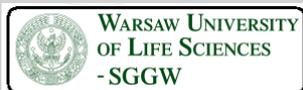


# Impact of different wood based materials treatments on surface quality assessed by contact angle



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Bringing new functions to wood  
through surface modification

# PLAN OF PRESENTATION

- **INTRODUCTION**
- **MATERIALS AND METHODS**
- **RESULTS OF CONTACT ANGLE ANALYSIS**
- **RESULTS OF SURFACE ENERGY ANALYSIS**
- **CONCLUSIONS**
- **REFERENCES**

# INTRODUCTION

Improvement of surface quality seems to be the most crucial factor affecting next stages of finishing process. Its importance follows from consequences in esthetic properties of product. Among various technological processes especially significant regards to surface roughness and wettability are:

- planning
- milling
- sanding
- hot pressing
- plasma treatment

Additionally, some of these processes cause changes of contact angle and surface energy. Wolkenhauer et. al [1] examined four wood variants: aged, freshly sanded, after plasma treatment and after plasma treatment and sanding. Results showed a significant increase of the polar component of total surface energy and work of adhesion of sanded samples in comparison to aged samples.

# INTRODUCTION

Cruz et al. [2] used three kinds of treatment (overdrying, extraction with water, and surface aging under light) to modify pine and eucalyptus. All these procedures result in an increase of contact angle. Moreover, remarkable changes in chemical structure of material were noticed.

According to researches of Gindl et al. [3], the changes of wettability for aged samples are caused by a decrease of oxygen to carbon ratio observed in XPS analysis. Moreover, they noticed a decrease of surface free energy with aging time.

Recently, NIR (near infrared spectroscopy) can be successfully implemented in order to obtain effects of surface modification which has considerable influence on surface wettability.

Thus, the aim of this work was to assess the impact of sanding and planing (wood) or milling (MDF) processes commonly used in industry on surface properties assessed by contact angle to hot-pressing.

# MATERIALS AND METHODS

Six wood species (planned, sanded and hot-pressed) and MDF boards (standard, milled, milled-hot pressed, milled-sanded, milled-sanded-hot pressed, hot-pressed) were subjected to different surface treatments. During experiments, the following wood species were studied:

- **beech** (*Fagus sylvatica*),
- **oak** (*Quercus robur* L.),
- **pine** (*Pinus sylvestris* L.),
- **obeche** (*Triplochiton scleroxylon* K. Schum.),
- **tatajuba** (*Bagassa Guianensis*)
- **wenge** (*Millettia laurentii* De Wild).

All working samples were subjected to a pressure of **4 MPa** at temperature of **160 °C** for **half an hour**. Sanding was carried out in two stages (abrasive paper of grid 80 and 180). Dimensions of samples were following:

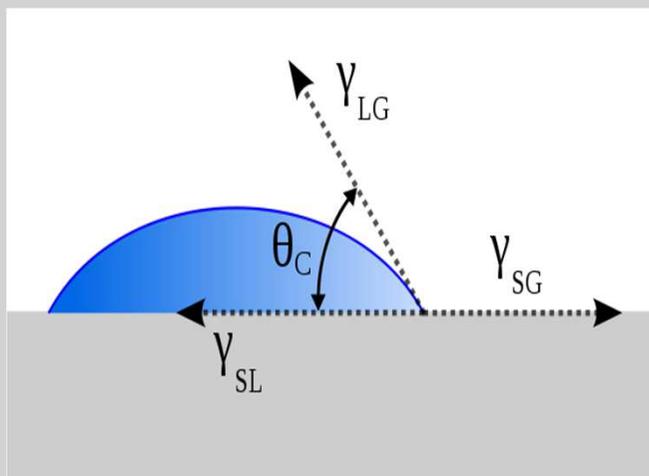
**Length** = 75mm, mm, **width** = 35mm, **thickness** = 22÷25 mm

(pressed samples were 22 mm of thickness, sanded samples 24 mm of thickness and planned samples 25 mm of thickness).

**Feed per tooth** (planning, milling) – 0,4 mm

# MATERIALS AND METHODS

The measurement of contact angle allow to estimate the surface energy which is commonly defined as the work required to build a unit of area of a given surface. It was used the sessile drop technique accessible on described below goniometer device. The quantitative evaluation of the wettability of a solid by a liquid is made in terms of contact angle. Figure below shows a schematic diagram for the contact angle and the interfacial tensions at the three phase boundary (liquid, solid and gas).



