final report

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Prepared by:	Gavin Inglis
	Machinery Automation and Robotics
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Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Robotic Kidney Fat Removal System

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Abstract

The removal of kidney fat from small stock manually is a repetitive and dirty task, has many associated OH&S risks and requires a very competent operator to maintain concentration to ensure that quality is maintained. The Automatic Kidney Fat Removal system allows for reliable Fat removal and routine cleaning/sterilisation of the vacuum tool.

This project involved the installation of an Automatic Kidney Fat Removal system into JBS Brooklyn. Improvements were made to the guarding and tooling as part of the ongoing development of this system.

The project achieved improved results in fat removal and modifications to the gambrel stabilisation system that combined with the system setup at Peel Valley would make the system suitable for installation into the majority of small stock plants across Australia.

Executive Summary

The removal of kidney fat from small stock manually is a repetitive and dirty task and has many associated OH&S risks. These include repetitive strain injury and potential for back and shoulder injuries. The speed that the carcasses travel on the chain requires a very competent operator to maintain concentration to ensure that quality is maintained. The Automatic Kidney Fat Removal system allows for reliable Fat removal and routine cleaning/sterilisation of the vacuum tool.

This project involved the installation of an Automatic Kidney Fat Removal system into JBS Brooklyn. Improvements were made to the guarding and tooling as part of the on going development of this system.

R&D development for this installation included the design modifications required to adapt the existing system at Peel Valley to make it suitable for the gambrel and carcass conveyor system used at Swift Brooklyn, plus continuous improvements in design to make the technology ready for commercialisation.

The project achieved improved results in fat removal and modifications to the gambrel stabilisation system that combined with the system setup at Peel Valley would make the system suitable for installation into the majority of small stock plants across Australia.

Benefits to be achieved by utilization and continued development of the Robotic Kidney Fat Removal System include:

- Improvements in OH&S;
    - Elimination of risk of operator strain injury from the size, weight and repetitive tasking
    - Elimination of dangerous operational practices
- Consistency;
    - Robotic mounting and control of the fat removal process improves accuracy and repeatability over manual removal systems
    - Improved sensing technology (laser) and software to provide an increase in efficiency "Remove more Fat". This improved sensing allows carcass variations to be identified providing a platform to implement variable robot positioning and paths.
- Improved yield through;
    - Improved yield payback by ensuring more kidney fat is removed consistently for every carcass prior to weighing
    - flexibility of system to change path specifications upon requests
- Labour cost:
    - The system will replace 1 unit of labour per shift.
- Line Speed:
    - The system can operate at line speed >10 carcasses/min.
- Efficiency:
    - Less rework required in boning room to remove Kidney Fat after chilling
- Hygiene:
    - Microbiological tests prove reduced contamination compared with manual operations
- Species:
    - The Kidney Fat Removal System is suitable for use in lamb, sheep and goat processing

Reliability and accuracy, along with processing speed which are critical to the success and acceptance of this technology have been achieved throughout this project.
Production levels at plants such as JBS Brooklyn justifies the investment in a robotic system and the recent inclination for Australian processing plants to participate in robotic developments shows the trend the industry is following towards further automation. This is fuelled by acute shortages in labour supply, which will likely get worse in the future.

Contents

1 Background

1.1 Robotic Kidney Fat Removal History

Removing the kidney fat manually is a repetitive and dirty task and has many associated OH&S risks. These include repetitive strain injury and potential for back and shoulder injuries. The potential for cross contamination from one carcass to the next is high. The speed the carcasses travel on the chain requires a very competent operator to maintain concentration to ensure that quality is maintained. The Automatic Kidney Fat Removal system allows for reliable Fat removal and routine cleaning/sterilisation of the vacuum tool.

Working with CRF and MLA, MAR assisted with the commissioning of the first Robotic Kidney Fat Removal system originally installed at CRF by Food Science Australia with assistance from Meat & Livestock Australia. The Kidney Fat Removal Robot was the first Robot on an Australian Red Meat Processing Plant and the first of its kind in the world. The system as originally installed at CRF included the use of an ABB IRB 2400 industrial Robot System which, since MAR's involvement in the project, has been deemed under rated for the application.

