Development of a Single Drum Chopper Concept for a Sugarcane Harvester

Thesis submitted by

Matthew Gavin Barnes

Bachelor of Engineering (Mechanical) with Honours
James Cook University, Townsville

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James Cook University

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Matthew Gavin Barnes

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Abstract

A global push towards renewable energy has seen the birth of cogeneration in Australian sugar mills. To maximise the amount of energy extracted from the material, whole crop harvesting has been introduced, where a higher proportion of total biomass is sent to the mill. The adverse affect of this is a significant reduction in bulk density of the harvested material. Transport costs to harvester owners and millers significantly increase as bin weights are reduced, and therefore there is a case for developing a harvester chopper system which maintains bin weight as the amount of trash sent to the mill increases. The single knife slicing of sugarcane stalks against a stationary anvil was investigated in this study and from the findings a single drum chopper system was developed. An explicit finite element model of the proposed concept was constructed for assessment of billet trajectories through the system. Positive results from these models gave confidence for the construction of a prototype for experimental assessment of the performance of the system. Cane and juice losses and billet quality were measured for a range of operational conditions which included varying the chopper drum speed, pour rate and chopper drum geometry. The cutting process was captured by high speed photography for analysis into the causes of damage and losses. Speeding up the chopper drum and therefore shortening the billet length proved to have the most detrimental effect on system performance, where a reduction in the target billet length from 200 mm to 100 mm resulted in over three times the overall losses. An increase in pour rate did not have a significant effect on losses or billet quality. The high speed footage provided invaluable insight into the behaviour of the stalks as they were cut by the single drum system. For the set of trial conditions most closely representing those previously done with differential choppers, the single drum system produced similar efficiency results. However, the advantages of this system are most prominent in whole crop harvesting where shorter billets are required to maintain bin weights.

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Symbols

D_{geom}	Drum inner curve geometry
D_{roller}	Feed roller diameter
E	Young's modulus of elasticity
K_f	Knife condition
K_s	Knife speed
L_{billet}	Billet length
$M_{damaged}$	Mass of damaged billets
M_{in}	Initial mass of specimen / test sample
$M_{mutilated}$	Mass of mutilated billets
M_{sound}	Mass of sound billets
M_{out}	Final mass of specimen
N	Number of stalks cut
N_{drum}	Chopper drum rotational speed
N_{roller}	Feed roller rotational speed
N_s	Number of tests
PR	Pour rate
R	Number of repeats
V	Cane variety
X_{drum}	Number of arms / knives on the drum
k	Number of levels
n	Number of factors
v	Poisson's ratio
θ	Anvil angle
$\theta_{knifewidth}$	Angle of chopper knife arc
ρ	Density