

# final report

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# 6 way cut – Stage 2 and Carcase split trials

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# Abstract

The objectives of these Carcase Splitting trials were focused on the development of a circular knife/saw with an integrated guidance mechanism. Once developed the goal was to test and trial this saw to ensure the concept will perform as required prior to exposing any individual processor to the risk of installing a system that has remaining unanswered design, operational and reliability questions.

The body of this report shows the design of this saw as being adapted from splitting saws used in the pork industry and the possibilities for its use as a lamb splitting and 6 Way Cut system for mutton and goat.

## **Executive Summary**

Draft designs for the manufacture of a carcase splitting tool with integrated guidance and stabilisation mechanism were based around proven technology used in pork splitting with design modifications made to suit lamb carcases. A saw to suit these specifications was fabricated and trials conducted. The trials found:

- To enable successful use of the saw the legs of the carcase had to be spread much further apart than is allowed for on the normal plastic gambrels used by Australian processors.
- The guidance mechanism worked well on both stationary and moving carcases providing the saw could locate on the centre of the spine when initially contacting the carcase and the carcase was not 'stiff' and was hung straight. It was found that if the inner guide rollers did not initially locate centrally on the spine of the carcase or the carcase was 'stiff' and not hung straight then these rollers were unable to guide the saw down the centre of the back bone.

It is concluded that with modifications to the current setup of the internal rollers that improvements in the accuracy of the cut down the centre of the spine could be made. However due to the requirement to spread the legs to enable the tooling to function correctly the splitting saw would struggle to perform adequately as a dedicated lamb carcase splitting system in an existing Australian processing plant without modifications to existing line formats and gambrel systems used. However from a 6 way cut point of view where the accuracy of splitting is not crucial it can be said that this saw and guidance mechanism is a success with the issue of leg spreading overcome by development of a carcase de-gambrel and restrainer unit described as part of a 6 Way cut system concept described in section 6 of this report.

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## 1 Background

The ultimate goal of this technology is to automate the splitting process in small stock (lamb, sheep and goats) to reduce injuries from processing equipment especially bandsaws by removing operators from the band saw hazard, with additional benefits to be gained through operational improvements being accomplished particularly relating to refrigeration savings provided by split carcases providing better chiller space utilisation.

In addition, automating the splitting process provides the first step for further development of MAR's automated 6 Way Cut system to be further developed for small stock (sheep and goats).

# 2 **Project Objectives**

The purpose of these Carcase Splitting trials are primarily focused on the development of circular knife/saw with integrated guidance and to test and trial this saw to ensure the concept will perform as required prior to exposing any individual processor to the risk of installing a system that has remaining unanswered design, operational and reliability questions.

The project is based upon the integration and testing of the following main components;

- Splitting Robot Manipulator
- Splitting Tool (specially designed circular knife tool with integrated carcase guidance)
- Minimal sensing technologies
- Cell Control System

At the completion of the Project, MAR will have completed the following:

- Executed Initial Design & Project R&D including project risk assessments
- Designed and manufactured a Lamb/Sheep Carcase Splitting Knife/Saw with integrated guidance suitable for trials.
- Performed staged Lamb/Sheep carcase splitting trials at MAR and on-site
- Address any Design, Operational & Reliability points identified
- Developed a potential concept design for Lamb/Sheep Carcase Splitting and 6 Way Cutting solutions adaptable to processing plants Australia wide.
- Provide system videos, reports and documentation detailing the outcome of the trials, its components and operational procedure to MLA for industry dissemination and promotional purpose

## 3 Methodology

The project is divided up into the following milestones and these formed the structure of the project.

#### Milestone 1 - Initial Design & Project R&D

- MAR will conduct and review with MLA a full project Risk assessment document that includes a detailed analysis covering technical, process, schedule, financial, resource, design and commercial risks including action plans to deal with each identified risk throughout the life of the project,
- Prepare draft design for new Carcase Splitting Tool with integrated guidance and stabilisation.
- Initial Design R&D, includes potential designs for future Carcase Splitting or 6 Way Cut sites and ensuring the design meets the requirements of potential future processors who will take on this technology.