Surface energy of anylized materials was calculated due to two components Owens/Wendt theory method. In this approach total surface energy is subdivided into two parts, namely: polar and dispersive component,

Liquid	Total Surface Tension (mN/m)	Dispersive Component (mN/m)	Polar Component (mN/m)
Formamide	58.0	39.0	18.0
Water	72.8	26.4	46.4

# MATERIALS AND METHODS

Water and formamide were used to obtain polar and dispersive part of surface energy. According to measurement of contact angle for each kind of liquid, surface energy was calculated (equation 1)

$$\frac{\sigma_L (\cos\theta + 1)}{2} = \sqrt{\sigma_S^P} \sqrt{\sigma_L^P} + \sqrt{\sigma_S^D} \sqrt{\sigma_L^D}$$

Equation 1

By dividing of both side by  $\sqrt{\sigma_L^D}$  it was obtained new form of this one (equation. 2)

$$\frac{\sigma_L (\cos\theta + 1)}{2\sqrt{\sigma_L^D}} = \sqrt{\sigma_S^P} * \frac{\sqrt{\sigma_L^P}}{\sqrt{\sigma_L^D}} + \sqrt{\sigma_S^D}$$

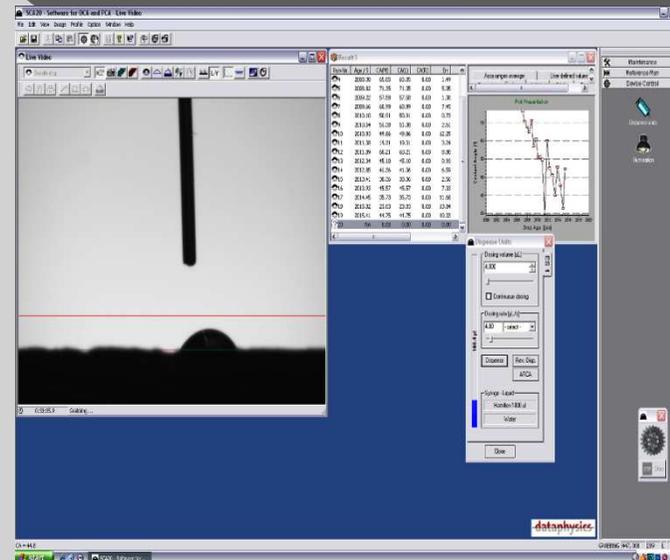
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y                    =                    m   \*                    x   +                    b

