Annals of Warsaw University of Life Sciences – SGGW
Forestry and Wood Technology No 71, 2010: 435-439
(Ann. WULS – SGGW, For. And Wood Technol. 71, 2010)

An attempt at the use of laboratory density analyzer for determination of solid wood cross section density distribution

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Abstract: *An attempt at the use of laboratory density analyzer for determination of solid wood cross section density distribution.* Density profile has an essential role in evaluation of both, physical and mechanical, properties of solid wood and wood based materials. Usefulness of x-ray laboratory density analyzer for evaluation of density distribution in solid wood, at cross section in radial direction has been determined within the present study. The laboratory density analyzer permits continuous measuring of solid wood density within entire specimen thickness. The specimen thickness is of essential importance during examination of solid wood density profile – the thicker the specimen, the greater scope of examined material measurement, and this means more correct and easiness of the analyzed data in consequence. The main vice of the applied instrument is that it can be used for examination of parallel grain wood density profile first of all.

Keywords: solid wood density, density profile, laboratory density analyzer

INTRODUCTION

Solid wood examinations, based on x-ray methods, were carried out as early as in the first half of the last century (Worschitz 1932, Fischer and Tasker 1940). At the beginning, the examinations referred to qualitative evaluation of wood (flaw detection). In the course of time, application of x-ray methods was extended and their use for quantitative evaluation of various sorts of solid wood was begun (densitometry), e.g. in wood saw milling (Bajkowski 2000, Mańkowski and Krzosek 2001). The x-ray methods are used especially for determining the degree of wood biodegradation by biotic factors, e.g. evaluation of the general condition of trees (Schwartz et al. 1989) and verification of the impact of certain forestry activities upon wood properties (Tomazello 2008) and diagnosing of historical objects (Paciorek 1993, Kozakiewicz and Gawarecki 2003).

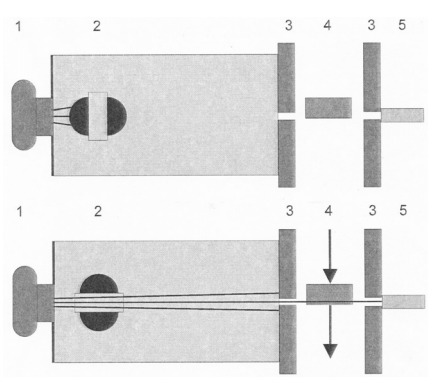

Fig. 1. Diagram of density distribution measurement with the use of x-ray density analyzer (1 – X-ray tube, 2 – Shutter: above – closed, below – open, 3 – diaphragm, 4 – sample, 5 – semiconductor detector)

Laboratory Density Profile Measuring System from GreCon, shortly called laboratory density analyzer, is widely used in both industrial and laboratory conditions, for examining of density distribution at cross section of wood based materials. The instrument measures the volumetric density profile of board specimen with the use of x-rays (fig. 1).

The laboratory density analyzer permits quick and precise determination of density distribution at the thickness of the examined wood based material. The specimen dimensions are: height and width 50 mm, thickness max. 150 mm respectively. The instrument can operate at measurement speed from 0.05 to 5 mm/s. The measurement of subsequent density values is carried out every 0.02 mm of examined material thickness. The examination results are generated by computer program operating the analyzer in a form of diagrams or digital data specifications (Excel format).

Type and structure of the board (plywood, particleboards, fiberboards, WPC etc.), density, thickness, size of wood particles used for their manufacturing, type of adhesive (resins, thermoplastics), way of board surface protection (foil, laminate, varnish), exert influence upon density distribution at cross section of wood based materials. Press closing time, i.e. the time span between starting of pressing until the assumed thickness is obtained is essential as far as density profile is concerned. The greatest differences in density distribution are obtained at short time of press closing and high pressure (Wong et al. 1998, Wong et al. 1999, Wong et al. 2000). The density profiles at cross section of the selected wood based materials are presented in figure 2.

