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FINAL REPORT
SRDC PROJECT BS65S
OPTIMISING CANE HARVESTER EXTRACTOR PERFORMANCE

by

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SD96004

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1. SUMMARY

The three year project to optimise cane harvester extractor performance was directed into three separate areas:

- evaluation of existing commercial or semi-commercial cleaning systems;
- development of an extractor hood design with improved aerodynamic properties; and
- refinement of the design of the extractor chamber to improve cleaning performance.

Initial testing of the Alfarm Mizzi harvester fitted with a pre-cleaning chamber to extend the length of the path for cleaning by the primary extractor proved inconclusive, due to mechanical problems with the test harvester. However, it was observed that the pre-cleaning chamber was ineffective at high feed rates and this problem has been partially addressed in the latest Joe Mizzi harvester by increasing the height of the chamber.

Preliminary testing confirmed that cleaning performance of a vertical arm extractor was superior to a cross-arm mounted extractor and efficiency was affected by factors such as the deflector plate angle and blade tip clearance.

The development of a prototype ‘lobster’ shaped steel hood showed that air velocities in the extractor chamber were increased by widening the cross-section of the hood towards the outlet and providing a more streamlined shape. A prototype moulded polyethylene hood was developed from the ‘lobster’ hood to facilitate manufacture of the tapered and smoothed shape. After refinement of the plastic hood in a further steel prototype a final plastic hood mould was constructed with the extractor fan mounted on a vertical shaft supported by external steel legs. This hood is mounted on an extended steel barrel.

Detailed testing of a range of extractor chamber configurations and inlet vent positions was carried out with results showing the following: improved cleaning and reduced cane loss with an additional rear vent directing air against the flow of cane from the chopper; similar improvements by introducing additional air into the bottom of the cleaning chamber by widening the base of the air inlet cone. It was noted that there needed to be a balance between the different locations for introducing air into the chamber to optimise separation of cane and leaf and trash without causing excessive cane loss.

The final cleaning system developed incorporated the plastic hood with extended steel barrel, additional air vent in the rear of the extractor chamber and a widened base on the air inlet cone. Field testing confirmed that this system gave superior cleaning and reduced cane loss compared to a standard steel hood with vertical arm extractor. It is recommended that the plastic hood, extended steel barrel and vertical extractor with support legs be developed as a retrofit option for pre-1996 Austoft 7000 harvesters. Commercial use is considered to be limited to wheeled harvesters due to the excessive height of the extended barrel system on low loaders. There is also the option of developing a suitable folding system to lower the height for transport.

2. BACKGROUND

Previous BSES trials showed losses of cane through harvester extractors in the range 4-10% for burnt cane and 6-16% for green cane, depending on variety and crop condition. Trials with varying rates of throughput showed that extraneous matter levels increased as harvester pour rates increased. The restriction of harvester pour rates in order to obtain satisfactory cleaning, and the high cane loss with particular varieties when harvesting green, were an important limitation to more widespread adoption of green cane harvesting.

Tests on machines modified for green cane harvesting (Project BS19S) showed that cleaning could be improved and cane losses decreased by suitable design refinements (Ridge and Dick, 1989). These included mounting the extractor on a vertical arm to remove restrictions from the extractor chamber, correct placement of the extractor in relation to the flow of cane from the chopper, and modifications to the design of the extractor chamber to aid separation of extraneous matter and cane billets. Research also suggested that the extractor needs to be adjustable for different crop conditions in order to minimise losses in thin stalked varieties. The current project aimed to follow up this preliminary work to develop a more efficient primary cleaning extractor. Partners in the project were BSES, University of South Queensland and Austoft Industries to provide both a theoretical and a practical input to the project.

3. OBJECTIVES

- To evaluate design options for improving separation of cane from extraneous matter in the primary cleaning chamber.
- To develop and test a vertically mounted extractor which should provide efficient cleaning and minimise cane loss.
- To develop variable speed or other controls which could be adjusted in the field in response to particular crop conditions.
- To disseminate information derived from the project to the industry via publication and extension programs to enable existing harvesters to be modified.

