

Test of Shear Mechanical Properties of Cassava Stalks

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Abstract. The parameters of cassava mechanical properties are very important for the design, dynamic simulation and mathematical model of cassava harvester. In order to study the cassava stalks cutting force, stress, power indicators influencing factors, using WD-200B computer-controlled electronic universal testing machine, orthogonal experiments are conducted to test the cassava stalks cutting force, cutting angle is selected, cutting speed, and cassava cutting parts diameter as the impact factors, results of the research show that when the cutting angle is 60 °and the cutting speed is 250mm/min, roots as the cutting site, the diameter in the coarse time, the required cutting force, cutting stress and power reach the maximum capacity. For the same cutting speed case, the cutting force of the middle is the maximum, the root is the next, the cutting force of the tip is the minimum; the stress of central part is the maximum, the root is the next, the smallest is tip stress; the middle has the maximum power, the root is the next, followed by tip power. For the same parts of the stalks, with the thinner diameter from coarse cutting force decreased; gradual decline of power; unrelated stress magnitude and diameter size have nothing to do with the stalks parts in 2.5MPa fluctuate. With the angle changes, the cutting Force, stress, and power of the tip portion ate significantly lower than the central and root. The study results provide a theoretical basis for grinding cassava stalks harvester developed.

Introduction

Cassava is widely grown in tropical and subtropical regions. Most areas in Hainan have cassava, it is one of Hainan's specialty crops, and brings a lot of benefits for the people's production and living. Have a lot of use of the various parts of the cassava value. It is the fruit of cassava root is known as the title of "King of the starch. Can be consumed by humans, livestock, and can also be processed into feed, can be used as industrial raw materials. In addition, Cassava detoxification swelling, commonly used to treat sores and ringworm [1]. The leaves can be used as some feed ingredients. Indians living in the Amazon jungle region of cassava leaves as an herbal use [2]. Cassava stalks can be made of the feed, but generally low domestic utilization of cassava stalks. In recent years, with the rising status of cassava economic development strategy, the rational utilization of cassava stalks relationship to the development of the industry as a whole, and even the development of China's agricultural economy.

Therefore, the urgent need to design and development for cassava stalks cutting device and milling machinery. Domestic and foreign specialized theory and test methods of the cassava stalks mechanical characteristics of the small, Yang Wang, research on the physical and mechanical properties of cassava stem parameters [3]. German scholar M.J.O 'Dogherty test research on the physical and mechanical properties of the wheat straw and green straw [4], Sun Li the previous years harvest, dry straw and milky stage of compression, shear properties testing and research [5]. Wu Fengsheng research design straw chopper device, using a vertical knife hovering cut, overcome difficulties such as rice and wheat straw's toughness, which is difficult to cut and broken [6]. The Chen Zhengguang corn stalks, a three-point bending, the sheared axial and radial shear test study [7]. Meng Haibo corn the stalks rubbing Chet modified test bench test study [8], most of the above studies slower loading conditions.

Whether the effect of harvest of cassava stalks is good or bad is determined by the factors such as cutting diameter, cutting angle, cutting position and so on. There is a lack of research at home and abroad on the cutting mechanical properties of cassava stalks .Cassava stalks diameter, cutting parts, cutting angle, cutting speed as influencing factors of cutting force, stress, power indicators tested. The

research on the development of cassava stalks cutting device has both theoretical and practical significance.

Materials and methods

Sample Preparation. Ten cassava stalks were taken from Dianbai village under the leadership of New Island village committee in Lingshan Town in Meilan District in Haikou. Cassava stalks by the core tissue and housing, and Setsuko dense core organization of stem substantially no strength, whereas the fibers of the housing into an axial distribution. Cassava stalks are mature straw, the average length of about 2 m thickness ranges. These 10 cassava stalks numbered 1, 2, 3, ... 9, 10 respectively. Then the whole root cassava stalks divided into three parts, namely the tip, middle, roots, and is divided into three parts stalks numbered. ID rules, the former figures represent stalks number, 1, 2, 3 ... 10, the latter figure 1, 2 and 3, respectively, on behalf of the sample taken from the former No. tip, in the roots. For example, NO 3 cassava stalks, and the tip portion of the number is 31, the middle of the number is 32, the root of the number is 33. Respectively measuring the outer diameter of the root of 10 stalks, No. 13 of the stalks outside diameter of 23.70mm, that is, the outer diameter of the root of the stalks in the No. 1 of 23.70mm. No. 23 is 28.20mm. Number 33 is 27.93mm. Number 43 is 20.30mm. No. 53 is 15.56mm. Number 63 is 21.83mm. Number 73 is 17.78mm. Number 83 is 19.20mm. Number 93 is 27.24mm. No. 103 23.72mm. Approximation with the outer diameter of the root of each stalks to represent the outer diameter of the root cassava stalks. Cassava stalks diameter based on the measured data, the 10 OD data is divided into three groups.

The first set of data is 15.56-19.77mm, a second set of data for the 19.77-23.98mm, and the third set of data to 23.98 to 28.20mm. Cassava stalks diameter divided into coarse, medium, fine three. Stalks outer diameter is located in the first set of data within a thin rod, is located in the third set of data within the range of within the range of the second set of data for the pole, located as a crude lever. For this, thin rod for 5,7,8 pole 1,4,6,10 thick shaft as 2,3,9.

