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INVESTIGATIONS ON IMPREGNATION ABILITY OF EUROPEAN ASPEN (*Populus tremula* L.) WOOD

by Kazimierz Lutomski, Grzegorz Cofta, Bartłomiej Mazela and Rafał Remi
Institute of Chemical Wood Technology
A. Cieszkowski Agricultural University of Poznań

European aspen wood was investigated immediately after cutting, after its 2 and 4 months storing in order to determine its impregnation ability. Samples were done from outer and inner zones of wood. Bath method in solution of sodium fluoride during 15 min, 2 and 8 hours was used. Liquid absorption was determined in g/m^2 as well as its depth of penetration across to the grain and along the grain.

Key words: european aspen wood, impregnation ability, bath, penetration, sodium fluoride

INTRODUCTION

Among many poplar species (*Populus* spp.) European aspen (*Populus tremula* L.) is a tree of a large extent of occurrence including the whole Europe and also Poland (Bugała 1979). European aspen is a fast growing species of little soil requirements. It is of large importance for reclamating stand densities, for instance during afforestation of dumps and excavations. During last years European aspen wood became material in research aiming to investigate its properties and possible utilization. There was also proved that European aspen wood has high ability for fungi attack causing brown and white rot as well as attack of microscopic fungi causing mould and soft rot (Lutomski 1995). The wood was also investigated due to utilize it as a component of wood-polymer composite. There was reported different ability of European aspen wood for impregnation with monomer due to cutting wood from different zones of the cross-section (Ławniczak 1993). It should be also stated that contrary to other poplar species European aspen has no heartwood (Krzysik 1973).

The aim of the paper is to determine impregnation ability of European aspen wood in a non-pressure process with regard to the influence of storing time after cutting, duration of soaking and a position of cutting samples from the cross-section and the longitudinal section of wood.

MATERIALS

The material in the research was European aspen wood logged in the Forest Experimental Station of Agricultural University of Poznań from the same region as wood used of durability investigations (Lutomski 1995). Six trees of European aspen of 30 year old and breast height diameter of about 40 cm were cut in May round 2 weeks after vegetation begun. The following procedure was applied to the cut trees:

– Two trees were processed immediately after cutting, i.e. there were cut rolls of 1m length from the high of 1 and 5 m from butt end. One disc of 5cm thickness was cut from the central part of every roll in order to determine moisture content. The remaining parts of rolls were used to cut squares. It let to obtain samples coming from outer and inner zones of the cross-section (fig. 1.). Squares were firstly heated up with steam in autoclaves to temperature of about 100^0C for time of 3.5 h. It was done in order to prevent forming tyloses by killing parenchymatic cells surrounding vessels,

– Four trees were left in forest after cutting heads and branches. After two months two trees were treated as described above. The next two trees were left for next two months and after that rolls and squares were cut.

It let to obtain material differing in its storing time after cutting. Squares were dried to moisture content of 8 %. Samples of dimensions of 20*20*60 mm were prepared and their surface was smoothly planed. The samples were separated into two groups. Fronts of samples from the first group were coated with silicone resin in order to prevent preservative penetration along the grain.

As the model preservative there was used 2 % solution of sodium fluoride (NaF). The preservative penetrates well air dry wood due to capillary forces and very small ion radii of sodium and fluorine. The preservative presence in wood can be easy revealed by the use of zirconium-alizarian indicator (Theden and Kottlors 1965). Solution of NaF was also used by Troy et al. (1995) in their research on impregnation ability of wood of fast growing trees. The same chemical compound was used by Prosiński and Ścisłowski (1959) during investigation of pine wood impregnation.