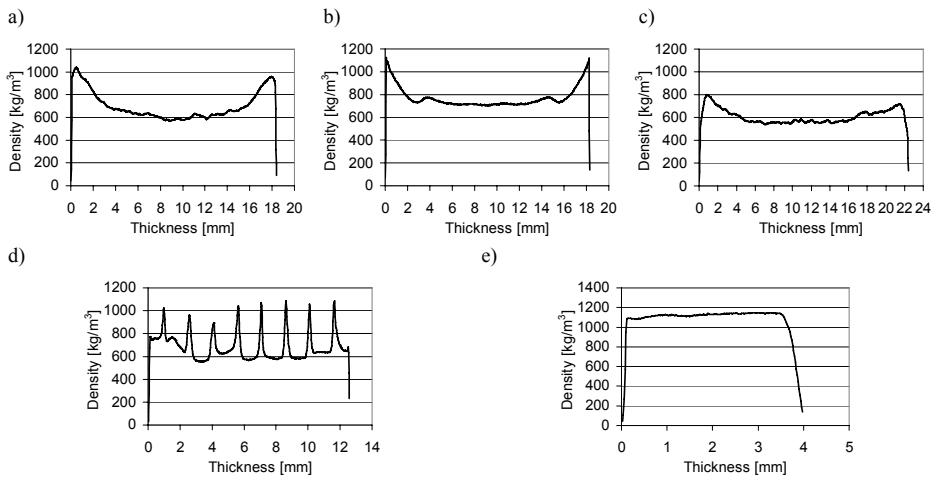

Fig. 2. Density profiles of selected wood based materials: a) 3-layer particleboard – density 697 kg/m^3, b) MDF – density 768 kg/m^3, c) OSB – density 605 kg/m^3, d) 9-layer birch plywood –density 680 kg/m^3, e) hardboard – density 1060 kg/^{3}

MATERIALS AND METHODS

Examinations aiming at adaptation of x-ray laboratory density analyzer for analysis of density distribution in solid wood cross section (in radial direction) have been carried out in the framework of the present study.

Density distribution at cross section of pine (*Pinus sylvestris* L.*)* poplar (*Populus alba* L.*)* and ash (*Fraxinus excelsior* L.*)* wood has been examined. Wood specimen with nominal dimensions (height x width x thickness) of 50x50x50 mm and 12 ± 2% MC have been used for examinations. It is worth mentioning that the weight of the specimen should not exceed 90

g, so with given dimensions of height and width of the specimen (50 x 50 mm) and solid wood density, the thickness of the specimen should be selected on the basis of adequate calculation. The examination has been carried out with measuring speed of 0.05 mm/s. The examined cross sections of the particular wood species have been presented in figure 3.

RESULTS

The results of profile density determination at cross sections of particular wood species have been presented in figure 3 and 4.

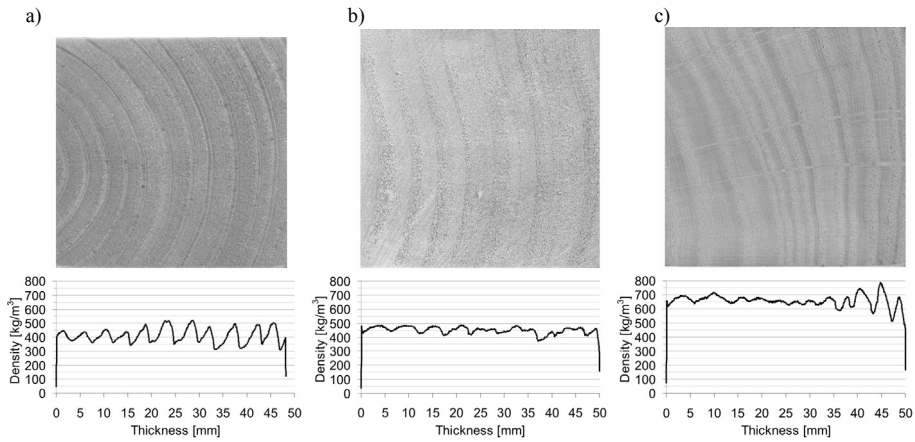

Fig. 3. Solid wood cross section density profiles: a) pine (*Pinus sylvestris* L.*),* b) poplar *(Populus alba* L.), c) ash *(Fraxinus excelsior* L.*)*