Take fine rods in rod thick shaft 3 for the experimental material. From the tip portion of each of the rod, the middle root sawn sample Sec length of 150mm, and the corresponding label affixed on the specimen, respectively. The order in the table according to the orthogonal experiment Experimental these thirty-six samples numbered 1,2,3, ..., 35,36. It is shown in Figure 1: Figure cassava stalks sample numbers.



Figure 1 Cassava stalks sample numbers

Test Instrument. Laboratory instruments and equipment for WD-200B microcomputer controlled electronic universal testing machine, protractor, tape measure, micrometer, hacksaw, label support base. WD-200B computer-controlled electronic universal testing machine for the main test instrument, its role is to cut the cassava stalks sample at a different set of universal testing machine speed to test the impact of cutting speed on cutting force and show the changes of the value of the cutting force by computer.

Protractor plays the role of cutting angle measurement and control. Measuring tape and a micrometer is used to measure the physical parameters of the cassava straw tape measure to measure the length of the cassava straw, the cassava stalks micrometer, measure the outside diameter, inside diameter and thickness. Hacksaw from the field, from the amputated cassava stalks, and the sample was produced by sawing the length in accordance with the regulations of the various parts of the cassava straw. The tags used to mark the sample, facilitate cassava Straw each sample parameter measurement and recording. The support base is a device to support cassava straw sample during the cutting experiments.

Methods. Use of WD - 200 - b microcomputer control electronic universal testing machine for good sample for cutting experiment, according to a set of experimental condition is different, different types of cutting experiments. Cutting speed change through the electronic universal testing machine control, speed change to 50 mm/min, 100 mm/min, 250 mm/min only in electronic universal testing machine set corresponding speed value can be. The change of the cutting Angle is through the control anchorage and experimental platform to realize the change of Angle.

When the blade and cassava straw sample between the cutting Angle of 30° , the control anchorage and experimental platform for Angle 60° . When the blade and cassava straw sample between the cutting Angle 45° , the control anchorage and experimental platform for Angle 45° . When the blade and cassava straw sample between the cutting Angle is 60° , the control anchorage and experimental platform Angle of 30° . When the blade and cassava straw sample between the cutting Angle is 90° , the cassava straw sample level of placed in the anchorage. Cutting parts of the change in the preparation material phase has been completed, and the cassava straw into tip department, central and root. It is shown in figure 2 : cassava straight cut 90° loading installation drawing. Figure 3 for cassava straw oblique loading installation drawing. Figure 4 for cassava straw to cut off the map. Figure 5 for experimental device structure diagram.



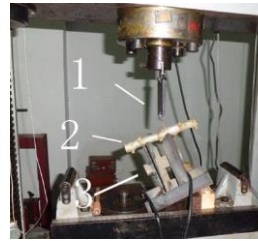
Figure 2 Cassava straight cut 90° loading installation drawing



Figure 3 For oblique cutting 45° loading installation drawing



Figure 4 Cassava straw to cut off the map



1 blade 2 cassava stem 3 support
Figure 5 Experiment device structure

The Impact of Cutting Force, Stress, Power Orthogonal Test. To select cutting angle, cutting speed, cutting site, and cassava rod diameter as the main influencing factors, and to study the impact of the cassava stalks cutting, cutting force, stress, power, and other indicators. Factors and level of inspection to schedule the test results to use the $L_{36}(4 \times 3^{10})$ orthogonal table, and can arrange a four-level factors and factors of three and three levels orthogonal test. Test indicators optional straw cut when the cutting force, stress, power. It is shown in Table 1: Test factor in the level of the table.

Table1: Test factor in the level of the table

level factor	Cutting angle A[°]	Cutting speed B[mm/min]	Cutting parts C	Diameter D
1	30	50	tress tip	thick
2	45	100	meddle	medium
3	60	250	root	fine
4	90			

Cutting Force, Stress, the Power with the Cutting Speed Change Experiments. During the experiment, the experimental variable cutting speed were taken as 50mm/min 100mm/min 250mm/min. Cassava stalks approximately the same diameter, cutting angle is 90. Taken outside diameter approximately the same tip, the middle of the roots, the material sample numbers were 71,42,83 the. From the tip portion of each of the rod, the middle root sawing out three sections of the specimen with a length of 100mm, and the corresponding label affixed on the specimen, respectively. The sequence according to the present experiment, this nine sample number is 37, 38, ... 44,45. Cutting test, and record the data of the straw is cut off when the cutting force, the calculated cutting stress and cutting power.

Cutting Force, Stress, Power Change in the Diameter of Experiments. During the experiment, the experimental variables cassava straw diameter, divided into coarse, medium, fine. Control variable cutting speed of 250mm/min, and a cutting angle of 90° . As a crude and an outer diameter approximately the same tip, central, root diameter, were 91,32,103. Each saw a long period for a sample of 100 mm. The diameter and the outer diameter of an approximation of the same tip, central, root, materials Sample No. 101,22,63. Each saw a long period for a sample of 100 mm. Taken into fine diameter and an outer diameter approximately the same tip, central, root, 81,72,53 respectively. Each saw a long period for a sample of 100 mm. And corresponding label affixed on the nine samples, respectively. Again, according to the present order of the experiment, these nine samples are numbered, as 46,47, ... 53,54. Cutting test, and record the data of the straw is cut off when the cutting force, the calculated cutting stress and cutting power.

