# New Generation ThermoWood® - How to Take ThermoWood® to the Next Level

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## ABSTRACT

ThermoWood® products have been on the market for almost 10 years and there are early examples of the products in the built environment dating beyond this time. The growth of production and sales has increased significantly in recent years to become the leading non chemical wood modification system.

Through assessment of ThermoWood® which has been in longer term use, it can be clearly seen that the early research results on biological durability and dimensional stability have been proven correct and it is performing very well in both these areas. It is fair to say that most research has been concerned with the biological durability of the material, and the track record has proven that it more than meets the requirements set in actual end use. In nearly all modification methods compromises exist between striving for higher durability and other factors, such as price, strength and appearance. In the case of ThermoWood® it should be studied if it is possible to consider milder treatments to gain improved strength properties. In this respect research on means to improve the micro level surface stability and strength of ThermoWood® material should be a key area for future study.

Looking to the future in respect to product development, clearly some of the other positive characteristics of ThermoWood® such as reduced thermal conductivity and low VOC emissions make it a very interesting material for joinery and interior decoration products. Growth for the product will clearly come through widening up of the end-use applications and possible utilisation of the by products. Continuous development of the process technology is also needed to ensure that the product will remain competitive in the longer term.

## COMMERCIAL STATUS OF THE THERMOWOOD® BUSINESS

### *International ThermoWood Association*

The International ThermoWood Association was established in 2000 (original name Finnish ThermoWood Association). In 2008 three non Finnish applicant companies were registered to be members of the ThermoWood Association. The membership of the association is open to all companies that fulfil the prerequisites. The main prerequisites are:

- the rules of the association have to be accepted
- ThermoWood® process has to be used in production
- entrance fee and membership fee have to be paid

Rights to use the association's internationally registered ThermoWood® trademark and quality stamp (Figure 1) is reserved to members that have implemented the quality control system. The quality control system was developed by the association in cooperation with Inspecta Oy, an internationally accredited certification body, and they also act as the third party auditor.


***Figure 1.The quality stamp of the International ThermoWood Association and the FI mark of the Inspecta Oy.***

### *Production volume*

The production volume has been progressively increasing since 2001 with significant jumps occurring from 2005 onwards (Figure 2). Today the ThermoWood® business is in excess of 80,000 $m^3$, and is by far the biggest of all the commercial wood modification businesses.

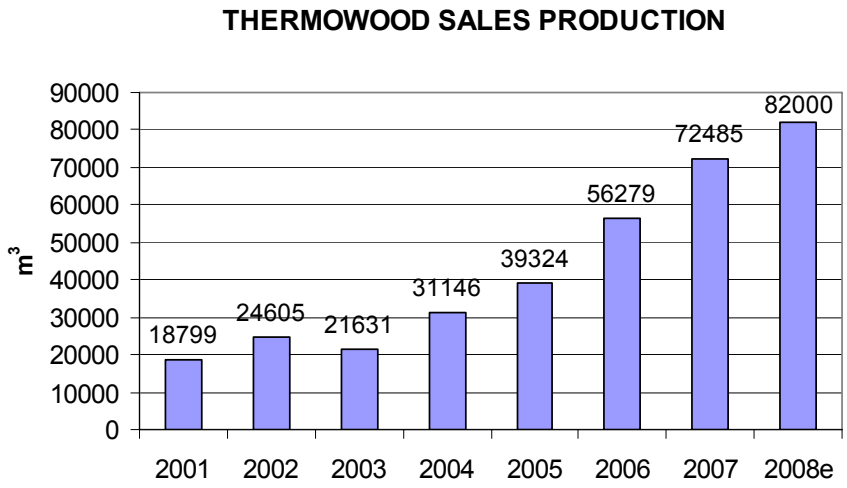


***Figure 2. ThermoWood® sales production in 2001 – 2007 and estimate for 2008.***

### *ThermoWood® end uses*

The end uses of ThermoWood® have remained quite constant since the launch of the product back in 2001 with up to 80% of the consumption going into:

- Exterior cladding
- Exterior decking
- Internal wall and ceiling panels
- Internal flooring

The main wood materials that ThermoWood® has taken market share from are Western Red Cedar, certain tropical hardwoods, untreated and preservative treated softwoods.

For external applications, such as cladding, the use of surface coatings has varied from region to region, example, in Holland the majority of cladding has been coated, where as in Belgium and UK a higher percentage has been left with no coating. In decking products the amount of pigmented film build coatings is lower but natural oil treatment to maintain surface quality is popular. In interior products, the flooring is either lacquered or waxed to improve the surface performance.

Other end uses for ThermoWood® have been developing but at this stage are still quite small and are in need of further development, for example; windows and doors, shutters, garden fencing systems and structures, and furniture. Utilization of the by products of ThermoWood® have also been studied and are in need of further development.

