final report

Project code: A.TEC.0081

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Date submitted: October 2011

PUBLISHED BY
Meat & Livestock Australia Limited
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NORTH SYDNEY NSW 2059

CO2 De-dagging Developments (Stage 1 of 3)

Milestone 2 report

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

Abstract

Dirty cattle within the Australian processing sector can slow down operations, contaminate product, result in the Veterinary Officer refusing dirty cattle to enter the slaughter floor, and increase daily labour costs to engage ‘de-dagging’ staff. Some processing companies engage live cattle de-dagging systems such as cattle yard washing, however this can cause stress within an animal which can lead to the dark cutting of meat. This project is aimed at investigating the commercial and technical viability of using CO2 under pressure to de-dag cattle immediately after the knocking box. Milestone 2 (this report) has proven that technically the concept is viable without damaging the hide. Hence all dags were easily removed. Milestone 3 will investigate possible in-situ designs of a system and take into account noise, waste removal and the safe use of CO2.

Executive summary

Dirty cattle within the Australian processing sector can slow down operations, contaminate product, result in the Veterinary Officer refusing dirty cattle to enter the slaughter floor, and increase daily labour costs to engage 'de-dagging' staff.

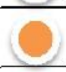
Various Australian processors have commented that dirty cattle costs the Australian industry millions of dollars each year, although this has not been substantiated to date. Although there are various existing methods to de-dag cattle within Australia, none have proven ideal for the wider processing sector. In 2009, the CEO of Teys Brothers, Brad Teys, requested that CO2 blasting be investigated as a potential to provide a cost effective solution to mid and large size processing plants for the removal of dags. In 2010, Meat and Livestock Australia (MLA) and the Australian Meat Processing Corporation (AMPC) approved a project with Scott Technology Australia (Scott) with support from John Hughes to pursue Brad's concept. The approved project was heralded as Stage 1 of a possible three Stage development program.

The aim of Milestone 2 was to address Stage gates 1 and 2 and shed light on gates 3 and 4. Milestone 3 will provide additional input into gates 3 and 4 and add information to gates 5 - 7 inclusive.

Using the following research Stage gate program (refer Figure 1) for CO2 de-dagging developments Scott has to date successfully proven that…

CO2 de-dagging is technical viable and does not damage the hide.

Table 1: Figure 1 colour code legend

Colour Code	Meaning
	All issues addressed
	Some concerns identified however solutions are apparent
	Concerns identified with no immediate rectification identified

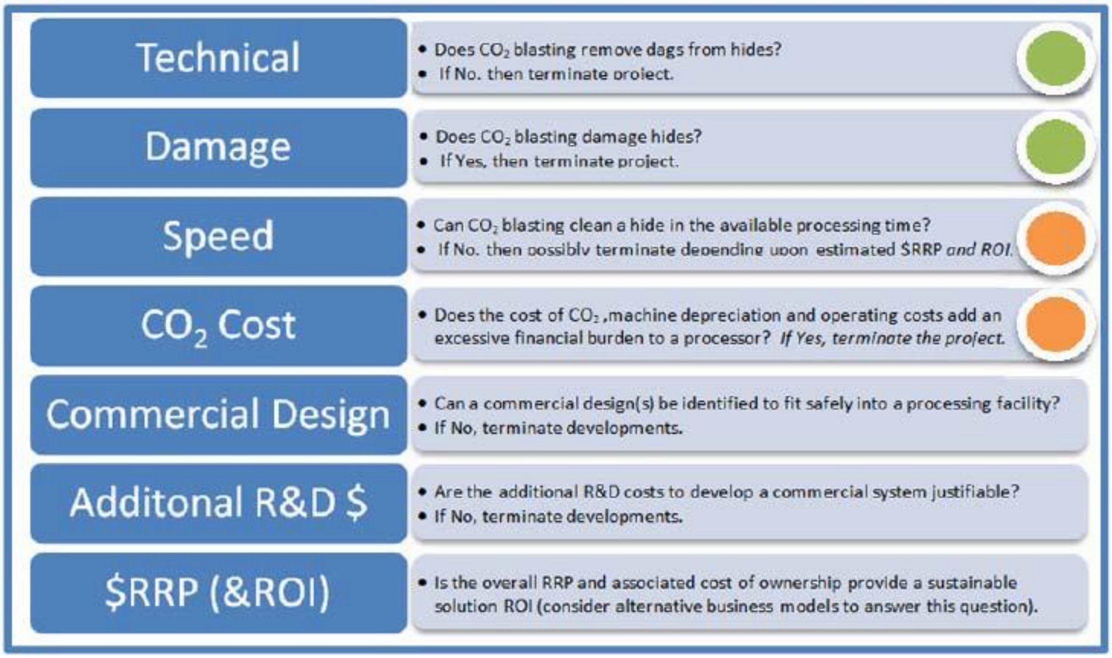


Figure 1: CO_2 De-dagging R&D Stage Gate Design and current knowledge

During the research John Hughes has conceptualised another option for de-dagging, known as the Dag Shear JH-101, that may be applicable for small throughput processing plants and could also provide a failsafe for medium to larger processing companies should CO2 de-dagging not provide to be commercially viable.

