SHORT, NON-REFEREED PAPER

AN INVESTIGATION INTO SUGARCANE VEHICLE LOADING EFFICIENCY AND ACCURACY

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Abstract

The sugarcane transfer system comprises sugarcane being moved, loaded, transloaded and off-loaded, which amounts to more than 25% of the total production cost of sugarcane, hence small adjustments can have significant economic benefits. The sugarcane loading operation has been identified as an inefficient and costly component as a consequence of poor management and the under-utilisation of equipment, making it a viable leverage point for improvement. This study evaluated consignment characteristics and investigated current loading operations in an attempt to generate best management guidelines. It was directed towards the handling of whole-stick loose sugarcane, which is loaded with grab-loaders. The data collected comprised photographs of sugarcane consignments, along with the payload. These photographs were examined to identify the factors that need to be considered during the loading operation. These factors include cane bulk density, the degree of cane alignment and the design characteristics of the vehicle. Cane bulk density was calculated by dividing the payload by an estimated volume attained from photographs. Two trans-loading sites were selected and video clips of loading operations were captured to assess typical loading practices. Factors such as the manner in which the sugarcane is presented, as well as the techniques adopted for loading, were evaluated. The results attained were utilised to generate practical recommendations for the improvement of the loading operation.

Keywords: sugarcane loading, grab-loader, guidelines, payload, transport

Introduction

There is room for improvement in the loading component within the sugar industry (Meyer, 2005a,b) (Benningfield, pers. comm.[1]; Phillips, pers. comm.[2]). Steward and Fischer (1983) reported that the insufficient training and supervision of the loader operators result in inaccurate loading and hence high production costs. Overloading of sugarcane vehicles results in road and tyre damage, increased maintenance costs and fines, and can compromise safety, i.e. overloaded vehicles are more prone to accidents (Cole *et al.,* 2006; Lagrange *et al.,* 2008; Giles *et al.,* 2009). Significant economic losses and increased productions costs are incurred when additional trips result due to under-loaded consignments (Cole *et al.,* 2006; Lagrange *et al.,* 2008). Training may aid in sensitising the operator to estimate cane bulk density (ρ_b) and hence load more accurately (Lagrange *et*

[1]T Benningfield, Bell Equipment, South Africa, 3 February 2010.
[2]B Phillips, Bell Equipment, South Africa, 3 February 2010.

al., 2008; Giles, 2009; Giles *et al.,* 2009; Bezuidenhout, 2010). This short paper reports on the creation of a set of guidelines and standards for loading of sugarcane vehicles.

Materials and Methods

The Sezela mill, located on the KwaZulu-Natal south coast, was selected for this study, which has a transport system cost of R58 million (Giles *et al.,* 2005). The data collected comprised photographs of consignments, along with the sugarcane payload (γ) and vehicle design payload (γ') from the weighbridge database. Sugarcane vehicles entering the mill were stopped before off-loading and a high resolution digital camera was used to capture the entire length of the consignment. Information in terms of the vehicle types, cane bulk density and cane distribution profile of the consignments were extracted from the photographs. Video footage was recorded of loading operations with grab-loaders into Hilo-spiller trailers at transloading zones. The camera was disguised, to ensure that a true reflection of the loading operation was obtained. This footage was then analysed to determine different operations and to ascertain possible causes for the differences in loading accuracies.

The surface area demarcating the entire sugarcane load within each trailer was calculated from the photographs and an approximate volume (v) of sugarcane for each consignment was then estimated by multiplying the surface area with the trailer width. The cane bulk density (ρ_b) was then calculated by dividing γ by v. The vehicle design density (ρ_b') was calculated following a similar approach (γ'/v').

The efficiency of the spilling was assessed visually resulting in a qualitative rating system. A score between 1 and 5 was allocated, with score 1 corresponding to approximately five sticks remaining in the trailer after off-loading, while score 5 was allocated to a trailer having a significant amount of sugarcane left over. The photographs of loaded consignments were also assessed in an attempt to predict the efficiency of off-loading through the allocation of a discharge rating, per trailer. The rating served as an indicator of the ease of off-loading, and there was also a rating between 1 and 5 which was allocated by assessing the angle at which the majority of cane within the trailer was orientated along with the degree of overhanging.

