



final report

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Robotic Y-cutter implementation

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Introduction

The Robotic Y cut project was conceived 12 years ago by IRL in New Zealand. It consisted of specially built stainless steel 2 axis robots with an attached Y Cut tool. As robotic flexibility increased and price drastically decreased the purpose built was replaced with a Kuka robot. Improving technical issues dealing with carcass variation, sterilisation, and quality of cut kept the Y cutter from the market place. With these issues solved IRL installed successfully the robotic Y cutter in New Zealand. However the attempt from IRL to install the Y cutter into Australia was met with limited success.

A MLA funded project for “Demonstration of sheep Y-cutter” completed by IRL in conjunction with Southern Meats Pty Ltd at their Goulburn processing plant resulted in a successful demonstration of the process.

MAR were chosen by MLA to commercialise the technology with IRL supplying and consulting on the Y Cut tool. This arrangement has worked well with the first installation at completed CRF, Colac.

In conjunction with Device Works (IRL) and Meat and Livestock Australia, MAR has developed the Y-Cutter technology at CRF Colac to a level where it is now in continuous production.



About the system

The system aims at replicating the actions traditionally completed by 3 manual knife operations completed sequentially to form a Y-Cut in the pelt and hence begin the pelt removal from the carcass. The objective of this system is to consistently perform these 3 operations with one robotic system creating these first incisions, a “Y” shaped cut, on the lamb or sheep carcass. By automating this process the Y-Cutter both reduces the risk of cross-contamination and improves the quality of the cut.

The system is designed to fit within existing slaughter/processing floors and incorporates the following key components integrated within the system;

- Kuka KR30-3 KS Six Axes Shelf Mount Robot System with 30kg payload capacity
- Y-Cutter Head (Cutting Tool fitted to robot)
- Spring Loaded Sock Ringer Saw
- Carcass Stabilisation (Spreader Guides & Sway-Bar)
- Conveyor Tracking Equipment (encoders, modules, software)
- Overhead Robot Base Frame to support and elevate the robot manipulator
- Robot Protection Bag (Protects and seals robot between mounting frame and the robot wrist)
- Robot Controller and stainless steel enclosure mounted on the robot system base frame.
- Kuka Control Pendant enclosure mounted on the side of the robot system base frame.
- Safety Guards (stainless steel posts & clear scratch resistant polycarbonate viewing windows)
- Safety Switches, & Emergency Stop circuits

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- Safety Integration
- Servo systems

- Cell Access Safety Mats on floor
- System Control Panel (HMI Panel View Screen & system control pushbuttons / indicator lamps).
- Brisket Wand encoder
- Leg Switch
- Sterilised water supply and dispensing system

Automated Y-Cutter Operations



- Sockringing
- Sensing
- Insertion
- Cut path
- Exit cutpath
- Sanitising



The suspended lamb is presented into the system hanging upside down on the chain conveyor with each hock restrained. As an initial step each carcass fed into the work cell passes through a Sock Ringer, this is a spring loaded rotary knife that cuts an opening in the foreleg enabling an opening for the Y-Cut cutting tool to be inserted.

The first of two cuts starts on the leading front foreleg hock where the tool is inserted to perform a cut path down to the breast or sternum area before the tool is then sterilised between cuts and the second cut path is initiated inserting the tool into the now trailing foreleg and performing a cut path down the leg to the breast bone down to the underside of the neck. The tool is again sterilised in preparation for the next carcass.

Via the control panel HMI the operator has the ability to vary the tool path either by setting individual path waypoints or choosing between carcass type (eg, Lamb, Mutton, Merino)



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|-------------------------|------------------------|-----------------------------|
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| • 24 hr/365 day service | • Safety Integration | • Servo systems |

System Design

The robot cell is located in approximately the same position as the original manual operations, however the chain and plant layout had to be modified by CRF in preparation for installation of the Y-Cutter and possible installations of future automation at the plant. Figure 1 below shows the safety guarding, safety mats, robot position, operator panel, and the main line which passes through the cell. Figure 2 shows a possible layout of similar systems in the future.