Scott will progress to Milestone 3. In addition, Scott recommends to the industry that they invest AUD$23,100 ($7,500 Fees and $15,600 Expenses) in Scott and John Hughes to develop and trial a JH-101 prototype.

Contents

1 Background

1.1 Key strategic issues

There are three key strategic issues driving this project as identified by Food Science Australia[1] and the industry. These strategic issues are as follows.

1.1.1 Cattle processing prohibition

Although Scott's have never personally witnessed the event Scott have been informed by multiple processing enterprises that at particular times of the year when cattle are extremely dirty with dags, AQIS Veterinary Officers will insist that the slaughter floor ceases to operate unless the cattle can be cleaned prior to progressing too far into the slaughter process.

1.1.2 Food Safety

The dag is comprised of a mixture of dirt, feed, hair and faeces. This mixture when introduced into the slaughter facility and cut through and around increases the total amount of contamination within the slaughter process which in turn increase the likelihood of carcase contamination and/or increased trimming.

1.1.3 Slower chain speeds

Manual de-dagging cattle is time consuming and depending upon available labour manning, can result in a need to slow the processing chain down to accommodate the additional requirements to undertake de-dagging steps. As the manual approach requires labour, which comes at an additional cost, the required labour is typically acquired from other more value adding activities.

1.2 Industry consultation

Brad Teys approached John Hughes and requested that CO2 be investigated as a potential solution to addressing the seasonal issues of cattle dag removal.
Approval was provided by Teys for Scott to continue this work with John Hughes and Teys.

1.3 What currently happens and why it needs changing

Currently there are four approaches to handling dirty cattle within the industry:

1. Rockdale beef developed (circa 15 years ago) a proprietary de-dagging system that works on a live animal whilst in the upright position. This solution integrates with Rockdale's feedlot infrastructure.
2. John Dee Warwick in conjunction with Food Science Australia modified a duck plucker (circa 15 years ago) to develop the manual tool depicted in Figures 1 and 2. This system is currently available as a set of drawings from MLA, free of charge, and an indicative price for a system including all required infrastructure is $100,000 not including an operator to use the system.

[1] Food Science Australia, "PRTEC.008 – Automated De-dagger", 16th October 2002.

Figure 2: John Dee manual De-dagger

Figure 3: John Dee manual De-dagger

3. Operators on slaughter floors use a combination of knives, shavers and other trimmers to 'de-dag' the animal on the slaughter floor.
4. Various companies try hot water systems and high pressure systems on live animals whilst retained in the holding yards.

There are concerns, and in some case research evidence, that any live cattle application can result in animal stress which in turn can result in the dark cutting of meat. It is anticipated that this will always be the case when an application to a live animal is pursued whereby the application will likely result in stressing the animal.

In addition to the potential to dark cutting meat, live animal applications has the potential to have a detrimental impact on animal welfare.

1.4 What alternatives have been investigated or are available?

In 2002-03 AMPC and MLA jointly invested in Food Science Australia and Industrial Research Limited to automate the John Dee Warwick manual tool. The justification for this approach was to remove the cost of the required operator(s) from the de-dagging task.

The project was terminated prior to conclusion.

1.5 Current experimental and investigation work

At Feedlot

MLA is working on the development of alternative processing procedures for daggy cattle. The approach is considering using an enzyme treatment for daggy cattle that allows them to be presented clean for slaughter[2].

On Processing Floor

[2] Meat and Livestock Australia, "MLA Feedlot Program - Livestock Production Research & Development Strategic Plan 2006-2011

John Hughes and Teys have prior to Christmas 2009 trialed the unit depicted in Figure 3. Although at the time of trialing, dagged cattle could not be located, John was able to demonstrate that the CO2 approach removed hair effectively from the hide. An extrapolation from this is that if the system can remove hair, then is should be able to remove the hair with dags attached.

Figure 4: ColdJet CO_2 blaster

1.6 Estimated cost before and after on the impact to the processor

Scott has been unable to find documented evidence of the cost of dags to the industry, however unsubstantiated comments from various processing companies seem to indicate that it could be in the order of millions each year.

1.7 Footprint required within plant for installation

As depicted in Figure 5, it is anticipated at this Stage that the processing line footprint for the automated CO2 solution will acquire an additional 500mm along the chain than the largest carcase it is design for and 1,000 mm additional depth (tangential to the chain) for the largest carcase the solution is designed for.