Cutting Force, Stress, Power with Cutting Angle Change Experiments. During the experiment, the variable cutting angle, divided into 30° , 45° , 60° , 90° . The outer diameter of the control variables cassava stalks approximately the same cutting speed 250mm/min. Taken outside diameter approximately the same tip, central, root, material samples were numbered 81,82,53. From the tip portion of each of the rod, the middle root sawing out three sections of the specimen with a length of 100mm, and the corresponding label affixed on the specimen, respectively. According to the sequence of the present experiment, the nine sample numbers are 55, 56, ..., 65 and 66. Cutting test, and record the data of the straw is cut off when the cutting force, the calculated cutting stress and cutting power.

Results and discussion

Orthogonal Experiment Results. Sequentially according to the order of the table of the orthogonal experiment design experimental groups experiment. Orthogonal experiment Table 2 as follows:

Table 2: Design and Results of orthogonal experiment

Numer order Factor	Cutting angle [°]	Cutting speed [mm/min]	Cutting parts	Diameter	Cutting force [KN]	Stress [MPa]	Power [W]
1	1(30)	1 (50)	1(tress tip)	3(fine)	0.3236	2.52988	0.2697
2	1(30)	2(100)	1(tress tip)	1(thick)	0.2186	1.70632	0.3643
3	1(30)	3(250)	1(tress tip)	2(medium)	0.2108	1.95940	0.8783
4	1(30)	1 (50)	2(middle)	2(medium)	0.677	2.61891	0.5642
5	1(30)	2(100)	2(middle)	3(fine)	0.6611	3.57995	1.1018
6	1(30)	3(250)	2(middle)	1(thick)	1.4291	3.16021	5.9546
7	1(30)	1 (50)	3(root)	1(thick)	1.5429	2.99698	1.2858
8	1(30)	2(100)	3(root)	2(medium)	1.6393	3.83473	2.7322
9	1(30)	3(250)	3(root)	3(fine)	0.6373	3.05472	2.6554
10	3(60)	1 (50)	1(tress tip)	1(thick)	0.3694	2.37211	0.3078
11	3(60)	2(100)	1(tress tip)	2(medium)	0.4545	2.45324	0.7575
12	3(60)	3(250)	1(tress tip)	3(fine)	0.4527	3.13530	1.8863
13	3(60)	1 (50)	2(middle)	3(fine)	0.946	5.03466	0.7883
14	3(60)	2(100)	2(middle)	1(thick)	1.0371	2.48580	1.7285
15	3(60)	3(250)	2(middle)	2(medium)	1.4135	3.49002	5.8896
16	3(60)	1 (50)	3(root)	2(medium)	1.6106	3.78178	1.3422
17	3(60)	2(100)	3(root)	3(fine)	0.9961	3.95544	1.6602
18	3(60)	3(250)	3(r)	1(thick)	1.8614	3.19936	7.7558
19	4(90)	1 (50)	1(tress tip)	2(medium)	0.2985	1.74083	0.2488
20	4(90)	2(100)	1(tress tip)	3(fine)	0.3137	2.13606	0.5228
21	4(90)	3(250)	1(tress tip)	1(thick)	0.2825	1.85158	1.1771
22	4(90)	1 (50)	2(middle)	1(thick)	1.1891	2.83396	0.9909
23	4(90)	2(100)	2(middle)	2(medium)	0.75	2.27258	1.2500
24	4(90)	3(250)	2(middle)	3(fine)	0.6315	3.83479	2.6313
25	4(90)	1 (50)	3(root)	3(fine)	0.6662	2.78057	0.5552
26	4(90)	2(100)	3(root)	1(thick)	1.6113	3.06307	2.6855
27	4(90)	3(250)	3(root)	2(medium)	2.1361	4.00985	8.9004
28	2(45)	1 (50)	1(tress tip)	3(fine)	0.2759	2.00060	0.2299
29	2(45)	2(100)	1(tress tip)	1(thick)	0.1627	1.33358	0.2712
30	2(45)	3(250)	1(tress tip)	2(medium)	0.3241	2.49530	1.3504
31	2(45)	1 (50)	2(middle)	2(medium)	1.2727	3.45857	1.0606
32	2(45)	2(100)	2(middle)	3(fine)	0.8692	4.68575	1.4487
33	2(45)	3(250)	2(middle)	1(thick)	1.6375	3.54615	6.8229
34	2(45)	1 (50)	3(root)	1(thick)	2.0096	3.67708	1.6747
35	2(45)	2(100)	3(root)	2(medium)	1.3262	3.16537	2.2103
36	2(45)	3(250)	3(root)	3(fine)	0.8224	3.46058	3.4267

Table 3: Analysis of range for orthogonal experiment

(Kj1) 1	7.3397	11.1815	3.6870	13.3512	
(Kj2) 1	8.7003	10.0398	12.5138	12.1133	
(Kj3) 1	9.1413	11.8389	16.8594	7.5957	Affect the cutting force of the primary and secondary order: CDAB
(Kj4) 1	7.8789				
(kj1) 1	0.8155	0.9317	0.30725	1.1126	
(kj2) 1	0.9667	0.83665	1.0428	1.0094	
(kj3) 1	1.0157	0.9865	1.4049	0.6329	Maximum combination of cutting force: A3B3C3D1
(kj4) 1	0.8754				
(Rj) 1	0.2002	0.14985	1.0977	0.4797	
(Kj1) 2	25.441	35.82593	27.06198	32.2262	
(Kj2) 2	27.8229	34.67189	41.0013	35.2805	The impact stress primary and secondary order: CDAB
(Kj3) 2	29.9077	37.19726	40.9795	40.1883	
(Kj4) 2	24.5232				
(kj1) 2	2.827	2.985	2.2551	2.685	
(kj2) 2	3.091	2.889	3.4167	2.940	Combination of the maximum stress level: A3B3C2D3
(kj3) 2	3.323	3.0997	3.4149	3.3490	
(kj4) 2	2.72481				
(Rj) 2	0.59819	0.2107	1.1598	0.664	
(Kj1) 3	15.8063	9.3181	8.2641	31.0191	Affect the power of the primary and secondary order: CDBA
(Kj2) 3	18.4954	16.733	30.2314	27.1845	
(Kj3) 3	22.1162	49.3288	36.8844	17.1763	
(Kj4) 3	18.962				
					Need to power the