However, since 2005 it was agreed that MAR would optimise this system, where possible, utilising the original robot. The system was improved by MAR to a point where the system had been operating in production for some time.

The above improvements did offer a system that operated continuously in production and that met production requirements (Fat Removal) for a large proportion of the processed lambs. However removal of more fat from the carcasses and in particular from larger carcasses was required. To do this effectively the system as a minimum must operate with increased suction and would require the robot to operate with higher load demands.

The following outlines the main improvements implemented in the 2nd Kidney Fat removal system installed at Peel Valley and in the system installed at JBS Australia, Brooklyn;

- New IRB 4600 Robot system can offer a payload capacity of 60Kg (> 300% increase)
- Improved sensing technology (laser) and software to provide an increase in efficiency "Remove more Fat". This additional sensing will allow for carcass variations to be identified providing a platform to implement variable robot programming paths and speeds.
- Reduced footprint of system allowing system to fit within more plants
- Increased capacity and improved vacuum system setup and installation configuration
- Improved guarding and safety systems
- New higher rated robot will offer the capacity of the system to operate with higher vacuum rates and increased efficiency and speed
- Cycle improvements utilising a robot system better suited to the task "Flexibility, Speed & Configuration"

1.2 Features and Benefits of the Robotic Kidney Fat Removal System

- Labour Reduction – 1 operator per working shift
- Line Speed – can operate +10/min
- Species – Lamb Sheep and Goat processing
- OH&S – reduced injuries and accidents
- Productivity - ensure fat removal from every carcass
- Efficiency – less rework for removal of kidney fat in boning after chilling
- Increased Yield – removal of more fat prior to weighing
- Hygiene – microbiological tests prove reduced contamination compared to manual operations

Production levels at the participating plants justifies the investment in the system and the recent inclination for Australian processing plants to participate in robotic developments shows the trend the industry is following towards further automation, fuelled by more acute labour shortages, which will likely get worse in the future.

1.3 Experimentation/Investigation work to date

Similar robotic, sensing and cutting technologies have or are currently being installed by MAR in the red meat industry for other small stock processing applications.

The approach as a whole is similar to these systems with the integration of sensing, robotics and adapted industry standard tool technologies performing the tasks. The differences between each process, does not allow for direct transfer of that technology, although the solution is not radically different.

MAR have implemented the learning's from the Peel Valley and CRF and other MAR installations such as the Sani-Vac systems to substantially improve the Kidney Fat Removal "Fat Sucker" robot system functionality.

2 Project Objectives

2.1 Project Summary

This project provides a solution to continue the development of the Robotic Kidney Fat Removal System and includes the manufacture, supply, installation and commissioning, of a Robotic Kidney Fat Removal System for JBS Australia, Brooklyn plant VIC, Australia as part of the development process.

The development of the Robotic Kidney Fat Removal system is currently in its defined Stage 2 development or assisted adoption phase with working systems now installed and in production at two plants in Australia.

The need to finalise and fine tune the development making it ready for commercialisation set the need for further R&D funding assistance from MLA and AMPC to install and test the Robotic Kidney Fat Removal system at this and one more Australian small stock processing plant.

R&D development for this installation will include the design modifications required to adapt the current development to make it suitable for the gambrel and carcass conveyor system used at Swift Brooklyn, plus continuous improvements in design to make technology ready for commercialisation.

The system for Swift offers different challenges including animal breed, site restrictions, line speed, chain types, gambrel variations, animal feed, customer specifications, fat removal specifications, available space, access and process location.

2.2 Project Purpose and Description

The Robotic Kidney Fat Removal system replaces the actions of the manual kidney fat removal process. When removing fat by hand, or using a manually operated vacuum, inconsistent results are produced.

An automated system will operate reliably and consistently to remove kidney fat for every carcass repeatedly increasing yields and improving down stream operations in the boning room where removal of fat is difficult to perform efficiently after carcass chilling.