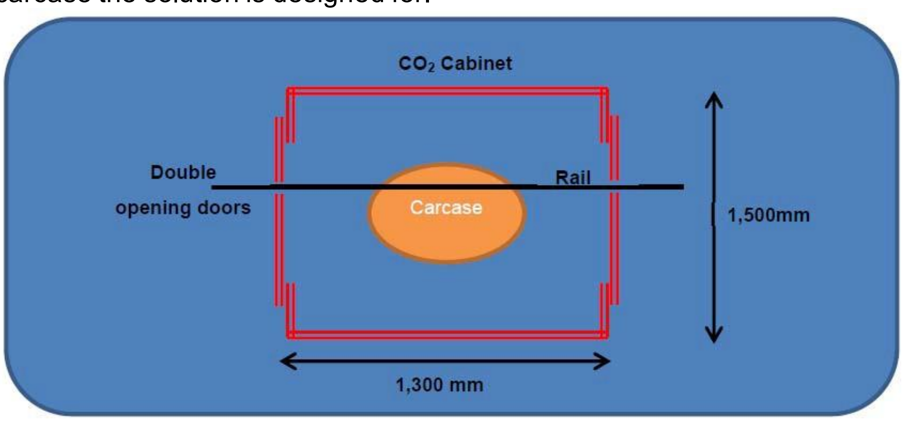


Figure 5: Indicative CO_2 system installed in a processing plant (carcase is 800 mm wide and 500 mm deep)

1.8 Where to go next after this project

Stage 1 aim is to investigate various ways to apply the CO2 blasting concept to the issue of de-dagging and develop a report and various videos and photos of the system in operation with before and after hide examples. These experiments, undertaken predominantly by John Hughes and Scott will enable Scott to develop a cost benefit analysis and develop the concept of a fully automated, self-contained, slaughter floor system with all the required safety issues (noise and CO2 evacuation and alarming systems) when dealing with such a blasting system.

2 Introduction

The key aspects of success for the application of CO2 to de-dagging is depicted in the flowchart in Figure 6. This is the Stage Gate process that Scott is following to both guide the research approach and make key research and financial decisions along the development curve.

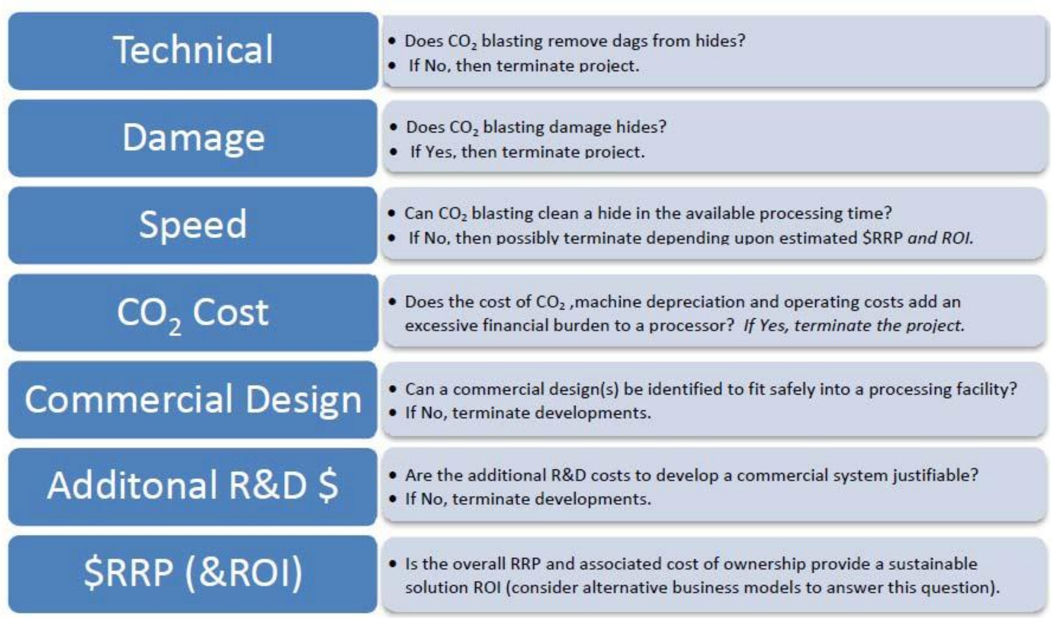


Figure 6: CO_2 De-Dagging Research Stage Gate Process

The current project addresses the first three gates. The fourth gate (CO2 Cost) will be discussed however alternatives for cheaper supply will not be investigated to the required degree to determine the cheapest option for CO2 supply. Commercial designs will be sketched and indicative budgets for additional R&D established and an estimated of Recommended Retail Prices(s) will be determined.

This Milestone 2 report addresses Stage gates one to three inclusive. Milestone 2 will also develop a preliminary understanding of the cost of the CO2 when used in the ColdJet blasting device at ColdJet supply prices. Milestone 3 will investigate other options to reduce the price of CO2 acquisition. Milestone 3 will also provide initial concept ideas and budget estimates for commercial designs, addition R&D expenditure and anticipated recommended retail pricing.

