Utilisation of sorghum waste for particleboard production - density profile

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The work is oriented on experimental verification of possibility of sorghum utilisation for manufacturing three layer particle boards. Were determined standard physical and mechanical properties and density profile using the gamma rays densitometry “the analyzer of density profiles”.

Sorghum vulgare var. *technicum*

a

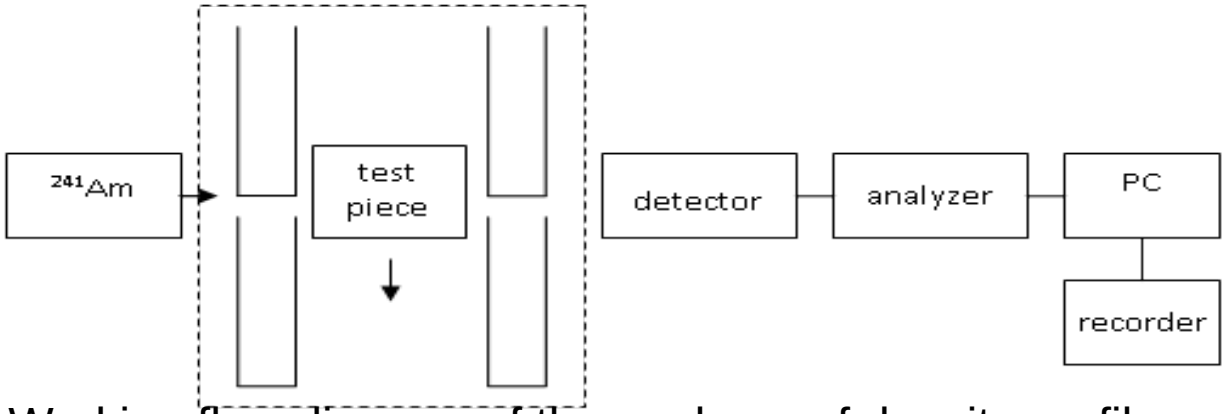
b

a) sorghum brooms, b) sorghum waste

Experimental methods

In laboratory conditions - produced boards

- dimensions of 360x360x16 mm
- density 720 kg.m^{-3},
- four variants with ratios of sorghum particles : wood particles: 3 : 0, 0 : 3, 1 : 2, 2 : 1.
- density profiles determination - apparatus constructed in laboratories of the Faculty of Wood Sciences and Technology, Technical University in Zvolen.
  - the gamma radiation - radioisotope ^{241}Am



Working flow diagram of the analyzer of density profiles

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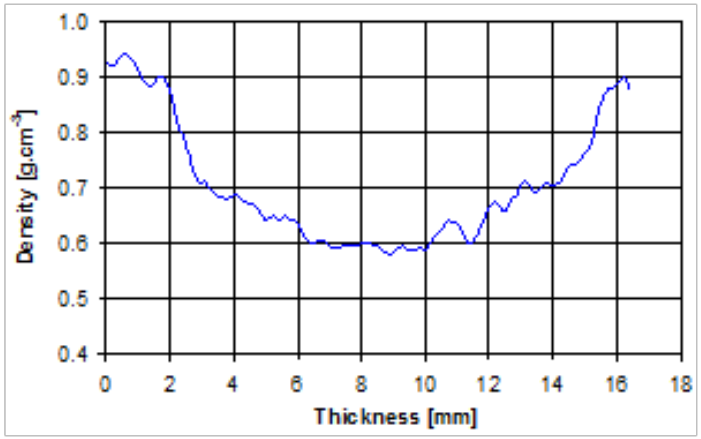
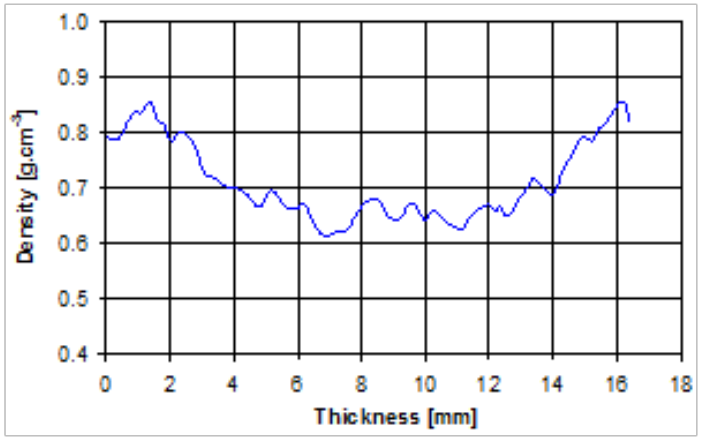
Results