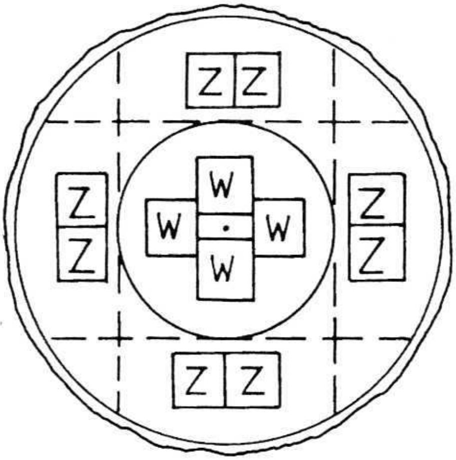

Fig. 1. Position of samples obtaining on the cross section of a log:
Z - outer zone, W - inner zone.

Rys. 1. Miejsca pobrania próbek na przekroju poprzecznym pnia;
Z – strefa przyobwodowa, W – strefa przyrdzeniowa.

METHODS

There was used a non-pressure process: bath in 2 % solution of NaF lasting 15 min, 2 and 8 h. Before the treatment samples were equilibrated to moisture content of 8 % and weighted with accuracy of 0.01 g. After that they have been placed in preservative in crystallizers on stickers made of glass rods. Samples were loaded from the top to prevent their emerging on the surface of preservative. The access of preservative was guaranteed to all surfaces of samples. The layer of preservative above samples was 10 mm. After the fixed time samples were taken out of preservative solution, dried from the excess of preservative and again weighted. The amount of absorbed preservative by every sample was calculated on basis of the difference of masses before and after impregnation and it was expressed in g/m^2 of wetted wood surface. After that samples were placed on polyethylene net and stored in laboratory conditions (temperature ca. 21^0C, relative humidity 50•60 %) for 24 h with free air circulation. After that samples were cut in places designated in fig. 2. Zirconium-alizarian indicator was placed on fresh cuts (Theden and Kottlors 1965). Presence of sodium fluoride manifested in yellow colour (unimpregnated wood became cherry coloured). The depth of impregnation was marked on exposed cuts. Measurements of preservative penetration depth were performed with accuracy of 0.01 mm in longitudinal and transverse directions at places designated in fig. 3. The number of samples in one variant was at least 6.

RESULTS

Moisture content

Results of wood moisture content determination after different storing time in forest are presented in table 1. Moisture content was higher in outer zones than in inner for all investigated cases. The highest moisture content was about 100 % and was reported in outer zone immediately after cutting. After two months of storing there was reported slight (no more than 20 %) decrease of moisture content in outer zone. Wood moisture content of inner zone was lower than in outer zone and its decrease during storing was smaller. However, there were reported smaller differences in moisture content of both zones after two months storing.

The reported results do not let for further generalization because they have been obtained only for two trees for every period of their storing in forest. Although, there is no doubt that moisture content of outer zones is high in the beginning of vegetation. During four months storing of logs with bark moisture content decreased of ca. 15 % obtaining the value over 80 %.

For the certain time of storage bark protects wood from fungi infection, i.e. after two months of storing there were no observed changes of wood colour which may testify to microscopic fungi development. The fungi cause changes of wood quality of other species including hardwoods (Chovanec et al. 1993). Such changes have been observed after four months storing of European aspen wood. They manifested in spots and some zone lines.

The observed changes of moisture content during storing are related to specific climate conditions in a given year and its season. Moreover, it should be stated that investigated

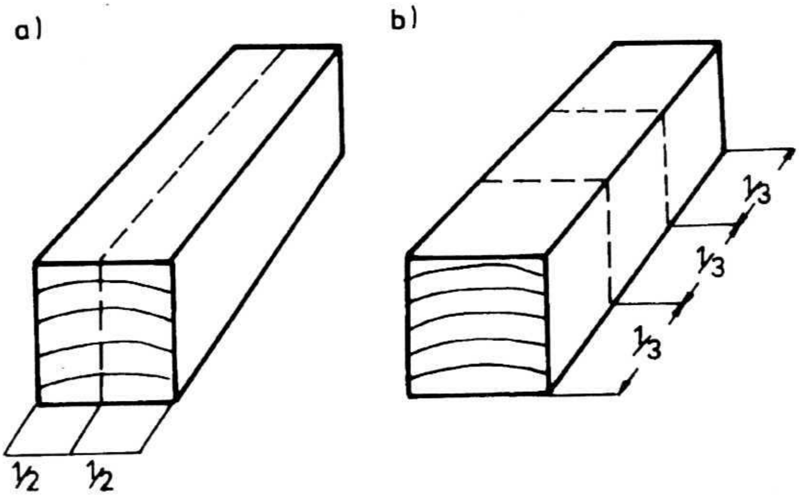

Fig. 2. Position of samples cut for determining depth of liquid penetration:
a) along the grain, b) across to the grain