(Kj1) 3	1.756	0.7765	0.6886	2.5849	maximum
(Kj2) 3	2.055	1.3944	2.519	2.2653	combination:A3B3C3D1
(Kj3) 3	2.457	4.1107	3.0737	1.4313	
(Kj4) 3	2.1068				
(Rj) 3	0.299	0.3425	2.3851	1.1536	

It is shown in table3:the cassava stalks cut off when the cutting force of the main factors: the cutting region C, straw diameter D, cutting angle A and the cutting speed B. Maximum cutting force of combination: A3B3C3D1, that cutting angle of 60° and speed 250mm/min, cutting parts of the roots, when the straw diameter elected rough cut off required cutting force to the maximum. The possible reason is that the biological fiber structure of the root of the cassava stalk is dense, which consume more energy to finish the stalk cutting, so the cutting force is larger. The larger the diameter of cassava straw is, the more the transverse fibers are cut off, which directly leads to the increase of cutting force. According to the theorem of momentum, the larger the blade speed, the larger the impulsive force we need to cut off the cassava stalk; the larger the cutting angle, the larger the force we need to cut off the structural fibrous tissue.

Cutting parts C for the order of the main factors affecting the primary and secondary shear stress cut straw straw: straw diameter D, cutting angle A and the cutting speed B. Combination of cut off when the maximum stress level: A3B3C2D3 cutting angle of 60° and speed 250mm/min, cutting parts of central and the straw diameter elected fine cut off when cutting stress.The possible reason is that the cutting stress of cassava straw mainly depends on the strength of the biological materials. The root of cassava stalk is strong, while the strength of the cassava stalk becomes small when the height increases. The diameter of the root of cassava stalk is always the largest and have the largest biological materials strength, so the required cutting stress values will increase dramatically when you want to cut off the root. The smaller the cutting angle is, the smaller the cutting stress is. The main reason is that the shear stress component of the blade to impact the straw section becomes small as the speed decreases, which leads to the decrease of cutting stress. According to the theorem of momentum, the larger the blade speed, the larger the impulsive force. But the fibrous structure of cassava straw will deform when the impulsive force is too large, the cutting stress is not necessarily proportional to the increase.

Primary and secondary order of the the straw stalks cut the power required impact factors: CDBA cutting parts C, straw diameter D, the cutting speed B and cutting angle A cut required maximum power combination. A3B3C3D1, namely that cutting angle of 60° and speed 250mm/min, cutting parts of the roots, the straw diameter elected rough cut when cutting power, was the largest.The main factors influencing the straw cutting power is the energy needed to cut off straw. The straw fiber organization is close and the number is of fibers is large when the diameter of the root is large, so the cutting power is large. When the straw fiber is cut forward, the fiber is rapidly deformed and gathered, and the energy consumed by this action is increase, the cutting power needed is greater. As the cutting speed increases, the energy consumption of the machine will be higher, this accords with the principle of energy theorem.

The comprehensive analysis result shows that: when the cutting angle of 60° , the cutting speed of 250mm/min, cutting site for roots, the diameter of the crude, the required cutting force, and cutting stress, and needs power reaches the maximum.

Table 4: Shear test results of cassava stalks

Cutting speed, the outer diameter is approximately the same, and the cutting angle of 90 °									
Number order	Cutting parts	Outer diameter [mm]	Thickness [mm]	Inner diameter [mm]	Sectional area [mm ²]	Cutting speed [mm/min]	Cutting force [KN]	Stress [MPa]	Power [W]
37	Tress tip	18.86	4.69	9.48	208.6759	50	0.4908	2.3520	0.4090
38	Tress tip	18.80	4.48	9.84	201.4423	100	0.5330	2.6459	0.8883
39	Tress tip	19.06	5.53	8.00	234.9376	250	0.5561	2.3670	2.3171
40	middle	19.20	5.70	7.80	241.6230	50	1.0178	4.2123	0.8482
41	middle	18.64	5.35	7.94	223.2587	100	0.7546	3.3799	1.2577
42	middle	19.18	5.62	7.94	239.2906	250	0.8834	3.6917	3.6808
43	root	18.96	5.62	7.72	235.4083	50	0.6099	2.5908	0.5083
44	root	18.76	5.40	7.96	226.5322	100	0.6377	2.8151	1.0628
45	root	18.26	5.40	7.46	218.0542	250	0.5852	2.6837	2.4383

Experiment I : Cutting Force, Stress, Change of Power with the Cutting Speed. In order to study the influence of different cutting speed on cutting force, cutting stress and cutting power of cassava stalks, the experimental data of the influence of cutting speed on the three indexes are obtained and shown in Table 4. In the experiment, the external diameter of cassava stalks were almost the same and the cutting angle was 90° .