4. METHODOLOGY

4.1 Preliminary evaluation of existing cleaning systems

During the 1991 season an Alfarm Mizzi harvester was transported to Bundaberg and the cleaning system evaluated using the BSES test facility, high speed video photography and air velocity measurements. This system was compared to an Austoft 7000 cleaning system. Both field and test facility comparisons of a standard Austoft 7000 cross-arm mounted primary extractor and a Greaves vertical arm primary extractor were also carried out. Trials included comparisons at two or more extractor speeds in order to study the relationship between air velocity, cane losses and extraneous matter levels. Air velocity profiles and swirl within the primary extractor chamber were recorded for the standard Austoft 7000 system. In addition limited testing was carried out to determine the effect of extractor blade tip clearance and deflector plate settings on cane loss and extraneous matter levels.

These comparisons between existing cleaning systems were designed to partially complete objective 1 on the project.

4.2 Redesign of the primary extractor hood

4.2.1 Preliminary steel prototype evaluation

Following detailed testing of air flow velocities and direction within a standard extractor chamber, a new extractor hood was designed using aerodynamic principles to minimise pressure drop at the outlet and improve uniformity of air velocities within the cleaning chamber. The prototype extractor shroud was constructed in steel by Austoft Industries and tested in three configurations:

- with the standard cross-arm fan mounting
- with the fan mounted at 30° to the horizontal on three struts, and
- with the fan at 30° on a single cross-arm with a trash wiping roller below the cross-arm

The cleaning fan and motor were inverted on both angled mounts. The initial configuration with standard cross arm mounting is shown in Figure 1. To facilitate testing with a range of fan speeds a variable flow pump was fitted to the BSES harvester. Bench testing of cleaning efficiency of the new hood and detailed measurement of air velocity profiles across the cleaning chamber were carried out. The BSES test facility at Bundaberg with feed conveyor and sorting equipment was used for the cleaning efficiency tests.

Air velocities in the cleaning chamber were measured using a standard grid of pitot tubes and successive velocity readings were used to assess turbulence in the cleaning chamber.

4.2.2 Prototype plastic hood

After testing of the steel prototype a two piece unit was designed consisting of a steel base with a 20° angled fan mounting and a plastic outlet shroud. The steel base allowed fitting of a replaceable wear liner and in the plastic hood the internal radius was increased to minimise problems with billet rejection by the angled fan. Longitudinal sections for the plastic mould were laser-cut in Brisbane and assembled by Complas Industries in Bundaberg. Three plastic mouldings of the hood design in polypropylene and two grades of polyethylene, respectively, were carried out by Complas for testing of performance and durability. The initial plastic hood mounting is illustrated in Figure 2.

Both bench testing and field testing of cleaning efficiency for the new hood and base was carried out, together with detailed air velocity measurements.

The steel base was initially designed with the extractor mounted on an angle and was subsequently modified to mount the extractor horizontally. It was then necessary to fit a steel outlet guide to the plastic hood to direct trash onto the ground.

4.2.3 Final steel prototype

A final steel prototype was designed by BSES and constructed by Austoft to improve directional control of the trash. This was tested in the field for cleaning performance, cane loss and direction of trash away from the cane transporters. The steel prototype hood is illustrated in Figure 3.

4.2.4 Final plastic hood

After testing of the steel prototype the design was modified to improve directional control of trash and it was decided to replace the cross-arm fan mounting with a vertical arm extractor. Components for a new steel mould were laser cut by Austoft and assembled by Complas Industries. Three plastic shrouds were subsequently moulded in different grades of polyethylene for field testing. A standard long barrel base from Austoft was modified for external mounting of a frame to support the vertical arm extractor. The external frame was manufactured to standard specifications for plastic hoods by Austoft and modified to fit the BSES plastic hood. The final plastic hood with modified chamber and rear vent is shown in Figure 4. Field tests were carried out comparing cleaning efficiency of the 1 200 mm diameter BSES hood with standard 1 200 mm vertical arm steel hoods and two 1 300 mm diameter Austoft prototype systems fitted with plastic hoods and a standard long barrel base.

4.3 Redesign of cleaning chamber air inlet vents

The standard extractor chamber in the Austoft 7000 harvester was compared with a number of modified designs in terms of air velocity profiles, cleaning efficiency and cane loss.

Initially a range of air-inlet vent configurations were tested in a re-constructed straight sided chamber which provided a wider cross-section at the base than the standard chamber (Mark 2 chamber). These are summarised in Figure 5. In addition the effect of the elevator on airflows was assessed by removing the elevator and subsequently fully perforating the elevator boot.