Rys. 2. Miejsca przecięcia próbek do pomiaru głębokości wniknięcia roztworu w drewno;
a) wzdłuż włókien, b) w poprzek włókien.

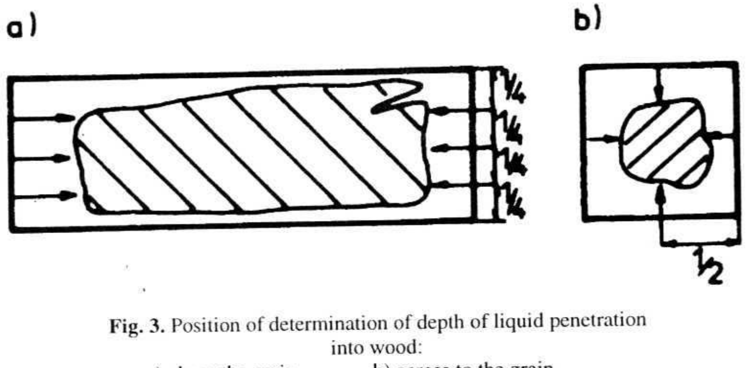

Fig. 3. Position of determination of depth of liquid penetration into wood:
a) along the grain, b) across to the grain.

Rys. 3. Miejsce pomiaru głębokości wniknięcia roztworu w drewno;
a) wzdłuż włókien, b) w poprzek włókien.

Table 1

Tabela 1

Moisture content of European aspen wood depending on time of storage and position of sampling

Wilgotność badanego drewna osiki w zależności od czasu składowania po ścięciu i miejsca pobrania próbek

Storage time (months) Czas składowania (miesiące)	Distance of a sample from butt (m) Odległość próbki od odziomka (m)	Position of samples on the cross-section Położenie próbek na przekroju poprzecznym	
		Internal zone Strefa wewnętrzna	External zone Strefa zewnętrzna
		Moisture content (%) Wilgotność (%)	
0	1	60.1	98.0
	5	64.9	103.8
2	1	74.5	83.1
	5	66.6	88.1
4	1	51.9	83.6
	5	56.4	86.1

wood was stored in the form of logs for which drying from ends and paths of infection are significantly restricted.

Results of impregnation

Statistical analysis of the obtained results was performed according to the Student's test (Gonet 1974). It was used to analyze consumption of preservative as well as to analyse depth of preservative penetration into wood along and across to the grain. It designated the lack of essential differences in European aspen wood properties related to samples position in the longitudinal direction from 1 to 2 m from butt.

Absorbing capacity through side-surfaces

The results of European aspen wood soaking in solution of sodium fluoride are presented in fig. 4. They indicate a distinct relationship between absorption (g/m^2) and duration of treatment. Wood absorbed about 200 g/m^2 of preservative during first 15 minutes of soaking. Extending time of soaking up to 2 h caused increase of preservative absorption to 2-3 times. Smoothly planed wood surfaces absorbed about 900 g/m^2 of preservative across to the grain during 8 h. It was reported for samples from outer zones of the cross-section. Wood coming from the inner zone indicates lower absorption and it is mainly related to longer times of impregnation. The results presented in fig. 4 do not indicate essential influence of storing time on preservative absorption by side-surfaces of samples. According to Langendorf (1961) the similar run indicates absorption of water solution of salt preservatives by pine wood of rough surface. Although, there is existing

