

## Research Paper :

## Performance evaluation of external knot removing machine of bamboo

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## ABSTRACT

The Konkan region of Maharashtra state contributes 70,000 tones of bamboo production that is about 28 per cent of total production of Maharashtra. The various varieties of bamboo are used for agriculture implements, fishing industry, basket making, horticulture and handicrafts etc. The cost of operation, energy requirement, sound level and capacity of bamboo external knot removing machine was studied for the bamboo variety *Dendrocalamus strictus* (Manvel). The fresh fully matured dull green bamboo contains the 40.96 per cent moisture. The dry yellowish bamboo contains 8.62 per cent moisture. At no load condition, the maximum and minimum sound level from the machine was 95 dB (A) and 77.1 dB (A), respectively. The maximum and minimum sound levels for freshly cut bamboo were 101 dB (A) and 83.65 dB (A), respectively. In case of dry bamboo maximum and minimum sound levels were 106.3 dB (A) and 89.9 dB (A), respectively. The sound level was more for dry bamboo as compare to fresh bamboo. The power required by machine at no load condition was 2.2 kW. At load condition for freshly bamboo energy consumed was 1.03 kWh whereas for dry bamboo energy consumption was 0.81 kWh. The capacity for freshly bamboo was found to be 188 knots per hour whereas the capacity of machine for dry bamboo was found to be 201 knots per hour.

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**Key words :** Bamboo external knot removing machine, Sound level, Moisture content, Energy consumption

The graceful gigantic grasses popularly and collectively known as bamboo are widely used for different purpose like craftwork, structural purpose, agricultural equipment, paper industries etc. Bamboo grows most abundantly in the orient where it is native to China, Burma, India, Japan, Europe and Canada. India has annual bamboo production as 4.5 million tones. In Maharashtra bamboo production is 2,47,239 tones. The Konkan region contributes 70,000 tones of bamboo production. Some of the prominent uses of bamboo are in house construction as structural material, agriculture implements, fishing industry, basket making, horticulture and handicrafts etc. besides extensive use in pulp and paper industry. Negi (2000) reported that in India 32 per cent, 30 per cent, 17 per cent, 71 per cent and 14 per cent of total bamboo produced is used for rural housing, agriculture implements, pulp, box making and other purpose, respectively.

Liese (1995) observed that immature bamboo of *Dendrocalamus strictus* lost its moisture content faster than mature bamboo of same species, but it took longer to dry completely due to it's higher initial moisture content. The strength of bamboo is higher in dry condition than in green condition. BIS (IS code 12207) (1987) stated that the maximum ambient noise emitted by the tractor and maximum noise of operator's ear level should not exceed 90dB(A) for 8 hr. duration. It is generally concluded that 40 hr. of exposure per week of noise of 90 dB or greater

will result in hearing loss.

The removal of external knot is very crucial for further operation of bamboo. As the knots have very hard structure, manually removal of knot requires more time and labour. Removal on bamboo external knot removing machine creates high sound level. Thus a study was undertaken to determine the sound level of bamboo external knot removing machine during operation. Bining (1985) studied on energy requirement in operation of cutting wooden material and found that total power required at load was 2.2 kW to 3.7 kW and energy required for cutting under optimum condition and 0.9 to 1.2 kW. The Table 1 shows the permissible noise exposures to human being.

**Table 1 : Permissible noise exposures**

Sr. No.	Duration per day (hours)	Sound level (dBA)
1.	8.0	90
2.	6.0	92
3.	4.0	95
4.	3.0	97
5.	2.0	100
6.	1.5	102
7.	1.0	105
8.	0.5	110
9.	0.25 or less	115

Energy requirement for different types of machines varies between 1.25 kWh to 15.14 kWh. Shrivastava (2003) studied the noise level of 3.7 kW diesel engine. He found that the noise level at 1.2 m height and 1m distances from engine was 92.4 dBA at minimum load condition while 99.2 dBA, at full load condition.