Following from these tests four other chamber designs were evaluated:

Mark 3	With the side of the chamber fully vented and with directional vanes to guide air towards the front of the chamber.
Mark 4	With the bottom of the chamber widened at the back and perforated.
Mark 5	As for Mark 4 but with an additional rear inlet vent.
Mark 6	With the original cone shaped air inlet widened at the base to the mid-point between a straight sided chamber and the standard cone width. This configuration was tested with the additional rear inlet vent. This was considered to be the optimum practical chamber design.

The range of chamber designs is illustrated in Figure 6.

5. RESULTS AND DISCUSSION

5.1 Preliminary evaluation of existing cleaning systems

5.1.1 Alfarm Mizzi evaluation

The comparison of the Alfarm Mizzi cleaning system with a standard Austoft 7000 system was inconclusive due to the poor condition of the Alfarm Mizzi harvester. The Alfarm Mizzi has a separation chamber between the chopper and extractor chamber where cane is agitated by four driven rollers and air is drawn through the disturbed mat of material. Visual observations indicated that this chamber was ineffective at commercial cane pour rates as there was insufficient room for separation of cane and extraneous matter prior to the extractor chamber. This feature has been improved in the latest Joe Mizzi harvester which has a larger chamber, and this would be expected to aid cleaning.

It was not possible to test the system fully due to failure of the wiping roller fitted below the cross-arm on the primary extractor and failure of the slewing mechanism on the elevator. This limited the amount of testing possible while the machine was available. Tests with the wiping roller inoperative gave poor cleaning relative to the Austoft 7000 harvester.

5.1.2 Greaves extractor hood

Comparison of the Standard Austoft and Greaves extractor hoods showed reduced cane loss and similar cleaning efficiency with the Greaves hood. This was attributed to the longer barrel in the Greaves hood allowing higher mounting of the fan and more spreading of the cane mat. Comparative results are given in Table 1.

Table 1
Effect of increased fan height employed in the Greaves extractor hood

Extractor	Fan speed rpm	Cane loss %	Extraneous matter (EM) %
Standard Austoft	1 500	16.3*	7.5
Greaves	1 500	12.7*	6.9

* significantly different at 5% level

5.1.3 Blade length evaluation

The effect of extractor blade length on air velocities, cleaning efficiency and cane loss was also evaluated for the standard Austoft 7000 system. Results are summarised in Table 2.

Table 2
Effect of blade length on air flows, cane loss and extraneous matter levels

Blade length	Fan speed rpm	Av velocity m/s	Cane loss %	EM %
Standard	1 200	12.3	6.2	9.4
Short	1 200	6.9	2.6	14.4
Standard	1 500	15.3	16.3	7.5
Short	1 500	9.2	7.1	10.4

These indicate a trade-off between reduced cane and increased extraneous matter levels and only limited opportunity for improving extractor efficiency.

5.1.4 Deflector plate setting

The comparison of high and low deflector plate settings is summarised in Table 3.

Table 3
Comparison of high and low deflector plate settings

Fan speed rpm	Deflector setting	Initial EM %	Final EM %			Cane loss %
			tops	leaf	total	
1 500	Low	13.3	1.9	2.8	4.7	12.1
1 500	High	13.3	1.1	2.0	3.1	13.6

As expected the higher deflector plate setting gave reduced EM levels but higher cane loss.

5.1.5 Airflow uniformity in the standard Austoft 7000 cleaning chamber

The air velocity patterns measured in a standard cleaning chamber are summarised in Figure 7. These indicate a significant variation in average vertical airflow velocities and degree of turbulence according to location in the chamber. Observations during tests with a smoke generator confirmed the existence of turbulence in the chamber and the influence of inlet vent configuration on airflow. Typical airflow patterns are shown in Figure 8. Separated flow occurs close to the inlets, then vertical flow, and close to the fan helical flow.

The non-uniformity of air velocities across the cleaning chamber, and in particular the high velocities towards the front of the chamber, modify the trajectory of cane within the chamber taking it closer to the fan and increasing cane loss.