The system will be located in the final trim area after final inspection but prior to weighing and grading stations where the carcass is presented hanging from its hind legs. The system is interfaced to an industrial robot and adopts the use of a specifically designed wand connected to a vacuum system.

Further development of laser profiling of carcass and mechanical compliance of the wand will take place to ensure the fat removal operation deals with carcass variations whilst the robot system tracks the conveyor, adjusting its position accordingly.

Improvements to ensure the system is easier to clean and maintain will be undertaken. The system will be designed to operate on a process floor environment where surfaces and materials used are adequately protected against wash down procedures and chemicals.

This robotic kidney fat removal system will be fully integrated and includes safety guarding, operator controls sterilisation and fat removal vacuum pump, all fully installed & commissioned ready for production.

The project consists of integrating these five main elements

- Carcass handling & stabilisation (Gambrels & Conveyor Rails)
- Sensing technology (partially developed)
- Robotic arm (commercial equipment)
- Vacuum/Fat Removal System (commercially available)

- Cell Safety System (plant specific)
- Design and manufacturing suitable gambrel guidance and stabilisation systems

At the completion of the project MAR will have achieved the following:

- Implemented the learning's from the PVE and CRF Kidney Fat Removal systems and other MAR RM installations to improve the Kidney Fat Removal robot system functionality.
- Tested and proved the solution at MAR in a controlled environment “FAT” prior to installation on-site.
- Implemented into JBS Brooklyn a fully functional robotic kidney fat removal system.
- Commissioned and trialed the system to achieve specifications according to client expectations.
- Satisfied the speed and accuracy requirements specified by the client.
- Trained operation and maintenance staff to competency in maintaining and operating the equipment
- Developed various commercial solution adaptations to suit processing plants Australia wide.

3 Methodology

The project will be progressed sequentially through set milestones:

Each milestone must be completed to the satisfaction of MAR, JBS Australia and MLA prior to continuation of the project, with some milestones having a GO / NO GO decision process attached to them.

Milestone 1 - Project Start-up and Prelim Designs

- Project risk assessment
  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,
- Submit proposed draft system design for approval.

Milestone 2 - System Components

- Purchasing of system components and delivery to MAR to begin system build integrating and programming.
- Robot, Robot Base Frame & Vacuum Head
- Kidney Fat Removal Vacuum system
- Control Systems and PLC and sensing
- Safety System
- Component Research & R&D includes Robot variants & Designs to suit plant specifics,

Milestone 3 - Carcass Stabilisation

- Design & Review Stabilisation System
- Manufacture & Installation of Stabilisation System
- Functional Test of Carcass Conveyor and Stabilisation systems
- Component Design, Manufacture & Trials to suit Plant Variants, processed species, gambrel types and line design

Milestone 4 - Sensing Trials On-Site

- Setup sensing systems on-site at proposed location for completion of test & trials.
- Vision and Sensing test & trials.
- Test & Trials of Sensing Technologies R&D to suit Plant Variants

Milestone 5 - System Build

- System Build & Installation for FAT at MAR
- Initial Programming, Robot and control system interfacing

- Manufacturing R&D to suit plant variants and to reduce complexity, cost and manufacturing techniques.

Milestone 6 - System Setup

- Mechanical & Electrical Setup & Test of System
- Setup & Test safety systems
- Test simulated robot operations
- Trial programming of robotic movements
- Manufacture Robot Protective Bag
- Integrate Sensing System
- Component Integration R&D to suit plant variant specifications

Milestone 7 - System FAT at MAR

- Factory Acceptance Testing of system at MAR prior to shipment to site for installation
- System Operation and Design Review
- Trial Simulated Operations
- Trial and troubleshoot programming scenarios
- Trial of cycle time
- Functional Operation R&D and improvements

Milestone 8 - Plant Setup

- Re-Location of existing Manual Workstations
- Prepare installation location
- Prepare system services including elect, water, waste

Milestone 9 - On-Site Installation of System

- Equipment Transport
- Installation of Kidney Fat Removal Vacuum system
- Robot & Equipment Installation
- Cabling and wiring
- Safety systems installation
- Site Integration