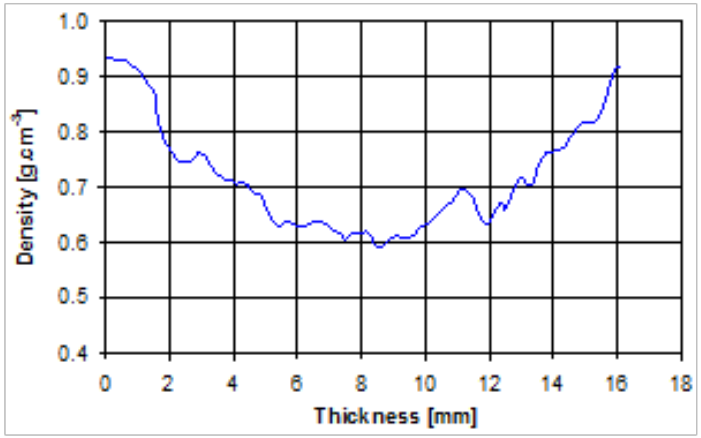
A sorghum particle 3:0 wood particle



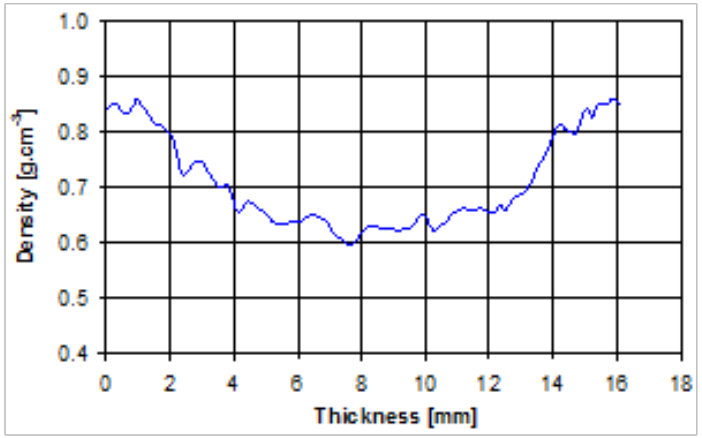
B sorghum particle 0:3 wood particle



C sorghum particle 2:1 wood particle



D sorghum particle 1:2 wood particle



Boards with higher proportion of sorghum cause significant densification of surface layers of boards which implies that sorghum ability to densify appears higher than for wood. The obtained research results indicate possibilities of the utilisation of sorghum particles to manufacture particle-boards.

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INTRODUCTION

Large amounts of lignocellulosic residues suitable for composites production (about 2.4 billion tons) are produced every year after the end of the agricultural season of the various agricultural species. These residues are either burned down or left over in the ground without any further utilization. The agricultural residues are a part of wheat, barley, oats, rye, rice straw, sugar cane, the stalks of maize, cotton, tobacco, bamboo and the husks or shells of walnuts, almonds, etc.
Also the growing demand for wood-based panels and the increasing price of chips has led to continuous efforts to find new resources as an alternative to wood (Barbu et al. 2013).

The work is oriented on experimental verification of possibility of sorghum (Fig. 1) utilisation for manufacturing three layer particle boards. Were determined standard physical and mechanical properties (Vrábľová et al. 2006) and density profile using the gamma rays densitometry "the analyzer of density profiles".

Figure 1: *Sorghum vulgare var. technicum* a) sorghum brooms b) sorghum waste

EXPERIMENTAL METHODS

In laboratory conditions were produced boards in four variants with the following ratios of sorghum particles : wood particles: 3:0; 0:3; 1:2; 2:1.