5.2 Re-design of the primary extractor hood

5.2.1 Preliminary steel prototype evaluation

Initial comparisons between the standard Austoft 7000 extractor hood and the 'lobster' shaped steel prototype hood were carried out with the standard cross-arm fan mounting. Results are summarised in Table 4. Tests were carried out with the variety Q110 which is a relatively high loss variety with high initial EM %.

Table 4
Comparison between standard Austoft 7000 hood and 'lobster' hood prototype

Hood	Fan speed rpm	Initial EM%	Final EM%			Cane loss %
			tops	leaf	total	
Standard	1 500	31.5	7.4	4.2	11.6	17.1
	1 250	31.5	7.7	5.3	13.0	12.5
Lobster	1 400	31.5	4.8	3.0	7.8	22.3
	1 250	31.5	5.8	4.5	10.2	12.7

These results indicate a significant improvement in cane cleaning with the lobster hood but also a significant increase in cane loss at the higher fan speed setting. Average air velocity in the cleaning chamber at 1 100 rpm fan speed increased from 13.1 m/sec to 17.2 m/sec with the most significant increase being at the rear of the chamber.

Following these initial tests the cross-arm fan mounting system was replaced with an angled three strut mounting system. The mounting system for this and later tests on different hoods are indicated in Figure 9. This mounting system was found to be unsatisfactory due to leaf and trash building up on the struts, and while cane loss was markedly reduced extraneous matter levels increased (Table 5).

Table 5
Tests on lobster hood with fan mounted on three struts placed on an angle to the horizontal

Fan mounting	Fan speed rpm	Initial EM%	Final EM%			Cane loss %
			tops	leaf	total	
Standard	1 400	31.5	4.8	3.0	7.8	22.3
	1 250	31.5	5.8	4.5	10.2	12.7
Angled struts	1 400	31.5	4.8	6.2	11.0	8.2
	1 250	31.5	5.2	5.8	11.0	4.8

As a result of the trash collecting on the three strut mounting system it was replaced with a single cross-arm fitted with a wiper roller to prevent leaf and trash buildup. This configuration was tested approximately one month later than previous tests with the three strut mounts, so results are not comparable due to the use of a different cane variety for testing. Never the less, cane loss was lower and extraneous matter levels satisfactory (Table 6).

Table 6
Testing of single cross-arm fan mounting in lobster hood with fan mounted on an angle

Fan speed	Initial EM%	Final EM%			Cane loss %
		tops	leaf	total	
1 400	17.1	2.4	2.4	4.7	12.1
1 250	17.1	2.8	2.8	5.6	7.5
1 100	17.1	2.9	2.9	5.7	3.1

In addition to the above tests a number of trials were carried out with various modifications to the extractor cleaning chamber. These are detailed later in this report.

Several features of this hood were considered unsatisfactory for commercial development. There were considerable difficulties in manufacturing, particularly in achieving acceptable fan blade tip clearances; the design was bulky; and the inside radius of the hood was too small which together with the angled fan caused any lost billets to be thrown a long distance, and danger to operators.

5.2.2 Prototype plastic hood

The prototype plastic hood was completed for testing in September 1993 and a number of trials were carried out with various configurations of the cleaning chamber. These are reported later. The initial comparative tests between the plastic hood and the steel lobster hood are detailed in Table 7. Trials were conducted with the variety CP51-21.

Table 7

Comparison between steel hood with 30° fan mounting and plastic hood with 20° fan mounting

Hood type	Fan speed rpm	Initial EM%	Final EM%			Cane loss %
			tops	leaf	total	
Lobster	1 400	20.2	1.0	1.9	2.9	6.0
Plastic	1 400	19.0	0.8	2.2	3.0	8.7
	1 250	19.0	1.0	4.0	4.9	5.9

The tests at the same fan speed were not statistically different and indicate a similar performance between the two hoods. Despite this there is some suggestion that the lobster hood was performing slightly better in terms of lower cleaning loss and higher cleaning efficiency (leaf removal). This could have been due to the closer fan blade tip clearance in plastic hood and its lower outlet cross-section.

This is reflected in average air velocities across the extractor cleaning chamber of 11.5 and 10.4 m/sec for the lobster and plastic hoods, respectively, when mounted on the same base with the fan at 20° to horizontal. Changing the fan position to horizontal and raising the average fan height increased the air velocity with the plastic hood to 11.6 m/sec and reduced cane loss and extraneous matter levels (Table 8). These tests were conducted with high cane loss material.

