final report

Project code: P.PSH.480

Prepared by: Gavin Inglis

Machinery Automation and Robotics

Date submitted: December 2011

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Robotic front hock cut, hind hock cut and neck wash system

This is an MLA Donor Company funded project.

Meat & Livestock Australia and the MLA Donor Company acknowledge the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

The process of Neck Tipping, Hock Cutting and Hock Tipping are typical cases of tasks in the Meat Industry that are arduous to all operators and due to the requirement of accuracy to maximise yield can not be performed by an unskilled person. They are also examples of tasks that, because of improved visioning and sensing capability, can be automated. The aim of this project is to substitute human operators with an automated system performing these tasks.

Due to various factors, the cell, at the time of the writing of this report - 20/12/11 -, was not being used in production. Issues with the Hock saw and synchronisation for the front and rear leg chains have lead to problems with the cutting and tipping of hocks. MAR is currently working with Peel Valley to resolve these issues.

Executive Summary

The process of Neck Tipping, Hock Cutting and Hock Tipping are typical cases of tasks in the Meat Industry that are arduous to all operators and due to the requirement of accuracy to maximise yield can not be performed by an unskilled person. They are also examples of tasks that, because of improved visioning and sensing capability, can be automated.

Potential benefits to be achieved by a automating the Front Hock Cut, Hind Hock Cut & Neck Tipping operations include:

- Improvements in OH&S;
  - Elimination of risk of operator strain injury from the size, weight and risk of trauma injury from the cutting blade
  - Elimination of dangerous operational practices
- Consistency;
  - Robotic mounting and control of the cutting systems used for the applications will provide improved cutting accuracy and repeatability over systems controlled by hand
- Improved yield through;
  - minimises waste product through;
    - improved cutting line accuracy
    - greater cutting line consistency
  - flexibility of system to change cutting specifications upon requests
- Labour cost:
  - The system will replace 2-3 units of labour per shift.

Two robots one with a Neck Washing tool and another with a Hock Tipping tool along with a saw on a linear slide, a cut hock flicking mechanism and 2 vision systems were installed at Peel Valley Tamworth. After some modifications to the tooling the system was commissioned successfully and has been put into production. However after approximately one month in production it became evident that there were issues with the hock cutting saw and problems being created by the out of sync running of the front and rear leg chains. MAR is currently working with Peel Valley to resolve these issues.

Contents

1 Background

The success of recent projects, industry open days to demonstrate automation and a European technology tour with MLA and various Australian Processors prior to the commencement of this project served, among other things, to illustrate how current technology can deliver clever solutions to automate manual tasks. Examples of these are neck tipping & hock cutting. These are typical cases where the tasks can be replicated by an automated system.

The tasks are arduous to all operators and due to the requirement of accuracy to maximise yield can not be performed by an unskilled person.

Food Science Australia (FSA) conducted Vision and Laser Sensing System trials to determine suitable sensing systems for the development of a Sheep Neck Tip and Hock Cutting system. These trials proved to be successful and it is recommended that a system be developed to perform two Hock cutting and one Neck tipping Task within a singular working cell.

Benefits:
Potential benefits to be achieved by a automating the Front Hock Cut, Hind Hock Cut & Neck Tipping operations include:

- Improvements in OH&S;
    - Elimination of risk of operator strain injury from the size, weight and risk of trauma injury from the cutting blade
    - Elimination of dangerous operational practices
- Consistency;
    - Robotic mounting and control of the cutting systems used for the applications will provide improved cutting accuracy and repeatability over systems controlled by hand
- Improved yield through;
    - minimises waste product through;
        - improved cutting line accuracy
        - greater cutting line consistency
    - flexibility of system to change cutting specifications upon requests
- Labour cost:
    - The system will replace 2-3 units of labour per shift.

Reliability and accuracy, along with processing speed are critical to the success and acceptance of this technology.

The production levels at Peel Valley Exporters, justifies the investment where labour savings alone is estimated at over $150,000 per shift per year.

Peel Valley Exporters recent inclination to participate in robotic developments shows the trend the industry is following towards further automation, fuelled by more acute shortages in labour supply, which will likely get worse in the future.

2 Project Objectives

The objective of the project is to substitute human operators with an automated system doing the same tasks.

Additionally, the project includes the design and manufacture of proper stabilisation structures, lighting and backing boards for vision and sensing equipment to keep the carcase in a consistent accurate position, allowing the correct sensing and cutting operations.

This project will utilise vision systems and/or 3D profiling to detect the carcase and accurately cut the Hocks and Necks with tools attached on the end of two separate robots.

