Post drying assessment of distortion

<table>
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<td>Completion date:</td>
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<td>CHA, BRE</td>
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<td>CHA(9), BRE(5). Total (14)</td>
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**Objectives**

- To determine whether the improvements in straightness achieved by the improved approaches (described in workpackage 2) remain during service (post kilning)

**PROGRESS**

No progress as yet.
Workpackage number: 5. Properties of timber converted by using novel drying Techniques

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<td>Month 35</td>
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<td>Person months per partner and total:</td>
<td>CHA(10), BRE(5), VTT(3), BFH(3), BRO(3), TNO(4). Total (28)</td>
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</table>

**Objectives**
- To assess growth characteristics of sawn timber after application of novel drying techniques and to link these data to the distortion, physical and mechanical properties. To improve computer models that predicts distortion in service.

**PROGRESS**

No progress as yet.
Workpackage number: 6. Integration and dissemination

Start date: Month 9
Completion date: Month 36
Partner responsible: VTT, All partners
Person months per partner and total: VTT(8), BRE(3), CHA(2), ABT(2), NTI(2), CTBA(2), BFH(3), BRO(1), TNO(2). Total (25)

Objectives
• To integrate the findings of the previous workpackages
• To disseminate the findings to European industry

PROGRESS

No progress as yet.
Annex 1.

Pressurised steam treatment for straightening warped timber (VTT)

According to the method developed in New Zealand Forest Research Institute timber, which is warped in kiln drying is treated with pressurised steam.

The warped timber was stacked with stickers and top loaded with iron blocks 320 kg/m². Distance between the stickers was 50 cm. The charge of 16 pcs 38 x 100 mm Spruce timber was heated up in VTT’s steam dryer with steam. Heating water in the bottom part of the kiln produced steam. When 100 °C saturated condition was reached, all outlets were closed. Thereafter the water was heated further to the treatment set point temperature. In VTT’s test maximum temperatures 118 / 118 °C in test 1 and 140 / 140 °C in test 2 (dry bulb / wet bulb) were reached. After the treatments the temperature was slowly reduced to 100 °C and cooled further, outlet pipes open, to 70 °C with a schedule.

Timber deformations were measured before and after the treatments. Additional measurements were performed after 11 days and 7 weeks from the treatment. The specimens were standing free leaning to the wall in the same room than before the treatment.

The moisture content was determined before treatment and 7 weeks after it.