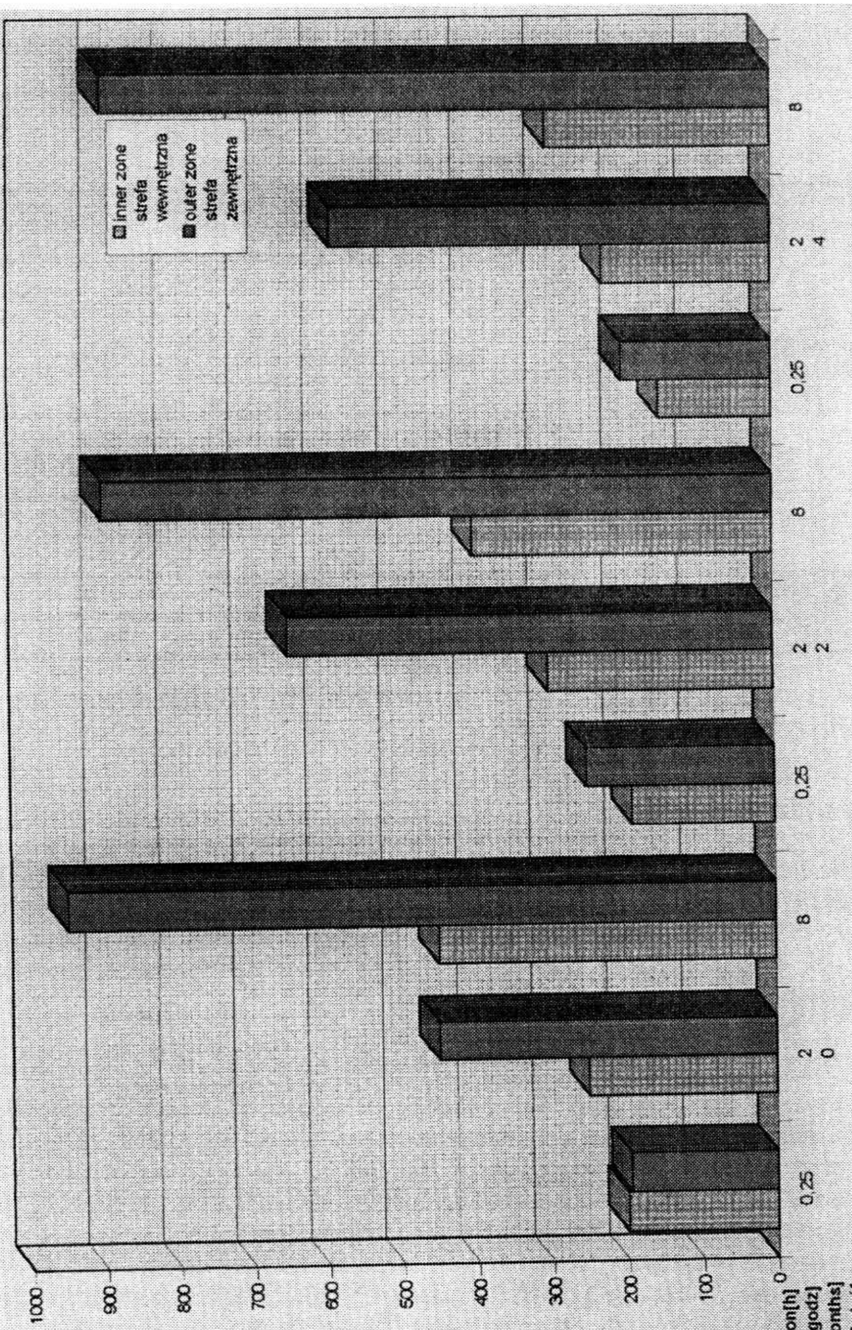

Fig. 4. Preservative absorption through side surfaces of European aspen wood samples

Rys. 4. Wchłonięcie roztworu impregnacyjnego przez powierzchnie boczne próbek drewna osiki significant differentiation of absorption due to quality of surface processing. Pine wood of smoothly planed surfaces absorbs significantly less of preservative in the same time.