As a base the project consists of integrating the following main elements

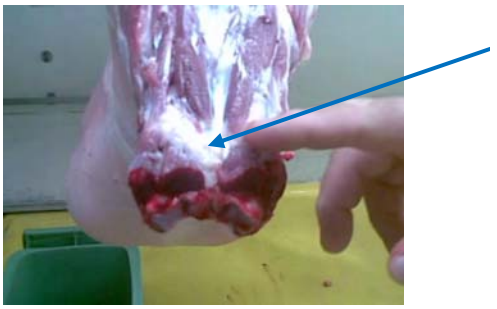
- Carcase handling & stabilisation (Rails & Backing Boards)
- Sensing technology (partially developed)
- Front Hock Cutting and Neck Tipping Robot (commercial equipment)
- Hind Hock Cutting Robot (commercial equipment)
- Fore Hock Cutting and Neck Tipping Cutting tool (specific to application with some components commercially available)
- Hind Hock Cutting tool (specific to application with some components commercially available)
- Cell Safety System (plant specific)

2.1 Process Specifications

The system will be designed to operate at rates no less than 8.5 carcase/min

(cycle includes each cutting process, sensing operation, carcase handling and sterilisation of blades)

2.1.1 Neck Cut/Neck Tipping



- Specified Neck Cutting Location
  OR
- Cut 10 – 15 mm above neck extremity
- Variable cut line specification if required

Fig. 1 Specified Neck Cut Location

2.1.2 Front Hock Cut

- Cut location is the hock joint
- Variable cut line specification if required

Fig. 2 Specified Front Hock Cut Location

2.1.3 Hind Hock Cut

- Cut above gambrel
- Variable cut line specification if required

Fig. 3 Specified Rear Hock Tip Location

3 Methodology – Design Phase

Designs shown in this section describe the original designs that were implemented, changes and modifications to these designs that were made throughout the project are described in the following section.

3.1 System Layout

A number of layouts were presented and discussed with Peel Valley, considerations that were to be taken into account included:

- Modifications to the platforms required for the neck trimmer and bung cutter
- Proximity and access to chain sprocket
- Space requirements for rear gambrel up operator
- Space requirements for camera system, robot and Front Hock Cutting mechanism.
- Space requirements needed should an operator be required to manually perform operations in case of cell break down.

The layout below was the one agreed upon:

