

Optimizing screw shredder rotations for efficient shrubby tree branch processing

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Abstract. The volume of trees and branches grown in Uzbekistan is increasing year by year. Foreign experiences on processing and use of antlers are analyzed. According to the analysis, it became known that in recent years the volume of bushy tree branches in our republic has increased by 2-3 times, and there is a need to prepare and use various products from the branches. Taking this into account, in our country, creation of the bushy tree branch crushing apparatus, one of the crucial jobs is the construction plan and the technological work method. Based on this, the number of rotations of the screw of the crushing device was studied. Researches were carried out by changing the number of revolutions of the screw or auger of the grinding machine from 800 r/min to 1200 r/min. When the number of revolutions of the grinding screw is 1000 r/min, the amount of small fractions in the content of crushed branches and the smallest amount of indestructibility was achieved, and it was found that the quality of crushing branches has an acceptable value.

1 Introduction

The President of Uzbekistan has issued two significant decrees aimed at enhancing the country's environmental sustainability and agricultural development. The first, "On approval of the strategy for the development of agriculture of the Republic of Uzbekistan for 2020-2030," was signed on October 23, 2019. The second decree, dated November 23, 2023, focuses on "Green establishment of 'green parks' and 'green public parks' to further increase the Republic's greenness" [1-2].

These decrees outline several crucial objectives for the nation's environmental and agricultural sectors. They emphasize the greening of transportation infrastructure, including automobile and railway routes, as well as planting trees along river and canal banks. The initiatives also call for enhancing green spaces around state bodies and organizations, contributing to the overall improvement of the republic's ecology. Furthermore, the decrees prioritize the acceleration of scientific research aimed at maintaining environmental

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cleanliness and effective waste management. A key aspect of these strategies is the widespread implementation of modern, resource-saving technologies in relevant fields. These comprehensive initiatives demonstrate Uzbekistan's strong commitment to sustainable development, urban greening, and ecological preservation. By focusing on these areas, the country aligns itself with global environmental goals while simultaneously advancing its local agricultural strategies, paving the way for a greener and more sustainable future.

Given that Uzbekistan places a lot of emphasis on planting new gardens and vineyards, growing the area of forests, and greening roads, avenues, and railroads, the amount of pruning that is done on these trees will also rise, which will lead to the bushy tree branch and raise the question of their intended use [3-4].

Taking this into account, it is necessary to develop a device for crushing bushy tree branches in Uzbekistan, justify its structural scheme and technological work process, and ensure the improvement of work quality during the processes of interaction of working parts with branches and their movement.

Today, it is considered one of the important tasks to develop a structural scheme and justify the technological processes of the bush tree branch-shredding device, to uphold the policies and practices that ensure the quality of work in the processes of the working components' influence with branches [5-6].

Based on the above, one of the urgent issues is the development of an energy-efficient shredding device for crushing the branches of bush trees in order to widely develop the systems of horticulture farms and improvement departments, to reduce the manual labor in the process of transporting and disposal of branches [7].

2 Materials and methods

Theoretical mechanics, mathematical probability and analysis, statistical analysis techniques, mathematical statistics laws and regulations, and the validation of the grinding device's parameters using one-factor experiments and current regulatory documents were all used during the study (GOST 33103.1-2017, GOST 33104-2014, GOST 33103.1-2017, ISO 17225-4:2014, GOST 16483.0-89) methods were used.

The validity of the research's findings, the fact that it was conducted with a method that worked and measuring instruments that were calibrated, and the theoretical basis for the parameters of the bushy tree branch crushing device's foundation in theoretical mechanics and higher mathematics, physics and other sciences, the theoretical and experimental research mutual adequacy is explained by the positive results of the shredder of bushy tree branches in farm tests and its introduction into practice [8,9].

The National Research University's "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" and Tashkent State Transport University conducted a laboratory study to examine the impact of the chipping device's number of revolutions on the quality of branch cutting of shrubby tree branches. Experimentation To carry out the work, a pilot copy of the device for crushing tree branches was prepared (Figure 1).