Taking into account mean rate of absorption of preservative across to the grain expressed in g/m^2 per h there can be noticed particularly high rate in the first period of the process. The rate of absorption was 800 g/m^2 per h for the first 15 min. For 2 h of absorption the rate dropped to 240 g/m^2 per h and for 8 h process it dropped to 120 g/m^2 per h. It testifies particularly high initial absorption of european aspen wood, which decreases highly with time of the process. Due to that it is possible to obtain sufficient preservation of European aspen wood after 15 min soaking in properly selected preservative.

Preservative penetration along the grain

The important attribute of liquid absorption by wood is its depth of penetration. The most important role in the bath method play capillary forces. Therefore, depth of penetration may be the measure of permeability of capillaries. Fig. 5 presents results of depth of sodium fluoride penetration along to the grain for European aspen wood. The maximum values, exceeding 25 mm, were obtained for wood from the outer zone immediately after cutting during 8 h soaking. Wood from the inner zone had significantly smaller depth of penetration of liquid along the grain. There was also reported decrease of absorption ability for wood from the inner zone after 2 months of storing in forest. Samples made of wood stored in forest for 4 months absorbed along the grain solution of sodium fluoride in much more worse way. The maximum depth of free penetration was ca. 50 % of the value reported for wood immediately after cutting.

Preservative penetration across to the grain

Fig. 6 presents depth of penetration of preservative across to the grain. For samples made of wood immediately after cutting there was reported depth of penetration of only 1.5 mm after 15 min of soaking. The depth was independent of the zone. During that treatment samples absorbed ca. 200 g/m^2 which is enough to preserve wood. However, from the point of view of thickness of preserving layer impregnation time is too short.

After 2 h of soaking there has been obtained depth of 3 mm which is sufficient value for the bath method.

Storing of European aspen wood in forest for two months reduces its impregnation ability, especially for wood coming from the inner zone. For such wood there was always obtained depth of impregnation smaller than 2 mm.

Increasing of storage time of wood with bark up to 4 months reduces depth of penetration of preservative for wood coming from inner as well as from outer zones.

The reported differences of penetration along the grain and across to the grain were analysed in the statistical way due to their dependence on storage time and treatment duration. It was stated that there is essential influence of storage time on capillary penetration of the liquid. It testifies that permeability of the capillary system of European aspen wood decreases with storage time in summer. The difference of liquid penetration was statistically proved due to two different zones - inner and outer.

