Using of knotty wood features in the manufacture of final sawn production

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Abstract. The objective of the work is the study of the features of knotiness of the produced boards faces and the development of directions for their use in the final sawn timber production. In order to have a quantitative understanding of the knotting peculiarities on the faces of produced boards, the nature of the knots distribution on sawn timber, experimental work was carried out. The initial data collection consisted of the following stages: selection and certification of saw logs, cutting logs into timber and their passporting. For certification boards used the method of photographing. According to passports and photographs, boards were analyzed using AutoCAD and MS Excel. There is a tendency of uneven knots distribution relative to the central axis of the board. The obtained data predetermine the need for further research on the trends of the location of the knots in the trunk. In this case, it is necessary to study not so much a specific trunk; it is required to obtain a pattern of the propagation of knots in forest stands along a group of homogeneous trees. In this case, predicting the location of the knots in the logs can influence the technology.

1. Introduction
Dimensional-quality features of a tree trunk are formed during the growth of a tree, as a living organism. This is accompanied by its structural and morphological changes, which can be expressed using the laws of bionics and dimensionless ratios. Analysis of structural and morphological characteristics, their synthesis with the internal structure of the tree allows us to conclude about the spiral-helix distribution of knots in the tree trunk.

On the other hand, from numerous studies of botanists, and this has long been a textbook, it is known about the whorled coniferous trees branches arrangement. And if the most common Russian breeds: larch, spruce, fir - are breeds with a weakly whorled branches arrangement, then pine belongs to a breed with a strictly whorled branches arrangement [1, 2]. S P Isaev [3] determined the average number of knots in the whorl: for larch - 3.08; for spruce - 5.02; for fir - 4.97. For pine this indicator is 5-7. In this case, the visible odd number of knots in a whorl affects their uneven distribution along the axis of the trunk around its circumference.

From the works of P P Aksenov school [4–11] is aware of the uneven knots distribution around the circumference of the log, the so-called concentration of knots in the logs. Knots are the main ones in terms of occurrence and variety-forming value of defects. This phenomenon is predetermined by the biological features of the growing tree trunk development, growth conditions, and the stronger branches development in the direction of the greatest luminous flux.
Research on this phenomenon and aspects of its use in sawmill technology were devoted works described above, primarily in the area of timber production. Naturally, the directions for improving the composition of timber produced by quality and increasing their cost, value output were considered due to sawing sawn logs oriented by knots, when knots in the greatest number and large sizes would fall not on the edge, but on the edge of sawn boards. This research area was also studied by foreign scientists [12-17].

However, most of the timber produced is processed, cut into sawn billets and parts. Ultimately, with the exception of the production of export sawn timber, the final product is important, its composition by quality. This part of the production chain: trunk - whip - saw log - sawn timber - sawn billets - sawn parts were viewed from the above point of view a lesser degree. In this case, the considered biological phenomenon, namely, the uneven knots distribution around the circumference of the log, the so-called concentration of knots in the logs should be used to improve the efficiency of the sawmill technology, primarily considering the part of the production chain: saw log (orienting it when cutting) - sawn timber (various knot saturation categories) - sawn billets. The objective of the work is the study of the features of knotiness of the produced boards faces and the development of directions for their use in the final sawn timber production.

2. Methods and Materials
In order to have a quantitative understanding of the knotting peculiarities on the faces of produced boards, the nature of the knots distribution on sawn timber, experimental work was carried out on the basis of the Schelkovo training and experimental leshoz of the Moscow State University of Forest (now the Mytishchi branch of Bauman Moscow State Technical University). The initial data collection consisted of the following stages: selection and certification of saw logs, cutting logs into timber and their passporting.

For experimental studies, 30 m$^3$ of pine timber ($\textit{Pinus sylvestris}$ L.) with a diameter of 20 to 40 cm and a length of 6 m were obtained using the method of assortment harvesting in the north-east of the Moscow region. Among them: Grade I - 40%, Grade II - 40%, Grade III - 20% in accordance with GOST 9463-88. Timber round conifers. Technical conditions. Each log was subjected to certification: its dimensions and quality characteristics were measured with simultaneous filling of the “log passport”. After certification, saw logs were sawn into pieces on a two-story saw-frame. When sawing logs, boards were marked accordingly.

