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E. E. Paul, PhD (Agriculture), assistant lecturer (BSTU);
A. V. Kozel, PhD (Agriculture), assistant professor (BSTU)

METHODOLOGICAL CHARACTERISTICS OF WOOD HARDNESS DETERMINATION

According to the Standard wood hardness is found by two methods: the main one – by pressing the standard puncheon into 5.64 mm in wood and the additional one by pressing the puncheon into 2.82 mm; the calculation of numerical values of hardness is done according to the formulas. The investigations found out that the numerical data received by the mentioned above methods differ essentially. The additional method gives overstating value in determining cross section hardness of dry wood by 12.1% and by 5–6% of moist wood; and in determining radial section hardness it gives understating values by 20.3% of dry wood and by 27.7% of moist wood. The paper gives an explanation of the difference in values received by both methods. Thus in defining wood hardness the additional method cannot be used instead of the main one due to its large error.

Introduction. Hardness is one of the most important qualitative characteristics of the wood. Taking into account the fact that the procedure of the wood hardness determining is simple and does not require sophisticated devices on the base of the hardness determination and knowledge of hardness correlation nature with other properties of wood you can get a complete description of the wood properties.

According to GOST 16483. 17-81 “Methods of static hardness determination” [1] the main point of the wood hardness determination method is to establish the magnitude of the load introduction of steel punch into the wood to a predetermined depth, and the calculation of static hardness (H_W) as the ratio of the load size to the area of the obtained fingerprint projection:

$$H_W = \frac{F}{\pi r^2}, \qquad (1)$$

F – is the load by pressing of a puncheon into the sample, N; r – is the radius of the hemispherical puncheon, mm.

The calculation of the hardness by the mentioned above formula is, when the diameter of the puncheon is 11.28 mm and its introduction is carried out to a depth of radius equal 5.64 mm. However, during testing of standard sizes wood samples, with a high hardness, they often split up to the moment of the puncheon penetration at the desired depth. It is not possible to avoid destruction of samples when using standard puncheon diameter and when, for some reason or another, there is a need to test small sample sizes, i.e. with the side of less than 50 mm. In such cases, GOST, recommends to bury a standard puncheon not up to 5.64 mm, but to the depth of 2.82 mm and to produce the calculation of hardness according to the formula:

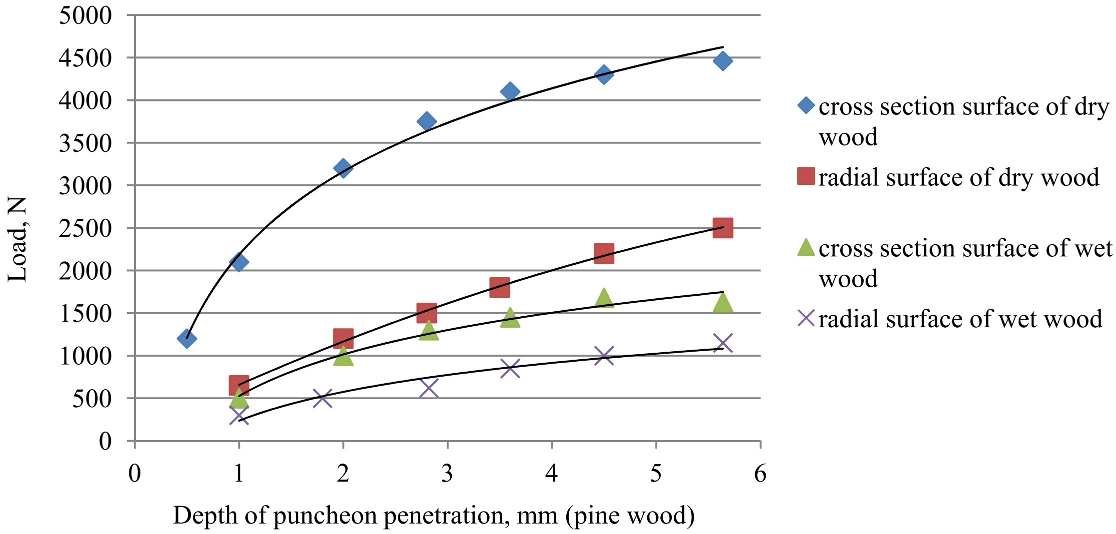
$$F_W = \frac{F}{3\pi r^2}, \qquad (2)$$

F_W – is the load when pressing a puncheon into the sample depth of 2.82 mm, N; r – is the radius of the hemisphere standard puncheon, mm.