Laboratory prepared board:
- three layer sorghum-wood particleboard
- dimension 360 x 360 x 16 mm
- density 720 kg.m^{-3}

Particles:
- wood mixture of softwood (industrially produced)
- sorghum waste *Sorghum vulgare var. technicum* (Fig.1b)
- moisture contend of surface particle 4%
- moisture contend of core particle 3%

Adhesiv:
- resin - Urea-formaldehyde (UF) 67% solution
  - surface layer 11%
  - core layer 8 %
- paraffin emulsion 37% solution
  - surface layer 0.8 %
  - core layer 0.6 %
- hardener 50 % solution
  - surface layer 2 %
  - core layer 4 %

Pressing process:
- three stage pressing diagram,
- temperature 190°C
- pressure 4.5 MPa
- pressing factor 13 s/mm

The standardized procedures according to STN EN 310, 319, 317 and 323 were used to determine the physical and mechanical properties of the pressed boards.

For density profiles determination was used apparatus constructed in laboratories of the Faculty of Wood Sciences and Technology, Technical University in Zvolen (Fig. 2). Source of the gamma radiation was a low-energy radiant AMG 50. It works with the radioisotope ^{241}Am having the energy of 59.5 keV, and its output power is 2.0 GBe. The shift of the samples was always after each 0.2 mm (Bahýl 1992).

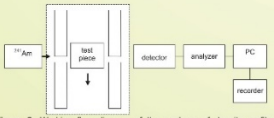

Figure 2: Working flow diagram of the analyzer of density profiles-densities evaluated by equation 1

$$I = I_0 \cdot e^{-C \rho d} \qquad (1)$$

where: "I," is the intensity of the incident gamma beam,
"I" is the intensity of the gamma beam transmitted through test piece,
"C" is the gamma-beam attenuation coefficient of the test piece,
"ρ" is the density of the test piece and
"d" is the thickness of the test piece in the direction of gamma beam.

RESULTS

Density profile on laboratory manufactured four variants of wood-sorghum particleboard is shown in Fig. 3 and the properties of wood-sorghum particleboard present Table 1.

Table 1: Physical and mechanical properties of wood-sorghum particleboards

Wood particles : sorghum particles	Density [kg.m^{-3}]	Swelling after 2 hours [%]	Swelling after 24 hours [%]	Water absorption after 2 hours [%]	Water absorption after 24 hours [%]	Bending strength [MPa]	Tensile strength perpendicular to the plane [MPa]
3:0	**720** (0.02)	**4.4** (1.07)	**24.9** (3.95)	**16.6** (3.12)	**56.7** (5.83)	**12.9** (1.49)	**0.55** (0.09)
2:1	**721** (0.02)	**11.6** (2.42)	**33.6** (2.67)	**36.1** (6.83)	**78.2** (4.90)	**13.1** (1.72)	**0.37** (0.05)
1:2	**717** (0.03)	**18.4** (3.52)	**36.9** (2.10)	**52.2** (8.06)	**84.6** (5.06)	**13.7** (1.92)	**0.29** (0.04)
0:3	**711** (0.02)	**19.2** (2.72)	**35.3** (3.13)	**58.4** (6.99)	**87.8** (5.39)	**14.4** (0.93)	**0.18** (0.02)

Notes: Values in the parentheses are the standard deviations

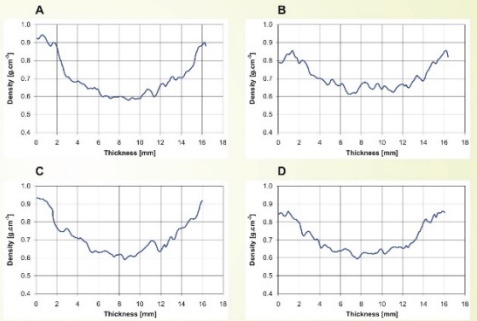

Figure 3: Density profiles : **A** - sorghum particles : wood particles 3 : 0, **B** - sorghum particles : wood particles 0 : 3, **C** - sorghum particles : wood particles 2 :1, **D** - sorghum particles : wood particles 1 : 2.

CONCLUSION

- Boards with higher proportion of sorghum cause significant densification of surface layers of boards which implies that sorghum ability to densify appears higher than for wood
- The addition of sorghum particles negatively affects values of swelling and water absorption of particle boards.
- The addition of sorghum particles improves bending strength which can be probably caused by improved densification of the surface layers of boards and by higher length of sorghum particles.
- The addition of sorghum particles negatively affects values of tensile strength perpendicular to the plane of the board.

The obtained research results indicate possibilities of the utilisation of sorghum particles to manufacture particle-boards, either as the basic raw material or as an additive to traditional wood raw material.

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