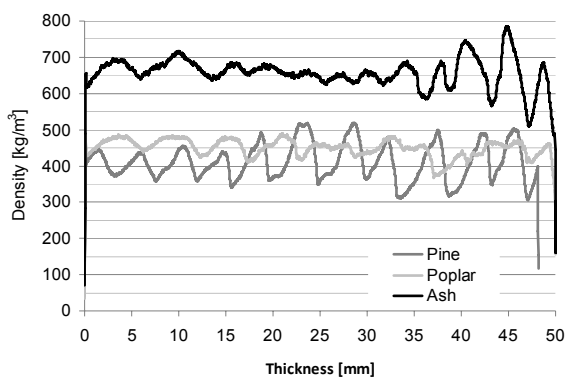

Fig. 4. Specification of density profiles for examined solid wood species: pine (*Pinus sylvestris* L.*),* poplar *(Populus alba* L.), ash *(Fraxinus excelsior* L.*)*

Laboratory density analyzer permits continuous measuring of solid wood density for entire specimen thickness. Apart from density, width of particular annual rings can be determined on the basis of the accumulated data.

On the basis of the performed examinations it has been found that the average density of the examined solid wood species: pine (*Pinus sylvestris* L.*),* poplar (*Populus alba* L.*)* and ash (*Fraxinus excelsior* L.*)* is 411, 449 and 656 kg/m^3 respectively. Kollmann (1951) presents

limit values of wood density variability in absolutely dry condition: pine - from 300 to 860 kg/m^3 (average value being 490 kg/m^3), poplar - from 320 to 710 kg/m^3 (average value being 410 kg/m^3 and ash - from 410 to 820 kg/m^3 (average value being 650 kg/m^3). The data coming from determinations confirm the data presented in literature.

The presented diagrams (fig. 3 and 4), within the given wood species, show density differences between early and late wood. As a result of the performed examinations it has been found that the density of early pine wood ranges from 306 to 372 kg/m^3 and from 430 to 519 kg/m^3 for late pine wood respectively. In accordance with the data as presented in literature, for pine wood in absolutely dry condition, the density of early wood ranges from 300 to 370 kg/m^3 and for late wood from 760 to 900 kg/m^3 respectively (Kollmann and Côte 1968). The ratio of late and early wood density is average 2.5 for pine wood, like for remaining coniferous species. It has been found that for poplar wood the density of early wood ranges from 368 to 441 kg/m^3 and for late wood from 450 to 489 kg/m^3 respectively. The ratio of late and early wood density in deciduous wood with dispersed vascular system is about 1.3 (Kollmann and Côte 1968). As a result of the performed examinations it has been found that early ash wood density ranges from 510 to 650 kg/m^3 and from 660 to 785 kg/m^3 for late wood respectively. According to the data as presented in literature, the ratio of late and early wood density in deciduous wood of ring vascular system is about 2.0 (for ash wood the early wood density ranges from 385 to 500 kg/m^3 and for late wood from 720 to 800 kg/m^3 respectively).

The data coming from the determinations confirm the data as in literature partly. This is because wood, as anisotropic material, shows much variability within given species. Moreover, the instrument can measure the volumetric density of specimen and the results, especially for non parallel grain wood, can make an average value, e.g. of early and late wood density measurement.

SUMMARY

On the basis of the performed examinations it has been found that it is possible to use x-ray laboratory density analyzer for evaluation of density distribution in solid wood cross section in radial direction. First of all it should be applied for parallel grain wood density profile examination.