## KEY FINDINGS FROM THE PAST 8 YEARS

ThermoWood® products have now been in the built environment in many cases for over 10 years and this time period is a good point to assess how the product is performing. Several detailed assessments have been carried out recently on some of the older external references; an example of an assessment is presented below:

### *Broughton Fields Primary School, UK*

The school building was completed in autumn 2004 and used Thermo-D spruce. No surface coatings were applied and material was used on all elevations of the building (Figure 3).

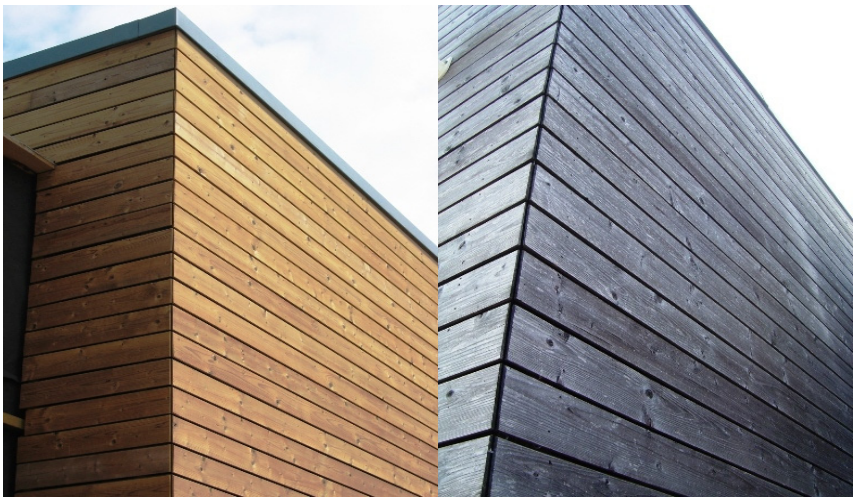

***Figure 3. Broughton Fields Primary School, UK. In June 2004 (left) and in June 2008 (right).***

Results from the assessment:

- Extensive weathering has occurred with colour change to grey except where the eaves have protected from the weather
- No visible sign of decay fungi
- No significant dimensional movement , cupping, swelling or shrinkage
- Significant signs of surface shakes and fibre erosion
- Wasp attack on loose fibres

As a conclusion of the assessments it can be clearly seen that the biological durability and dimensional stability of ThermoWood® used in U.C 3 applications such as cladding is proving to be very good. The micro surface performance is an area which appears to need further development and research. It is quite clear that the effect of weathering is leading to surface erosion which might affect the long term performance and maintenance free period of the product. Also the experience so far in relation to surface coating of decking products has led to the conclusion that film based coating with pigment have a very short life span and require regular maintenance, thus it can be concluded that natural oil based surface protections are a better option although colour will not be maintained. The interior products are maintaining their good appearance and the dimensional stability is proving to be a real positive. Some issues in relation to the surface hardness of flooring especially softwoods need to be considered.

In addition to real life examples, studies have been commissioned by the ThermoWood Association in the subjects of "performance of external cladding" at the BRE, UK and "Emission measurements and classification of building materials" at VTT, Finland. Some results of these studies are outlined below.

### *The ThermoWood cladding project – BRE, UK, - dimensional stability*

The following results (table 1) have been obtained from six on-site assessments over a period of 48 months at the BRE site in Garston. The test materials have ranged from uncoated to fully factory finished coating cladding rigs.

***Table 1 maximum cupping of cladding boards over a 48 month period (Source BRE cladding project)***

| Test cladding material | Min/Max concavity (cupping) over 48 months |
|---|---|
| Western Red Cedar | 0,5-4,0mm |
| ThermoWood Pine (Thermo-D) | 0,0-0,5mm |
| ThermoWood Spruce (Thermo-D) | 0,0-1,0mm |
| Untreated Spruce | 1,0-3,0mm |
| Cu Azole treated Pine | 1,0-2,0mm |

As it can be seen from the results both ThermoWood® Pine and Spruce have remained very stable over 48 month period and this clearly indicates that the material will continue to remain stable over a much longer period.

### *The Finnish emission classification system of building materials*

The Finnish emission classification (M classification) system has three emission classes. Emission class M1 corresponds to the best quality and emission class M3 includes materials with the highest emission rates. Classified materials have to fulfil the following criteria at the age of 28 days (Table 2).

