FOLIA FORESTALIA POLONICA
Seria B, zeszyt 22, 1991

PROPERTIES OF WOOD OF SCOTS PINE FROM FOREST STANDS POSITIONED IN VARIOUS DISTANCE FROM INDUSTRIAL POLLUTION SOURCE

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Wood of Scots pine (*Pinus silvestris* L.) trees from stands exposed on the sulphuric acid, phosphoric and fluorine compounds were investigated under special consideration to physical and mechanical properties. Age of sampled trees was under 60 years (55 years) and they were exposed into emissions during last 40 years. It was revealed that such young trees, despite of damage to their foliage have had affected wood properties. Decrease was in mechanical properties (static bending, modulus of elasticity at bending and other) about 10 - 15% in comparison with control wood of the some age, and stand quality class. Method of investigation of considerably young trees prooved satisfactory.

INTRODUCTION

Industrial pollution from many years negativey influence forest ecosystems, effecting in so called forest decline phenomenon. We face many theories trying to explain this situation determined in short as: acid rains, ozone influence, ecological stress and other [1, 10].

Interesting from the industrial point of view properties of wood from such damaged forest stands accordingly to some authors [3, 6] are not different in average from properties of wood collected from such stands, where such damages did not occur. But all authors agree that there is observed considerable decrease of year growth rings width in forest stands stressed by industrial emission [3, 6, 11]. It was observed by the authors that the main research made for instance in West Germany were carried out on the pine trees in the age of 130 - 230 years where natural decrease of growth occurs [3]. It may create certain feeling of the doubt in respect to determined properties. Therefore authors of this paper decided to conduct research on rather younger trees of age below 60 years, which without doubt were exposed to industrial emissions during the last 40 years. The scope of investigation was to determine whether in such younger trees occur changes which could be discovered on the basis of investigating their properties. It was assumed that decreased growth may result in the change of anisotropy of wood.

Some authors obtained such result on the way of prunig the crowns of pine trees (reduction of assimilation apparatus 30 to 50%) [9]. Therefore we are of the opinion that absolute results of properties data are to be taken as relative ones and could not to be compared with literature data obtained mainly for mature trees.

MATERIAL AND METHODS

For the investigation were taken pine trees in the age below 60 years (namely 55 years) sampled 5 km, 10 km and 15 km from the emiter (sulphuric acid and phosphatic fertilizer factory near Poznań, in the Great Poland Province). As controls pine trees were taken 50 km distance from emitter outside of prevailing in this part of Poland direction of winds. Accordingly to taxation data those trees were in one age class, while the type of forest and bonitation were alike — Fresh Forest Stand with bonitat II/III. The number of trees was for each stand 9, and sampling method was accordingly to the Urich Method [8]. For the choosen stands main danger were emitted to atmospherae volatile sulfur compounds, sulphuric acid in form of mist and dropelets and phosphatic dusts and pure superphosphate and fluorine compounds [7]. From sampled trees above breast diameter were cut bolts of 1,5 m length for small clear specimens. Obtained samples from seasoned squares were then conditioned and tested accordingly to polish standards, which are similar as in whole Europe [12 - 18]. Only sap-wood samples were used for testing physical and mechanical wood properties.

There were determined following properties: moisture content, density, total shringkage of crossection surface, water absorption, static bending strength, modulus of elasticity at static bending, compression strength along the grain at equilibrium moisture content $W=W_r$,[1] compression along the grain at saturation moistrue content [2], bending stress on the proportional limit, deformations at static bending on the proportional limit, maximum deflection at static bending.

Modulus of elasticity at static bending, bending stresses on the proportional limit, deformations on the proportional limit and maximum deflection has been measured on the some samples on which static bending strength was determined. Data for calculations were taken from recorded, in continuous way diagram stress-strain. On this diagram was also determined proportional limit. The compression strength along the

[1] W_r — equilibrium moisture for air temperature 20±2°C and relative air humidity 65±5%.

[2] W_n — moisture content above the range of fibers saturation.