#### GO / NO GO

#### Milestone 2 – Carcase Splitting Tool Development

- Design for manufacture of carcase splitting tool with integrated guidance and stabilisation equipment based on draft design review.
- Purchase standard saw components
- Purchase components and manufacture of new splitting tool setup
- Setup and install carcase splitting tool at MAR

#### Milestone 3 – Trial System Components

- Purchasing of system components and delivery to MAR to begin system build integrating and programming.
- Robot system for trails
- o Robot Base Frame and accessories
- o Control system interface and saw control components
- Carcase Stabilisation components

#### Milestone 4 – Carcase Splitting Setup at MAR

- o Setup and install robot and splitting tool
- Mechanical & Electrical Setup & Test of System
- Programming of robot & control system interfacing
- Test tooling robotic operated
- Perform dry run trials (no carcase)
- o Perform carcase splitting trials (chilled)
- o Videos, reports and documentation detailing results of trials

#### GO / NO GO

#### <u>Milestone 5 – Site Preparation for on-site trials</u>

- Prepare site (chiller space) for installation
- Preparation of Services (water, power, etc)

#### Milestone 6 - On-Site Installation of Trial Equipment

- Equipment Transport to Site
- o Installation of robot system
- Installation of other system components
- Electrical and services installation

#### Milestone 7 – System Setup Testing & Trials

- o Mechanical & Electrical Setup & Test of System
- Test tooling robotic operated
- Setup and test manual operations
- Setup and test guidance system (dry cycle operations)

#### Milestone 8 – Carcase Splitting Trials

- Perform a series of Chilled Carcase Splitting Trials
- Perform a series of Warm Carcase Splitting Trials
- Cycle Time, Tool Life, Carcase Type Trials
- o Document and video all trials

#### Milestone 9 - Presentation Video, Documentation

 System Videos, reports and documentation detailing the outcome of the trials, its components and operational procedure to be provided by MAR to MLA for industry dissemination and promotional purpose

#### Milestone 10 - Presentation & On-site Open Day

- Preparation, contact potential clients & arrangements
- Site Setup For Presentation
- Presentation to Industry by MAR with MLA
- Document and video all trials

## 4 Results and Discussion

### 4.1 Initial Design, Project R & D and Tool Development

Draft designs for the manufacture of a carcase splitting tool with integrated guidance and stabilisation mechanism were based around proven technology used in pork splitting with design modifications to be made to suit lamb carcases. The image below shows the draft design for the saw based on the pork equivalent,



#### Fig.1 Carcase Splitting tool Concept

The saw and guidance mechanism consists of the saw motor and blade along with two sets of rollers and a second motor for driving the saw blade in and out of the housing. The front set of rollers, designed to roll down the outside of the spine, are raised and lowered via a pneumatic cylinder.

The basic principle of operation is that the saw approaches the carcases with the open belly of the carcase facing the saw. The pneumatic cylinder is retracted causing the arm holding the front rollers to be extended allowing the front rollers to pass through the spread rear legs of the carcase. Once the rollers are through the carcase and the rollers on the inside of the carcase are contacting the

inside of the spine the cylinder extends causing the front rollers to close and contact the back of the carcase. Both sets of rollers at this point should be centrally located on the spine. The saw blade is then extended and then the saw is moved vertically down the carcase splitting it down the centre of the spine.

## 4.2 System Components and Carcase Splitting Setup at MAR

The base splitting saw unit was manufactured by NAWI in The Netherlands, MAR modified the saw to suit lamb carcases and fitted to a robot in our Silverwater work shop. The images below show the setup including the frame that was designed and built to support and stabilize the carcase and the robot base required to raise the robot to a suitable height.





Fig.2 System Components setup in MAR's workshop

The integrated guidance mechanism is shown in the image below and consists of a pneumatic arm that closes on the back of the animal.



#### Fig.3 Integrated guidance mechanism

In preparation for trials a carcase was hung on the frame as shown above and as can be seen the legs had to be spread significantly further apart, to allow the tooling to pass through, than is normally the case when the carcase is hung from standard plastic gambrels used in most Australian plants.