3 Aim

The aim of the research are:

- Demonstrate the ability for a CO2 blaster to remove dags from a hide after being removed from the animal (Milestone 2).
- Cost benefit analysis on the viability of a CO2 blaster to remove dags (Milestone 3).
- A proposal developed with detail design for a fully automated slaughter floor integrated CO2 system as part of a Stage 2 proposal (Milestone 3).

4 Methodology

4.1 Collaborative host processor(s)

To undertake the research a collaborative company with supply of 'dirty' cattle was acquired. The first round of trials were undertaken at Teys Beenleigh and second round trials undertaken at Cargill Wagga Wagga.

4.2 CO2 blasting unit and CO2 supply

A CO2 blasting unit (Model Number Aero 40), refer Figure 7, was leased from ColdJet Pty. Ltd. and located in an outside area at Teys and then Cargill, refer Figure 8. Three hundred kilograms of dry Pallet CO2 at $3/kg was supplied for each trial period by ColdJet and supplied in a blue reusable pallecon, refer Figure 8. The pallets were transferred from the pallecon to the blasting device using a bucket, refer Figure 9. Whilst not in use the CO2 pallets where stored in the relevant host's blast freezer area to reduce the rate of CO2 evaporation.

Figure 7: ColdJet Blaster used for trials

Figure 8: Area used at Cargill for trials

Figure 9: Filling the Blasting unit with CO_2 pallets

In addition to dry ice pallets, the basting device required 240 volts AC power and compressed air supplied at 7 barg through a 25mm supply line.

4.3 Hide selection, collection and preparation

A day before each trial the research team investigated the cattle in the supply yard to identify the hides that where the dirtiest. Once the cattle were selected and the 'kill' agenda determined, the trial staff monitored the hide discharge point and collected the relevant hides and relocated them to the trial area.

Once at the trial area the hide was laid out on the ground (refer Figure 10), split open at the foreleg, neck and head areas and photographed, refer Figure 11. Note, as the hide has already been removed from the animal, the actual cutting lines cannot be de-dagged as these lines are the edges of the hide as depicted in Figure 11.

Once the hide was split open, the hide was measured along the cut lines and positioned on a plastic barrel ready for processing, refer Figure 12. The purpose of using the barrel was to simulate the hide still being on the contour of the body.

Figure 10: Hide as collected, prior to splitting

Figure 11: Hide after splitting

Figure 12: Hide on a barrel to simulate being on a carcase (ready for processing)

4.4 CO2 blasting device operation

Operation of the device required two actions. The first was setting the CO2 feed supply flowrate (refer Figure 13), then depressing the hand piece yellow trigger, refer Figure 14.

Figure 13: Blasting device control panel

Figure 14: CO_2 Blaster hand piece

Figure 15: Device on operation

4.5 CO2 flowrate calibration

To ensure the flowrate control panel on the blaster (Figure 13) was accurate the research team undertook flowrate calibrations.

4.6 CO2 blaster nozzle dimensions

According to ColdJet the nozzle configuration/design is a critical aspect. Scott is not sure how true this statement is, however recorded the dimensions of the nozzle, refer Figure 16.

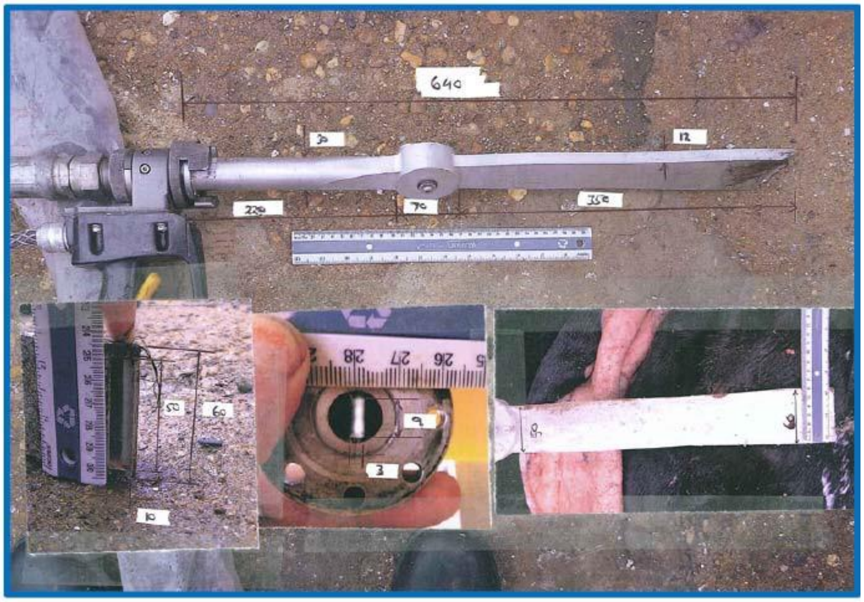


Figure 16: Blasting nozzle critical dimensions

4.7 CO2 blasting device design

The design of the system is very simple and hence as a result robust with few moving parts. This makes the solution ideal for use within the meat processing sector. Figure 17 depicts a schematic of the design and Figure 18 is a photograph of the CO2 metering barrel.