Milestone 10 - Commissioning and Trial

- Integration and Test of system components
- Test & Trial of Fat Removal Operations
- Trial and troubleshoot programming scenarios
- Production and cycle time trials
- Site support & Operator Training
- Process Improvement R&D

Milestone 11 - Presentation Video, Documentation

- Two sets of documentation including Electrical Drawings, System operation procedures, Safety Audit and Risk Assessments and Operation manuals will be provided upon commissioning.
- Conduct industry Site Visits. *(Requirements to be discussed with MLA)*
- System Videos, reports and documentation detailing the system, its components and operational procedure to be provided by MAR to MLA for industry dissemination and promotional purposes

4 Results and Discussion

4.1 Installation

The system was installed onsite at Brooklyn during June and July 2011. The images below show the installed cell.

Fig. 1 View of operator panel and the rear of the sanitization tank

Fig. 2 View of robot and sanitization tank with safety mat in the foreground

Fig.3 View of vacuum cyclone tank and diaphragm pump

Fig 4 View of Control panels located in control room

Fig 5 External views of cell showing guarding and cyclone tank

4.2 System improvements

All of the improvements that were incorporated into the Peel Valley Fat Removal system flowed through to the JBS System, these included:

- An IRB 4600 Robot system was used. This offered a payload capacity of 60Kg, more than a 300% increase on that used at CRF. This robot has allowed a more aggressive removal path, ensuring that the tool gets in around the rib cage without the robot torqueing out as was experienced at CRF.
- Improved piping and pump location, allowing more effective removal of fat from the system.
- Improved tool design and compliance, further modifications were made to the already modified tool at Peel Valley, and these are discussed below.
- Stabilization bar that supports the back of the carcass as the robot is removing fat. The bar at Peel Valley was required to be sterilized between each carcass, the bar installed at JBS Brooklyn does not need to be sterilized since it is positioned after final inspection.
- Improvements in guarding, further changes have been made here and these are discussed below.
- Improved laser sensing technology and software has allowed carcass variations to be identified and variable robot positioning and paths to be implemented.
- Reduced footprint
- Improved safety system
- Cycle time improvements to meet the plant production rates, this has been achieved via the improved sensing and utilising a robot system better suited to the task "Flexibility, Speed & Configuration".
- A compliance mechanism was used in the tooling connection to the robot roll face this provided full 360 degree compliance and improved system flexibility. Modifications to the system used at Peel Valley have been made and are discussed below
- The spray tank was mounted on the fence at operational height, decreasing robot moves and increasing the time the robot has to work on the carcass.

4.2.1 Guarding

As can be seen from the image below perforated stainless steel guarding has been preferred in this installation over the traditional Perspex guarding. The Perspex has a tendency to crack and become scratched due to cleaning and the use of hot water and caustic wash down chemicals. The perforated stainless steel guarding used provides the same protection and good visibility into the cell without the issues associated with Perspex.

Fig.6 Perforated Stainless steel guarding

4.2.2 Tool Design

The images below show the tool design as used at Peel Valley and the revised tool as used at JBS Brooklyn. The major changes that can be seen are:

- The compliance mechanism has been simplified with the spring mechanism being replaced with off the shelf rubber mounts, making replacement simpler and easier should it be necessary.

- The tail end of the tool has been angled out to avoid damage to the hose and issues with the hose contacting the carcass.