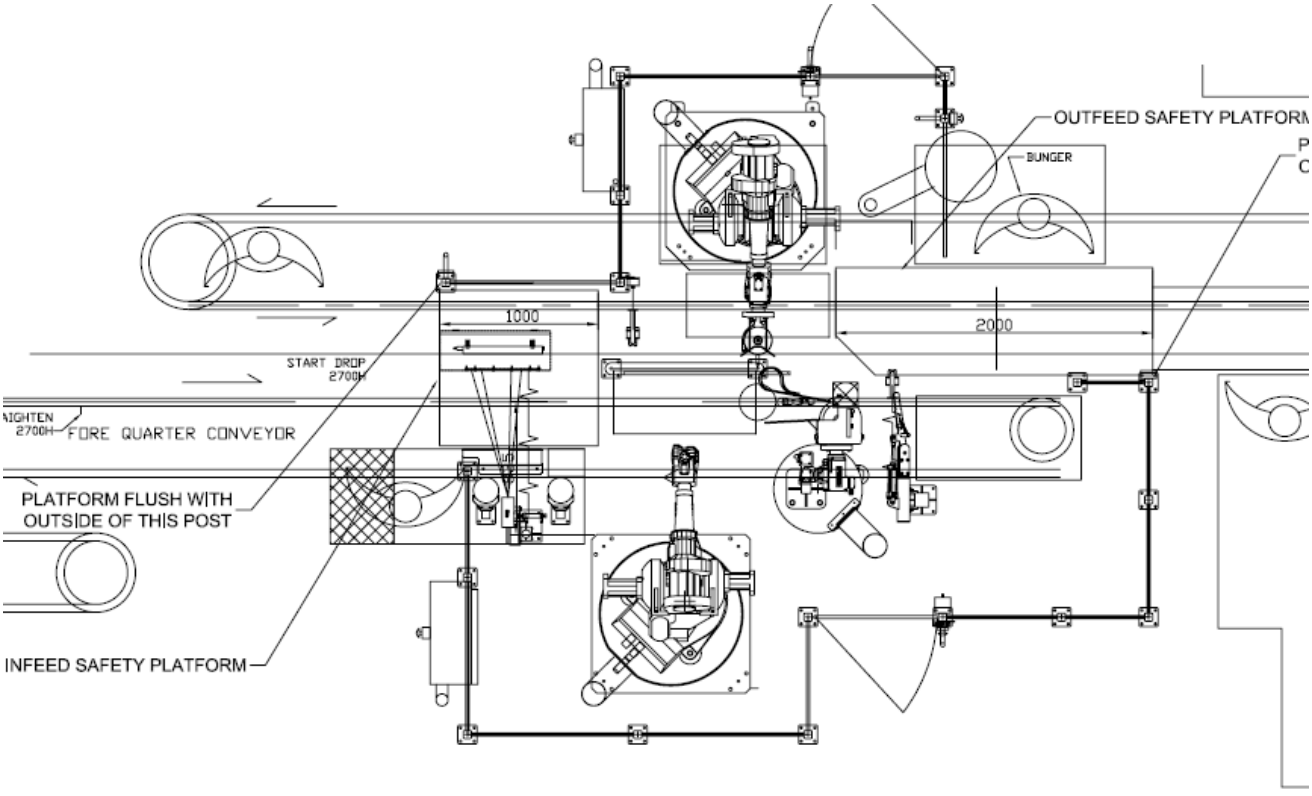


Fig. 4 System Layout

3.2 Tool Design

3.2.1 Front Hock Saw

The following images show the design of the Front Hock Saw:

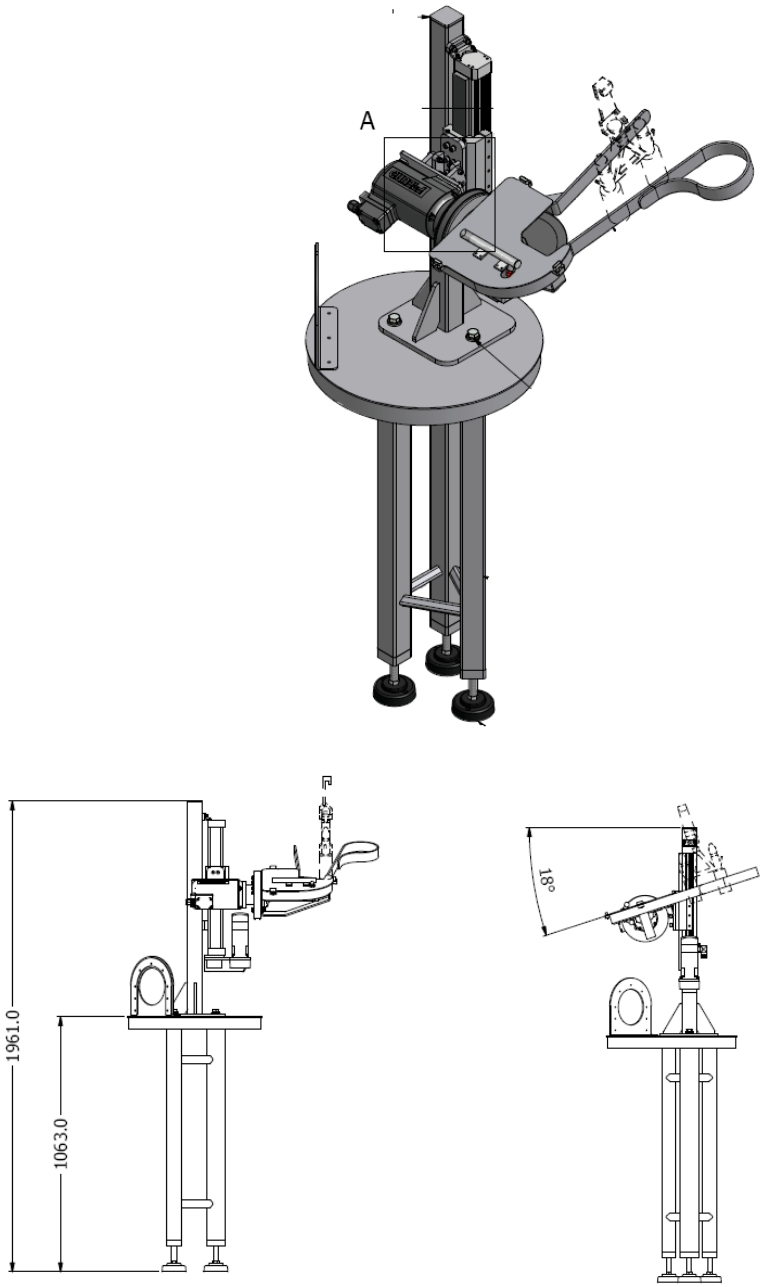


Fig. 5 Front Hock Saw Design

The saw and blade were purchased from Freund in Germany and it can be seen from the images above that:

- The saw is mounted on a linear slide to allow vertical adjustment for different height hocks
- The cutting blade is angled to account for the angle of the rail as it declines to the chain return sprocket.
- The guides at the front of the saw are designed the guide the front legs to the correct cutting position in front of the saw blade
- The saw blade will be washed between carcases within the confines of its cover. The pipe work for this can be seen on the drawings above.

