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DESIGN OF ELASTOPLASTIC STRAIN OPERATIONS OF TIMBER BAND SAWS TO IMPROVE THEIR DURABILITY

The article dwells upon the technique for increasing the fatigue life of band saw by the generation of a curved blade and inner compensating tension. Optimal strengthening operations have been defined which ensure the maximum fatigue life of band saws of different steel grades. The paper also outlines the structure of the machine for band saw setting-up procedures.

Introduction. One of the most acute problems occurring in the maintenance of scroll band saws is their short fatigue life. There are many possible ways of increasing the service life of this woodcutting tool [1] but the most promising one is the generation of compensating tension of the saw blade along with its pre-curving by means of elastoplastic strain.

Main part. The essence of elastoplastic strain technique consists in rolling-in a new band saw on a small-diameter pulley before it is installed in the machine tool. In so doing, those parts of the saw which embrace the pulley experience bending stress exceeding yield point of the saw material. After rolling-in the saw assumes a curved state with residual curve radius ρ_{res}, the surface layers of the saw experience inner residual compression stress. When the saw is installed onto the pulleys of bandsaw machine, the tension of the curved blade is reduced due to the fact that the saw bends because of its curved state and there are compensating residual stresses.

The value of the residual stress σ_{res} in the surface layers of the saw can be calculated according to the formula [2]

$$\sigma_{res} = \sigma_t - \frac{6\left(\sigma_t \frac{s^2}{4} - \frac{\sigma_t^3}{3E^2}(R_t + 0,5s)^2\right)}{s^2}, \quad (1)$$

where σ_t is the yield point of the saw material, MPa; s is the saw thickness, mm; E is elastic modulus of the saw material, MPa; R_t is the radius of the pulley on which straining is carried out.

The residual radius of the surface curvature ρ_{res} is calculated by the function

$$\frac{1}{\rho_{res}} = \frac{1}{R_t + 0,5s} - \frac{12\sigma_t}{E}\left(\frac{1}{4s} - \frac{1}{3s}\left(\frac{\sigma_t\left(R_t + 0,5s\right)}{E \cdot s}\right)^2\right). \quad (2)$$

To define the modes of straining operations, it is essential to be well-informed about the mechanical properties of the materials the saws are made of. The research [1] has shown that the steel grades for manufacturing band saws can be divided into three groups. Group 1 is carbon steel, the counterparts of which are70A steel and 75A steel, group 2 is nickel-alloy steel, its counterpart being 75H2A steel, group 3 is alloy steel with 45% carbon content, its counterpart being 45XГНМФА steel. Strength properties have been defined for each group, such as elastic modulus, yield point, breaking point and hardness.

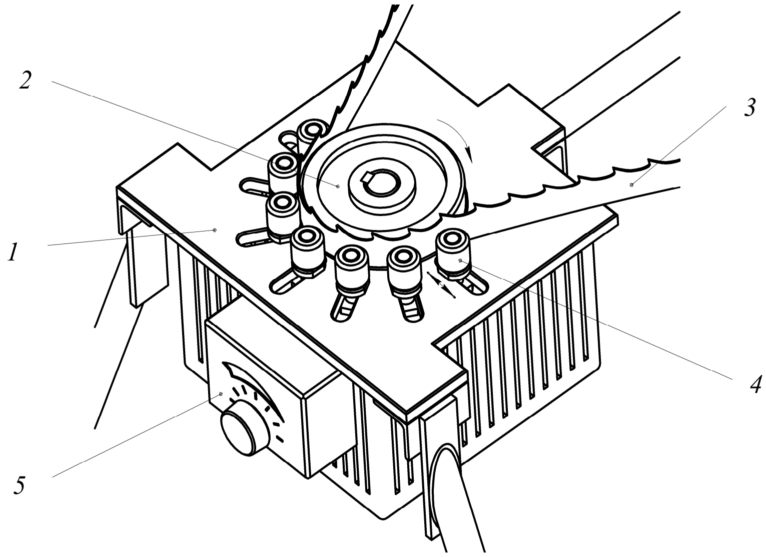
To carry out elastoplastic strain operations, a special apparatus was designed built (see Figure). It consists of foundation *1*, which bears a drive pulley *2* with a band saw *3* rolling onto it, and pressure rollers *4* which are able to radially move relative to the pulley rotation axis.