*Table 2 Criteria of M classification (source www.rts.fi)*

| Examined qualities | M1 [mg/m$^2$h] | M2 [mg/m$^2$h] |
|---|---|---|
| The emission of total volatile organic compounds (TVOC). A minimum of 70% of the compounds shall be identified. | < 0,2 | < 0,4 |
| The emission of formaldehyde(HCOH) | < 0,05 | < 0,125 |
| The emission of ammonia ($NH_3$) | < 0,03 | < 0,06 |
| The emission of carcinogenic compounds belonging to category 1 of the IARC monographs (IARC 1987)[1] | < 0,005 | < 0,005 |
| Odour (dissatisfaction with odour shall be below 15 %)[2] | Is not odours | Is not significantly odorous |

1. IARC 1987, does not apply to formaldehyde (IARC 2004)
2. The result of sensory evaluation shall be > +0.1

The emissions of ThermoWood® were measured by VTT. The tests were carried out in accordance with the following test methods VOC ENV 13419-1 and ISO 16000-6, Formaldehyde, ISO 16000-4, Ammonia RTESIS295 (accredited method), sensory evaluation, untrained panel of 5+10 persons.

*Table 3 Results of the emission measurements of ThermoWood® products*

| ThermoWood® Product | TVOC mg/[m² h] as toluene equivalents between $C_6$-$C_{16}$ | Formaldehyde mg/[m² h] | Ammonia mg/[m² h] | Carcinogens SER> 0,002 mg/[m² h] as toluene equivalents or MS quantification | Sensory evaluation Average of acceptability |
|---|---|---|---|---|---|
| **Pine Thermo-S** | 0,090 | < 0,005 | < 0,005 | < 0,005 | +0,1 |
| **Spruce Thermo-S** | 0,084 | < 0,005 | < 0,005 | < 0,005 | +0,2 |

The results show that ThermoWood® Pine and Spruce treated at Thermo-S fulfil the criteria of the M1 class of the Finnish emission classification of building materials.

## WHERE TO FOCUS DEVELOPMENT IN THE FUTURE

### *Thermal performance*

The continual tightening of requirements for thermal efficiency in buildings is leading to a heavy pressure on raw material manufacturers, final product producers and building companies to innovate their products. There is a great opportunity to utilise the reduced thermal conductivity of ThermoWood® in meeting some of these challenges. So far the utilisation of the insulation properties of ThermoWood® has been limited. This may partly be due to process ability and knowledge of the product. Tighter control of raw-material selection in relation to density could help to industrialise the opportunity further. In addition possibilities to utilise ThermoWood® fibre as an insulator should be further studied.

***Surface and strength performance***

As it can be seen from real life results, there appears to be a need to study and develop the micro surface level performance of ThermoWood®. Surface erosion and checking is quite common in ThermoWood®, although from the results of the BRE cladding project in UK, this phenomenon is not exclusive to ThermoWood and substrates such as WRC also experience deterioration. With all modification technologies there appears to be a series of compromises such as higher durability versus lower strength or higher durability versus cost. Consideration of the compromises needs to be taken seriously in the development.

There are several approaches which need to be considered as a means to improve the micro surface level performance of ThermoWood®.

1. Assessment of the affects of treatment temperature on the surface and strength performance of ThermoWood®. Do lower temperatures cause less degradation of cross links between lignin and hemi-cellulose? And what impact do the cross links have on surface performance? Possible outcome: Consider a slight reduction in biological durability rating in Use class 3 applications as a compromise to better and longer lasting surface performance. Determination of an optimum treatment level where biological durability is sufficient for intended lifetime and surface performance is significantly improved to give far longer maintenance free periods.

2. Better control of the raw-material inputs and processing can lead to a significant improvement in surface performance. Selection of more homogeneous raw-material through density, knot distribution and narrowing of variance will lead to more even performance. During the sawing process consideration to optimise year ring angles with 45 degrees or more (radial sawn being optimal) will improve surface performance. During the further processing stage further development is needed to reduce the impact of micro level surface pressure which causes cracking and fibre damage.

3. Further study of the possibilities of combining ThermoWood® with other materials to improve the surface performance of the final product. This can be though several different approaches such as surface impregnation, durable film based coatings, combining other substrates through glue press technology.

***End use development***

Based on the experiences so far the ThermoWood® is performing pretty well in its base applications, with some improvements needed. However a stronger focus is needed to build on its other strengths and this indicates the need to put more effort into developing the window and door segments due to the thermal properties, and the interior decoration and furniture sector where its strengths lie in appearance, stability and low emissions. In addition more research into the possible utilisation of by-products such as saw dust, chips or extractives needs to be carried out which may lead to some new and interesting end use areas.

## CONCLUSIONS

As a conclusion it can clearly be stated that ThermoWood® has succeeded commercially and continues to grow. The transition to an International ThermoWood Association underlies the success and importance of such an organisation in maintaining quality and development, and also adds credibility for companies wishing to expand their sales regions.

The ThermoWood® material is performing as expected in most applications and in general is satisfying expectations. However there are clearly needs to further improve and develop the product to ensure its long term performance and competitiveness. Additionally, a far greater focus on the other positive characteristics of ThermoWood® needs to be exploited in product development to ensure continued growth. Through the continuation of strong research and development, guided by the ThermoWood Association, the next generation of ThermoWood® products will take the material to a new and even higher level of performance.

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