3.2.2 Neck Tipping Tool

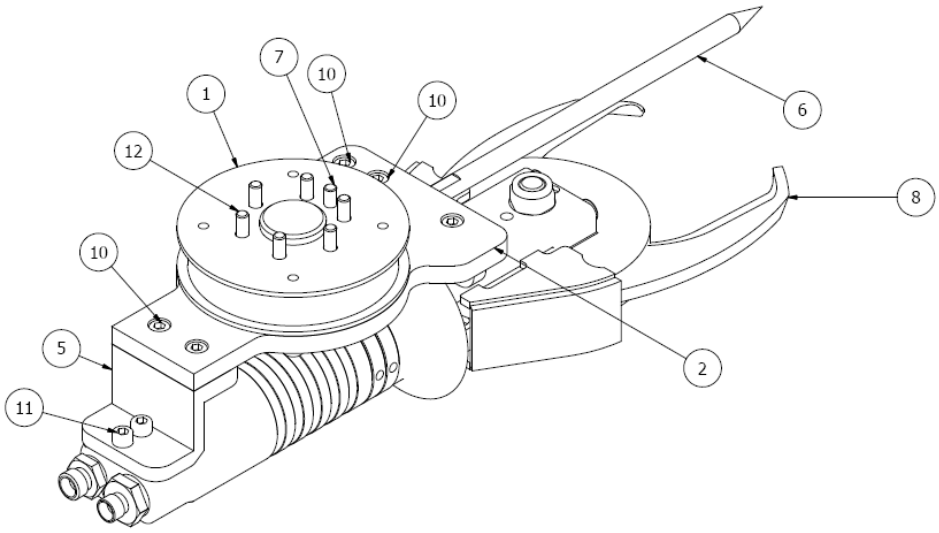


Fig. 5 Neck Tipping Tool Design

The above shows the design of the neck tipping tool. The tool body and cutting blades were purchased from Freund and an adaptor palate manufactured to make it suitable for robot mounting. Item number 6 in the above drawing is the robot pointer tool and is used for robot setup it is removed once the tool is in operation.

3.2.3 Hock Tipping Tool

The image below shows the hock tipping tool design. Again the saw and saw blade are purchased from Freund with the adaptor plate for robot mounting and deflection plate for guiding the Hock Tips away from the blade after being cut being manufactured items. Again the pointer tool is shown in this image and is removed for production.