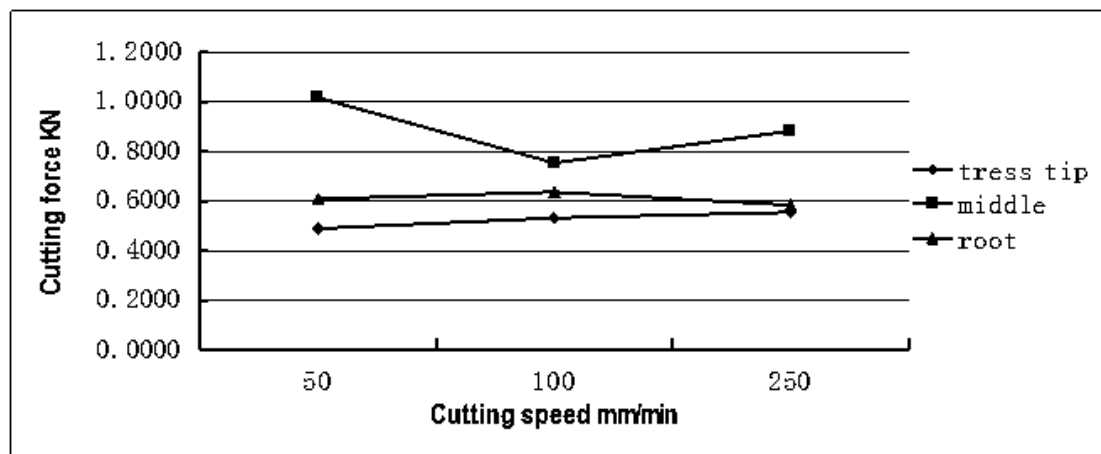


Fig. 6 Effects of cutting speed on cutting force

It is shown in Figure 6: For the same cutting speed, the cutting force of the central maximum, roots, followed by the tip of the cutting force minimum. The denser the straw fiber is, the greater the cutting force is, the reason is that the peripheral parts of straw is fragile tissue, which have a small number of fibers and the cutting force needed to cut off the straw is small. The experiment results show that the cutting force of the middle stalk is greater than the cutting force of the straw root. Indicating that the fiber in the middle of the straw is very dense, while the water content of straw root is relatively high so that the cutting force is decrease. From what we have discussed above, we can draw a conclusion that we have to make sure that the blade is design to cut off the root of stalk when we doing the design the work of straw cutting harvester, so that we can cut down energy consumption of the machine.

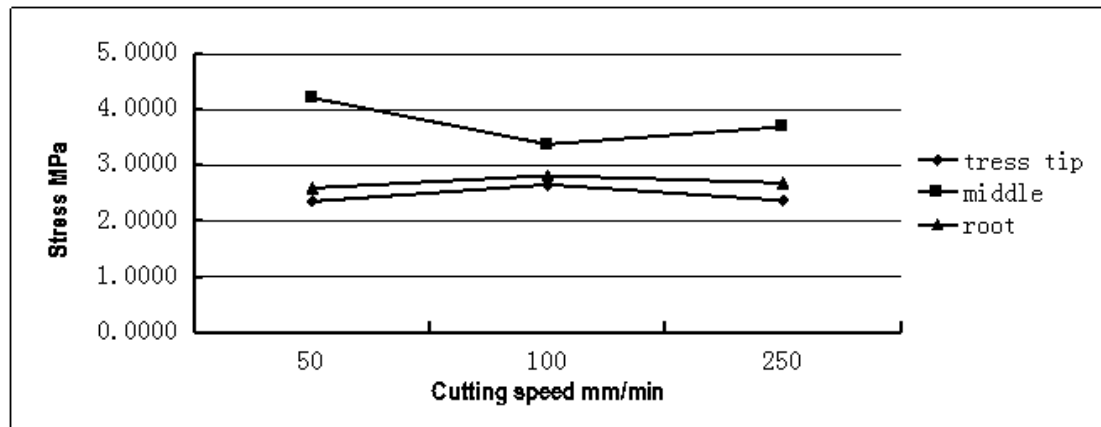


Fig. 7 Effects of cutting speed on stress

It is shown in Figure 7: For the same cutting speed, the middle of the maximum stress, the roots, followed tip portion of the minimum stress. The experimental results show that the strength of the material in the middle of the straw is larger than the strength of the material of the root. The possible reason is that the root of the stalk is close to the cassava fruit, high moisture content leads to less strength of fibrous tissue of the root than the middle of the straw. The rapid growth of the material of the end of the straw makes it weak and low in strength.