Table 1 - Tabela 1

Statistical coefficients of tested properties of pine wood from various danger zones

Zestawienie wskaźników statystycznych badanych właściwości drewna sosnowego z różnych stref zagrożenia

Tested property Badana właściwość	Number of samples Liczba próbek	Statistical coefficient Wskaźnik statystyczny	Measure unit Jednostka miary	Control wood Drewno kontrolne	Wood from danger zone Drewno pochodzące ze strefy zagrożenia		
					I	II	III
Equilibrium moisture content		$\bar{x}$	%	9,1	9,6	10,5	9,7
Wilgotność równoważna	90	σ	%	0,6	0,7	0'8	0,7
($\varphi = 65 \pm 5\%$, $t = 20 \pm 2°C$)		v	%	6,1	6,8	7,8	7,6
Density at equilibrium moisture content		$\bar{x}$	kg/m^3	552	548	572	556
Gęstość przy wilgotności równoważnej	180	σ	kg/m^3	52	42,1	44,9	50,7
		v	%	9,4	7,7	7,8	9,1
Shrinkage at crossection area		$\bar{x}$	%	14,1	14,2	13,5	13,0
Skurcz powierzchni przekroju poprzecznego	90	σ	%	1,1	1,0	2,1	2,4
		v	%	7,9	7,4	15,3	18,8
Absorbability		$\bar{x}$	%	91,1	92,7	93,1	97,4
Nasiąkliwość	90	σ	%	14,2	9,6	13,9	11,2
		v	%	15,2	10,3	14 9	11,5
Deformation at static bending on the proportional limit		$\bar{x}$	cm	0,24	0,26	0,27	0,26
Odkształcenie przy zginaniu statycznym na granicy proporcjonalności	90	σ	cm	0,03	0,03	0,24	0,04
		v	%	11,3	12,5	16,3	13,6
Maximum deflections at static bending		$\bar{x}$	cm	0,76	0,73	0,81	0,80
Odkształcenie maksymalne przy zginaniu statycznym	90	σ	cm	0,10	0,15	0,2ς	0,20
		v	%	14,8	20,1	18,7	19,5
Static bending of strength		$\bar{x}$	MPa	180	108	103	97,4
Wytrzymałość na zginanie statyczne	90	σ	MPa	19,7	18	19,7	16,8
		v	%	18,2	16,7	19,1	17,2
Modulus elasticity at static bending		$\bar{x}$	GPa	10,9	10,4	9,7	9,1
Moduł sprężystości przy zginaniu statycznym	90	σ	GPa	1,6	1,6	1,0	1,9
		v	%	14,9	15,3	19,1	21,1
Compresion strength along the grain at $W = W_r$		$\bar{x}$	MPa	62,0	61,6	57,1	56,3
Wytrzymałość na ściskanie wzdłuż włókien przy $W = W_r$	180	σ	MPa	9,4	7 9	7,8	8,7
		v	%	15,1	12,8	13,7	15,5
Compression strength along the grain at $W \geqslant W_n$		$\bar{x}$	MPa	20,3	18,7	19,4	18,2
Wytrzymałość na ściskanie wzdłuż włókien przy $W \geqslant W_n$	180	σ	MPa	3,0	2,9	2,4	3,6
		v	%	17,0	15,3	12,3	19,6
Bending strength on the proportional limit		$\bar{x}$	MPa	57,3	57,8	55,7	50,1
Naprężenia zginające na granicy proporcjonalności	90	σ	MPa	9,4	10,4	8,5	8,9
		v	%	15,1	17,9	15,3	14,2

Remarks: Each damage zone and control wood was represented by 9 trees (thick, medium, thin) chosen accordingly to the Urich method. From each tree 10 or 20 samples were taken for each investigated property. The presented data are calculated for 90 or 180 samples.

Uwagi: Każda strefa zagrożenia i drewno kontrolne jest reprezentowane przez 9 drzew (grube, średnie, cienkie) pobranych wg metody Uricha. Z każdego drzewa pobrano 10 lub 20 próbek bielu do badania każdej właściwości. Przedstawione dane obliczono dla 90 lub 180 próbek.

grain in the moisture $W \geqslant W_n$ was determined after previous soaking samples in distillated water during 48 hours. From each tree were sampled 10 samples for measuring mentioned properties, with the exception density and compression along the grain, for which 20 samples were taken from each tree. Before determination of properties samples were conditioned in normal climate during about 4 weeks, till the moisture content has been stabilised.

