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THE CONCEPT OF VALUE ACTIVATION - WOOD PROPERTIES AT DIFFERENT ANNUAL RING ORIENTATION IN PINE (PINUS SILVESTRIS L)

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ABSTRACT: An integrated R&D program called "Value Activation" has been carried out for the past eight years at the Royal Institute of Technology, Div. of Wood Technology and Processing (KTH-Tra). The concept of Value Activation is focused on the basic understanding of wood, and the fact that there are properties that are not fully exploited in conventional wood manufacturing systems to date. The strategy is to activate these inherent properties by a better understanding of the fundamental behaviour of wood, combined with new applied process technology and the development of the required manufacturing systems.

The Value Activation program has so far shown that there are great possibilities of utilizing the properties of wood in a better way than our conventional wood production concept can achieve. New wood products with desirable properties can be developed. Most of these products are expected to give a greater added value to the wood. The R&D program will continue with the further development of improved products and also with the development of cost-efficient production systems for implementing the ideas from our R&D in profitable production units.

Within the Value Activation program the following properties, which were judged to be the most important ones for future wood products were chosen:

- Aesthetic and tactile factors
- Controlled moisture movements
- Accuracy in size and geometry
- No checks and splits
- Strength and hardness

These properties are all strongly influenced by the annual ring orientation in the cross section of the sawn timber. This paper describes the influence of the annual ring orientation on these properties and how they can be improved by using a new sawing pattern.

INTRODUCTION

Wood of different tree species is one of the most used and useful materials in the world. It is by habit and tradition used for many different products, products of different value, from extremely high value products such as designed art products to a simple but efficient material for energy production. During hundreds of years craftsmen have learnt and applied knowledge about wood, and it is possible to find very clever uses in different areas.

With industrialization followed that we wanted to produce as much volume yield as possible out of the logs in the shortest and cheapest way, often with very little attention to the properties of the produced wood material.

In the beginning of the 1990-th a new R&D program was introduced at the Royal Institute of Technology, Div. of Wood Technology and Processing (KTH-Tra). The idea was to create an overarching program which could be the base for education for the under-graduate programs as well as the Ph. D. programs.
VALUE ACTIVATION

One of the basic ideas behind creating the new R&D program was our profound belief that it is possible with new flexible technique to manufacture wood products so that the very best of the wood properties will be taken advantage of.

The first step was to define areas where wood will be highly appreciated in future.

A shortlist of such types of products read:

- Visible products
- Cost effective constructions
- Composites

Wood based composites were and are of highest interest, but it does not fit into the priority list of subjects for our division, KTH-Tra.

When scrutinizing the properties that are the most valuable and appreciated ones in visible wood products and for efficient timber structures we put up the following list:

- Aesthetic and tactile factors
- Controlled moisture movements
- Accuracy in size and geometry
- No checks and splits
- Strength and hardness

Aesthetical and tactile factors are in many cases underestimated in wood. The value of wood would be increased considerably if we find and expose the beauty in wood and take advantage of the feeling for wood which most people have got.

When wood is used as a material for industrial production it is very important that it can be offered with a high accuracy.

Checks and splits in wood are not accepted in high value wood products. This requirement is often there both for functional and aesthetical reasons.

We need to know and to be able to calculate moisture movements in wood in the proposed use and for an easy use of wood components in industrial handling and assembling of products. The same reasons apply valid for demanding wood pieces and components with good accuracy.

Strength as well as hardness are very much appreciated properties, but in many applications they are not crucial.

The next step for creating the R&D program “Value Activation” was to formulate a strategy and an aim for the program.

The work method and the strategy for the program was to collect and find out all kinds of knowledge about wood, its behaviour and properties, which could influence the value of the wood, in different applications. This knowledge will then be used for finding out how wood should be manufactured and used for different products for getting the best quality and the highest value out of the products.

The name “Value Activation” refers to the basic understanding of wood, where at present there are properties that are not fully exploited, but which with the help of new technique could be fully utilized in a much better way than they are today.

Wood is an anisotropic material. Therefore, all the physical and aesthetical properties of wood have different values in different directions.

In our project we started studying different properties in Scots pine, but there are similar relations in most tree species.

Among the irregularities and specific features we started studying were the following documented facts:

i) Density. The density of the wood, and with that the strength, increases with increased distance from the pith to the tested wood sample. The wood density is also higher in the lower part of the stem than higher up from the ground.

ii) Rays. In the tree trunk there are rays. They distribute nutrients radially from the inner bark in the living tree. In the cross section of timber the moisture flow is higher perpendicular than parallel to the annual rings. The main reason for this seems to be the presence of the rays.

iii) Moisture movement. A well known fact is that the moisture movement in wood is twice as high in the tangential than in the radial direction. This is true with reasonable accuracy for most tree species. In practice, the consequence of this is that ordinary sawn timber will cup when drying, and that the shrinking/swelling movement due to the moisture content changes gives more or less cupping. See figures 1-3.