REFERENCES

1. BAJKOWSKI B., 2000: Układy tomografii komputerowej do skanowania kłód. XIV Konferencja Naukowa wydziału technologii drewna SGGW „Drewno - materiał wszechczasów" Rogów 13-15 listopada: 7-10.
2. FISCHER R.C., TASKER H.S., 1940. The detection of wood boring insects by means of X-rays. Annals Applied Biology 27 (1): 92-100.
3. KOLLMANN F., 1951: Technologie des Holzes und der Holzwerkstoffe, Vol. I, 2nd ed., Springer-Verlag, Berlin-Göttingen-Heidelberg. J.F. Bergmann, München.
4. KOLLMANN F., CÔTE W.A., 1968: Principles of wood science and wood technology. Solid wood – part I. Berlin-Heidelberg-N.York.
5. KOZAKIEWICZ P., GAWARECKI K., 2003: Examination of Historical Wood Internal Structure Using Roentgen-Ray Computed Tomography. Annals of Warsaw Agricultural University. Forestry and Wood Technology No 53, s.223-227. Warszawa.
6. MAŃKOWSKI P., KRZOSEK S., 2001: Zastosowanie promieniowania RTG w nieniszczących badaniach drewna. Przemysł Drzewny nr 6 : 19-24.
7. PACIOREK M., 1993: Badania wybranych tworzyw termoplastycznych stosowanych do impregnacji drewna. Studia i materiały Wydziału Konserwacji i Restauracji Dzieł

Sztuki Akademii Sztuk Pięknych w Krakowie. Tom III. Wydawnictwo Literackie Kraków.
8. SCHWARTZ V., HABERMEHL A., RIDDER H.W., 1989: Zerstorugsfreier Nachweis von Kern- und Wandfaulen im Stamm stehender Baume mit der Computer – Tomographie. Forstarchiv 60: 239-245.
9. TOMAZELLO M., BRAZOLIN S., CHAGAS M. P., OLIVEIRA J. T. S., BALLARIN A. W., BENJAMIN C. A., 2008: Application of x-ray technique in nondestructive evaluation of eucalypt wood. Maderas: Ciencia y tecnología 10 (2): 139-149.
10. WONG E.-D., ZHANG M., WANG Q., KAWAI S., 1998: Effects of mat moisture content and press closing speed on the formation of density profile and properties of particleboard. Journal of Wood Science. Volume 44 (4) 1998: 287-295.
11. WONG E., ZHANG M., WANG Q., KAWAI S., 1999: Formation of the density profile and its effects on the properties of particleboard. Wood Science and Technology. Volume 33 (4): 327-340.
12. WONG E.-D., ZHANG M., HAN G., KAWAI S., WANG Q., 2000: Formation of the density profile and its effects on the properties of fiberboard. Journal of Wood Science. Volume 46 (3): 202-209.
13. WORSCHITZ F., 1932. L'utilization des rayos X en vue de l'etude de la qualité du bois. In. Congrès IUFRO. 459-489. Paris. France.

Streszczenie: *Próba wykorzystania profilomierza gęstości do oznaczania rozkładu gęstości w drewnie litym na przekroju poprzecznym*. Profil gęstości odgrywa istotną rolę przy ocenie właściwości, zarówno fizycznych jak i mechanicznych drewna litego oraz tworzyw drzewnych. W ramach niniejszej pracy określono przydatność rentgenowskiego profilomierza gęstości do oceny rozkładu gęstości w drewnie litym na przekroju poprzecznym w kierunku promieniowym. Profilomierz gęstości, umożliwia ciągły pomiar gęstości drewna litego na całej grubości próbki. W trakcie badania profilu gęstości drewna litego istotną rolę odgrywa grubość próbki - im grubsza próbka, tym większy zakres pomiarowy materiału badawczego, co w konsekwencji przekłada się na większą poprawność i łatwość analizowanych danych. Zasadniczą wadą przyrządu jest to, iż może być stosowany przede wszystkim do badania profilu gęstości drewna równoległowłóknistego.

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