Indian Journal of Sugarcane Technology **27(01)**: 11–4, June 2012

Performance of animal operated sugarcane crushers

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ABSTRACT

The performance of animal operated KVIC and ATDA sugarcane crushers was evaluated and compared with traditional sugarcane crushers. The results revealed that the average juice extraction was 6.0-7.1% higher as compared to traditional Kirloskar's Kumar crusher. Juice extraction varied with the cane varieties and was higher for the varieties having lower fibre content. The increase in juice extraction was not significant with recycling of crushed cane as compared to without recycling in KVIC crusher. In ATDA design crusher, the juice extraction increased significantly with 4th roller in comparison to without 4th roller. There was non-significant difference in the juice extraction by the KVIC crusher with recycling and ATDA crusher with 4th roller. However, there was significant increase in juice extraction in ATDA crusher with 4th roller as compared to KVIC crusher without recycling of crushed cane.

Key words: Sugarcane, Crusher, Performance, Juice extraction, Crushing capacity

Sugarcane occupies a prominent place as a cash crop in India. It is cultivated in an area of about 4.83 million hectares, with an annual production of about 355 million tonnes (Anon. 2008). Over 45 million farmers constituting about 7% of the rural population and a large force of agricultural labourers are engaged in sugarcane cultivation in the country (Jain 1999). Out of the total sugarcane production, 27.7% is used by unorganized or semi-organized sector for production of *jaggery* and *khandsari* by cottage based industry which provides employment to over 25 lakh people in rural areas (Alam 2000).

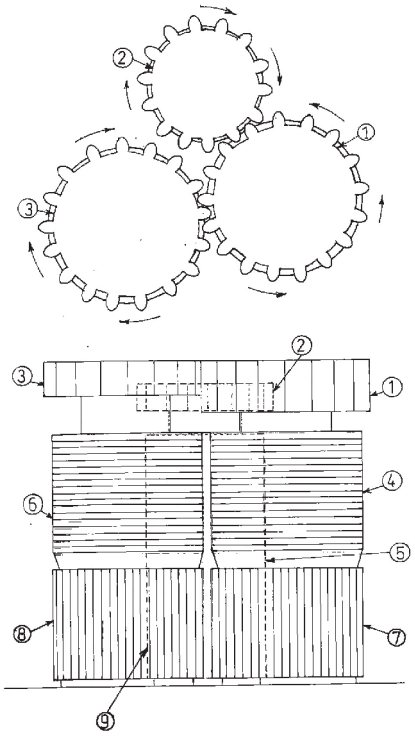
Sugarcane crushers are used for juice extraction by farmers and *jaggery* and *khandsari* industry. However, most of the traditional sugarcane crushers used by the farmers have less juice extraction capacity. Two improved designs of animal operated sugarcane crushers (*Khadi* and Village Industries Commission of India (KVIC) and Appropriate Technology Development Association (ATDA) were procured at Indian Institute of Sugarcane Research (IISR), Lucknow (Singh 1992; Singh 1998). The present study was undertaken to evaluate the performance of these crushers and compare their performance with traditional Kirloskar's Kumar crusher.

MATERIALS AND METHODS

Design details of crushers tested

Two improved sugarcane crushers as given below were procured for evaluation of their performance. Their design details are as follows:

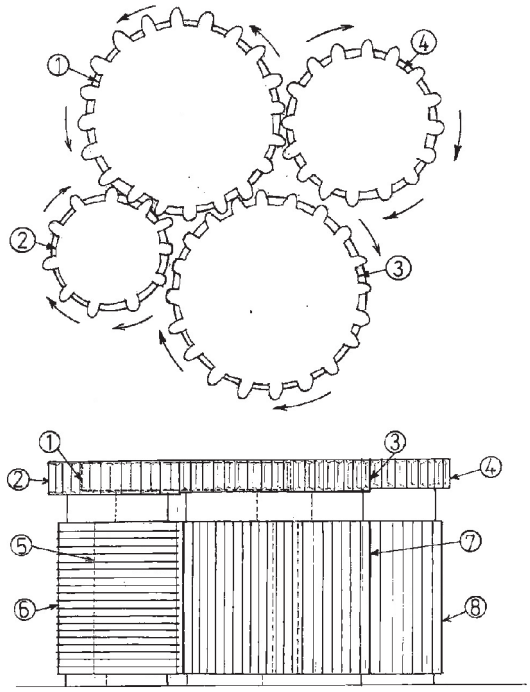
Animal operated KVIC design crusher: It is a three roller vertical crusher provided with a chute for recycling of crushed cane. The engineering drawing (Plan and Elevation) of the crusher is presented in Fig 1.



1. King roller's gear (17 teeth) 2. Crushing roller's gear (14 teeth) 3. Extraction roller's gear (17 teeth) 4. King roller, dia- 225 mm, 19 circumferential V-grooves in upper 200 mm length 5. Crushing roller, dia- 175 mm, 19 circumferential V-grooves in upper 200 mm length 6. Extraction roller, dia- 225 mm, 19 circumferential V-grooves in upper 200 mm length 7. King roller, dia- 225 mm, 43 longitudinal grooves in lower 160 mm length 8. Crushing roller, dia- 175 mm, 43 longitudinal grooves in lower 160 mm length 9. Extraction roller, dia- 225 mm, 43 longitudinal grooves in lower 160 mm length

Figure 1 Engineering drawing (Plan and Elevation) of KVIC Crusher

Animal operated ATDA design crusher: It is a four roller vertical crusher of which the engineering drawing (Plan and Elevation) is presented in Fig. 2.



1. King roller's gear (20 teeth) 2. Crushing roller's gear (11 teeth) 3. 1st Extraction roller's gear (20 teeth) 4. 2nd Extraction roller's gear (16 teeth) 5. King roller, dia- 225 mm, length- 180 mm, 66 longitudinal grooves 6. Crushing roller, dia- 125 mm, length- 180 mm, 23 circumferential V-grooves 7. 1st Extraction roller, dia- 225 mm, length- 180 mm, 66 longitudinal grooves 8. 2nd Extraction roller, dia- 175 mm, length- 180 mm, 66 longitudinal grooves

Figure 2 Engineering drawing (Plan and Elevation) of ATDA Crusher

Methodology

KVIC design crusher was provided with recycling chute. This crusher was tested under both the conditions i.e. with recycling chute (for recycling of crushed cane through the extraction roller) and without recycling chute. The effect of fourth roller in juice extraction by ATDA crusher was tested by increasing the gap between fourth roller (second extraction roller) and king roller. A constant gap of 0.7 mm was maintained between king roller and extraction roller in both the crushers.

Four extensively used *jaggery* making varieties of sugarcane namely 'CoLk 8001', 'CoS 767', 'CoJ 64' and 'Co 1148' were used for evaluating the performance of the crushers. The proximate composition of all the varieties were recorded and presented in Table 1. The fibre content of above varieties was 14.18, 13.28, 12.65 and 12.63%, respectively. Typical composition of total soluble solids (TSS) of cane juice is given in Table 2 (Madan *et al.* 1998). 25 kg of sugarcane was fed manually through the crusher for extraction of juice and the extracted juice was collected in a container. The number of replications was 5 for each treatment of crushing. Methodology used for testing of crushers was as prescribed by Bureau of Indian Standards (IS: 6997-1973). Weight of juice and time taken for crushing was recorded. Juice extraction (percentage of juice extracted on cane weight basis) and cane crushing capacity of crushers were calculated by using following mathematical relationships;