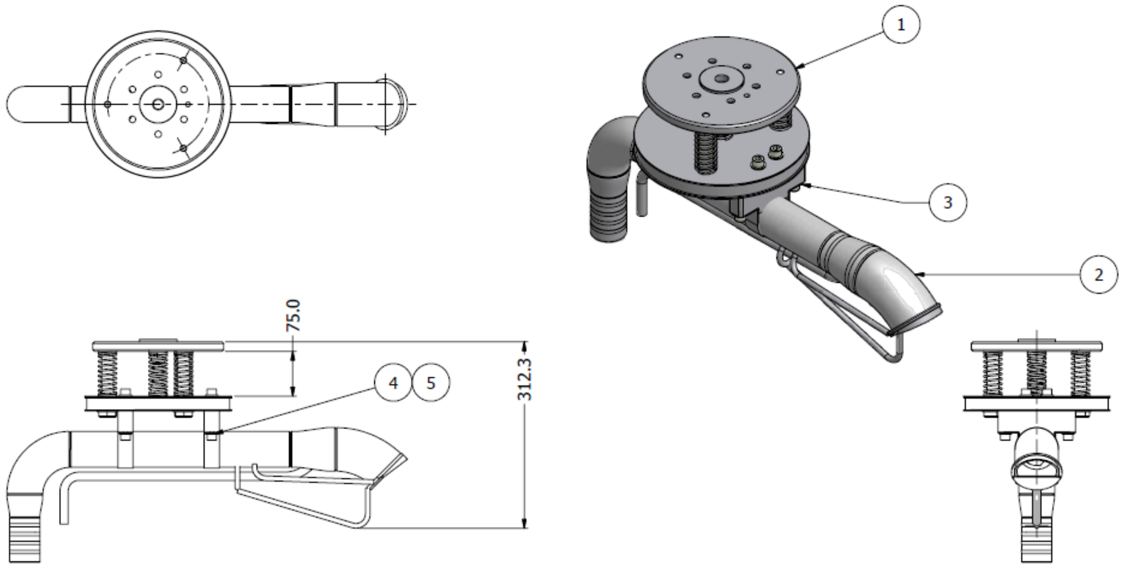

Fig.7 Tool design used at Peel Valley

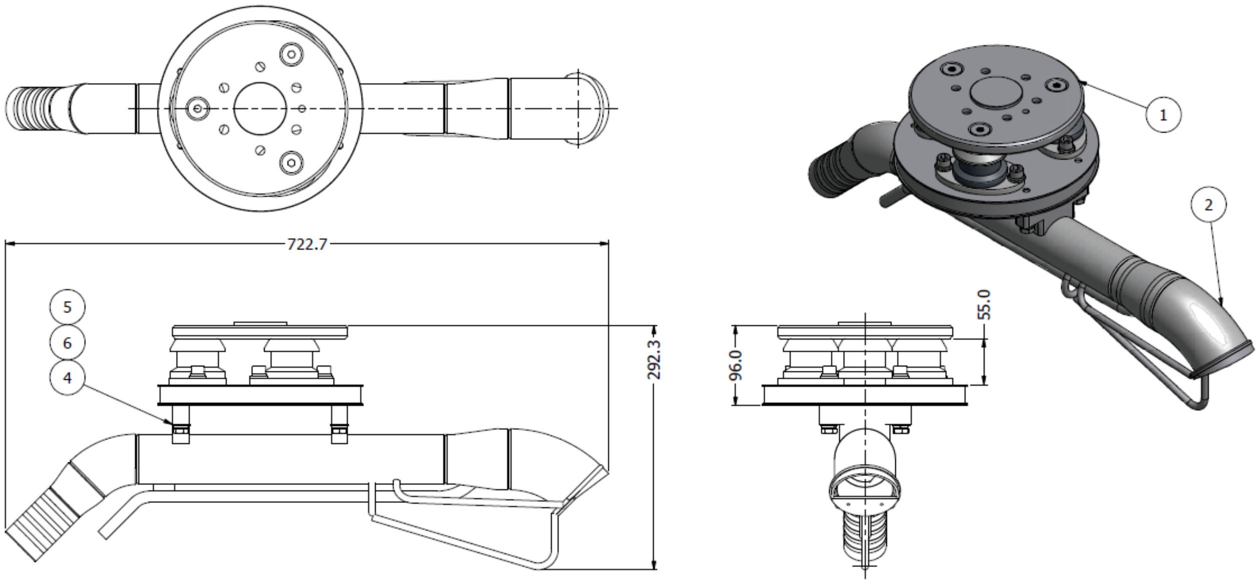

Fig.8 Tool design used at JBS Brooklyn

4.2.3 Site Commissioning

The aim during commissioning was to achieve a better result than was achieved at Peel Valley, particularly in the anal cavity area.
The nose of the tool at the commencement of commissioning was unchanged from that used at Peel Valley and is shown below.