Table 8
Effect of fan angle on cane loss and cleaning efficiency

Hood type	Fan angle	Initial EM%	Final EM%	Cane loss %
Lobster	20°	23.2	9.5	16.7
Plastic	0°	24.5	7.8	10.0

The features of a horizontal fan mounting and increased outlet cross-section of the hood were incorporated in the prototype steel hood constructed as a preliminary to developing a new plastic hood mould. Comparative outlet areas of the different hood configurations are given in Table 9. The shape of the hood was also altered to improve direction of leaf and trash onto the ground away from cane transporters. In the initial plastic hood it was necessary to fit a steel guide to direct leaf and trash to the ground.

Table 9
Outlet areas of standard and prototype hoods

Type of outlet	Outlet area (m^2)
Standard	1.16
Lobster	1.81
Plastic	1.22
Revised Plastic	1.54

5.2.3 Final steel prototype

The final steel prototype hood was fitted to the Austoft 7000 test harvester and field tested cutting cane for planting material. Cane loss was assessed by collecting material in the field from a 5 m section of row during normal harvesting. Extraneous matter was determined by sampling the cane delivered into the cane transporters. The prototype was compared with a standard commercial 7000 harvester fitted with a vertical drive extractor. Results are given in Table 10.

It was noted in the field that cleaning was impeded by the cross-arm mounting of the fan and there was a minor problem with direction of leaf and trash back into the bin in windy conditions. These factors were taken into account in re-designing the plastic hood and the shape was altered to give better control of leaf and trash; the cross-arm extractor mounting was replaced by a vertical drive mounted on an external frame.

Table 10
Comparison between prototype steel hood and standard Austoft 7000 with vertical arm

Hood type	Fan speed rpm	EM%	Cane loss t/ha
Standard vertical arm	1 500	1.4	6.0
BSES steel hood	1 500	0.6	7.6
	1 400	1.2	5.4

5.2.4 Final plastic hood

The comparative results between the BSES plastic hood, standard Austoft 7000 vertical arm extractors and two 1 300 mm diameter prototypes are summarised in Table 11. These indicate superior cleaning and reduced cane loss with the BSES hood compared to the standard Austoft 7000. Results are similar for the BSES hood and the 1 300 mm diameter Austoft prototypes.

Table 11
Comparison of BSES plastic hood with standard Austoft vertical arm and two Austoft 1 300 mm diameter fan prototypes

Trial	Harvester	EM%	Trash %	Cane loss t/ha
1	BSES	6.6	3.2	2.1
	Austoft Standard	7.9	3.6	3.2
2	BSES	1.9	-	3.2
	Austoft Standard	3.4	-	6.4
3	BSES	4.6	-	2.9
	Austoft Standard	5.5	-	5.2
Mean	BSES	4.4		2.9
	Austoft Standard	5.6		5.2
4	BSES	8.9	-	0.9
	Austoft Prototype 1	9.4	-	1.3
5	BSES	10.0	5.1	2.8
	Austoft Prototype 2	6.9	3.7	3.6
6	BSES	7.5	3.8	2.6
	Austoft Prototype 3	9.6	4.0	2.8
Mean	BSES	8.8		2.6
	Austoft Prototype	8.6		2.8

The improvement in performance with the plastic hood represents a significant advance in that a significant reduction in cane loss and/or extraneous matter levels can be achieved with a 1 200 mm diameter extractor.

There is a difficulty in achieving widespread adoption of the hood because of the extra height of the hood and barrel. This gives an overall harvester height of 4.56 m compared to 4.18 m for the 1996 Austoft 7000 with extractor motor removed and 4.05 m for the previous standard vertical arm extractor. The overall height limit for road transport is 5.0 m with trailer bed heights ranging from 0.7 to 1 m. This would be a major limitation for full-track harvesters unless a folding system was developed for the new hood to reduce the height.

5.3 Re-design of cleaning chamber air inlet vents

5.3.1 Vent configuration and elevator effects (Mark 2 Chamber)

5.3.1.1 Elevator effects

The effect of the removal of the elevator and perforation of the elevator boot on airflow is summarised in Table 12.