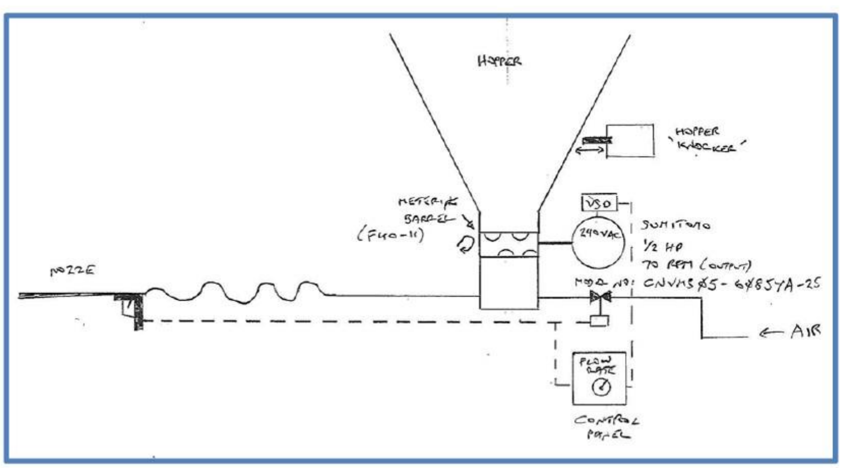


Figure 17: ColdJet System Schematic

The system comprises of a hopper to hold the CO2 pallets. The hopper has 'knockers' installed that on a timed basis 'shake/knock' the hopper to ensure the pallets are not bridging either in the hopper or at the feed point to the 'metering barrel'. A metering barrel that is comprised of a series of dimples (refer Figure 18) is connected to a variable speed drive that is controlled by the dosage flowrate switch on the control panel (refer Figure 13), meters in the CO2 pallets to a chamber that is pressurised with air. When the trigger on the nozzle is depressed, the air supply valve is opened and a short time period after the metering barrel begins to discharge pallets into the air chamber resulting in CO2 pallets being discharged at the nozzle exit point.

Figures 19 and 26 inclusive depict various views of the workings of the system.

Figure 18: Blaster CO_2 metering barrel (view is looking into the top of the hopper)

Figure 19: Feed hopper (top view)

Figure 20: Motor and discharge air pipe from chamber

Figure 21: Knocker, right side (hexagonal shape)

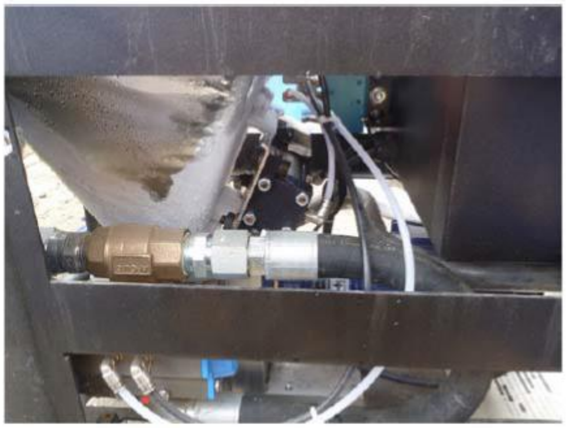


Figure 22: Air valve (top view)

Figure 23: Air valve (bottom view)

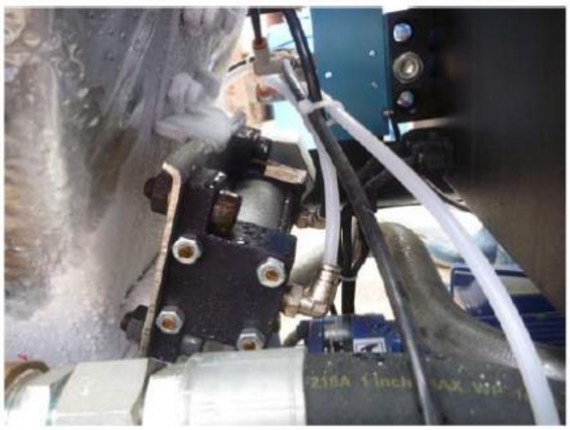


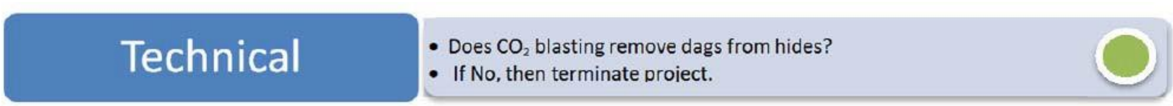
Figure 24: Knocker, left view (black device)

Figure 25: Feed hopper (side view)

5 Results

Referring back to Figure 6, the results section will address indubitably Stage gates 1 and 2. Stage gates 3 and 4 will be analysed and discussed with preliminary deductions reached. The Milestone 3 report will add to the deduced preliminary findings pertaining to Stage gates 3 and 4 and shed light onto Stage gates 5, 6, and 7 inclusive.