Equation 2

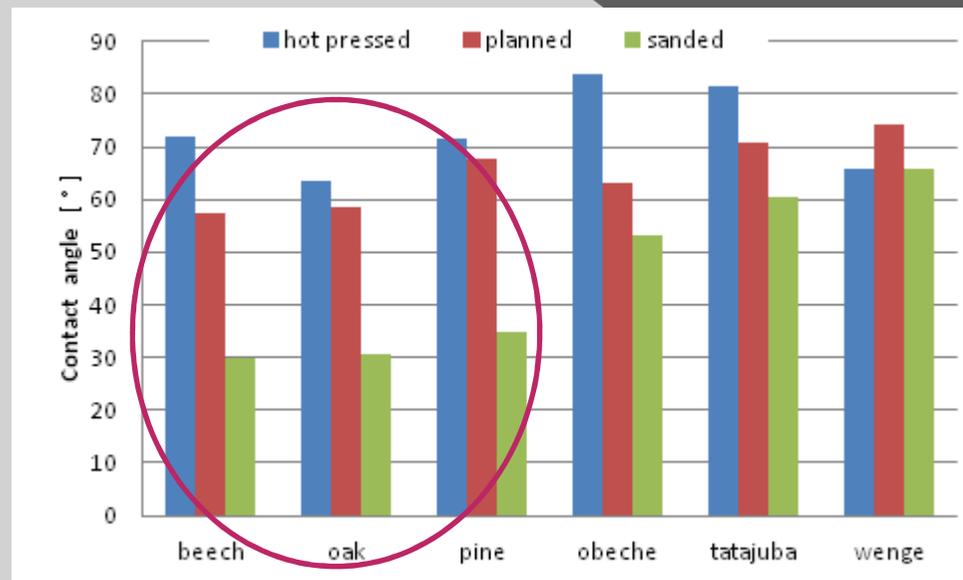
# MATERIALS AND METHODS

The measurement of contact angles was carried out, using the sessile drop method, on the goniometer **DataPhysics OC 20**. The measurements were performed in the grain direction. For each sample, an average of 10 droplets were considered, each of them with a volume of 4  $\mu\text{L}$ , both for water and formamide. Contact angles of the two liquids were performed over time during approximately 5 s and the data acquisition was carried out at a frequency of two samples per second. For calculations, the values of contact angles collected at a fixed time (4 seconds) were considered



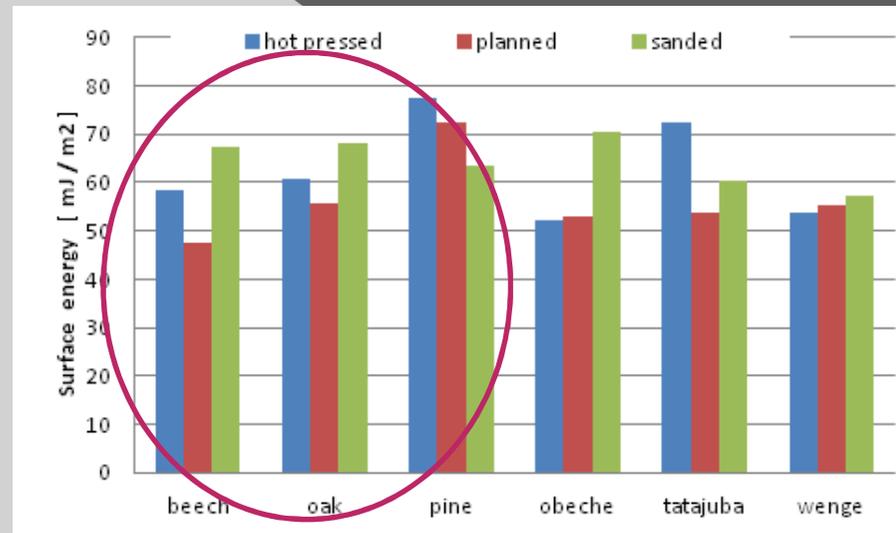
## RESULTS AND DISCUSSION - WOOD

In all showed samples (except wenge) the highest values of contact angle was noticed for hot pressed samples. Samples subjected to planning distinguishes by lower level of contact angle. According to above figures, especially significant decrease of contact angle took place after sanding of European wood species. Within exotic wood species the level of contact angle for sanded wood is higher and it became much more similar to the values measured for hot pressed and planned samples. Moreover, in case of wenge, the highest value was obtained for sample subjected only to planning.