Results and Discussion

The results attained from t-tests, for both ρ_b and ρ_b' are reflected in Table 1. These values differed highly significantly between the interlink and rigid drawbar type vehicles (p = 0.007 and p = 0.001 respectively). Cane bulk density (ρ_b) in vehicles with frames also differed significantly from vehicles with bolsters (p = 0.002), although ρ_b' did not differ between these vehicles. Sugarcane packs differently on frame trailers compared to bolster type, even though these trailer types are designed for similar densities. The sugarcane appears to be more confined on frame type trailers, and it would seem that designers of this type of trailer did not consider actual cane bulk density, as there is generally an over-estimation of ρ_b' within the designs (Bezuidenhout, 2010).

Table 1. Mean cane bulk density and mean design bulk density (kg/m^3) for different vehicle types.

Vehicle or trailer type	$\bar{\rho}_b$	$\bar{\rho}_b'$	% difference
Interlink	313.12	349.73	10.47
Rigid drawbar	335.70	374.01	10.24
Bolster	323.06	352.22	8.28
Frame	303.38	353.66	14.22

Table 2 summarises how often the actual cleaning score coincided with the predicted discharge scoring. A perfect prediction would imply that only cells along the diagonal would have non-zero values. The colour intensity coincides with higher values. A relatively good predication was achieved even though the author was inexperienced in this field.

Table 2. Comparison between the discharge and cleaning rating for each trailer.

Trailer 1	Discharge					Trailer 2	Discharge				
Cleaning	1	2	3	4	5	Cleaning	1	2	3	4	5
1	7	5	2	1	2	1	3	4	2	1	1
2	12	19	16	8	7	2	7	16	19	6	14
3	8	9	9	3	10	3	1	9	9	5	5
4	1	1	1	3	3	4	5	5	4	1	7
5	0	0	2	1	3	5	0	0	2	0	2

The results were used to establish guidelines for whole-stick loose sugarcane, grab-loader, on-zone loading operations. A DVD demonstrating these guidelines is currently being produced for distribution throughout the South African sugar industry. These guidelines are relatively simple; however, more research is required with respect to sugarcane varieties and other on-zone dynamics.

REFERENCES

Bezuidenhout CN (2010). Beneficial loading configurations to increase sugarcane haulage vehicle performance. *Int Sug J* 112(1342): 569-573.

Cole AK, Baier T and Lyne PWL (2006). Performance of an on-board weighing system on a sugarcane vehicle. *Proc S Afr Sug Technol Ass* 80: 86-99.

Giles RC, Downing EW and Lyne PWL (2009). Payload distribution in the light of the sugar industry's decision to self-regulate. *Int Sug J* 82: 107-117.

Giles RC (2009). Simulation study of cane transport system improvements in the Sezela mill area. MSc Eng. Thesis, School of Bioresources Engineering and Environmental Hydrology, University of Natal Pietermaritzburg, South Africa.

Giles RC, Bezuidenhout CN and Lyne PWL (2005). A simulation study on cane transport system improvements in the Sezela mill area. *Proc S Afr Sug Technol Ass* 79: 402-408.

Lagrange LF, Pletts TR, Bezuidenhout CN and Lyne PWL (2008). The feasibility of automatic on-board weighing systems in the South African sugarcane transport industry. *Proc S Afr Sug Technol Ass* 81: 439-444.

Meyer E (2005a). Cane transport costs and benchmarking. South African Sugar Technologists' Association Transport Workshop held 20 September 2005.

Meyer E (2005b). Sugarcane road transport: The challenges ahead. *S Afr Sug J* 89(2): 4-6.

Steward EAW and Fischer WB (1983). Operation clean cane. *Proc S Afr Sug Technol Ass* 18: 8-9.