5.1 Technical



One of the most significant challenges for the research team throughout this project was accessing the dirty hides that were believed to be representative of the worst that the processing sector in Australia experiences. The research team undertook trials at both Teys Beenleigh and Cargill Wagga Wagga to ensure a range of hides from various feedlots, and hence dag consistency was obtained and processed. In all cases the dags were easily removed by the CO2 system.

Figure 26: Hide prior to CO_2 dag removal

Figure 27: Hide after a single pass

Figure 28: Hide after a second pass

Figure 29: Hide after a third pass

Figure 30: Hide after CO_2 dag removal

The research team cannot categorically state that it has seen the worst type of dag experienced by the industry. Although, the research team believes that as the CO2 system can be used to actually remove hair from the hide, these 'harder' dags should not prevent a CO2 removal system from being technically feasible. In total, over 30 hides have been processed and all successfully had the dags removed from the hide.

5.1.1 Trial videos

Supporting this report are four videos of the recent trials at Cargill.

Table 2: Trial Videos

Video Name	Notes
CO_2 Black Hide First pass	Very dirty hide processed at maximum CO_2 flowrate. A single pass to depict how a commercial system would operate. Processing time was eight seconds
CO_2 Black Hide Second pass	Very dirty hide processed at maximum CO_2 flowrate. A second pass to show how a nozzle twice as wide would clean the hide.
CO_2 Black Hide Third pass	Very dirty hide processed at maximum CO_2 flowrate. A third pass to show how a nozzle three times as wide would clean the hide.
CO_2 Red Hide First pass	A dirty hide processed at maximum CO_2 flowrate. A single pass to depict how a commercial system would operate. Processing time was four seconds

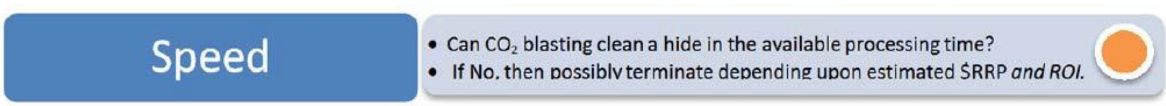
5.2 Damage

There are two types of damage that need to be considered. The first is a 'visual' damage and the second is a 'real' damage. As depicted by the circles in Figure 31, the white spots are where the CO2 blaster has removed all of the hair from the hide. On first glance this 'visual' damage appears to have devalued the hide. However, John Hughes had the hide tested to determine that this was surface level damage only and will not devalue the hide.

Figure 31: Photo depicting 'visual' damage (orange circles)

The research team could ultimately control the amount of visual damage that occurred by ensuring that the angle of the nozzle at the hide interface was as shallow as possible. This actually has two advantages, the shallower the angle the less visual damage and the faster the dag removal.

5.3 Speed



The research team was able to determine that speed is related to:

- CO2 flowrate.
- CO2 nozzle size.
- Nature and extent of dirtiness of the hide.
- The angle of the nozzle to the hide.

Acknowledging these influences on processing speed Table 3, is provided as an example only of the processing speeds obtained during trials at Wagga. Processing speeds of a commercial system are indicated by the Wagga trials only and it is anticipated that during detailed design and commercial developments the speeds will be able to be increased significantly.

Table 3: CO_2 Dedagging surface cleaning velocity

Hide	'Daggyness'	Machine Setting (kg/min)	Calibrated Flowrate (kg/min)	CO_2 flowrate Machine Dial (kg/min)	Distance Cleaned (mm)	Cleaning Time (s)	Cleaning Speed (mm/s)
Black	Excessive	1.0	1.16	1.0	1,000	8	125
Black	Excessive	2.5	2.9	2.5	1,000	7	143
Red	Mild	2.5	2.9	2.5	1,000	4	250

The largest hide processed at Cargill was measured to determine the cutting line lengths along the hind legs, forelegs and the belly as depicted in Figure 32.