Fig.11 Original tool nose piece as used at Peel Valley

During commissioning it was found that it was difficult to remove the fat in this anal cavity area and that there were ‘strings’ of fat being held on by sinew/membrane left inside the carcass particularly on larger animals.

Fig.12 String of fat left inside the carcass

To overcome these issues various modifications were made to the nose of the tool. Attempts were made to reduce the size of the opening to increase the velocity of the air flow through the tool, inverted ‘teeth’ were added in an attempt to capture the string of fat as the tool pulled away and scrapers were added in an attempt to provide more of a ‘finger nail’ effect.

Each of these modifications had varying impacts:

- Reducing the size of the opening did increase the flow but also had an effect on the size of material that could be sucked down the tool. Vacuum lock was created on a number of occasions which lead to poor results.
- The inverted teeth did reduce the strings of fat being left behind but also had a tendency to damage the tenderloin as it was sucked against the tool.
- The initial scraper that was welded into position worked well but JBS requested that this be made removable so that it could be swapped out when it became worn. The

removable piece created problems with fat being caught on the lugs that were needed to hold the piece in place and in gaps between the removable piece and the tool.
- The second scraper that was added improved the quantity of fat removed but damaged the tender loin in the process.

Following the limited success of these modifications the nose of the original tool was modified so as to give it an edge and the ‘finger nail’ effect required and a small modification was made to the robot program to bring the paths closer into the spine. These changes eliminated the stringy piece of fat being left behind and removed an acceptable quantity of fat from the anal cavity as well as the rest of the carcass.

PVE

JBS Brooklyn

Fig.16 Results achieved at Peel Valley and at JBS Brooklyn, note improved fat removal from anal canal.

4.2.4 Gambrel/Carcass Stabilisation

The images below show the form of gambrel/carcass stabilization used at Peel Valley. The top bar in the first image is designed to stop the gambrel ‘skipping’ ahead of the chain dog as the carcass is processed by the kidney fat removal tool or ‘swung’ into the robot system by the operator performing the previous task. The lower bar stops the gambrel and hence the carcass from rotating while in the robot system. The second image shows the support bar used at Peel Valley to prevent excessive carcass movement during fat removal.

Fig.17 Gambrel and Carcass stabilization as used at Peel Valley

Fig.18 Carcass support bar at Peel Valley to prevent excessive movement of the carcass during fat removal

A different approach was required at JBS Brooklyn due to the metal gambrels that are used. The images below show the three types that are used on site.

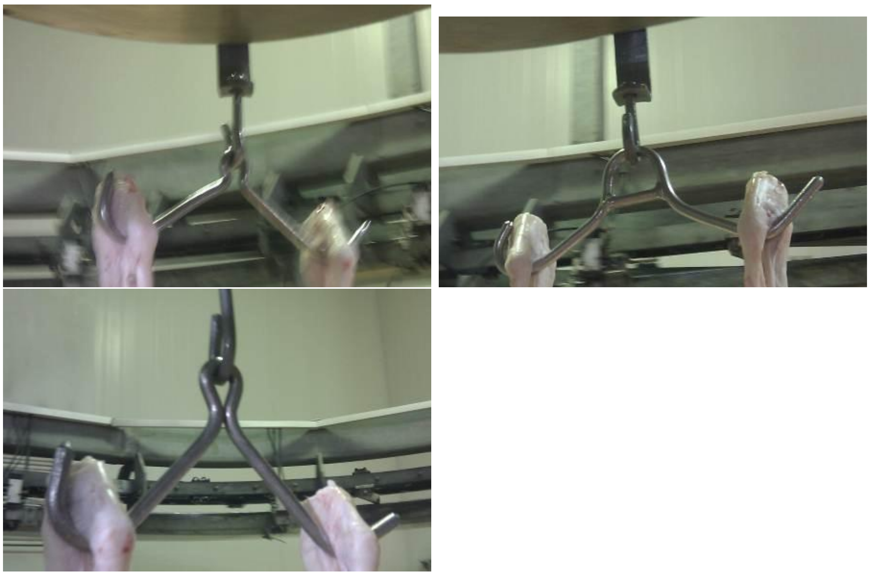

Fig.19 Various stainless steel gambrels used at JBS Brooklyn

The initial install consisted of the hard plastic rub bar, shown below, to rub against the top part of the gambrel and inhibit the gambrel from skipping forward ahead of the drive dog, as well as the carcass back support bar shown in Fig.19 used to prevent excess carcass movement while in the robot system. This bar had no need for sterilisation between carcasses as was required at Peel Valley since the system was installed after final inspection.