Main part. Thus, in the current standard for wood hardness determining essentially, there are two equivalent methods. To be convenient for their further consideration, the first of them is the main denoted as method No. 1 with hardness calculating formula (1) and the second – additional method No. 2 with the formula (2).

In the formula (2) ratio of 4/3 is introduced to convert a numerical index of hardness with punch pressing into 2.82 mm on the index that corresponds to pressing at a depth of 5.64 mm. This proceeded from the considerations that the resistance of wood to the pressing of the puncheon, and hence the attached load to overcome this resistance and the square projection of the received imprint when pressing of a puncheon increase in proportion to the magnitude of its penetration. The square projection of the imprint received by pressing of a puncheon into the depth 5.64 mm, is equal to 100 mm^2, and with pressing at a depth of 2.82 mm is 75 mm^2. The ratio of these areas is equal to 4/3 (100 / 75). Thus, by introducing into the formula (2) of a ratio 4/3 actual load received by at a smaller pressing depth is converted to the load by pressing at the depth of 5.64 mm only on the basis of the square imprints projections ratio in different methods. However, this recount is not correct, as our research has shown that the relationship between the depth of the puncheon and the necessary load is not linear, but has the shape of typical curves (figure).

In addition, the specific pressure of the applied load on the spherical surface of the imprint in the different methods is significantly different (table 1 and 2), that also does not correspond to the linear nature of the relationship between depth of a puncheon pressing and the required load. It is therefore of interest to investigate how hardness values, determined according to method No. 1 accurately coincide to the method No. 2 for the same wood surface.



Curves of load increase from the depth of puncheon penetration

For this purpose it was made a series of standard samples for hardness testing of the cross section and the radial surface of the pine wood in the room-dry condition and at a humidity of more than 30%. The results of the study are shown in table 1 and 2.

Evidently the above data of the wood hardness, identified by different methods vary significantly both for different surfaces of wood and for different humidity condition. Moreover, when testing of the cross section hardness, the application of method No. 2 gives overstated values of hardness. This overestimation of the wood in the dry state is 7.1–17.4% with an average of 12.1 per cent, and for wet is 5–6%.

Higher calculated values of hardness by puncheon pressing at a smaller depth (2.82 mm) can be explained by the greater resistance of wood to the introduction of the puncheon during the initial period of its penetration, which consequently results to a higher specific pressure on the spherical surface of the imprint in this period. Apparently from the tables, the average specific pressure when applying the method No. 2 exceeds the pressure in method No. 1 in about 1.6-1.8 times. If cross section method No. 2 compared with a method No. 1 gives overstated values of hardness, for the radial one, on the contrary, is greatly understated. For example, for the studied samples this understatement for dry wood in the average is 20.3%, and for wet wood is 27.7%. For some wet samples the decrease of calculated hardness parameters was significant and reached 36%.

Table 1

Deflections of the wood hardness indices determined by method No. 2, in comparison with the characteristics of the method No. 1 for indoor-dry wood