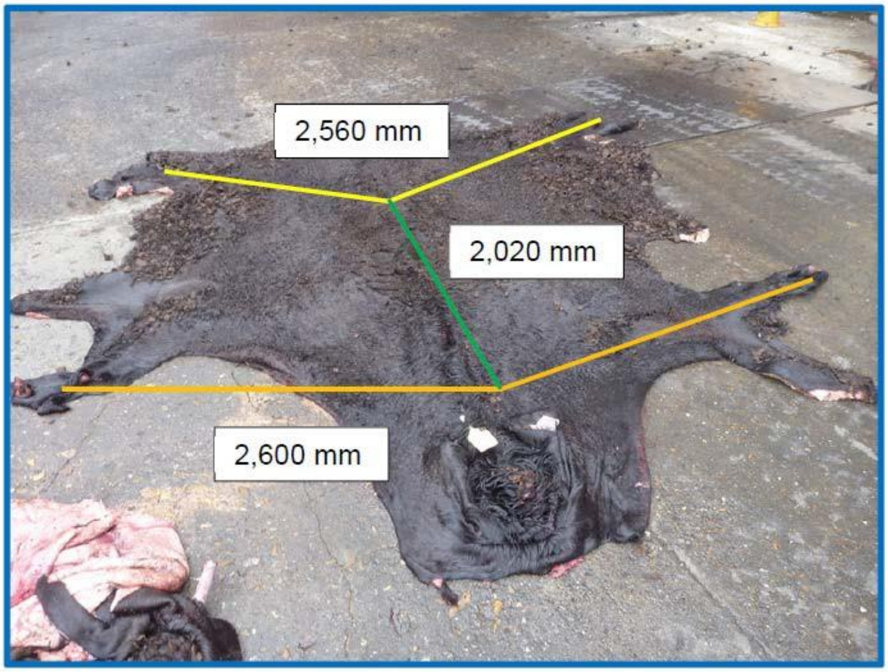


Figure 32: Cutting line lengths on large hide (hind legs = yellow, forelegs = orange and belly = green)

Applying the cleaning speeds in Table 3 along with the hide dimensions show in Figure 32 result in indicative whole of hide cutting line processing time.

Table 4: Indicative hide processing times with Trial system

Hide	'Daggyness'	Machine Setting (kg/min)	Calibrated Flowrate (kg/min)	CO_2 flowrate Machine Dial (kg/min)	Distance Cleaned (mm)	Cleaning Time (s)	Cleaning Speed (mm/s)	Indicative Cleaning Time: Hindlegs (s)	Belly (s)	Forelegs (s)	Total (s)
Black	Excessive	1.0	1.16	1.0	1,000	8	125	20	16	21	57
Black	Excessive	2.5	2.9	2.5	1,000	7	143	18	14	18	50
Red	Mild	2.5	2.9	2.5	1,000	4	250	10	8	10	29

Using an average large Australian processing speed of 20 seconds, the results determine that the research blasting device could not process the cutting lines of a hide within the required meat processing cycle time.

Possible solutions to this could include increasing the CO2 flowrate to reduce the time or have multiple CO2 nozzles working simultaneously. For example two nozzles focused on a discrete area each of the carcase such as forelegs and half the belly with nozzle one, with nozzle two focused on the second half of the belly and the hind legs.

The reader is reminded that the trial conditions that the data in Table 3 and Table 4 were obtain under conditions that were not conducive to the fastest processing speed possible.

Another alternative is to have multiple de-dagging units in larger plants. These larger plants have currently have multiple carcase splitting saws and de-hiding stations to enable these faster processing speeds to be achieved.

5.4 CO2 Cost

CO_2 Cost

- Does the cost of CO_2 ,machine depreciation and operating costs add an excessive financial burden to a processor? *If Yes, terminate the project.*

CO2 for the trials was purchased from ColdJet at a price of $3/kg. The quantities purchased were of small volume and the research team did not investigate alternative cheaper suppliers for the sake of the small quantities required. In addition ColdJet provided a guarantee that the pallets would function with their machine and hence mitigated any potential research risk in this area.

Table 5 calculations have been based on a CO2 purchase price of $3/kg and using the hide processing times from Table 4. As such the research team believes that these values could be more than halved for a full scale installation. Milestone 3 will investigate alternative pricing models for CO2.

Table 5: Worst case per carcase De-Dagging CO_2 pallet purchase costs

Hide	'Daggyness'	Machine Setting (kg/min)	Calibrated Flowrate (kg/min)	CO_2 flowrate Machine Dial (kg/min)	Distance Cleaned (mm)	Cleaning Time (s)	Cleaning Speed (mm/s)	Indicative Cleaning Time: Hindlegs (s)	Belly (s)	Forelegs (s)	Total (s)	Carcase CO_2 Cost ($/carcase)
Black	Excessive	1.0	1.16	1.0	1,000	8	125	20	16	21	57	$ 3.33
Black	Excessive	2.5	2.9	2.5	1,000	7	143	18	14	18	50	$ 7.29
Red	Mild	2.5	2.9	2.5	1,000	4	250	10	8	10	29	$ 4.16

The cost per carcase using the trial equipment at the fastest processing speed was calculated to be $3 to $7 per carcase depending upon the dirtiness of the carcase. Scott believe that along with alterative CO2 purchase/generation options and improved design this price could be at least halved.

5.5 Commercial Design

Commercial Design

- Can a commercial design(s) be identified to fit safely into a processing facility?
- If No, terminate developments.

Milestone 3 will undertake conceptual design work and commence addressing the following items. Although the focus is on an automated solution it is anticipated that the same 'hand piece' could be utilised in a manual operation, albeit with additional safety requirements.

5.5.1 Waste (dags and hair)

The CO2 system produces a significant volume of waste in the predominant form of dags with some loose hair. During Milestone 3 a system will be conceptualised for extracting this waste either through vacuum on the hand piece and/or vacuum on the cabinet and/or a floor extraction system.