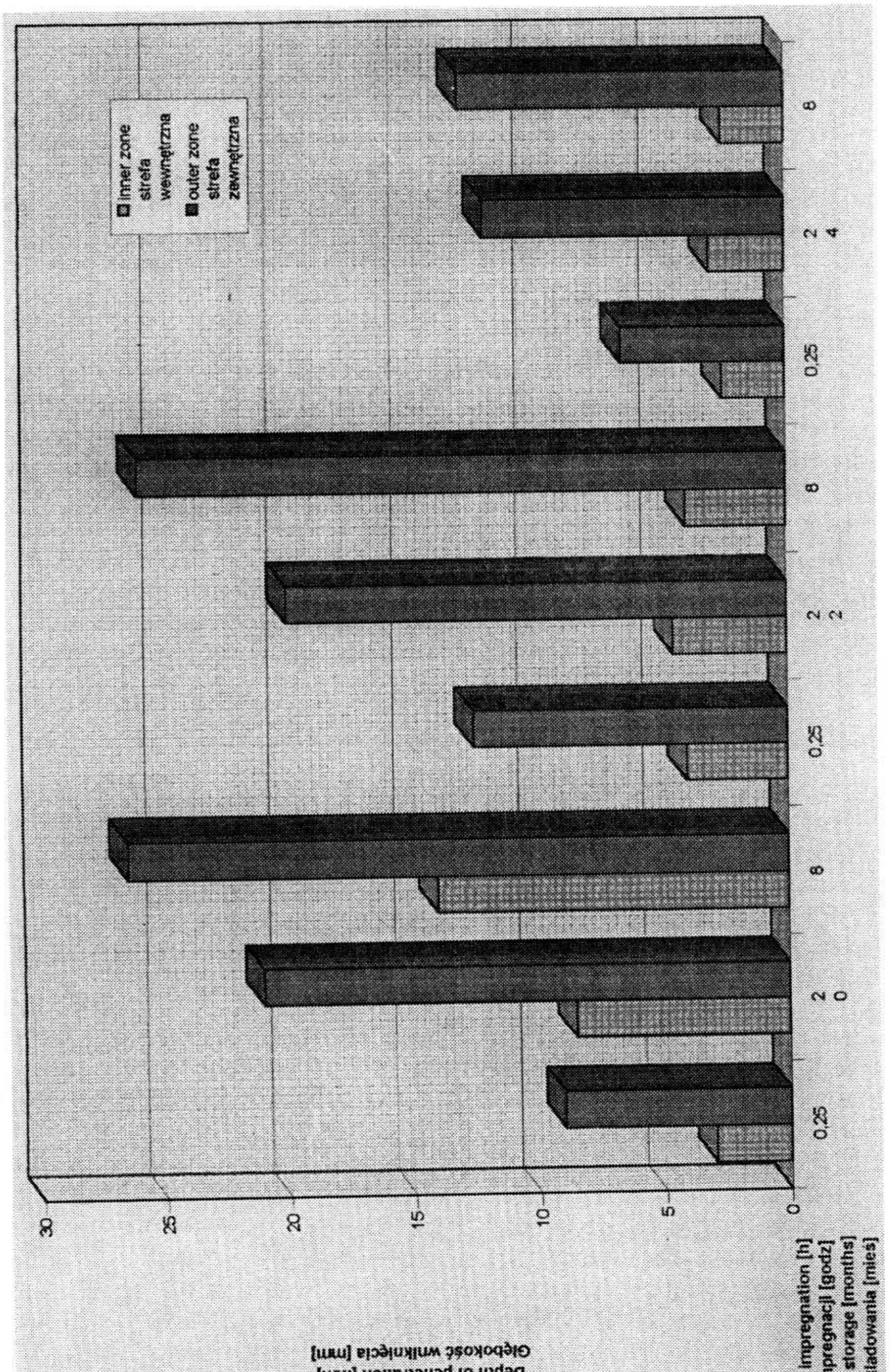

Fig. 5. Preservative penetration along the grain of European aspen wood
Rys. 5. Wnikanie roztworu impregnacyjnego wzdłuż włókien drewna osiki