Table 1 Proximate composition of sugarcane varieties tested

Sugarcane variety	Fibre content %	Juice content (%)		
		Total soluble solids (TSS)	Water	Total
'CoLk 8001'	14.18	20.10	65.72	85.82
'CoS 767'	13.28	20.13	66.59	86.72
'CoJ 64'	12.65	20.28	67.07	87.35
'Co 1148'	12.63	20.08	67.29	87.37

Table 2 Typical composition of total soluble solids (TSS) of cane juice

Sugar	
Sucrose, %	70-88
Glucose, %	2-4
Fructose, %	2-4%
Salts	
Inorganic, %	3.0-4.5
Organic, %	1.5-4.5
Organic acid	
Carboxylic acids, %	1.1-3.0
Amino acids, %	0.5-2.5
Other organic non-sugars	
Protein, %	0.5-0.6
Starch, %	0.001-0.050
Gums, %	0.3-0.6
Waxes, fats, phosphotides, %	0.05-0.15
Others	3-5

Juice extraction % = W_2*100/W_1

Cane crushing capacity of crusher kg/h = W_1*60/t

Where,

W_1 = Weight of cane crushed (kg); W_2 = Weight of juice extracted (kg); t = Time taken in crushing of cane (min)

RESULTS AND DISCUSSION

Performance of crushers

The average juice extraction of KVIC (with recycling) and ATDA (with 4th roller) crushers was 64.2 and 65.3%, respectively (Table 3). The average juice extraction cane was 58.2% in traditional Kirloskar's Kumar crusher. The increase in juice extraction was 6.0 and 7.1%, respectively in KVIC and ATDA crusher as compared to traditional crushers.

Table 3 Test results of KVIC and ATDA crushers

Variety	Juice extraction, %				Cane crushing capacity, kg/h			
	KVIC crusher		ATDA crusher		KVIC crusher		ATDA crusher	
	With recycling	Without recycling	With 4th roller	Without 4th roller	With recycling	Without recycling	With 4th roller	Without 4th roller
'CoLk 8001'	63.6	63.2	63.2	60.4	86.7	107.1	107.1	121.0
'CoS 767'	62.0	60.0	64.0	61.6	73.5	126.1	111.9	116.3
'CoJ 64'	64.0	63.2	64.8	63.6	101.1	111.1	98.0	111.9
'Co 1148'	67. 2	66.4	69.2	68.4	80.6	88.2	78.1	86.7
Mean	64.2	63.2	65.3	63.5	85.5	108.1	98.8	109.0
C.V. %	0.72	1.01	1.30	1.22	4.75	6.55	4.19	5.71
S.E.	0.206	0.286	0.381	0.347	1.814	3.166	1.851	2.782
C.D. (P=0.05)	0.634	0.881	1.175	1.069	5.590	9.755	5.703	8.572

Table 4 Effect of recycling of crushed cane in KVIC and 4th roller in ATDA crusher (Variety: 'CoJ 64')

Particular	Juice extraction, %						
	R1	R2	R3	R4	R5	Mean	Difference
KVIC crusher with recycling of crushed cane	64.1	64.1	62.6	63.8	65.4	64.0	-
KVIC crusher without recycling of crushed cane	63.2	63.5	62.1	62.8	64.4	63.2	0.8
ATDA crusher with 4th roller	64.7	64.4	64.5	65.0	65.4	64.8	1.6*
ATDA crusher without 4th roller	63.6	64.0	63.3	63.4	63.7	63.6	1.2*
C.D. (P=0.05)						0.83	

Effect of variety

The maximum juice extraction of 67.2% was observed in case of variety 'Co 1148' followed by 'CoJ 64' (64.0%), 'CoLk 8001' (63.6%) and 'CoS 767' (62.0%) by KVIC crusher with recycling of crushed cane (Table 3). In case of ATDA crusher with 4th roller, the maximum juice extraction occurred for variety 'Co 1148' (69.2%) followed by 'CoJ 64' (64.8%), 'CoS 767' (64.0%) and 'CoLk 8001' (63.2%). The fibre content (Table 1) of 'Co 1148' was minimum (12.63%) followed by 'CoJ 64' (12.65%), 'CoS 767' (13.28%) and 'CoLk 8001' (14.18%) indicating that the juice extraction was the highest for the variety having lowest fibre content. It may be due to availability of more juice on cane weight basis and increased extraction of juice, at applied compressive pressure by the rollers.