The number of pressure rollers and their position ensure full contact of the saw blade and the pulley, angle of contact being not less than 180°. Other parts of the saw are supported by some bearings. The pulley drive and roller-moving mechanism are beneath the foundation.

To estimate the efficiency of the elastoplastic straining and to determine rational modes of this operation, some inveestigation was carried out [3]. Basic parameters for carrying out the strengthening operation are speed of straining, radius of the pulley on which rolling-in is carried out and associated values of residual stresses and residual curve radius ρ_{res}.

Since rolling-in of the saw is done in the area of plastic straining, the most optimal mode is when the saw is strained only once. The treason for this is the fact that if the saw is rolled in scores of times, the saw blade will accumulate damage that can have negative effect on the saw fatigue life.

The research results have shown that the minimum time required to define specified residual curve radius is 8–9 sec. In this case the residual curve radius reaches its calculated value and remains unchanged. The efficiency of the strengthening operation was determined by means of fatigue tests of sample saws according to the standards of GOST 25.502-79 “Methods of mechanical testing of metals. Methods of fatigue testing”. The tests were carried out at the experimental apparatus mentioned before [4].



Apparatus for band saw elastoplastic straining:
1 – foundation; 2 – pulley; 3 – band saw; 4 – pressure roller;
5 – speed regulator

The tests of the samples were made for different levels of residual stress in band saws. The number of fatigue cycles of bending force was determined until the samples were broken. The analysis of the results revealed that fatigue life increases with increasing residual stress in the surface layers of band saws. However, when its value reached 150–200 MPa, the durability remained virtually the same and then decreased with increasing residual stress.

The reason for this is the fact that the damage occurring in the band saw blade during elastoplastic straining reduces the effect of lower stress from bending on the pulleys when using the modes of large residual stress (over 200 MPa).

Thus, the largest fatigue life is ensured when the residual stress in the surface layers of the band saw does not exceed 150–170 MPa. In this case the strength limit is increased by 19–23%.

The results obtained made it possible to determine the modes of straining of band saw blade ensuring its maximum fatigue life. These parameters include maximum straining rate and pulley diameter. The Table below shows their values for different steel grades and saw thicknesses.

To estimate the efficiency of the operations of increasing band saw fatigue life, factory tests were carried out at woodworking enterprises. The tests involved the band saws which had undergone elastoplastic straining.

The tests were carried out in the sawmill shops of CJSC “Molodechnomebel” and JSC “Postavymebel”.

These enterprises have horizontal bandsaw machines which cut logs into edged and unedged boards. The prevailing timber comes from hardwood species.

The analysis of performance of the band saws shows that a significant number of saws break down due to generation and development of fatigue cracks (up to 58%). Only 34% of saws get out of service because the blade width reduces to the minimum value. The average output is 18–20% m^3 per saw.

The number of saws which is usually expended monthly underwent straining operations according to the modes shown in the Table above. Further setting-up procedures and maintenance did not differ from those of the saws not subjected to the strengthening operations.

Diameter of the pulley involved in the straining of band saw to ensure its maximum fatigue life

Steel grade	Saw blade thickness					
	0.9 mm		1.0 mm		1.1 mm	
	Pulley diameter, mm	Strain rate, not more than, cm/sec	Pulley diameter, mm	Strain rate, not more than, cm/sec	Pulley diameter, mm	Strain rate, not more than, cm/sec
Group I	96	1.51	106	1.66	116	1.82
Group II	92	1.44	102	1.6	110	1.72
Group III	88	1.38	98	1.54	108	1.7

The results of the tests showed that the rate of band saw breakage had gone down to 38%. At the same time the accuracy of cutting remained unchanged as compared to the saws not subjected to the strengthening operations. The average output made up 25–27 m^3 per saw.

Conclusion. Being efficient and easy to carry out, elastoplastic straining of a band saw is a promising technique to improve the fatigue life of timber band saws. The efficiency of the technique for setting-up procedures has been proven by laboratory and factory tests. If rational modes of setting-up are adhered to, the fatigue life of a band saw can be increased by 20–23%.

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