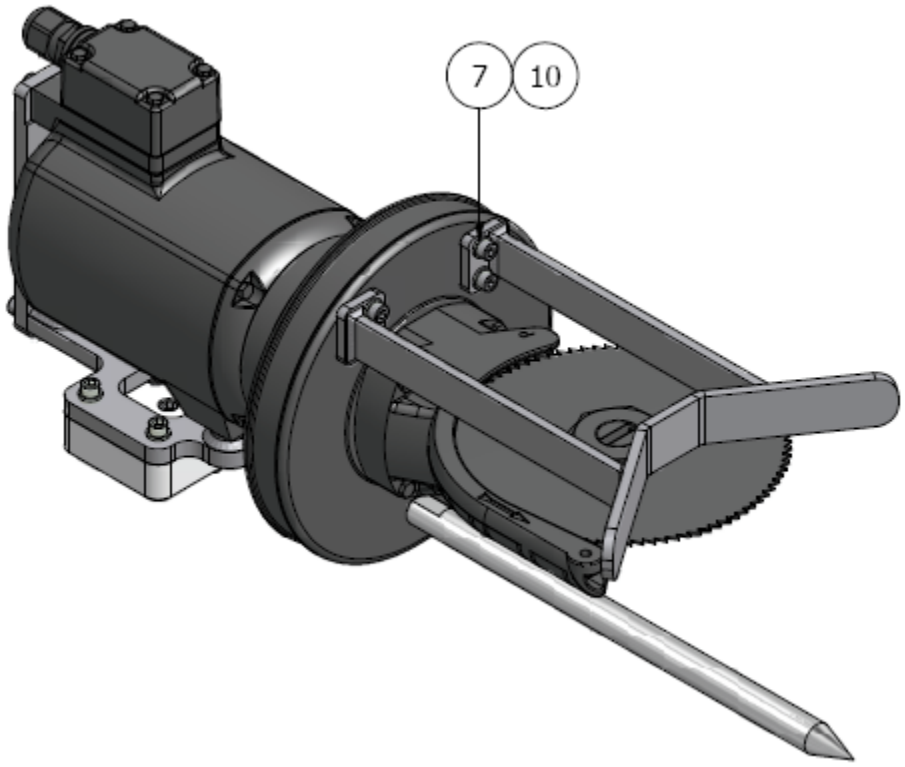


Fig. 6 Rear Hock Tipping Saw

3.2.4 Hock Flicker

The image below shows the ‘Hock Flipper’ designed to remove the front hocks from the gambrels after the hocks have been removed from the carcase. The operation of this hock flicker is such that it actuated as the gambrel passed to flick the front hock of and then retracted the remove the second hock, a video of its operation is shown on the accompanying CD.

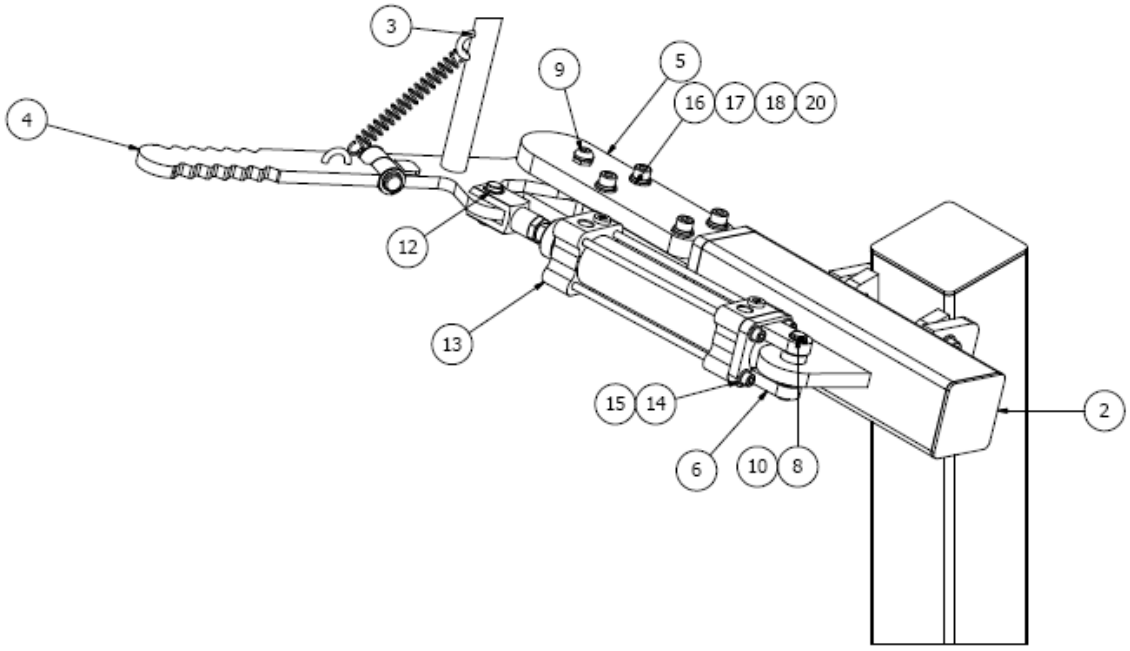


Fig. 7 Front Hock Flicker

3.2.5 Carcase Stabilization

Stabilisation of the carcase was deemed necessary for all three processes in this project. The issue that was observed during site visits and the vision trial process was that if the chain dog on the hind leg chain, used to guide the plastic gambrels, is slightly lagging the corresponding foreleg gambrel, the plastic gambrel, and hence the rear of the carcase tends to get pulled along the rail ahead of the chain dog. This will create issues for the Hind Hock tipping process where the robot is tracking the carcase according to chain speed and potentially effects the position of the neck and front hocks as the rear of the carcase is 'jerked' along. A stabilisation bar has been designed installed on site with a view to inhibiting the plastic gambrel from moving ahead of the dog. The aim of the mechanism is to apply enough force to retain the gambrel so that it does not get pulled ahead by the front of the carcase but allows the chain dog to move it forward at chain speed. An image of the mechanism is shown below.