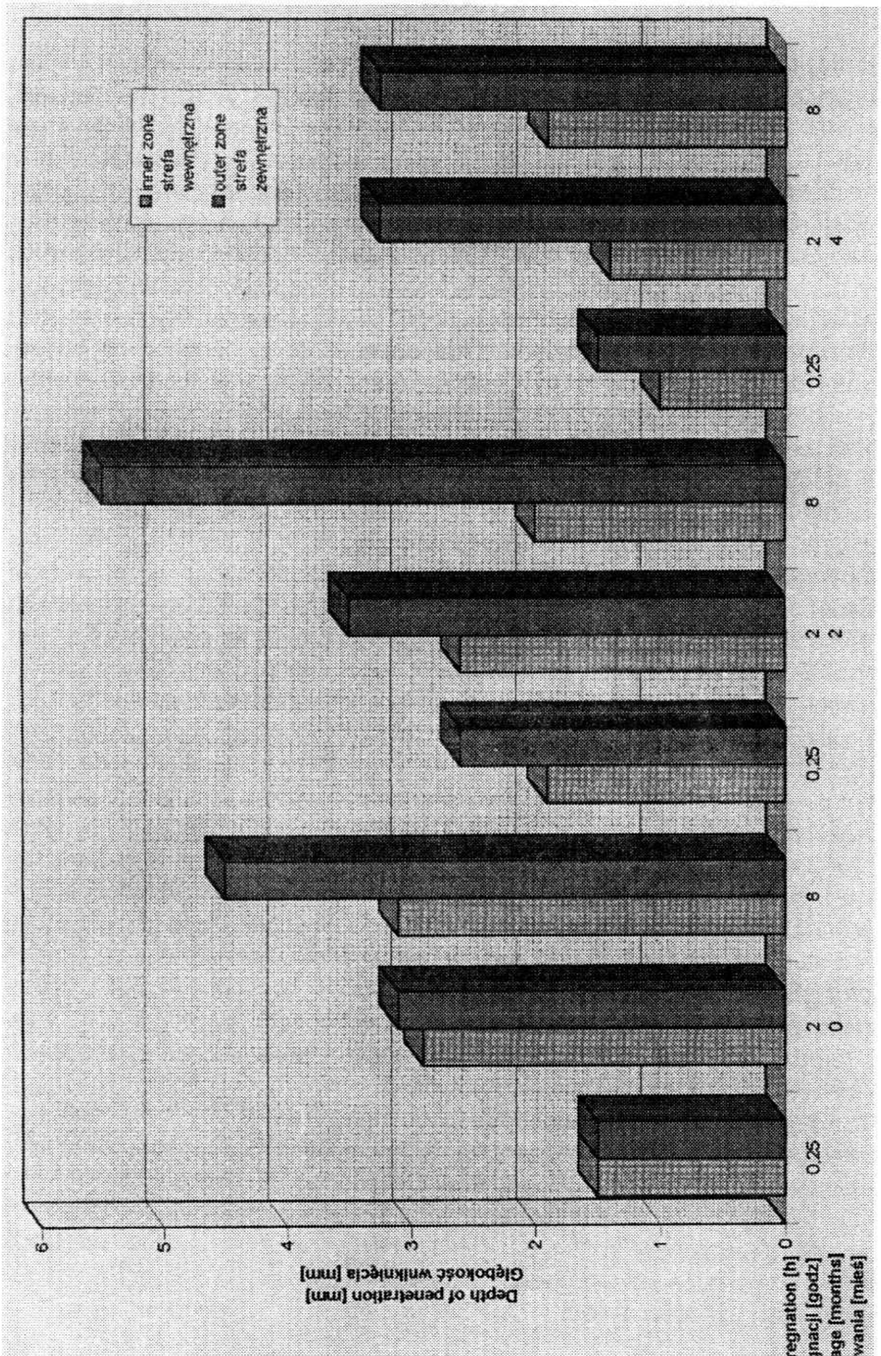

Fig. 6. Preservative penetration across to the grain of European aspen wood
Rys. 6. Wnikanie roztworu impregnacyjnego w poprzek włókien drewna osiki

DISSCUSION

According to the present state of knowledge European aspen is classified as a non-heartwood species. Wood of European aspen does not demonstrate a distinct differences between outer and inner zones of a log (Krzysik 1974). Water is transported by the whole cross-section during grow of a tree, however moisture content of the central part is lower then outer. It was proved in this research (table 1). The central zone is considered as inner, dry sapwood. Other species of poplar (*Populus* spp.) show a distinct difference between sapwood and heartwood. Van Acker et al. (1990) stated during research on impregnation ability of different parts of a log of poplar hybrids, that the most resistant to pressure treatment is the intermediate zone between sapwood and heartwood. They also reported that preservatives better penetrate sapwood than heartwood.

The surprising result during research of impregnation ability of black poplar (*Populus nigra* L.) was obtained by Wytwer (1995). He used the non-pressure process (bath) for different preservatives and stated that there is no difference in impregnation ability for sapwood and heartwood. Krzysik (1974) classifies black poplar as a heartwood species with distinctly brown colored heartwood.