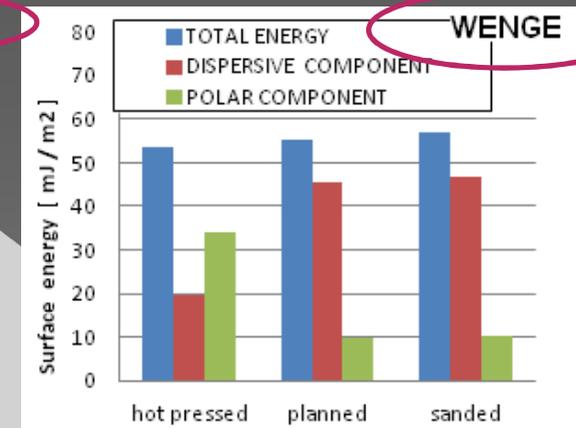
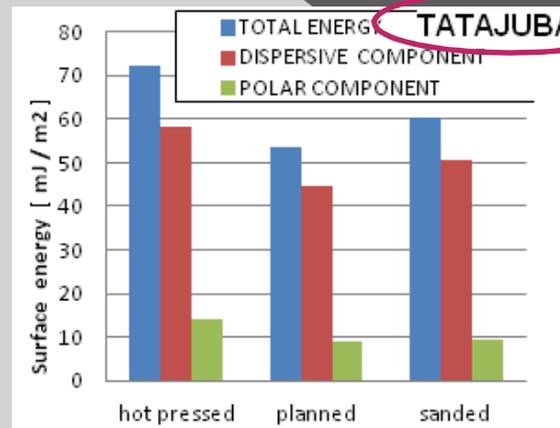
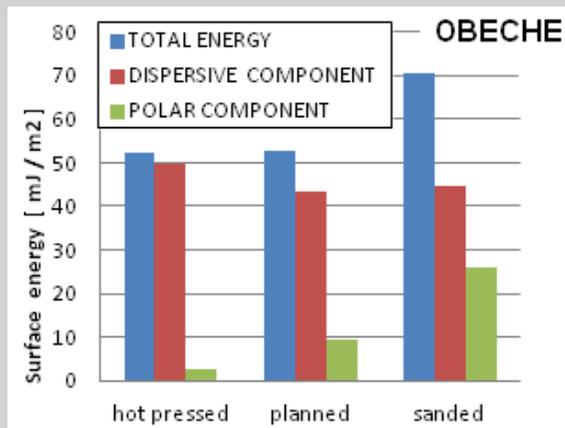
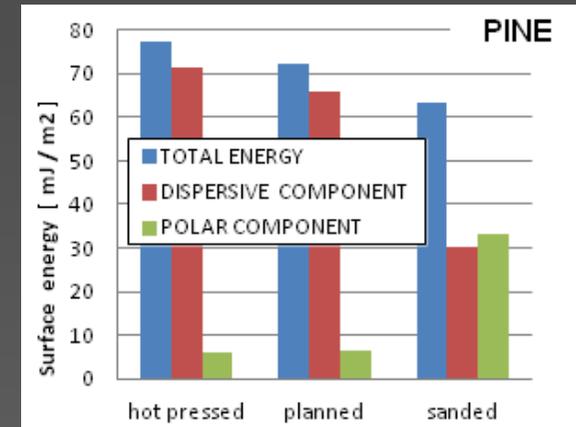
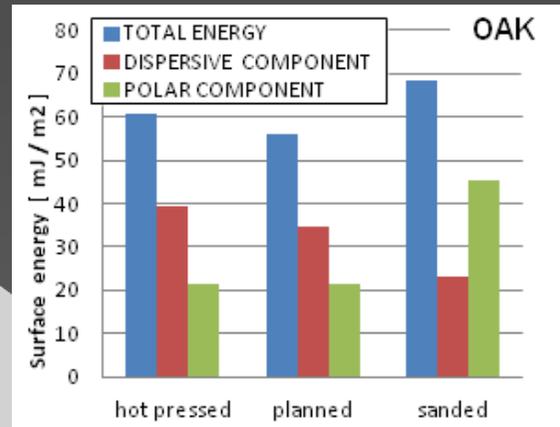
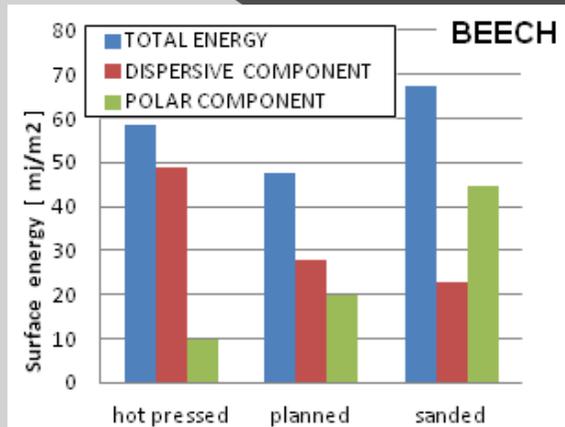


## RESULTS AND DISCUSSION - WOOD

In figure below the total surface energy for all analyzed kinds of work samples is presented. It can be assumed that there is no clear relation between contact angle of water the and total surface energy. Even in case of beech, despite the lowest level of contact angle for sanding treatment (which is twofold lower than for hot pressing) the spread of total surface energy values in case of all treatment methods not exceed about 20 %. Moreover, the total surface energy for all wood samples noticed for sanding remains on comparable level in spite of the clear increasing of contact angle refereed to this type of treatment within all wood species (from beech up to wenge).