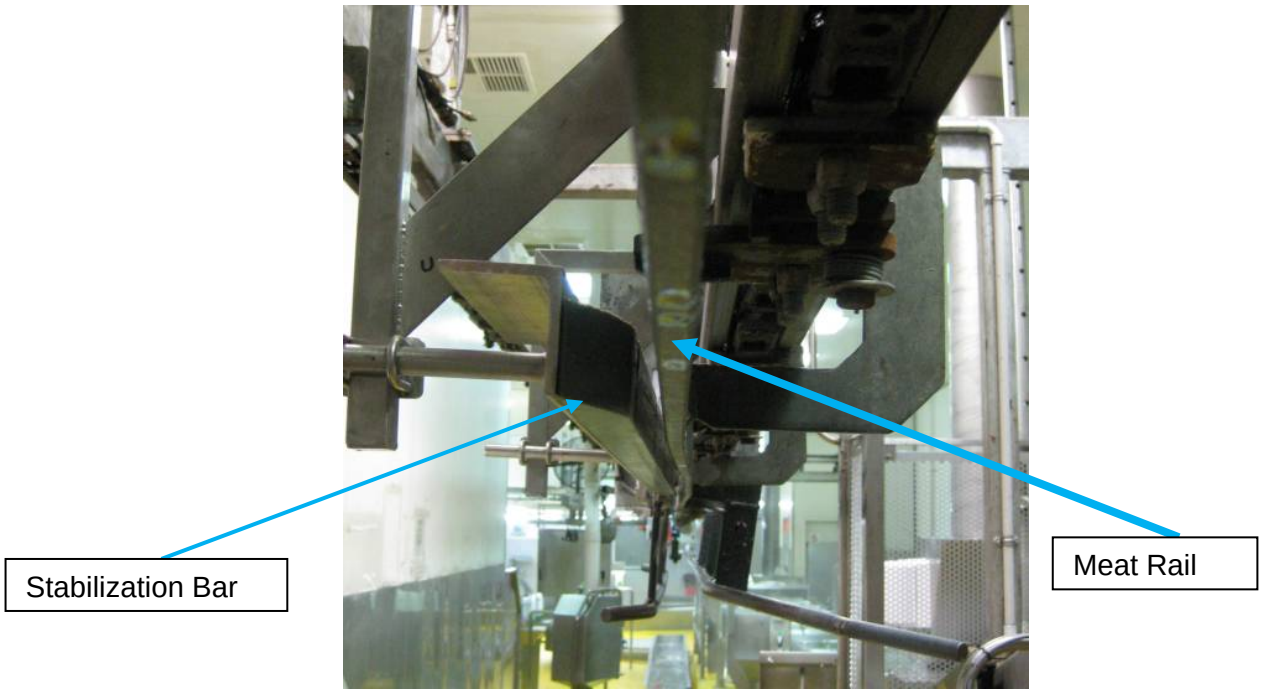


Fig. 8 Rear Gambrel Stabilization Bar

3.2.6 Vision and Sensing

The Robotic Front Hock Cut, Hind Hock and Neck Tipping System has been designed to use two different vision systems to perform the required Front Hock Cut and Neck Tipping operations. The Front Hock Cutting uses a standard vision camera and software with a back light to locate the required cut position while the Neck Tipping Operation utilises a TYZX Stereo Vision Camera.

Results and Discussion

Installation of the system occurred during May and June 2010, the sections below describe modifications and redesign that occurred following this initial installation

3.3 Front Hock Saw

The saw was installed onsite and experienced a number of a number of strength and reliability issues. Redesign of the mounting and guide mechanisms of the saw assembly followed and the final design is shown below