## METHODOLOGY

The bamboo external knot-removing machine is electrically operated 3- phase, A.C. induction motor. The overall dimensions of bamboo external knot removing machine manufactured by M/s. Garnet Tools, Dewas, M.P. (Fig. 1) are 1m x 1m x 1.2 m, power consumption is 2.3 kW or 3 HP and spindle speed is 2800 rpm. The machine can clean the maximum diameter of 0.2 m of bamboo. The *Dendrocalamus strictus* variety which is a deciduous, densely tufted bamboo with strong culms, 8 to 16 m height, 2.5 to 8 cm in diameter, pale blue green when young and dull green or yellow on maturity was selected. The various materials used for moisture content measurement were hot air oven and weighing balance. The instruments digital sound level meter, tripod, measuring tape and stopwatch were used for measurement of sound level. Multi meter and tong tester measured the energy consumption of machine at no load and load conditions. The range of sound level instrument was 30 to 130 dBA. A grid of 1m x 1m was plotted around the machine. On each side 4m distances were covered. Sound level measurement readings were taken at 1.2 m height on each grid point. Three replications were taken for the sound level measurements and energy consumption of machine at load conditions. The co-ordinate ( $X_0, Y_0$ ) denote the grid point at zero distance from machine whereas ( $x_4, y_4$ ) denote the point at 4m distance from machine. Similarly, at 1m, 2m, 3m and 4m distances the

points  $x_1, x_2, x_3$  and  $x_4$  were marked in positive direction and  $x_1', x_2', x_3'$  and  $x_4'$  were marked in negative direction on x-axis. On y-axis at 1m, 2m, 3m and 4m distances from machine the points  $y_1, y_2, y_3$  and  $y_4$  were marked in positive direction and  $y_1', y_2', y_3'$  and  $y_4'$  were marked in negative direction. Thus, the four quadrants were formed. Three replications were taken for sound level at each grid point at 1.2 m height. The bamboos with external knot are shown in Fig. 2 while the bamboo after removing external knot are shown in Fig. 3.



Fig. 2 : Bamboo with external knot



Fig. 3 : Bamboo after removing external knot



Fig. 1 : View during operation

## RESULTS AND DISCUSSION

The findings obtained from the present investigation have been discussed in the following sub heads:

### Moisture content

The data from Table 2 shows that fresh fully matured; dull green bamboo contained the average moisture content on dry basis was 40.96 per cent and the dry, yellowish bamboo contained average 8.62 per cent moisture content

Table 2 : Moisture content of bamboo			
Sr. No.	Sample number	Moisture content, (db %)	
		Freshly cut bamboo	Dry bamboo
1.	A	38.00	8.64
2.	B	42.56	8.56
3.	C	41.11	8.51
4.	D	39.34	8.43
5.	E	43.80	8.45
6.	F	41.40	8.64
7.	G	40.00	8.41
8.	H	42.30	8.36
9.	I	39.00	8.70
10.	J	42.10	8.73
Average		40.96	08.62

on dry basis.

**Sound level of machine at no load condition:**

Table 3 shows sound level at no load condition. At

Table 3 : Sound level of machine at no load condition						
Quadrant	Average sound levels at grid points, dBA					
First	(X, Y)	Y <sub>0</sub>	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>	Y <sub>4</sub>
	X <sub>0</sub>	95	94.2	86.2	85.3	82.4
	X <sub>1</sub>	86.1	82.1	85.5	84.2	81.4
	X <sub>2</sub>	83.1	83.2	84.5	83.9	80
	X <sub>3</sub>	86.4	80.7	80.3	82.4	79.8
	X <sub>4</sub>	87.3	84.2	78.5	80.3	79.4
Average sound level of first quadrant = 83.9 dBA						
Second		Y <sub>0</sub>	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>	Y <sub>4</sub>
	X <sub>0</sub> '	95	94.2	86.2	85.3	82.4
	X <sub>1</sub> '	84	83.4	85.4	80.8	81.4
	X <sub>2</sub> '	83.4	81.4	84.4	79.4	78.7
	X <sub>3</sub> '	82.2	80	83	77.8	77.4
	X <sub>4</sub> '	78.2	76.4	77.6	76.5	76
Average sound level of second quadrant = 82.0 dBA						
Third		Y <sub>0</sub> '	Y <sub>1</sub> '	Y <sub>2</sub> '	Y <sub>3</sub> '	Y <sub>4</sub> '
	X <sub>0</sub> '	87.3	86.4	87.1	88.4	89.4
	X <sub>1</sub> '	85.1	85.6	84.2	83.6	83.2
	X <sub>2</sub> '	82.1	83.4	83.4	81.2	80.4
	X <sub>3</sub> '	80.1	81.5	82.6	80.6	79.5
	X <sub>4</sub> '	78.2	77.8	80	77.1	78.5
Average sound level of third quadrant = 82.7 dBA						
Fourth		Y <sub>0</sub> '	Y <sub>1</sub> '	Y <sub>2</sub> '	Y <sub>3</sub> '	Y <sub>4</sub> '
	X <sub>0</sub>	95	86.4	87.1	88.4	89.4
	X <sub>1</sub>	86.1	87.2	85.2	84.4	81.2
	X <sub>2</sub>	83.1	86.9	84.5	82.4	80.1
	X <sub>3</sub>	82.2	85.2	83.5	80.2	79.8
	X <sub>4</sub>	81.3	80.7	77.7	79	79
Average sound level of fourth quadrant = 83.8 dBA						