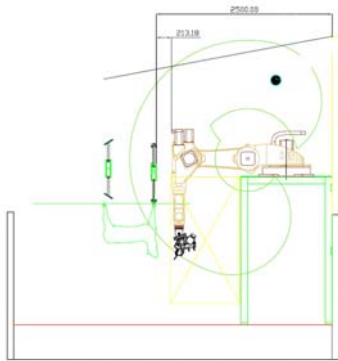


Figure 1a

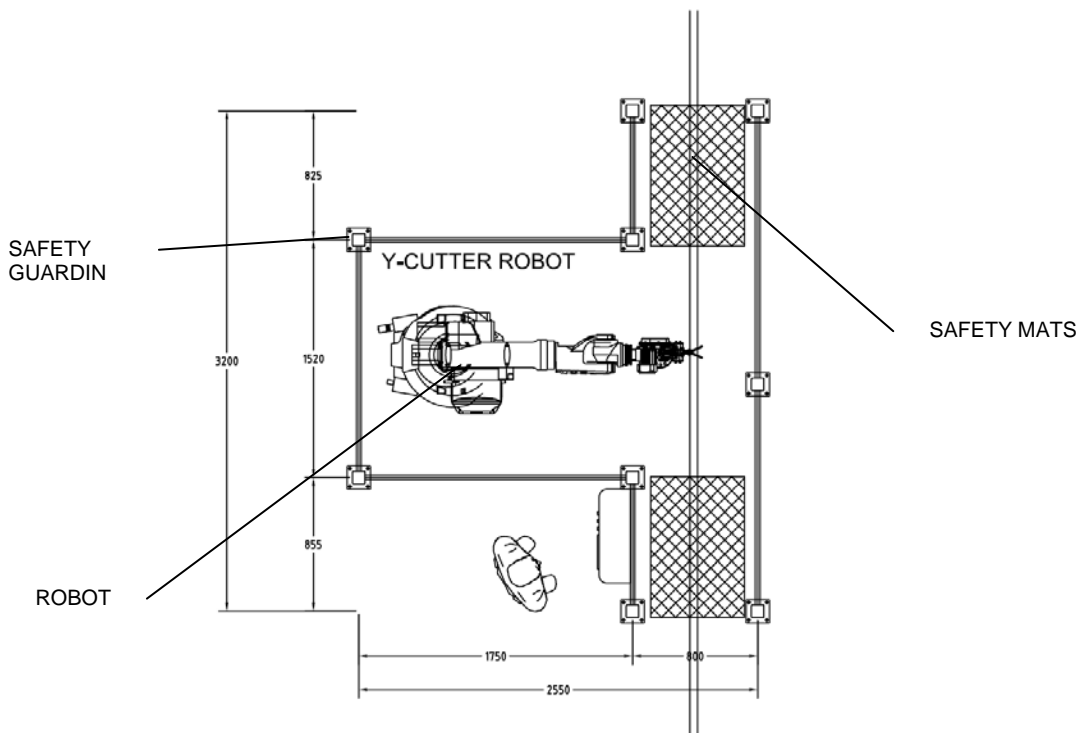


Figure 2b

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Safety System

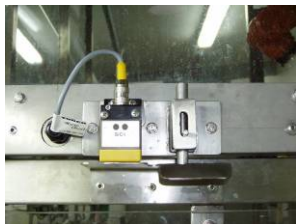
The Y-Cutter cell safety system comprises safety guarding, safety switches and safety mats as the main components protecting against injury whilst the system is in operation

Safety Guarding

The safety guarding is made with stainless steel posts and 6mm clear scratch resistant polycarbonate sheets. The safety guarding is designed to prevent personnel from coming in contact with the robot.



Robot cell with protective guarding



Guard door safety Switch



Cell access door safety Switch

Safety Mats

The safety mats have been installed to protect personnel around the robot cell from coming in contact with the robot. There are two safety mats installed. The safety mats trigger when a person or a weight is on them.