5.5.2 Noise

At a result of the velocity at which the CO2 is discharged from the nozzle there is significant noise generated. It is believed that sound proofing of the cabinet will abate the noise to below 85 dB.

5.5.3 CO2 Extraction

With the proposed installation of the system within a processing facility care and consideration is required pertaining to CO2 extraction from the CO2 cabinet.

5.5.4 CO2 purchase / generation / regeneration options

The more cost effective the acquisition of CO2 can be achieved the increase in return on investment of the CO2 concept is to the processing sector. Preliminary discussion will be held with CO2 suppliers and CO2 generation equipment companies to obtain an improved high level understanding of the anticipated acquisition price(s) of CO2.

5.5.5 Other Safety Considerations

Due to the nature of the high pressure of the system, the research hand held nozzle could introduce additional safety issues within a processing facility. If the hand held unit was directly aimed at an individual within a 1 metre range, there is a high probability that the individual could be permanently impaired. As a result Scott will investigate how a hand held unit might be able to be operated safely if a non-automated solution is required by a processing company.

5.5.6 High Pressure system and Nozzle designs

Scott will develop a wider 150 mm (6 inch) nozzle for the requirement of a single pass dedagging clean as well as investigate Scott designed/built pressure supply systems to meet the rigorous equipment demands of the Australian meat processing sector.

6 Discussion

Throughout the duration of the research John Hughes has been contemplating other alternatives to de-dagging along with Scott staff. As a result John has conceptualised the device depicted in Figure 33.

The device is based on a morph between an angle grinder with a diamond tipped blade and a pair of wool shears.

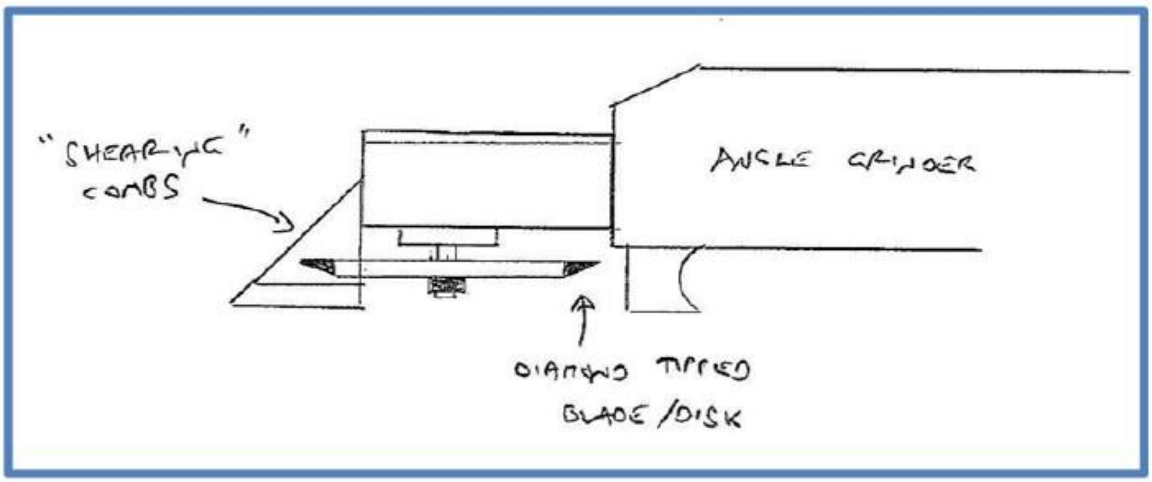


Figure 33: Dag Shear JH-101 concept

Research into the design and manufacture of this concept may serve the industry well as a back-up if CO_2 does not prove to be financially viable. Second, the solution might be ideal for smaller processing companies that operate at less than 20 head per hour.

This concept has been labelled the Dag Shearer JH101.

7 Recommendations and Conclusions

Milestone 2 was aimed at determining whether CO_2 could be used technically as a way to de-dag dirty cattle.

It has been shown by the research team that a CO_2 blasting system, from a technical perspective, can remove dags from very dirty cattle, without resulting hide damage.

Using processing speeds recorded during the trials additional consideration needs to be focused in the future on determining the maximum processing speed of a system, and it is proposed that this is undertaken as the Stage 2 project.

The cost of CO_2 does not appear on the surface to be cost prohibitive, although additional work needs to be undertaken to determine how a supply price of considerably less than $3/kg can be achieved.

Milestone 3 will commence the concept development phase of an automated in-situ solution, provide options for reducing CO_2 purchase price and provide an R&D budget price for the proposed Stage 2 project.

Scott recommends that:
1. Milestone 3 is executed.
2. Industry is requested for a variation to the existing contract, or a new contract to undertake preliminary trials of the Dag Shearer JH-101. A budget of AUD$23,100 is requested.
a. Fees @ $7,500.
b. Expenses @ $15,600 (note John Hughes is an expense).