no load condition, the maximum and minimum sound levels from the machine were found to be 95 dBA and 77.1 dBA, respectively. The contour map of sound level is shown in Fig.4. The average sound level of first, second, third and fourth quadrant was to the tune of 83.9, 82.0, 82.7 and 83.8 dBA, respectively. The sound level of machine at one-meter distance was 82.1, 83.4, 85.6 and 87.2 dBA in the first, second, third and fourth quadrant, respectively.

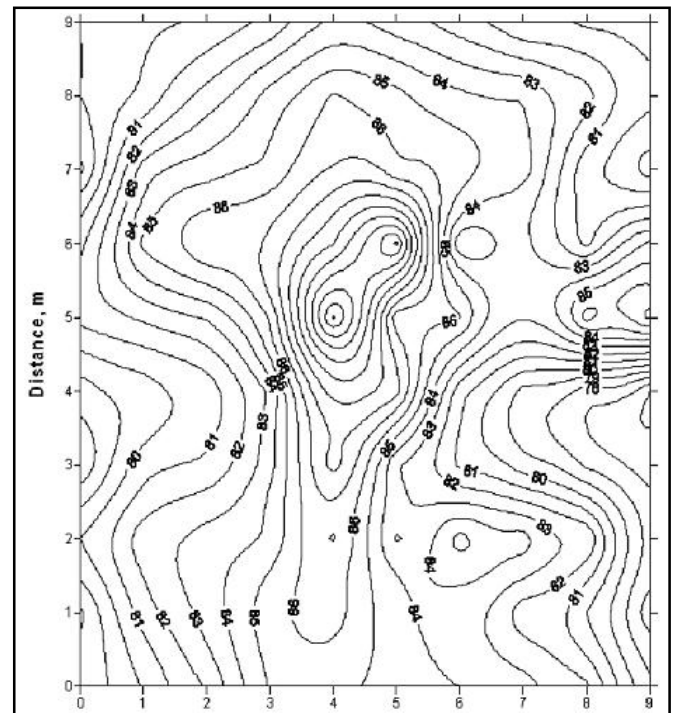


Fig. 4 : Contour map of sound level of no load condition

**Sound level of machine at load condition for freshly cut bamboo:**

The Table 4 shows data on the sound level of machine for freshly cut bamboo. It is the average of three replications. For fresh bamboo, maximum sound level of machine was 101.0 dB (A) at 1m distances from the machine. Similarly, average minimum sound level was observed 83.65 dB (A). The average sound level of first, second, third and fourth quadrant was to the tune of 89.6, 88.4, 85.9 and 89.1 dBA, respectively. The sound level of machine at one-meter distance was 92.9, 87.5, 86.4 and 91.7 dBA in the first, second, third and fourth quadrant, respectively.