Safety Mats

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Sock Ringer

Each carcass fed into the work cell passes through the Sock Ringer, this is a spring loaded rotary knife that cuts an opening in the foreleg enabling an opening for the Y-Cut cutting tool to be inserted.



Spreader Guides & Sway-Bar

The spreader guides and sway bars are used to stabilise each carcass for measurement and operation of the Y-Cutter enabling better consistency of operations and quality of the Y-Cuts



Robot

The robot used for the Y-Cutter is a Kuka KR30-3 KS, a six axes shelf mount robot system with 30kg payload capacity that is designed to operate at low levels whilst the robot is mounted from above (shelf). This robot allowed the design of the cell to be incorporated within the processing floor with personnel access underneath the robot frame.



The robot has a protective cover made from PVC taught-liner material and is custom designed to fit the robot and protect the robot from water entering into the motors. The bag is inflated to allow free movement of the robot within the bag and create Positive pressure to also stop ingress of water into bag.

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Y-Cutter Tool

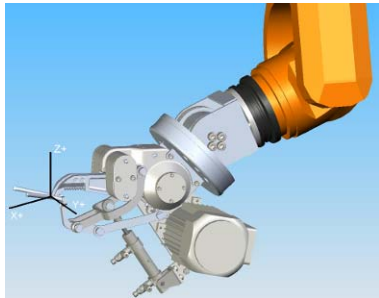
The Y-Cutter Tool is designed and supplied by Device Works NZ.



The tool is mounted on the roll face of the Kuka KR30-3 KS robot system.

Tool outline of specifications:

- Electric motor driven
- Toothed belt drive requires only infrequent inspection
- Leg guide operation is pneumatic using standard components
- Lubrication is provided by six grease nipples
- Blades are easily removed and can be recycled for re-sharpening.
- Stainless steel and anodised aluminium construction

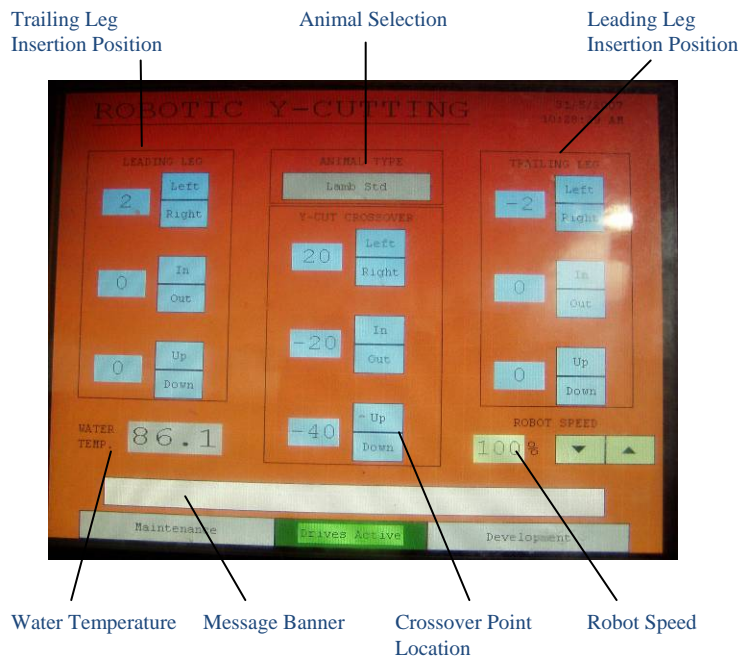


Operator Controls

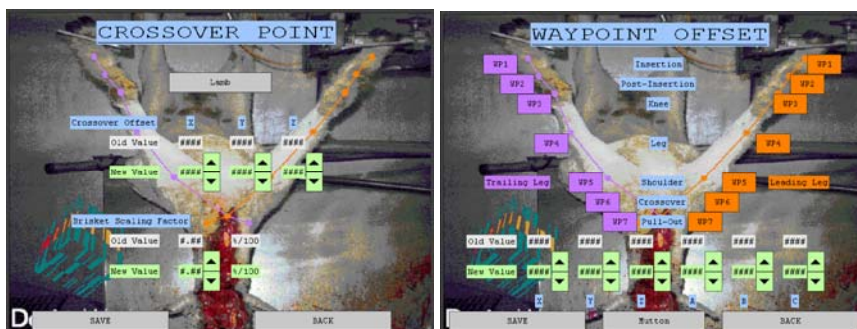


The robot system is started, stopped and reset from the operator control station mounted on the outside of the robot frame. The control station may be used to stop the robot immediately using the emergency stop.