Fig.4 Spreading of carcase legs required to enable correct saw function

Trials of the saw followed and the images below show the initial problems that were encountered when splitting was attempted. The carcase became caught, after being cut, in the structure of the saw.





Fig.5 Initial issues encountered when splitting was attempted

The guards/guides shown in the images below were added to the saw to guide the carcase away from the saw structure after being cut.





#### Fig.6 Guards added to the saw to guide the carcase away from the saw structure

These guards proved successful and in combination with the wide spread legs enabled the splitting of 10 carcases with good results on carcases that had not been chilled for a long period of time. With the saw approaching the carcase centrally between the legs the front and rear guides successfully guided the saw down the centre of the spine with no soft siding occurring. The images below show the results of the 10 split carcases.



#### Fig.7 Results from the splitting trials

Some carcases trialed, however, were stiff and out of shape due to extended chilling, storage method and transportation, as with the carcase in the image below.



#### Fig.8 Carcase not hung straight and soft siding in the neck area

In these cases the guides struggled to guide the saw to cut the carcase centrally as can be seen in the neck area in the second image. Under normal processing conditions carcases would not be this stiff and would remain in shape and straight due to standard chilling practices. It should also be acknowledged that in most, if not all cases, a splitting system would be installed on the slaughter floor where the carcases would be cut hot and hence stiffness of the carcase would not be an issue. Processing of carcases in most 6 Way cut systems would also be performed on hot carcases but in the case where the carcases are chilled a stiffer carcase would not create an issue as accuracy is not paramount.

The other issue experienced was the amount of bone dust that was created with the toothed blade. Eliminating or minimizing bone and saw dust would be seen as a high priority in the industry as this increases yield, improves shelf life and appearance and improves hygiene by reducing potential biological load. Contact was made with Freund in Germany, the supplier of the blade, and a dustless blade was sourced.



## Fig.9 Resulting bone dust

## 4.3 Setup, testing and Carcase Splitting Trials

At this point it was agreed with MLA that the further splitting trials would be conducted at MAR, the requirement being that carcases be tracked along a conveyor while the splitting of the carcase takes place. A conveyor was manufactured and assembled at MAR to allow this to occur. The images below show the conveyor setup along with the setup of hung carcases. The accompanying videos show the splitting taking place.







#### Fig.10 Conveyor setup in MAR's work shop

Carcases ranging in size from 21kg to 28kg were used for these trials and the conveyor was run at 10m/min or equivalent to approximately 10 carcases/min with the carcases spaced 930-950 mm apart (Peel Valley Exporters/Gundagai Meat Processors). Again the legs we spread apart to allow the tooling to pass through.

The trials used the dustless blade that had been sourced from Freund in Germany and as can be seen from the image below the resulting bone dust was much less. The blade was run without any water on the blade for cooling purposes at a speed of 1450rpm. This blade is used successfully in a production environment for pork splitting and as can be seen from the videos cut though the lamb carcases with no issue.

Cycle times from the videos of the trials performed on the moving conveyor are shown in the table below along with times from a video of a similar tool performing pork splitting which should be achievable with refinement of the process.

Action	Trial Time	Achievable with refinement
Positioning between legs from	2	1 (positioned and clamped)
wait position		
Clamping	1	-
Move Saw forward	2	0.5
Cutting	6	3
Remove tool	7	1.5
Sterilisation cycle (only required	Undefined	2
when splitting occurs on kill		
floor)		
Reposition for next cut	Undefined	1.5
Total	18	9.5



Fig.11 Reduced bone dust from dustless knife blade (5 carcases cut)

The results from these trials on moving carcases showed once again that if the saw hit the carcase centrally the existing guidance mechanism was capable of guiding the saw centrally through the spine. However if the saw contacted the carcase slightly off centre then the smaller inside rollers were unable to bring the spine back to the central position and an off centre cut resulted. It is felt that if the stainless steel rollers were modified to be of similar construction to the white Teflon rollers that are used to run down the out side of the back then better results would be achieved.