Table 12

Chamber air velocities with standard elevator, fully perforated boot and elevator removed

Elevator boot	Average air velocity m/sec	Uniformity m/sec	Turbulence m/sec
Normal	11.9	2.9	5.2
Removed	16.7	1.4	3.0
Perforated	14.3	2.5	4.0

These measurements indicate a large improvement in flow volume and uniformity and reduced turbulence as more air is introduced through the bottom of the cleaning chamber.

The effect of the additional air flow on cleaning efficiency and cane loss is indicated in Table 13.

Table 13
Effect of perforating the elevator boot on cane loss and cleaning

Elevator boot configuration	Initial EM%	Final EM%	Cane loss %
Perforated	21.9	4.8	12.6
Non-perforated	21.9	4.7	7.0

Perforation of the boot gave no apparent benefit in cleaning but a highly significant increase in cane loss. This is thought to be due to the higher air flow lifting the cane matt without giving greater breakup and cleaning.

5.3.1.2 Inlet vent directional effect

The replacement of the standard inlets with side inlets in the Mark 2 extractor chamber gave a reduction in average chamber velocity from 13.6 m/sec to 12.9 m/sec. Velocities increased in former low velocity areas towards the outside of the chamber resulting in more even flow, and there was a small but significant effect of vent direction on cane loss. This occurred with vents directed to assist the normal swirl pattern in the chamber and with air directed to the front of the chamber. Additional horizontal air flow was thought to have resulted in more breakup of the cane matte at the rear of the chamber, reducing entrainment of leaf and trash. The most effective configurations are given in Table 14.

Table 14
Effect of vent direction of air on cleaning efficiency and cane loss

Trial	Vent configuration	Initial EM%	Final EM%	Cane loss %
1	standard	27.8	7.9	4.9
	swirl assist	27.8	8.3	3.4
2	standard	21.9	4.5	8.8
	swirl assist	21.9	4.7	7.0
3	standard	20.2	2.6	10.1
	air to front	20.2	2.9	6.0

5.3.2 Mark 3 chamber design with mid-vents directed to front

The Mark 3 chamber design gave more air entry at the rear of the chamber and less through the bottom of the chamber due to the change back to a conical shape with lower area at the base. Surprisingly, this configuration reduced cleaning efficiency significantly and increased cane loss by a small but non-significant amount (Table 15).

Table 15
Effect of mid-vents in Mark 3 chamber design
on cleaning efficiency and cane loss

Inlet vents	Initial EM%	Final EM%	Cane loss %
Mark 2 - air to front	19	2.9	8.7
Mark 3	18.4	6.2	10.2

It was concluded that restoring the cone shaped inlet had decreased air entry into the bottom of the chamber and additional air introduction to the middle of the chamber did not give effective cleaning.

5.3.3 Mark 4 chamber design

The Mark 4 vent and chamber design reduced average chamber air velocity from 12.1 to 10.4 m/sec, with the decrease in air velocity being mainly in the rear corners of the chamber. Air flow was also more turbulent and air velocity increased in the rear centre of the chamber. The nett effect on performance was a significant increase in cane loss and a non-significant trend to higher extraneous matter levels. This is indicated in Table 16.

It was felt that this was due to the increased air flow in the rear centre of the chamber where cane flow was closest to the fan.

Table 16
The effect of the Mark 4 chamber design on cleaning efficiency and cane loss

Vent design	Initial EM%	Final EM%	Cane loss %
Mark 3	20.3	7.7	12.1*
Mark 4	20.3	9.5	17.8*

* statistically significant 5%

5.3.4 Mark 5 chamber design

The introduction of additional air to the rear of the chamber in the Mark 5 design had no significant effect on average air velocity across the chamber, but gave a similar concentration of high air velocities in the rear centre of the chamber. The extra vent directing air in from the rear centre of the chamber created additional turbulence at the rear of the chamber and appeared to aid breakup of tangled cane. However, overall cleaning performance and cane loss was not statistically different to the Mark 4 chamber (Table 17) although there was a trend to better cleaning and reduced cane loss.

Table 17
The effect of the Mark 5 chamber design on cleaning efficiency and cane loss

Vent design	Initial EM%	Final EM%	Cane loss %
Mark 4	20.3	8.6	20.0
Mark 5	23.2	9.5	18.0

5.3.5 Mark 6 chamber design

In the Mark 6 chamber design average air velocity increased from 12.0 m/sec (Mark 5) to 14.7 m/sec (Mark 6) at 1 100 rpm. The improvement was spread uniformly across the middle and rear of the chamber increasing the area of flow suitable for separating cane from leaf and trash.