The HMI interface is used to control all production and maintenance features



The HMI interface is also used to change the setup and control paths for different animal types



- | | |
|--------------------|----------------------------------------------------|
| Insertion Point: | Point at which robot tool enters leg incision. |
| Crossover Point: | Point at which cuts from both legs meet at brisket |
| Waypoint Height : | Heights of the seven waypoints per cut |
| Waypoint Offset: | Physical position of the seven waypoints per cut |
| Waypoint Tracking: | The behaviour of the robot can be altered |

Sensors used on the Y-Cutter System

The main sensors include the following:

1. Leg Switch
2. Brisket Wand
3. Chain Encoder
4. Water Temp

Leg Switch

This sensor is a mechanically operated limit switch located above the chain conveyor and is used to determine position of leading and trailing leg

Brisket Wand

This brisket wand is a mechanically operated analogue feedback sensor used to determine the brisket height of each carcass as it is fed into the cell.

The sensor/wand takes measurements of each carcass as they pass into the cell, this measurement is used to determine the height of the brisket from the sock ringer cut and the information is translated for use in the robot program and cut paths of the Y-Cutter

Chain Encoder

Feedback from a resolver fitted to the overhead chain conveyor which measures chain displacement and is used to allow the robot to track the chain and carcass

Hot water temperature Sensor

There is a temperature sensor located on the tool tip sterilizing water drain manifold. The temperature is displayed on the HMI operator panel. Once the temperature reaches the minimum operating temperature of 82.5°C an output from the display allows the robot system to run. If the temperature falls below 82.5°C the error lamp will be lit and a warning message will be displayed on the teach pendant and allow the system to continue. If the temperature falls below 70°C during autonomous operation the system will automatically shut the cycle down.

Y-Cutter Challenge's

Prior to the installation of the Y-Cutter at CRF the Y-Cutting system had been installed in New Zealand for some time and had been trialled in one other Australian lamb processor.

The New Zealand lamb industry is very different from production in Australia, In New Zealand lambs are predominantly Romney based and are killed at a much younger age (avg carcass 18 Kgs), compared to Australian Lambs which are generally at an age nearing a hogget and are approx. 25 Kgs average weight.

Each lamb is washed down prior to slaughter (outlawed in Australia). A consistent wool length at slaughter with a much cleaner product is achieved based upon operational practices of the industry in NZ.

These factors have meant that the performance of the machine installed at CRF was different from the performance that had been experienced when installed at other New Zealand plants.

The following items where areas that required significant re-design and improvements to the process including the use of sensors and more complex programming methods.

Working with CRF and Device Works, MAR has made significant improvements to address these challenges:

- Carcass Variation (species)
- Line Speed
- Sockringing System
- Tool Design
- Carcass Sensing
- Chain Conveyor Tracking
- Safety System (Safety Mats)
- Sterilisation

Benefits

The installation of the Y-Cutter system at CRF has delivered a number of significant Economic, OH&S and operational benefits;