Fig. 20 Initial gambrel Stabilization used at JBS Brooklyn

Fig. 21 Back support bar

Issues arose with this method of stabilisation when burrs on the gambrels damaged the rub bar and caused contamination of the carcasses the damage can be seen in the image above.

The rub bar was removed and replaced with the guidance mechanism shown below, the aim here was to contain the ‘hook’ part of the gambrel to prevent it from ‘skipping’ forward. This also had the added advantage of preventing the gambrel and hence the carcass from rotating while in the robot system.

Fig.22 Second stabilization mechanism trialed

This method had issues as it went into production due to the different lengths of flat bar used on the different gambrels, as can be seen in the image below, and caused major problems when the carcasses were hung on plastic gambrels when supply of the steel gambrels ran low.

Fig.23 Different length of flat bar on gambrels used at JBS Brooklyn

The third and final method tried is shown in the image below. Here a stainless steel round bar pushes against the hind legs or the carcass, this creates enough friction to stop the ‘skipping’ ahead of the gambrel and also inhibits carcass/ gambrel rotation. The bar does not need sterilising between carcasses since the system is after final inspection.

Fig.24 Final stabilization method used.

5 Success in Achieving Objectives

MAR has achieved the objectives of this project by the successful implementation of the Kidney Fat Removal System into JBS at Brooklyn, specifically MAR has:

- integrated the learning's from PVE and CRF Kidney Fat Removal systems as well other MAR RM installations to improve the Kidney Fat Removal robot system functionality.
- tested and proved the solution at MAR prior to shipping to site
- Commissioned and trialed the system onsite and achieved the required level of fat removal and cycle time as specified by JBS Brooklyn.
- Trained the operation and maintenance staff to a level where they are competent in maintaining and operating the system.
- Adapted the equipment to suit the stainless steel gambrel system at JBS Swift. This combined with the setup at Peel Valley would cover the setup required to install a Kidney Fat Removal System at the majority of small stock processing plants in Australia.

The aim of achieving improve fat removal, particularly in the anal cavity area, from the Peel Valley System was also realised, as can be seen in the comparison images below.

PVE

JBS Brooklyn

Fig.25 Results achieved at Peel Valley and at JBS Brooklyn, note improved fat removal from anal canal.

6 Impact on Meat and Livestock Industry – now & in five years time

Benefits to be achieved by utilization and continued development of the Robotic Kidney Fat Removal System include:

- Improvements in OH&S;
  - Elimination of risk of operator strain injury from the size, weight and repetitive tasking
  - Elimination of dangerous operational practices
- Consistency;
  - Robotic mounting and control of the fat removal process improves accuracy and repeatability over manual removal systems
  - Improved sensing technology (laser) and software to provide an increase in efficiency "Remove more Fat". This improved sensing allows carcass variations to be identified providing a platform to implement variable robot positioning and paths.
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Reliability and accuracy, along with processing speed which are critical to the success and acceptance of this technology have been achieved throughout this project.
Production levels at plants such as JBS Brooklyn justifies the investment in a robotic system and the recent inclination for Australian processing plants to participate in robotic developments shows the trend the industry is following towards further automation. This is fuelled by acute shortages in labour supply, which will likely get worse in the future.

7 Conclusions and Recommendations

It is evident from the discussion and images shown throughout this report that the Kidney Fat Removal System installed at JBS Brooklyn is very much a success. Improvements have been made to the guarding and tooling and modifications have been made to the gambrel/carcass stabilisation system to make it suitable for use with stainless steel gambrels. MAR would recommend adoption of this system in further plants.