**Sound level of machine at load condition for dry cut bamboo:**

The three replications were taken for measurement of sound level of machine at dry condition of bamboo. The averages of three readings are given in Table 5. In

**Table 4 : Sound level of machine at load condition with freshly cut bamboo**

Quadrant	Average sound levels at grid points					
First	(X, Y)	Y <sub>0</sub>	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>	Y <sub>4</sub>
	X <sub>0</sub>	88.9	91.4	89.4	84.8	85.6
	X <sub>1</sub>	91.9	92.9	88.9	87	86.5
	X <sub>2</sub>	92.9	89.9	89.8	88.3	85.8
	X <sub>3</sub>	96.4	89.2	90.1	89.7	88.1
	X <sub>4</sub>	97.7	90.5	89.6	88.2	87.4
Average sound level of first quadrant = 89.6 dBA						
Second		Y <sub>0</sub>	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>	Y <sub>4</sub>
	X <sub>0</sub> '	89.2	88.2	92.5	94.7	95.9
	X <sub>1</sub> '	88.3	87.5	90.4	89.6	91.8
	X <sub>2</sub> '	87.2	87.2	88.8	88.5	89.9
	X <sub>3</sub> '	86.1	86.1	86.6	86	88.4
	X <sub>4</sub> '	85	85	85	85	86
Average sound level of second quadrant = 88.4 dBA						
Third		Y <sub>0</sub> '	Y <sub>1</sub> '	Y <sub>2</sub> '	Y <sub>3</sub> '	Y <sub>4</sub> '
	X <sub>0</sub> '	92.1	89.1	93.6	95	103.2
	X <sub>1</sub> '	90.7	86.4	89.5	93.2	93.4
	X <sub>2</sub> '	88.4	86.1	88.4	89.7	9.5
	X <sub>3</sub> '	85.7	85	84.8	86.7	88.2
	X <sub>4</sub> '	85.4	84.2	83.7	85.5	89.9
Average sound level of third quadrant = 85.9 dBA						
Fourth		Y <sub>0</sub> '	Y <sub>1</sub> '	Y <sub>2</sub> '	Y <sub>3</sub> '	Y <sub>4</sub> '
	X <sub>0</sub>	101	95.6	91.9	89.9	87.7
	X <sub>1</sub>	93.9	91.7	92.3	88.9	89.1
	X <sub>2</sub>	90.7	88.2	88.7	88.5	87.2
	X <sub>3</sub>	91.7	86.3	87.3	86.4	85.1
	X <sub>4</sub>	85.2	85.7	85.6	84.4	85.4
Average sound level of fourth quadrant = 89.1 dBA						

**Table 5 : Sound level of machine at load condition with dry bamboo**

Quadrant	Average sound levels at grid points					
First	(X, Y)	Y <sub>0</sub>	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>	Y <sub>4</sub>
	X <sub>0</sub>	95.4	96.3	93.6	92.9	91.7
	X <sub>1</sub>	96.6	96.7	95	93.5	92.9
	X <sub>2</sub>	97.3	96.6	95.3	94.4	91.3
	X <sub>3</sub>	97.9	96.7	96.2	95.1	93.9
	X <sub>4</sub>	99.9	96.4	96.4	95.3	93.7
Average sound level of first quadrant = 95.2 dBA						
Second		Y <sub>0</sub>	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>	Y <sub>4</sub>
	X <sub>0</sub> '	97.56	97.33	98.1	100.2	98.6
	X <sub>1</sub> '	96.06	96.66	96.93	97.96	97.4
	X <sub>2</sub> '	94.63	95.06	95.16	96.4	95.5
	X <sub>3</sub> '	93.26	93.31	94.3	94.53	93.6
	X <sub>4</sub> '	91.46	90.6	91.53	92.6	91.6
Average sound level of second quadrant = 95.2 dBA						
Third		Y <sub>0</sub> '	Y <sub>1</sub> '	Y <sub>2</sub> '	Y <sub>3</sub> '	Y <sub>4</sub> '
	X <sub>0</sub> '	105	99.5	100.53	102.3	99.3
	X <sub>1</sub> '	99.46	97.2	99.1	100.1	98.8
	X <sub>2</sub> '	96.43	96.03	97.03	98.4	96.6
	X <sub>3</sub> '	95.66	94.66	95.9	96.72	93.9
	X <sub>4</sub> '	94.06	93.33	93.34	94.7	93.1
Average sound level of third quadrant = 92.7 dBA						
Fourth		Y <sub>0</sub> '	Y <sub>1</sub> '	Y <sub>2</sub> '	Y <sub>3</sub> '	Y <sub>4</sub> '
	X <sub>0</sub>	104.66	100.93	99.5	98.26	96.1
	X <sub>1</sub>	106.3	99.53	97.8	95.4	94.1
	X <sub>2</sub>	98.83	98.66	96.06	94.33	93
	X <sub>3</sub>	95.7	95.46	94.53	92.86	91.9
	X <sub>4</sub>	94.63	93.66	92.56	92.033	89.9
Average sound level of fourth quadrant = 96.3 dBA						