Ławniczak (1993) paid attention on diversified impregnation ability of outer and inner zones of European aspen wood. During research on possible utilization of that wood in production of composite wood-polymer, he reported lower ability of impregnation with styrene monomer of the outer zone. Microscopic research proved the presence of tyloses in vessels of European aspen wood. However, there was no reported time of their forming because wood for that research was stored 6 months after cutting. It results from the research, that European aspen wood differs in impregnation ability of salt solutions transported due to capillary forces. Wood of the outer zone impregnates easily and absorbs large amounts of preservative. Wood of the inner zone absorbs in analogous conditions lower amount of preservative if wood was dried directly after cutting. Storing of wood in summer for 2 months did not influenced significantly impregnation ability of European aspen wood. However, distinct influence on impregnation ability was observed after 4 months storing of logs in forest. It manifested in the reduction of the depth of preservative penetration along the grain, which may prove reduction of wood permeability.

According to the research of Ławniczak (1993) it can be stated that 4 months storing of European aspen wood with bark in summer causes changes in wood structure, for instance forming of tyloses. It reduced liquid penetration along the grain. Absorption through the side surfaces was also distinctly changed.

The reported research reveals distinctly different impregnation ability of outer and inner zones of european aspen wood. It suggests that european aspen may be classified to trees of non-colored heartwood or indicating traumatic heartwood. It is not unlikely, that the investigated trees were hybrids of European aspen and other species of poplar with distinct heartwood. As it was reported by Van Acker et al. (1990), Van Acker and Stevens (1995) different hybrids of poplar indicate strong differentiation in impregnation ability of wood coming from outer and inner zones.

CONCLUSIONS

1. European aspen wood is characterized by large impregnation ability of water solutions impregnating salts by side surfaces across to the grain. Impregnation ability of wood coming from the outer zone is higher during longer soaking.

2. Capillary transport of water solutions along the grain is much better for wood from the outer zone than from the inner zone.

3. Storing of European aspen wood without bark in summer during 2 months decreases impregnation ability along the grain of wood from the inner zone. The same effect is observed after 4 months storing of wood from the outer zone.

4. However, European aspen is classified as a non-heartwood spice its wood from the outer and inner zone differs in impregnation ability during non-pressure treatment. It suggests a possibility of existence of poplar hybrids forming distinct heartwood.

5. European aspen wood cut during vegetation and appropriated for production of goods to be impregnated during a non-pressure process should be stored with bark no longer than 2 months. After that time changes distinctly decreasing its impregnation ability occur.

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BADANIA NAD NASYCALNOŚCIĄ DREWNA OSIKI (*Populus tremula* L.)

Streszczenie

Drewno osiki pozyskane na początku okresu wegetacyjnego składowano w korze w postaci dłużyc przez 2 i 4 miesiące. Z takiego surowca wykonano próbki ze strefy przyobwodowej i przyrdzeniowej, które moczono w roztworze fluorku sodowego w czasie 15 min, 2 i 8 godzin. Oznaczono wchłonięcie impregnatu oraz jego wniknięcie w drewno w kierunku podłużnym i poprzecznym. Stwierdzono, że absorpcja użytego roztworu impregnacyjnego przez drewno strefy przyobwodowej jest większa od absorpcji strefy przyrdzeniowej, dla której właściwość ta maleje w wyniku 4 miesięcznego składowania surowca w korze. Stwierdzono wyraźnie gorsze wnikanie cieczy wzdłuż włókien w drewno pochodzące ze strefy przyrdzeniowej. Czteromiesięczne składowanie surowca osikowego w okresie letnim w korze powoduje zmniejszenie głębokości wniknięcia w drewno impregnatu zarówno wzdłuż jak i w poprzek włókien.

Authors' address:
Prof. dr hab. Kazimierz Lutomski
Mgr inż. Grzegorz Cofta
Mgr inż. Bartłomiej Mazela
Mgr inż. Rafał Remi
Akademia Rolnicza im. A. Cieszkowskiego w Poznaniu
Instytut Chemicznej Technologii Drewna
60-627 Poznań, ul. Wojska Polskiego 38/42 POLAND