RESULTS AND DISCUSSION

Results of tests of control wood and wood sampled from three zones of industrial emissions are presented in table 1. There are given: $\bar{x}$ — mean arithmetic value, σ — standard deviation, v' — coefficient of variation, n — indispensable (statistically) number of samples. As it can be seen in the table the indispensable number of samples was greater than needed and it can be assumed that obtained results are reliable. Analysing data presented in table 1 it can be seen that static bending strength, modulus of elasticity at static bending, compression strength parallel to grain, bending stress on the proportional limit of wood from zones I, II and III were lower than properties of control wood.

Wood sampled 5 km from pollution source (emitter) is characterized by generally lowest mechanical properties. Physical properties: moisture content, density, deformations at static bending on proportional limit and maximum deformations at static bending of wood from I, II, III zone are equal or higher than those of control wood. Only shrinkage of

Table 2 - Tabela 2

Strength quality coefficient for pine wood from I, II and III danger zone determinated at compression along the grain

Współczynnik jakości wytrzymałościowej dla drewna sosny z I, II i III strefy zagrożenia określony przy ściskaniu wzdłuż włókien

Wood moisture* content in course of compresion sterength testing Wilgotność* drewna w czasie badania wytrzymałości na ściskanie	Strength quality coefficient Współczynnik jakości wytrzymałościowej			
	control wood drewno kontrolne	wood form the zone drewno ze strefy		
		I	II	III
$W=W_r$	11,2	11,2 km	10,0 km	10,1 km
	100%	100%	89%	90%
$W \geq W_n$	3,7 km	3,4 km	3,4 km	3,3 km
	100%	92%	92%	89%

* W_r — equilibrium moisture content, W_n — fiber saturation moisture content; W_r — wilgotność równoważna, W_n — wilgotność w przedziale punktu nasycenia włókien

crossection area of wood from II and III zone is characterised by decrease of values in comparison with control wood. Similar phenomena were observed in course of investigation of properties of popular wood fertilized by flooding with municipal water (irrigations) sewage, where increased quantity of nitrogen compounds disturbed growth of trees and influenced some wood properties [4]. Such side effects are also reported by Canadian scientists, considering negative and positive effects of air pollution on forest trees [2]. In some uses of wood there is also considered strength quality coefficient [5] determined by formula:

$$I=\frac{\text{compression strength along the grain}}{\text{density}}\ \text{km.}$$

Calculated values of quality coefficient — I are given in table 2.

From the presented data results that also strength quality coefficient decreases maximum 10%.

REASUMPTION

It was observed, that industrial emissions have various effect on wood of the pine trees, which lave had grown in the damaged forest stands. There was observed in the II zone up to 10 km distance from emitter, the increase of equilibrium moisture content, absorbability and deformations at bending. Much more distinct influence was observed in the III zone, near emiteer, what manifested with the decrease of bending strength, modulus of elasticity and stresses on the proportional limit.

In reasumption it can be stated that:

— industral emissions have negative influence on strength of wood of pine trees in the age up to 60 years,

— this influence was stronger in the vincinity of emission source,

— the sampling of the younger pine trees for experiments allowed to observe mentioned above changes, because beyond doubt those trees during last 40 years were exposed onto industrial emissions.

Received July 1990

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WŁAŚCIWOŚCI DREWNA SOSNY ZWYCZAJNEJ (*PINUS SILVESTRIS L.*) Z DRZEWOSTANÓW ZNAJDUJĄCYCH SIĘ W RÓŻNYCH ODLEGŁOŚCIACH OD ŹRÓDŁA ZANIECZYSZCZEŃ PRZEMYSŁOWYCH

Streszczenie

Drewno z drzew sosny zwyczajnej (*Pinus silvestris* L.) z drzewostanów narażonych na działanie związków siarki, kwasu siarkowego, fosforanów i fluoru badano pod kątem właściwości fizycznych i mechanicznych. Wiek pobranych do badań drzew wynosił około 60 lat (55 lat) i były one poddane emisjom przemysłowym w ciągu ostatnich 40 lat. Okazało się, że takie stosunkowo młode drzewa obok zmian w aparacie asymilacyjnym miały zmienione właściwości drewna. Spadek zaobserwowano w zakresie mechanicznych właściwości drewna (zginanie statyczne, moduł sprężystości przy zginaniu statycznym i inne), rzędu około 10 - 15% w porównaniu z drewnem drzew kontrolnych w tym samym wieku i tej samej bonitacji siedliska. Okazało się, że metoda badania stosunkowo młodych drzew dała zadowalające wyniki.

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