For boards certification used the method of photographing. This method is specifically designed to account for the characteristics and possible further cutting of timber into pieces. Before photographing, a scale ruler was laid along the board. For photographing the boards, a Canon PowerShot SX10 IS camera with an effective pixel number of 10 million was used, which made it possible to take pictures with high resolution and quality. In this case, you can examine the face of the board in detail, eliminating the need to outline the defects along the contour.

According to passports and photographs, 30 boards were analyzed. Timber specifications were analyzed using AutoCAD. Information about the board was entered as a JPEG photo into AutoCAD, and information from the board passports was also taken into account. In AutoCAD, the board was scaled and the dimensions and location of the knots were fixed on a 1:1 scale. At the same time, in the MS Excel spreadsheets such output parameters as the number, size and area of the knots, their location on the board, and a map of the knots were created on the board with coordinates. This method allowed us to obtain data both on the size of the knots, their location on each board, and the average values for a group of boards.

The developed method allowed to simulate the actual process of reading data from the timber layers using modern scanning systems and take into account all timber features.

3. Results and Discussion
Even without regard to the conditions and technology of sawing logs, when considering ordinary timber, intended or not intended for subsequent cutting, the naked eye can be appreciated quite a
noticeable difference in the saturation of the parts of the faces symmetrical about the longitudinal axis of the board. Measurements were carried out on indicators that are used to assess the timber quality. This is – the number of knots, the total size (width of the knot), the total area of the knots on the face of the board (0).

There is clearly a tendency of uneven distribution of knots relative to the central axis of the board. The number and area of knots on one side of the face is always greater than on the other (Figure 1).

![Bar chart showing knot saturation](image)

**Figure 1.** Characteristics of knot saturation of the left and right (relative to the central axis) part of the board face.

Analysis of the distribution of knots across the width of the board shows that the largest number of knots are located 50 mm to the left and 50 mm to the right of the central axis, then there is a gradual decrease in the number of knots (Figure 2). This quite confirms the results of Anikin’s research, also carried out previously for pine timber [4].
Figure 2. The average number of knots in the width and length of the board, pcs.

By the length of the board knots are also uneven, the greatest concentration of knots is at a height of 2-4 meters from the ground. This will help to optimize the cutting plans for sawn timber, taking into account the zone with the maximum number of knots.

According to the experimental data (Figure 2), mathematical descriptions of the envelopes of the curves were obtained, both for each board and on average.

4. Conclusion
Technologically, it is possible to consider the results of sawing logs without their orientation on knots before sawing, and to optimize the technology of cutting the resulting timber into pieces of a given size and quality. The variety of best options will significantly expand, given the technological capabilities - conditions:
- cutting timber into two or more dimensional-quality groups of blanks;
- increase the production of glued blanks;
- sorting of sawn timber prior to their cutting according to the criterion for the main blank yield;
- uneven distribution of knots relative to the central longitudinal axis of the board.

The choice of technological schemes obviously can and should be considered not only from the point of view of yield (both volume and cost), but also in terms of labor costs.

The obtained data predetermine the need for further research on the trends of the location of the knots in the trunk. In this case, it is necessary to study not so much a specific trunk; it is required to obtain a pattern of the propagation of knots in forest stands along a group of homogeneous trees. In this case, predicting the location of the knots in the logs can influence the technology.

Of particular interest are the sizes of knots, the appearance (encased, black, sound, rotten, tobacco) of knots and their location in the trunk. The situation on the timber market has recently changed and healthy knots have been tolerated in a number of products where previously their presence was considered not acceptable. The knot size ceases to have a strong influence on products. Timber is often produced in excess quality. First of all, it is necessary to single out the zones where black knots, rotten and tobacco, are located. It is the zones with the location of these knots that need to be found in the forest stands, since timber of a completely different quality is obtained from them. Research confirms that black, rotten and tobacco knots are in certain areas. In the trunk there are knot-free zones, zones of intergrown knots and black knots, these zones boundaries are mobile. Finding these zones for certain conditions and forest stands will improve the technological process of timber cutting, taking into account the areas of rotten, tobacco and black knots. Analysis of data on the grade, quality, completeness of forest stands and the knots location in the trunk will help to have a clear idea of the quality of saw logs, which is produced from a certain group of forest stands, as well as determine its purpose.
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