Drying checks in timber occur most frequently on the bark side of the timber and the checks have a radial direction. [1]

Figure 1. Disc of Pinus silvestris; saturated.
iv) **Juvenile wood.** In Scots pine as well as in many other tree species the cells in the first 10 to 20 annual rings are what we name juvenile. The microfibril angle in the cellwalls is bigger than in cellwalls of mature wood. The moisture movement in the juvenile wood has therefore a bigger component in the longitudinal direction. A part of the twist, bow and crook which can occur when drying timber may be caused by the juvenile wood.

v) **Hardness and wear.** Radially cut wood surfaces are in many tree species significantly harder than tangential surfaces. The wearing properties have as well been found to be better on radial surfaces.

vi) **Knots.** In the tree trunk all the knots start at the pith and they grow in the radial direction from the pith. Some limbs die early and fall off. The knots are then healed over when the tree grows. This means that for instance the butt log from Scots pine has often got quite a few knots in the central part of the trunk while the outer part may be clear wood.

These mentioned examples of anisotropism all indicate that timber with annual rings perpendicular to the main surface has got better properties than timber with flat annual rings. This is well known by craftsmen but in spite of some attempts to produce timber with vertical annual rings during the past decades there are very few industrial mills working with this as a goal.

Scots pine timber with vertical annual rings and free from juvenile wood has got the following favourable properties:

- Good aesthetical and tactile properties
- Good accuracy in shape and size
- No checks and splits
- Predictable moisture movements
- Increased hardness and wearness

This list of properties is in principle the same as mentioned above for the requested properties for high value wood products. At KTH we early started sawing logs with the sawing pattern shown in figure 4. One of the aims with that was to get test material for further investigations.

A couple of examples from our research may be mentioned.

Outdoor exposure of wood

Panels with radial and tangential wood surfaces were exposed outdoors for 33 months. The annual ring orientation was found to be the most important factor for crack development on weathering. The total crack length on the tangential surfaces of pine exceeded 13 times the corresponding crack length on the radial surfaces [2]. A picture of the surfaces is showed in figure 5 and the number of cracks per square meter in figure 6.
Paint on timber cladding usually deteriorate within 5 to 10 years. Tests in a wheatherometer show that surface treatment on a radial surface has a much longer lifetime than on a tangential surface. Field tests are going on, and they seem to confirm our hypothesis.

**Solid wood flooring**

The moisture movements in solid wood floorings were measured on both tangential and radial sections. The result is shown in figure 7. The tangential to radial moisture movement ratio is more than the expected two times. This could be due to the difference in sorption rate between the tangential and the radial sections [3].

Figure 7. Measured and approximated relative movement S of solid wooden floorings (Scotch pine) with radial and tangential sections, and measured and approximated fluctuating climate (Rh) during one year.
Knots

Sawing patterns for producing timber with vertical annual rings give a 40% longer distance between knots on the timber pieces than on pieces from common square sawing pattern [4]. All knots are however perpendicular to the annual rings and therefore parallel to the surface of boards with vertical annual rings. The knots with their moisture movement often have influence on the boards so that the bow increases at the knot. Besides that, knots from this viewpoint are not attractive and they are surrounded with a disturbed grain direction.

As a conclusion we found that we should remove the knots and produce a fingerjointed knotfree board.

The R&D program "Value Activation" covers ideas from the sawing pattern to the final high value wood product. The product areas where properties of wood with vertical annual rings are highly appreciated, and where we can expect a reasonable high price are the following: Windows, doors, floors, timber cladding, stairs, wooden furniture, joineries and garden furniture. One example may be mentioned. Figure 8 shows a piece of furniture designed by Olle Pira. It is made of Scots pine with vertical annual rings.

![Cupboard](image)

Figure 8. Cupboard, an example of the use of PrimWood. Design by prof. Olle Pira.

FUTURE WORK

The R&D program "Value Activation" continues with projects with the goal to improve gluing and surface treatment of different wood surfaces. A special interest is put to endgrain surfaces which could be used for very durable floors, table-tops also. Another part of the program is to develop basic knowledge for developing production systems for producing boards, planks and products within our new production concept called the PrimWood Method.

REFERENCES