The technological work process of the shredder of small tree branches works in the following sequence: the branches 2 are placed on the transmission shaft 1, the electric motor 7 is transmitted to the reducer 11 through the pulleys 8, 10 and the belt drive 9, then the shredder goes to 3. Branches are crushed in the crushing device under the influence of plates mounted on the crushing screw 4 and fixed knives 5 mounted on the side wall of the crushing chamber. The crushed branches are taken out through the outlet 13.

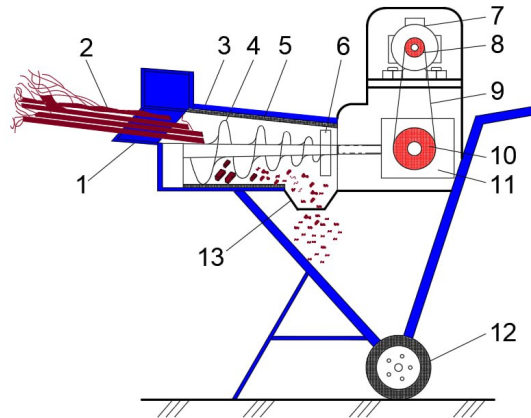


Fig. 1. Scheme of the device for shredding bushy tree branches: 1- transmission line; 2-horn; 3- grinding device housing; 4-grinding auger; 5-internal cutting board; 6-spade; 7- electric motor; 8,10 pulley; 9-belt transmission; 11- reducer; 12- wheel; 13- product output line.

3 Results and discussion

In order to confirm the findings of the theoretical research on the shredder of bush branches and branches, as well as to identify the parameters of the primary components of the shredder that crush the branches and the reasonable values of the operating modes, experimental investigations were done.

In the experiments, the effect of the number of revolutions of the auger of the crushing device of the shredding device of the bushy tree branches on the quality of crushing of branches was studied. In order to study the influence of the number of revolutions of the screw of the crushing device on the quality of crushing of branches, experiments were carried out by changing the number of revolutions of the screw of branch crushing from 800 r/min to 1200 r/min every 100 r/min. But in the experiments, during the process of crushing branches, the number of revolutions of the screw at values less than 800 r/min occurred in the crushing device of branches, and because the amount of small fractions exceeded the required level at values greater than 1200 r/min, the experimental results showed that the number of revolutions of the screw of the crushing device It was obtained in the range from 800 r/min to 1200 r/min. When researching the number of rotations of the screw of the grinding device, the diameter of the screw was 200 mm, the length was 400 mm, the distance between the steps of the screw was 50 mm, and the installation angle of the screw was 15°.

In the conducted experiments, when the number of rotations of the screw of the shredding device of the bushy tree branches was increased from 800 r/min to 1200 r/min in 100 r/min intervals, the degree of branch crushing changed to the following value (Table 1).

When analyzing the results obtained from the experiments on the crushing of branches of a bushy tree in a shredder, the amount of small fractions up to 3.15 mm is from 5.4 percent to 9.4 percent, and the main ones from 3.15 to 45 mm the amount of fractions was found to be from 84.0% to 86.2%, the amount of fractions larger than 45 mm was from 4.7% to 7.6%, and the amount of indestructibility was from 0.8% to 1.9% (Figure 2).

Table 1. The impact of the grinding machine's screw rotational number on the grinding quality.

Work quality indicators	The grinding machine's screw's number of revolutions, r/min				
	800	900	1000	1100	1200
Amount of fractions smaller than 3.15 mm, % (maximum 10 %)	5.4	5.9	6.3	7.9	9.4
Amount of fractions with 3.15-45 mm, % (at least 60%)	86.2	86.7	87.5	85.7	84.0
Amount of fractions larger than 45 mm, % (maximum 6%)	7.6	6.5	5.1	5.0	4.7
Amount of failure,% (maximum 2%)	0.8	0.9	1.1	1.4	1.9

According to the established regulatory document and requirements, the amount of small fraction of crushed branches, the amount of fractions smaller than 3.15 mm is at most 10 %, the amount of main fractions from 3.15 mm to 45 mm is at least 60%, fractions larger than 45 mm the amount is set to a maximum of 6% and the amount of non-compliance is set to a maximum of 2 %.