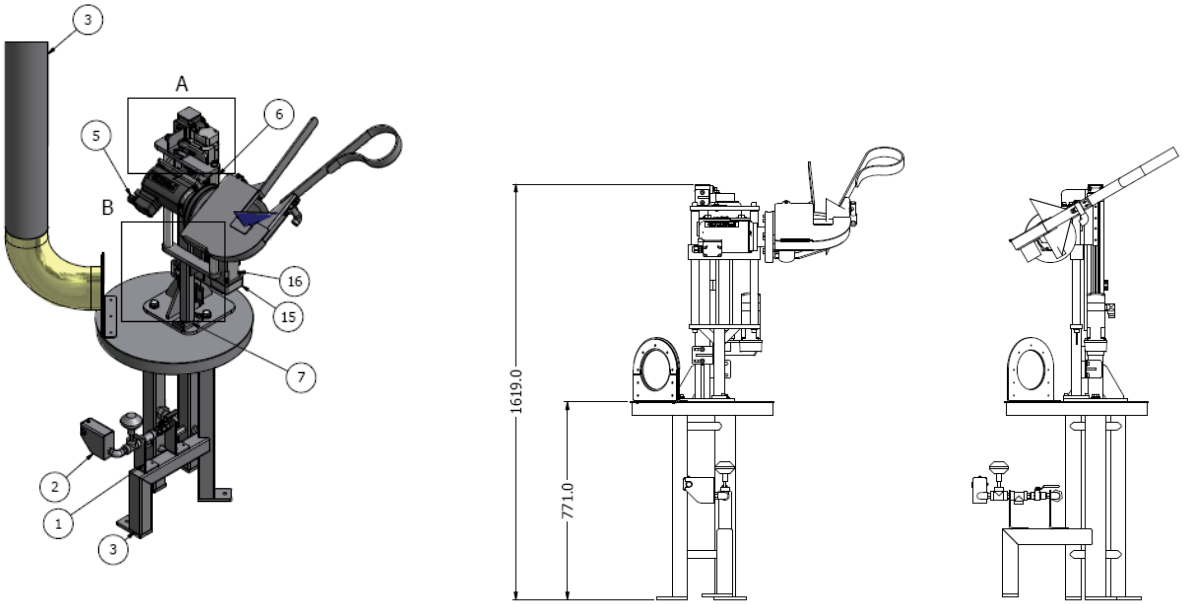


Fig. 12 Front Hock Saw revised design

This strengthened version ran onsite for approximately a month before issues with saw bearings and synchronization of the front and rear leg chains caused use of the saw to be halted. MAR is currently working with Peel Valley with a view to replacing the saw and correcting the chain synchronisation.

3.4 Neck Sanitisation

In parallel with this project MAR were also conducting Neck Vac San trails (P.PSH. 0543) and separate unfunded Neck wash trials. Neck Vac Sanitising or washing is seen as an advantage in that it removes the necessity to cut the tip off the neck therefore increasing yield. These Neck wash trials used a third party, Food Safety Services (S.A.) Pty Ltd, to conduct testing on four small stock carcase groups with four different processing techniques for sanitising the neck area:

Group 1 - Tipped necks – currently approved process

Group 2 - High pressure washing with cold water followed by steam treatment using SanVac technology – novel process.

Group 3 - High pressure washing with hot water followed by steam treatment using SanVac technology – novel process. (See note A)

Group 4 - High pressure washing with Twin Oxide – novel process.

The data obtained from the microbiological sampling and testing that followed the trials was assessed by Food Safety Services (S.A.) Pty Ltd. This assessment showed that there was little statistical difference between the four procedures assessed and that on the basis of this it can be determined that all of the proposed alternate neck sanitisation techniques do give equivalence to the current tipping technique. Of this (since twin oxide is not allowed to be used in EU markets) the treatment used in Group 2 above (High pressure washing with cold water followed by steam treatment using SanVac technology) was the recommended treatment.

MAR gained approval from AQIS for the use of this process and designed and manufactured the tool shown below.