# 5 Success in Achieving Objectives

Through the course of this project MAR has

- Submitted, as Milestone 1, initial design and R&D and completed a Project Risk assessment.
- Had designed and manufactured a Carcase Splitting Saw with integrated guidance mechanism which was used to perform trials on lamb and sheep carcases. This guidance mechanism proved successful when initial contact was made centrally with the carcase and the carcase was not stiff or over chilled. If the carcase was chilled and stiff then the guidance mechanism struggled to realign the carcase if it contacted the carcase off centre or if the carcase was not hanging straight. However as already discussed in practically all lamb splitting and the majority of 6 way cut instances the carcase will be split while they are hot and hence the stiffness of the carcase is not an issue. It is felt that redesign of the guide rollers used to guide the saw on the inside of the carcase would rectify any issues of re aligning the carcase if initial contact was no made centrally on the spine.
- Modifications were made to the saw once it arrived at MAR with the addition of guarding on the outside of the saw blade to deflect the inside thigh away from the saw structure and prevent jamming of the carcase. Changes were also made to the saw blade, it was changed to a dustless blade which eliminated the majority of the bone dust that was generated with the tipped blade. This dustless blade had no issue cutting the lamb carcases and is used successfully in a production environment for pig splitting.
- Identified issues with the fact that the legs of the carcase had to be spread significantly
  further apart than is normally the case when hung from the standard plastic gambrels used
  by Australian producers. This was required to allow enough room for the rollers that guided
  the saw down the outside of the back bone to pass through prior to clamping the carcase.
  This is seen as an issue for a dedicated lamb splitting system but is addressed in the
  description of the 6 Way Cut concept described below.

## 6 Conclusions and Recommendations

From the above trials it can be concluded that the splitting saw with integrated guidance mechanism can successful split carcases but would require some modifications to the guidance mechanism and processing floor for it to be installed in existing Australian processing plants.

The modifications to the guidance mechanism are minor and would involve swapping the existing stainless steel guide wheels, used on the inside of the carcase, for some Teflon wheels similar to those used down the outside of the carcase. This would better enable the guidance mechanism to align the carcase to the saw if initial contact was not centered and would be refined during the development of a fully automated lamb splitter or 6 way cut system

The modifications to the processing floor have to do with the spreading of the carcase legs required to enable the tooling to function correctly and this is addressed below in the 6 way Cut Concept by the development of a carcase de-gambrel and restrainer unit.

## 6.1 6 Way Cut Concept Design

MAR are currently working with Norvic Food Processing in Wodonga Victoria to develop a fully automated 6 Way cut system based upon results achieved in this project and previous 6 Way cut 'on plant trials' completed at Norvic in 2006.

This proposed Robotic 6 Way Cut System for sheep and goat processing at Norvic incorporates a basic design principle utilizing robot(s), carcase de-gambrel & restrainer units, safety guarding, robot bases, dustless blade cutting tools and sensing.

Development of the carcase de-gambrel and restrainer unit is the subject of a current application to APMC and MLA. This unit will be suitable for hot and chilled sheep and goat carcases and its basic operation is described below:



- Remove carcase from gambrels
- Spread carcase legs and present carcase to the splitting saw
- After splitting carcase halves will be presented into restrainer
- Restrainer will then re-clamp carcase halves to form a full carcase shape ready for cross cutting
- Grip, hold and position carcase for stabilisation of split carcase during cross cutting operations
- Restrainer is fixed dimension offering a number of fixed cut positions to be used based upon carcase size
- Each 6 Way primal piece will be deposited on exit conveyor.

This 6 Way Cut System concept is based upon supply of a system capable of 300 carcases/hr. This design requires only one (1) Carcase Splitting Robot and one (1) carcase de-gambrel & restraining unit. To obtain production rates greater than 300 carcases/hr additional hardware will be required including a second Carcase Splitting Robot and a second carcase de-gambrel and restraining unit as shown in the figures below.

As can also be seen in the figures below the plan is to further develop this system into a sheep and goat meat cubing system and again MAR have submitted a research proposal to AMPC and MLA for the development of this automated cubing system.





Fig.12 Layout of concept 6 Way cut cell