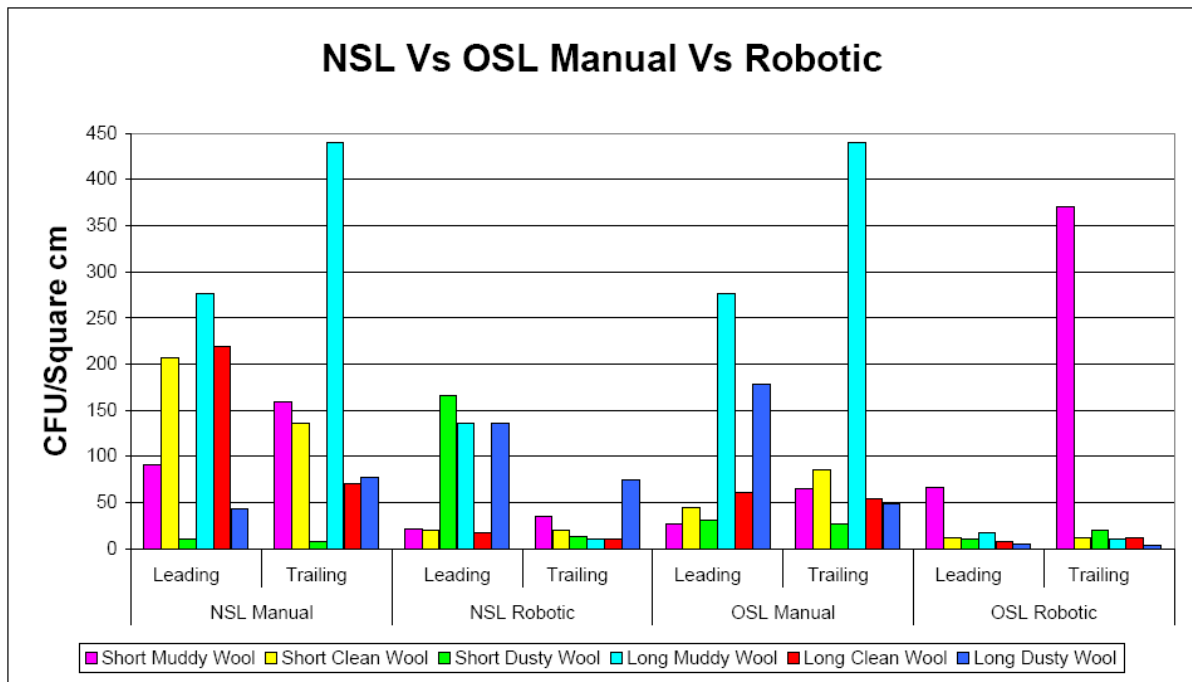
- Labour – *2-3 operators per working shift*
- OH&S – *No injuries or accidents reported since installation Jan 2005*
- Pelt Improvement – *improved quality and less damage*
- Improved processing efficiencies – *less rework*
- Improved consistency and quality of carcass dressing
- Reduced Contamination – *Test prove reduced contamination compared to manual knife operations*

AQIS inspection and Swab Testing

The Y-Cutter operation has a risk of contamination spread from the pelt to the carcase surface below.

Before and after automation swab testing was carried out by the CRF.

Swabs were taken before the Vac Sans and trimming stations. Refer to Automated Robotic Y Cutter Microbiological Feasibility Report, CRF (Colac Otway) for details of the testing regime. In the majority of samples, the robotic Y-Cutter performed better than manual cutting at reducing the TVC CFU/square cm on the carcase at swab sites.



Project Outcomes

Operational Success Rates

In relation to operational success, CRF have indicated that they are achieving upwards of 95% successful Y-Cuts on lambs irrespective of breed.

The additional 5% of animals not processed via the automated system are processed manually with one operator who also performs the dentition inspection function

Although not designed for Sheep & Mutton, the machines operational efficiency when producing Sheep “Merinos” at CRF is less than 50%.

The reasons that the automated system is less successful on the sheep/mutton is as follows:

- Carcass Variation (animals are bigger and more varied in shape)
- Wool is longer and often matted
- Animals are older and fatter producing a range of fat thickness and gathered fat area variations
- Older animal skin is tougher and thick

Rates of Operation

The system is currently operating at a line speed of 8.5 carcass/min.

Where to next

MAR will be seeking future development of the Y-Cutter project with other plants.

In particular MAR will work to improve upon the following features and will seek future plant participation to do so.

- Increased Line Speed
- Improved efficiency for lamb processing
- Sheep/Mutton processing capability improvements
- Y-Cutter Tool Development (with Device Works)