The number of sample	Basis density, kg/m^3	Cross section surface					Radial surface				
		Method No. 1		Method No. 2		Deflection, %	Method No. 1		Method No. 2		Deflection, %
		Hardness, N/mm^2	Specific pressure, N/mm^2	Hardness, N/mm^2	Specific pressure, N/mm^2		Hardness, N/mm^2	Specific pressure, N/mm^2	Hardness, N/mm^2	Specific pressure, N/mm^2	
1	397	44.3	22.2	50.6	37.9	+14.2	27.4	13.7	21.4	16.0	–22.1
2	352	42.6	21.3	45.9	34.4	+7.7	24.1	12.0	19.0	14.2	–21.1
3	353	42.0	21.0	45.8	34.4	+9.2	22.3	11.1	18.8	14.1	–16.0
4	384	45.3	22.6	49.9	37.4	+10.1	23.4	11.7	20.7	15.6	–11.6
5	483	48.9	24.5	55.8	41.8	+14.1	26.7	15.6	20.9	17.7	–24.3
6	400	44.1	22.1	49.3	37.1	+11.8	25.4	12.7	18.0	13.5	–29.0
7	408	43.7	21.9	46.8	35.2	+7.1	24.7	12.0	20.1	15.0	–16.5
8	380	43.7	21.9	51.0	38.3	+16.8	25.5	12.8	19.7	14.7	–22.7
9	423	45.4	22.7	53.3	40.0	+17.4	24.7	12.4	20.5	15.0	–18.9
10	415	43.6	21.8	48.9	38.4	+12.2	26.2	13.1	20.9	14.5	–20.2
Average	–	44.4	–	49.7	–	**+12.1**	25.1	–	20.0	–	**–20.3**

Table 2

The deflection of the wood hardness indices determined by method No. 2, in comparison with the characteristics of the method No. 1 for wet wood

The number of sample	Basis density, kg/m3	Cross section surface					Radial surface				
		Method No. 1		Method No. 2		Deflection, %	Method No. 1		Method No. 2		Deflection, %
		Hardness, N/mm^2	Specific pressure, N/mm^2	Hardness, N/mm^2	Specific pressure, N/mm^2		Hardness, N/mm^2	Specific pressure, N/mm^2	Hardness, N/mm^2	Specific pressure, N/mm^2	
1	368	14.7	7.4	15.5	11.7	+5.5	11.5	5.8	7.4	5.5	–35.9
2	353	13.7	6.8	14.7	10.2	+6.9	10.2	5.1	6.8	5.1	–32.9
3	483	17.5	8.8	18.4	13.8	+5.0	13.7	6.9	10.5	7.9	–23.4
4	425	19.0	9.5	20.1	15.1	+5.8	14.1	7.1	10.0	7.5	–29.1
5	432	19.6	9.8	20.8	15.1	+6.1	13.9	7.0	9.8	7.4	–29.5
6	413	18.0	9.0	18.8	14.1	+4.4	11.8	5.9	7.5	5.6	–36.4
7	379	13.5	6.8	14.3	11.1	+5.9	9.4	4.7	7.3	5.5	–22.3
8	404	15.0	7.5	15.6	11.7	+4.0	9.2	4.6	7.8	5.9	–15.2
9	418	15.0	7.5	16.0	12.0	+6.7	8.8	4.4	6.9	5.2	–21.6
10	408	16.8	8.4	17.7	13.0	+5.4	12.6	6.3	8.7	6.8	–31.0
Average	–	16.3	–	17.2	–	**+5.5**	11.5	–	8.3	–	**–27.8**

Such a large difference in hardness when applying these methods to the radial surface of the wood is explained by the fact that when pressing of a puncheon at a small depth under the puncheon occurs only cross local crumpling of the wood fibers, the resistance which the timber has is small (ultimate strength of pine wood with humidity of about 30% during the local compression is 5.6 MPa) [2]. Therefore, the necessary effort for the introduction of the puncheon will also be insignificant.

Pressing the puncheon at the depth of 5.64 mm after compression the cross-cutting of fibers occurs, requiring significantly more effort (17.6 MPa) [2] in comparison with crumpling, and therefore the rate of hardness obtained during penetration of a puncheon at the depth of 5.64 mm, because of the different wood nature destruction cannot be comparable to the rate during penetration of a puncheon at the depth of 2.82 mm.

Conclusion. Thus, when determining the wood hardness the method No. 2 with its update formula (2) because of the large errors cannot be used instead of the main method No. 1.

References

1. Древесина. Метод определения статической твердости: ГОСТ 16483.17–81. Введ. 01.01.83. М.: Госстандарт СССР: Изд-во стандартов, 1986. 4 с.

2. Уголев Б. Н. Древесиноведение и лесное товароведение: учебник. М.: ГОУ ВПО МГУЛ, 2007. 351 с.

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