case of dry bamboo maximum sound level of machine at 1.2 m height and 1m distances was observed as 106.3 dB (A). The minimum sound level of machine for dry bamboo was 89.9 dB (A). The average sound level of first, second, third and fourth quadrant was to the tune of 95.2, 95.2, 97.2 and 96.3 dBA, respectively. The sound level of machine at one-meter distance was 96.7, 96.66, 97.2 and 99.53 dBA in the first, second, third and fourth quadrant, respectively.

It is recommended as per IS 12207 (1987) that maximum noise at operators' ear level should not exceed 90 dB (A) for 8 h durations. It is generally conceded that 40 h of exposure per week noises of 90 dB (A) or greater will result in hearing loss. But in case of fresh bamboo the sound level was observed more than permissible limit up to 3 m distance. The sound level of 101.0 dB (A)

operators can hear up to 75 minutes only. Similarly, in dry condition the maximum sound level was observed up to 4 m distance and this exposure is allowable for 42 minutes only. Thus while working with dry bamboo operator can safely work for four hours and in case of fresh bamboo he can work safely for six hours.

The contour map as shown in Fig. 4 reveals the sound distribution pattern around the machine at no load condition. Fig. 5 and Fig. 6 show the sound distribution pattern around the machine at load condition for fresh and dry bamboo, respectively. Sound pressure levels were found maximum around the machine very close to it but it goes on decreasing as distance increases from machine.