Effect of recycling in KVIC and 4th roller in ATDA crusher

In order to study the effect of recycling of crushed cane in KVIC and 4th roller in ATDA crusher, the performance data of KVIC crusher (with recycling and without recycling) and ATDA crusher (with 4th and without 4th roller) were statistically analyzed for the variety 'CoJ 64' and presented in Table 4. The average juice extraction was 64.0% with recycling of crushed cane as against 63.2% without recycling. However, the increase in juice recovery was not significant due to recycling. Non-significant increase in the juice extraction with recycling of crushed cane may be due to re-absorption of extracted juice (of the first cycle crushed cane) by the recycled bagasse. It is also evident from the data in Table 4 that the average juice extraction of 64.8% with the fourth roller was significant than that without the fourth roller (63.6%), which may be due to two stage extraction consecutively without giving much time for re-absorption of extracted juice (of the first stage crushing) by the bagasse. On comparing the KVIC crusher with recycling and ATDA crusher with 4th roller, it was found that there was non-significant difference in the juice extraction. However, there was significant increase in juice extraction (1.6%) in ATDA crusher with 4th roller as compared to KVIC crusher without recycling of crushed cane (Table 4).

The average cane crushing capacity was 88.0 and 108.1 kg/h with recycling and without recycling, respectively in KVIC crusher (Table 3). Hence, the cane crushing capacity decreased by 18.6% with recycling of crushed cane in KVIC crusher. In case of ATDA crusher, the crushing capacity was 98.8 and 109.0 kg/h with 4th and without 4th roller, respectively. Thus, there was a reduction of 9.4% in the cane crushing capacity in case of 4th roller. Reduction in the cane crushing capacity with recycling in KVIC crusher and with 4th roller in ATDA crusher was due to increased power requirement for cane crushing thereby reducing the speed of animals for operating the crushers.

REFERENCES

Anon. 2008. Statement showing figures of area under sugarcane, yield of sugarcane, production of sugarcane, number of factories, working capacity, cane crushed, recovery, sugar production,

duration and molasses production from 1930-31 to 2006-07. *Indian Sugar* **58**(2): 70-1.

Jain S L. 1999. Indian sugar economy – Problems and prospects. *Indian Sugar* **49**(4): 235-54.

Anon. 2008. Utilization of Sugarcane for Production of Sugar, *Gur* and *Khandsari* in important states. *Cooperative Sugar* **40**(1): 106.

Alam A. 2000. Industrial and policy issues including export potential of *jaggery* and *khandsari*. In: National Seminar on Status, Problems and Prospects of *Jaggery* and *Khandsari* Industry in India, Indian Institute of Sugarcane Research, Lucknow on Dec 2-3, 2000.

Singh A K. 1992. Report on Subject Matter Training, Division of Agricultural Engineering. Indian Institute of Sugarcane Research, Lucknow.

Singh J. 1998. Jaggery and Khandsari Research Digest. IISR (JK-Cell)/Tech. Bull./98-39, IISR Lucknow.

Anon. 1973. Indian Standard Test Code for Sugarcane Crushers. IS:6997-1973, Bureau of Indian Standards, New Delhi.

Roy S C. 1951. Results of Crushing Tests of Bullock Power Cane Crushers. Monograph on the *gur* industry of India. Indian Institute of Sugar Technology, 1951, pp 270-271.

Madan V K, Misra S R, Soni N and Solomon S. 1998. Manual for Sugar Analysis. Technical Bulletin No 36, IISR Lucknow.