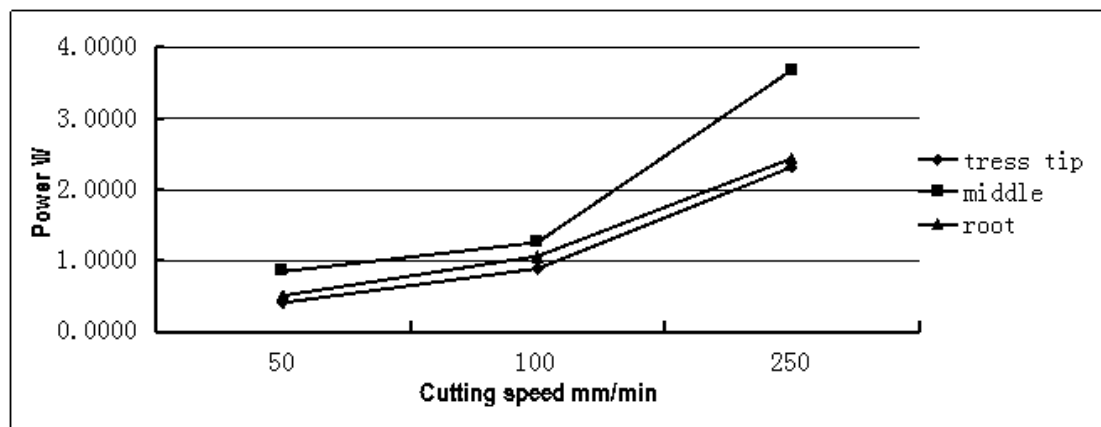


Fig. 8 Effects of cutting speed on power

It is shown in Figure 8: For the same parts of the straw, as the cutting speed increases, the power increases. For the same cutting speed, the power of the central is the maximum, followed by the power of roots, the tip is the minimum.

Table 5: Shear test results of cassava stalks

Different diameters, the cutting speed of 250mm/min, and the cutting angle of 90 °

Number order	diameter	Cutting parts	Outer diameter [mm]	thickness [mm]	Inner diameter [mm]	Sectional area [mm ²]	Cutting force [KN]	Stress [MPa]	Power [W]
46	thick	Tress tip	25.80	7.78	10.24	440.2142	1.5110	3.4324	6.2958
47	thick	middle	24.84	7.19	10.46	398.4770	0.8609	2.1605	3.5871
48	thick	root	24.81	6.73	11.35	382.0702	1.1706	3.0638	4.8775
49	medium	Tress tip	21.90	5.72	10.46	290.6057	0.7701	2.6500	3.2088
50	medium	middle	19.38	5.80	7.78	247.3190	0.7259	2.9351	3.0246
51	medium	root	20.77	5.93	8.91	276.3238	0.5729	2.0733	2.3871
52	fine	Tress tip	16.30	4.87	6.56	174.7853	0.3368	1.9269	1.4033
53	fine	middle	16.77	5.55	5.67	195.5309	0.6168	3.1545	2.5700
54	fine	root	16.40	5.20	6.00	182.8736	0.5890	3.2208	2.4542

Experiment II: Cutting Force, Stress, Power with Diameter Changes. In order to study the influence of different diameter on cutting force, cutting stress and cutting power of cassava stalks, the experimental data of the influence of diameter on the three indexes are obtained and shown in Table5. In the experiment, the cutting speed was set to be 250mm/min and the cutting angle was 90° .

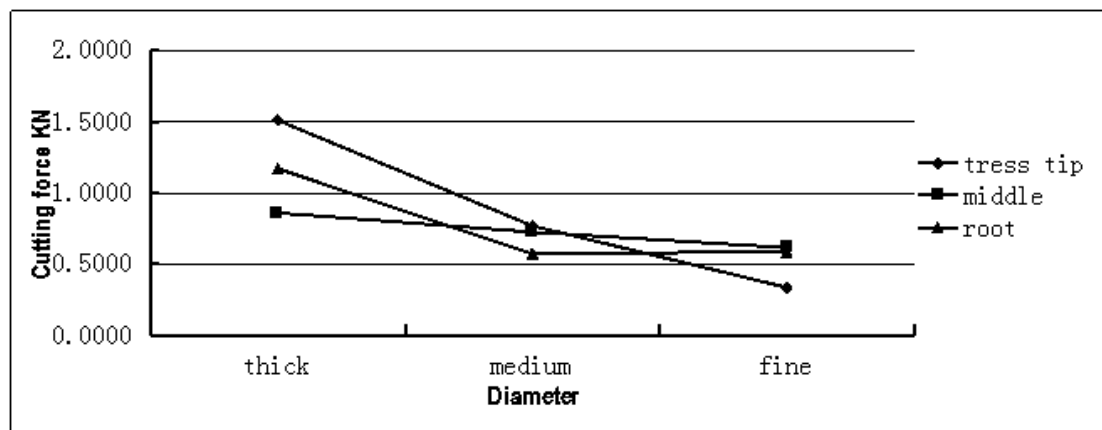


Fig. 9 Effects of diameter on cutting force

It is shown in Figure 9: straw for the same position, with diameters ranging from coarse to fine cutting force decreased. The reason is that the smaller the diameter, the smaller the number of fibers, the less the cutting force required.

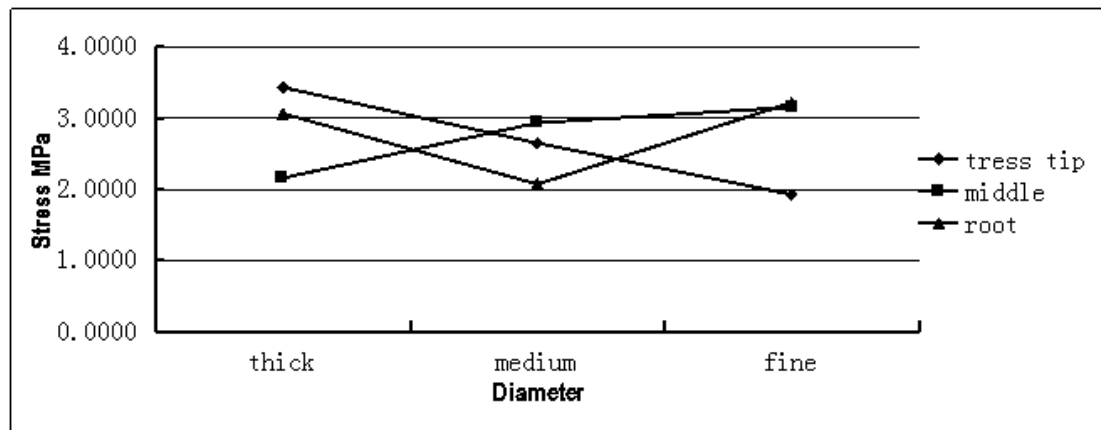


Fig. 10 Effects of diameter on stress

It is shown in Figure 10: stress magnitude and is independent of the diameter, has nothing to do with the straw parts in 2.5MPa fluctuate. The possible reason is that the strength of the various parts of the straw material is almost the same, the change of the diameter of them are not too large, so that there was no significant difference in the strength of straw in each experiment.