#### Energy consumption:

The readings of energy consumption were taken at

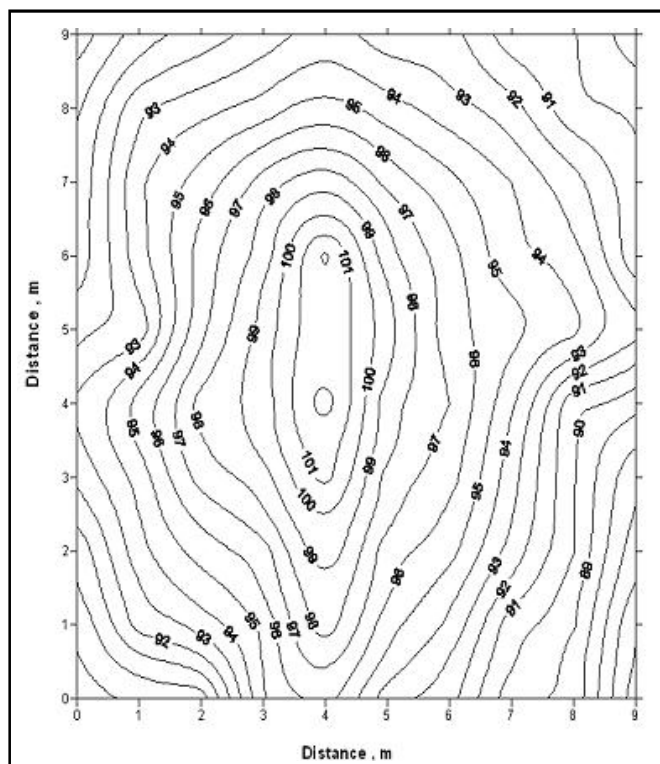


Fig. 5 : Contour map of sound level for fresh bamboo

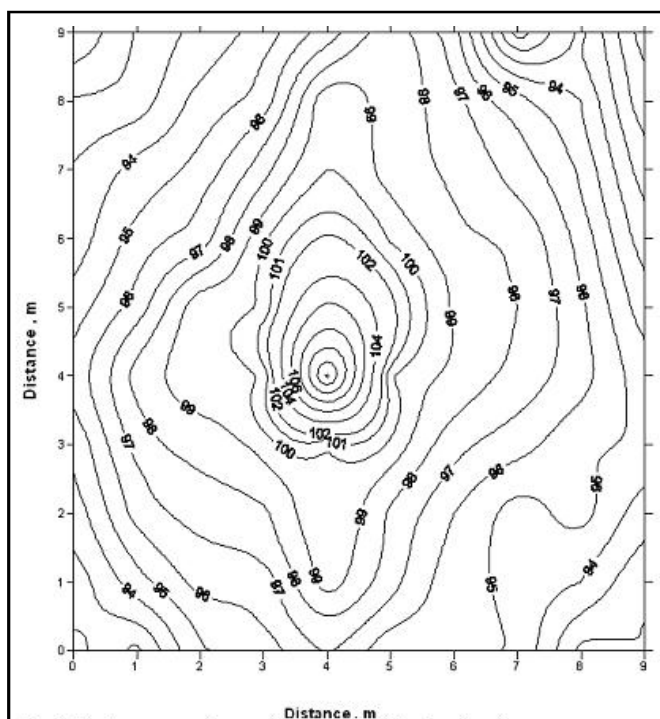


Fig. 6 : Contour map of sound level at load for fresh bamboo

no load condition and at load conditions for fresh as well as dry bamboo. The current and voltage measurements were taken with the help of tong tester and multi meter, respectively.

[Internat. J. agric. Engg., 3 (2) October, 2010]

**Energy consumption at no load condition:**

The data revealed that energy requirement at no load condition was less than the load condition. The Table 6 shows the power required at no load condition was 2.21 kW.

**Table 6 : Energy consumption at no load condition**

Sr. No	Voltage (V)	Current (A)	Power required, kW
1.	380.3	4.0	2.24
2.	376.3	4.2	2.32
3.	380.43	3.86	2.16
4.	388.2	3.9	2.22
5.	390.4	3.7	2.12
Average			2.21

**Energy consumption at load condition:**

The Table 7 shows the data on energy requirement at load condition for freshly cut and dry cut bamboo. Data from Table 7 revealed that the average power required at load condition for freshly cut bamboo and dry bamboo was found to be 3.10 and 2.43 kW, respectively.

Data from Table 7 showed that the average energy consumption for freshly cut bamboo was found to be 1.03 kWh and that for dry cut bamboo it was 0.81 kWh. Thus, at higher moisture content more energy was consumed.

**Table 7 : Energy consumption of machine at freshly cut bamboo**

Sr. No.	Replication	Total time of operation (min)	Power required, kW	
			Freshly cut	dry
1.	First	20	3.22	2.56
			3.16	2.42
			3.08	2.44
2.	Second	20	3.20	2.51
			3.07	2.52
			2.96	2.35
3.	Third	20	3.12	2.36
			3.08	2.43
			3.02	2.33
Average			3.10	2.43
Energy consumed, kWh			1.03	0.81

**Capacity of machine:**

Capacity of the bamboo external knot-removing machine is expressed as number of knots per hour. Table 8 shows the capacity of machine of fresh and dry bamboo. The number of knots removed during each respective replication for freshly cut bamboo was found to be 60, 63

**Table 8 : Capacity of machine for bamboo**

Sr. No.	Replication	Total time of operation (min)	Freshly cut		Dry	
			No. of knots removed	Capacity, knots per hour	No. of knots removed	Capacity, knots per hour
1.	First	20	60	180	64	207
2.	Second	20	63	189	73	221
3.	Third	20	65	195	71	196
	Average		62.67	188	69.33	201

and 65 knots during twenty-minute duration. The capacity of machine for fresh cut bamboo was found to be 188 knots removed per hour.

Data from Table 8 revealed that the number of knots removed for dry cut bamboo were 64, 73 and 71 during each replication of twenty minutes, respectively. Capacity of machine for dry cut bamboo was found to be 201 knots removed per hour. Thus capacity of external knot removing machine was higher for dry bamboo than fresh bamboo. The operating cost of machine was found out to be Rs 33.21 per hour.

### Conclusion:

The result of research work can be clutched in the following conclusion:

- The sound level of machine is more for cutting dry bamboo than fresh bamboo.
- While working with dry bamboo operator can safely work for four hours and in case of fresh bamboo he can work for six hours only.
- The sound level of machine at one-meter distance in no load condition was 84.6 dBA; for freshly cut bamboo was 89.6 dBA and for dry cut bamboo was 97.5 dBA.
- The power required at no load condition is 2.2 kW. Energy consumption at load condition for freshly cut bamboo is 1.03 kWh and for dry cut bamboo is 0.81 kWh.

The capacity of machine is more for dry bamboo than fresh bamboo.

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