In experiments, when the number of revolutions of the screw of the grinding device is 800 r/min, the amount of fractions smaller than 3.15 mm is 5.4 percent, the amount of fractions from 3.15 to 45 mm is 86.2 percent, the amount of fractions larger than 45 mm is 7, 6 percent and the amount of fineness 0.8 percent, when the number of revolutions of the screw of the grinding machine is 900 r/min, the amount of the fraction smaller than 3.15 mm is 5.9 percent, the amount of fractions up to 3.15-45 mm is 86.7 percent,

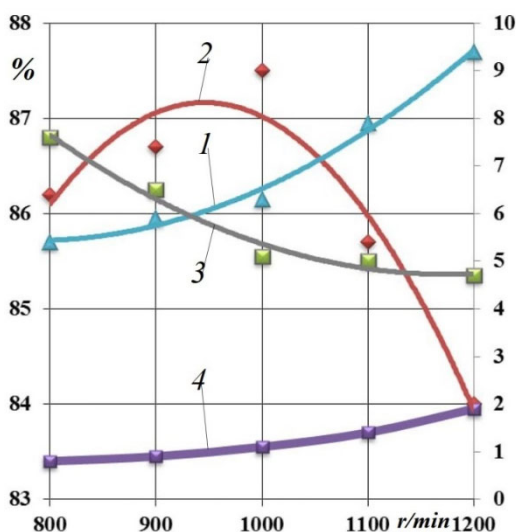


Fig. 2. The impact of the grinding auger's rotational count on the grinding quality: 1) up to 3.15 mm 2) up to 3.15-45 mm 3) larger than 45 mm 4) amount of indestructibility.

The amount of fractions larger than 45 mm is 6.5 percent and the amount of coarseness is 0.9 percent, the amount of fractions smaller than 3.15 mm is 6.3 percent when the number of revolutions of the screw of the grinding machine is 1000 r/min, fractions up to 3.15-45

mm amount is 87.5 percent, the amount of fractions larger than 45 mm is 5.1 percent, and the amount of impermeability is 1.1 percent, the amount of fractions smaller than 3.15 mm is 7.9 percent, 3 , the amount of fractions from 15-45 mm is 85.7 percent, the amount of fractions larger than 45 mm is 5.0 percent, and the amount of coarseness is 1.4 percent, and the fraction is less than 3.15 mm when the number of revolutions of the screw of the grinding machine is 1200 r/min. It was found that the amount of fractions up to 3.15-45 mm is 84.0 percent, the amount of fractions larger than 45 mm is 4.7 percent, and the amount of indestructibility is 1.9 percent.

Based on the examination of the aforesaid experiment's outcomes, the shredding and separation of the branches into specified fractions fully meets the requirements of the regulatory documents when the number of revolutions of the screw of the shredding device is 1000 r/min. For this reason, it is considered appropriate that the number of rotations of the auger of the shredder of the bushy tree branches should be 1000 r/min.

4 Conclusion

When the number of rotations of the screw of the shredding device of the shrubby tree branches is changed from 800 r/min to 1200 r/min, with the increase of the number of rotations of the shredding screw, the amount of crushed branches up to 3.15 mm the amount of fractions is from 5.4 percent to 9.4 percent, the amount of main fractions from 3.15 to 45 mm is from 84.0 percent to 86.2 percent, the amount of fractions larger than 45 mm is from 4.7 percent to 7.6 percent and it was found that the amount of failure varies from 0.8 percent to 1.9 percent. Based on regulatory documents, preliminary requirements and technical requirements, the optimal value was achieved when the number of revolutions of the screw of the grinding machine was 1000 r/min. It was found that the amount of fractions smaller than 3.15 mm is 6.3 percent, the amount of fractions up to 3.15-45 mm is 87.5 percent, the amount of fractions larger than 45 mm is 5.1 percent, and the amount of inertness is 1.1 percent.

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