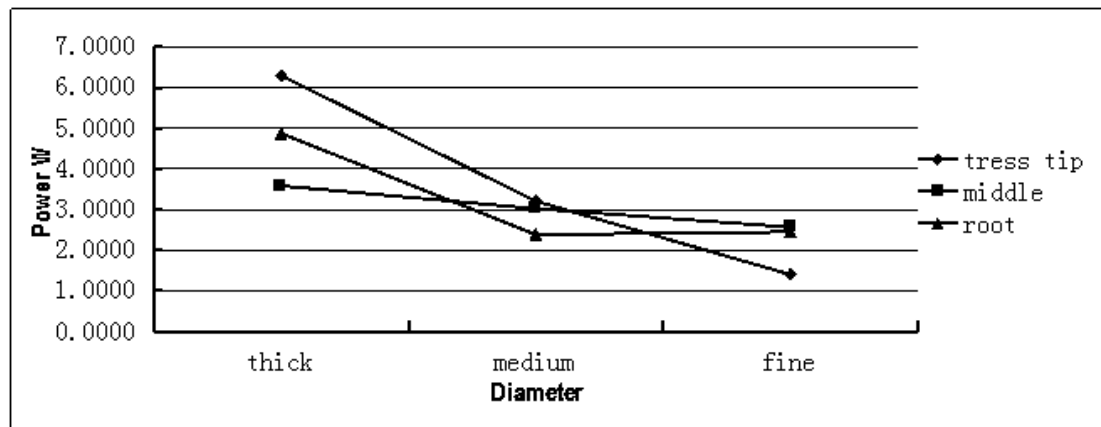


Fig. 11 Effects of diameter on power

It is shown in Figure 11: straw for the same position, with diameters ranging from coarse to fine, the power decreased. The possible reason is that with the reduction of straw materials, the energy needed to cut off materials decreased sharply so that the cutting power decreased gradually.

Table 6: Shear test results of cassava stalks

Cutting angle is approximately the same outside diameter, cutting speed 250mm/min

Number	Cutting	Outer	Thickness	Inner	Sectional	Cutting	Cutting	Stress	Power
order	parts	diameter	[mm]	diameter	area	g angle	force	[MPa]	[W]
		[mm]		[mm]	[mm ²]	[°]	[KN]		
55	Tress tip	16.60	4.03	8.54	159.0633	30	0.2025	1.2731	0.8438
56	Tress tip	15.54	4.20	7.14	149.5519	45	0.2893	1.9344	1.2054
57	Tress tip	16.24	4.04	8.16	154.7643	60	0.2547	1.6457	1.0613
58	Tress tip	15.18	3.71	7.76	133.6186	90	0.2954	2.2108	1.2308
59	middle	16.98	5.38	6.22	195.9611	30	0.7932	4.0477	3.3050
60	middle	17.06	5.24	6.58	194.4816	45	0.6486	3.3350	2.7025
61	middle	16.76	4.71	7.34	178.2123	60	0.6720	3.7708	2.8000
62	middle	16.47	4.95	6.57	179.0554	90	0.5551	3.1002	2.3129
63	root	16.18	4.96	6.26	174.7448	30	0.6338	3.6270	2.6408
64	root	16.48	6.18	4.12	199.8736	45	0.8888	4.4468	3.7033
65	root	15.54	6.22	3.10	182.0271	60	0.9647	5.2998	4.0196
66	root	16.40	5.20	6.00	182.8736	90	0.5890	3.2208	2.4542

Experiment III: Cutting Force, Stress, the Power with the Cutting Angle Changes. In order to study the influence of different cutting angle on cutting force, cutting stress and cutting power of cassava stalks, the experimental data of the influence of cutting angle on the three indexes are obtained and shown in Table 6. In the experiment, the external diameter of cassava stalks were almost the same and the cutting speed was set to be 250mm/min.