At the same time overall turbulence decreased suggesting cleaner air flow with the wider base of the air inlet cone. This had the effect of reducing extraneous matter levels significantly and producing a non-significant reduction in cane loss (Table 18).

Table 18
Comparison of cleaning and cane loss between Mark 5 and Mark 6 chamber designs

Vent design	Initial EM%	Final EM%	Cane loss %
Mark 5	24.5	7.8*	10.0
Mark 6	25.7	6.2*	7.6

* statistically significant 5%

5.4 Combined effect of plastic hood and modified cleaning chamber

The final plastic hood with vertically mounted extractor drive shaft and a modified cleaning chamber combines the features found to optimise cleaning efficiency with minimal cane loss. These are an increased hood outlet area of 1.54 m^2 compared to 1.16 m^2 for a standard steel hood; improved aerodynamics in the plastic hood; increased height of the extractor fan; a wider cross-section for the cone inlet at the bottom of the cleaning chamber; and an additional air inlet vent at the rear of the cleaning chamber.

The improved performance of the hood and chamber combination compared to the pre-1996 standard cleaning system on the Austoft 7000 is indicated in Table 11. The final design is illustrated in Figure 4.

Airflow velocity at 1 100 rpm approximated that for the prototype plastic hood with Mark 6 chamber design indicating no change in average airflow with a vertical arm extractor but possibly less impediment to separation of leaf and trash from cane.

6. DIFFICULTIES ENCOUNTERED DURING PROJECT

The main difficulty encountered during the project was the change in characteristics of test cane during the season which meant that it was difficult to compare successive harvester modifications accurately in terms of cane loss and extraneous matter levels. Where major modifications were made to the extractor chamber or extractor hood there was often a considerable time lapse between comparative tests and characteristics of test cane changed significantly. This was countered to a certain extent by progressive measurements of the distribution of air velocities across the cleaning chamber, turbulence in the chamber and average air velocities.

In terms of the project objectives commercial developments during the project meant that a variable speed, vertically mounted extractor became standard and it was no longer relevant to develop such a system.

The loss of the project research officer, Frank Pearce, before the completion of the project also created problems in finalising the design of the extractor hood for possible commercial use.

In the final stages of the project it became evident that overall height of the modified cleaning chamber and hood would cause difficulties in the commercial adoption as an improved cleaning system. A folding arrangement for the hood is under investigation to facilitate transport on a low loader without exceeding the maximum allowable height of 5.0 m. This will be most applicable to fulltrack harvesters.

7. RECOMMENDATIONS FOR FURTHER RESEARCH

Further advances in cleaning efficiency are possible with a change in trajectory of cane from the chopper, a longer cleaning path, or if more spreading of cane was possible without the constraint of excess height of the chamber and shroud. These areas may warrant further research.

8. APPLICATION OF RESULTS TO THE INDUSTRY

The major advance in cleaning efficiency obtained in this project was from a combination of: widening the base of the inlet cone at the bottom of the cleaning chamber, providing an additional inlet vent at the rear of the cleaning chamber and using a more aerodynamically streamlined plastic hood and vertical arm extractor.

The rear vent system has been adopted commercially by Austoft in a modified form but not the widening of the air inlet cone. A smooth shaped plastic secondary extractor hood is now used commercially on the Austoft 7000 harvest. This gives improved cleaning by the secondary extractor.

The plastic primary extractor hood with steel base and external mounting frame for the vertical arm is being developed as a package for retrofitting to pre-1996 harvesters. The commercialisation arrangement is not yet finalised but would involve manufacture of the hood by Complas Industries in Bundaberg and marketing through Austoft or a retrofit specialist such as Trail Brothers. Austoft have developed a parts kit for the extended barrel steel base, vertical arm extractor and external support legs.

The 1996 model Austoft 7000 is fitted with a 1 300 mm diameter extractor in place of the 1 200 mm standard extractor and is not suitable for the BSES hood.

9. PUBLICATIONS ARISING

No details of the hood performance have been officially published due to commercial confidentiality prior to taking out a registered design.

10. REFERENCES

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