# RESULTS AND DISCUSSION - WOOD

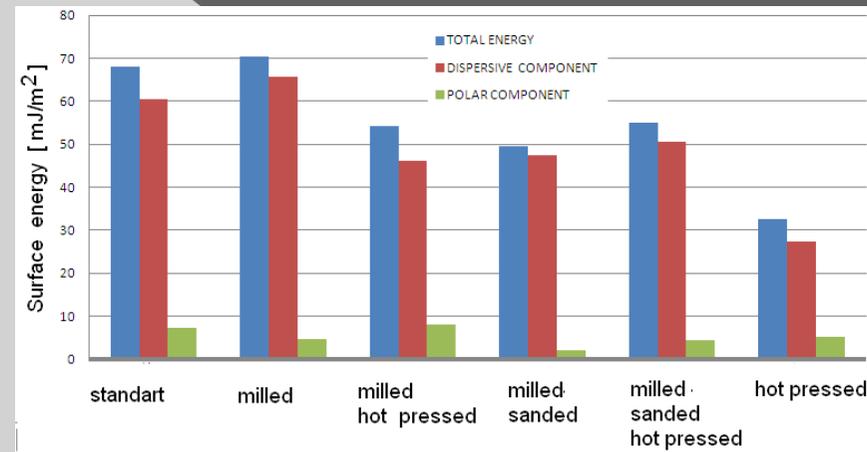
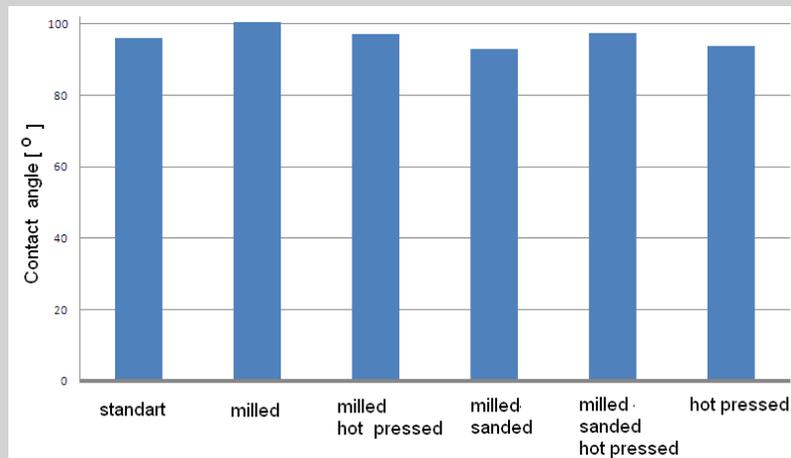


## RESULTS AND DISCUSSION - WOOD

Analyzing contribution of particular components of surface energy, especially relevant changes can be observed in its polar component. For European wood species and obeche subjected to sanding is remarkable the relatively high level of this part of surface energy. However, in case of tatajuba and wenge, is visible inverse effect. For these two wood species, the highest level of the polar component is found for hot pressed samples. For planned and sanded samples of tatajuba and wenge, unlike to the rest of wood species, the values of polar component of surface energy are comparable.

## RESULTS AND DISCUSSION – MDF BOARDS

In case of MDF boards there are no significant differences in polar component of surface energy between different surface treatments. The contribution of polar component of surface energy is very low what could explain the much higher level of contact angle for all MDF boards where the minimum angle amounted about 90°, in comparison with values obtained for wood. The highest value for wood was noticed for obeche subjected to hot pressing, namely 83°. In general, the influence of treatment methods of MDF boards is not of so great importance as in wood. However, the high values of contact angle might indicate that further efforts to improve the wettability of this kind of wood based material are needed in the future



# CONCLUSIONS

- Contact angle for European wood species (beech, oak and pine) subjected to sanding is especially low. Exotic wood species used in experiments distinguishes by much lower differences of contact angle regards to methods of wood treatment.
- Hot pressing caused visible increasing of contact angle for fast all wood species (except wenge).
- Changes of wettability determined with contact angle are visible in fluctuation of polar component of total surface energy.
- MDF boards have comparable wettability for all variants of material processing methods. The contact angle amounted above 90 ° what is much more than the values observed for all analyze wood species.
- Contribution of polar component of total surface in comparison with dispersive component for MDF boards is much less than for wood.

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***THANKS FOR YOUR  
ATTENTION !***

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