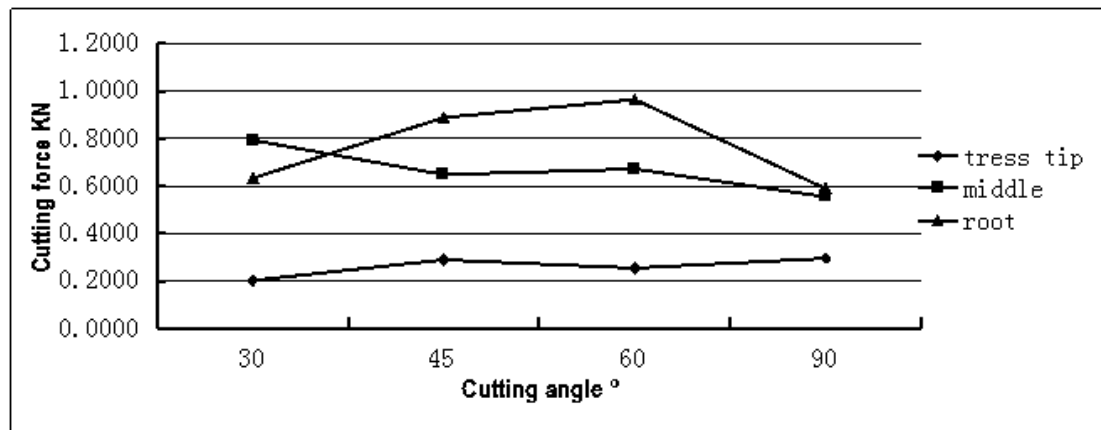


Fig. 12 Effects of cutting angle on cutting force

It is shown in Figure 12: tip portion of the cutting force was significantly lower than the central and the root of the cutting force. That is relevant to the materials used in the experiment. No other obvious rule.

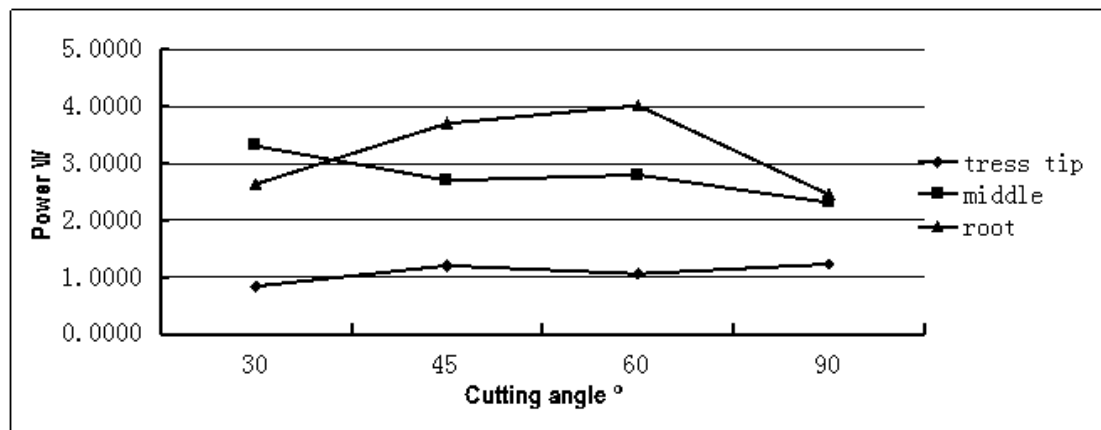


Fig. 13 Effects of cutting angle on power

It is shown in Figure 13: the power is significantly lower than that of the tip portion of the power of the central and roots. That is relevant to the materials used in the experiment. No other obvious rule.

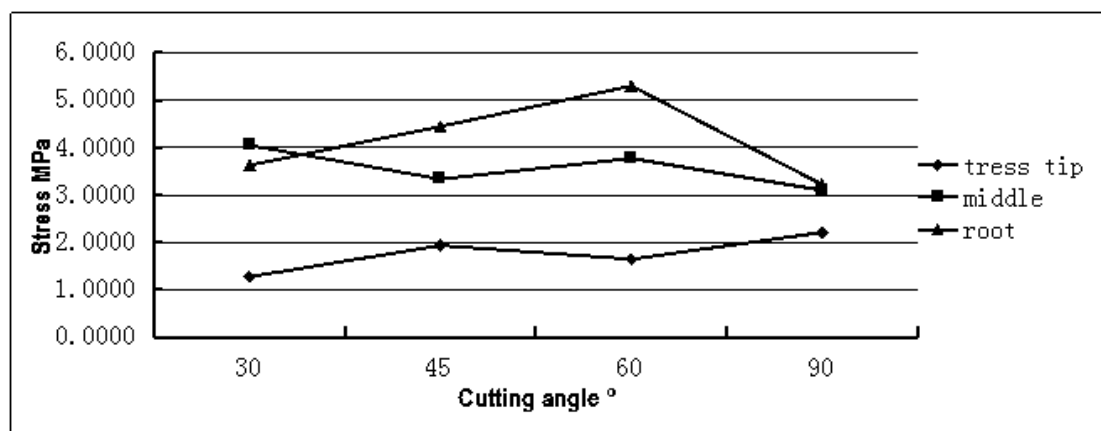


Fig. 14 Effects of cutting angle on stress

It is shown in Figure 14: the stress of the tip was significantly lower than the stress of the central and roots. That is relevant to the materials used in the experiment. No other obvious rule.

Conclusions

The investigation of shear mechanical properties of cassava stalks revealed the followings.

(1) when the cutting angle is 60° , the cutting speed is 250mm/min, cutting site is the root, the diameter in the coarse time, the required cutting force, cutting stress and power reach the maximum.

(2) for the case of the same cutting speed, the cutting force of the central is the maximum, followed by roots, the cutting force of tip is the minimum; the central part stress is the maximum, the roots as the second, the smallest is the tip stress; maximum power in the middle, the roots as the second, the power of the shoot portion is the minimum.

(3) for the same parts of the straw, the cutting force and power decrease with the diameter changes from coarser to thinner. Stress has nothing to do with the diameter size and straw parts. Floating up or down at 2.5MPa.

(4) with the angle changes, the cutting force, stress, and power of the tip portion are significantly lower than the central and roots.

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