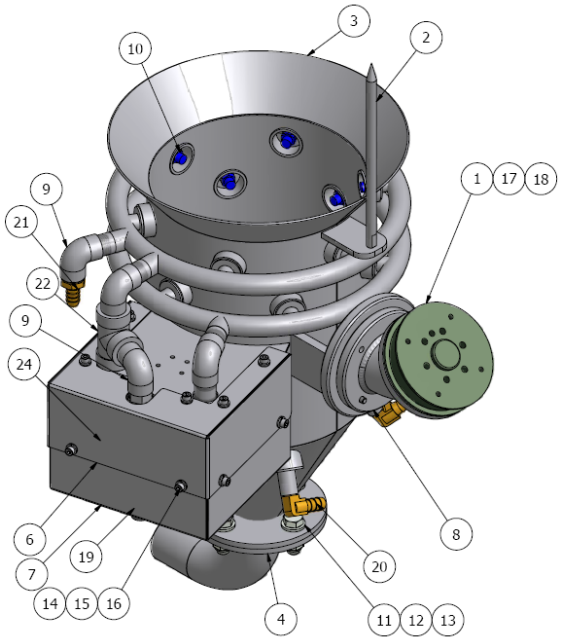


Fig. 13 Neck Wash Tool Design

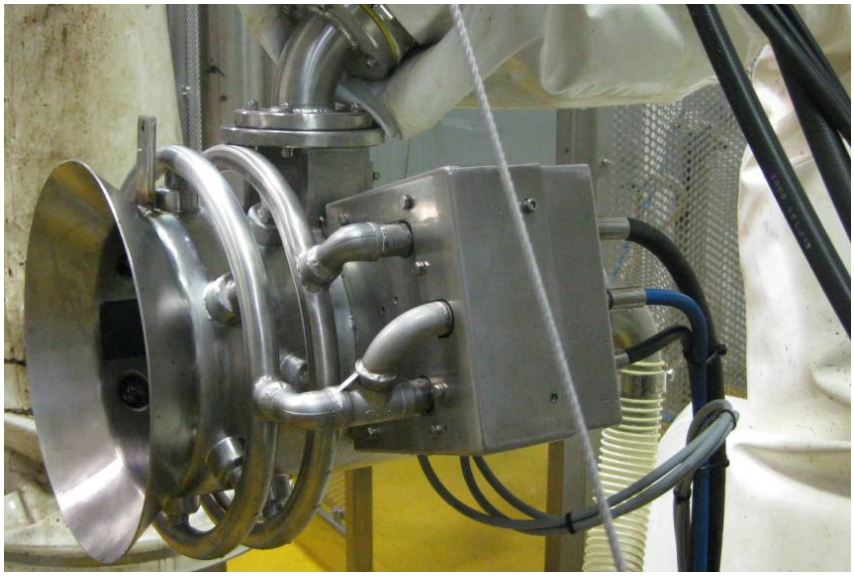


Fig. 14 Neck Wash tool installed

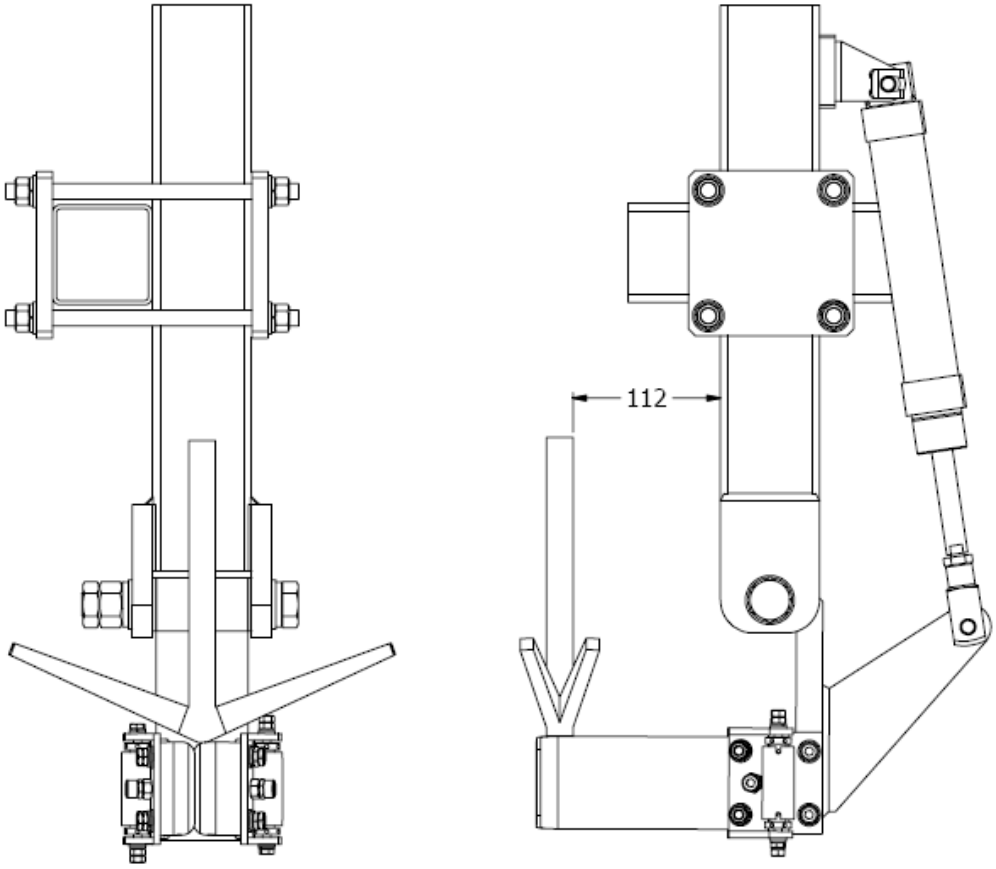
3.5 Hock Tipping

When the designed tool was installed onsite and testing began it was soon realised that the dustless blade that was fitted to the saw was not going to effectively cut the tips off the rear hocks. Changing the blade to a tipped or toothed blade was not an option since it was not possible to guard the blade to collect the bone dust that would be generated and still effectively cut the tips. The decision was made to change the operation from a saw to a pair of clippers and the clipping tool that was originally to be used for the Neck Tipping operation was utilized for the rear Hock tipping. The image below shows the tool that has been commissioned. This is now capable of running in production however is not being used due to issues associated with the chain synchronization.

Fig. 15 Rear Hock Tipping Tool installed on site

3.6 Hock Flicking

Due to the speed of the line and the angle of the conveyor (declining towards the chain return sprocket), issues were experienced with the original design for removing the cut hocks from the gambrels. Redesign was under taken and the new flicker mechanism is shown below:



Front view Side view

Fig. 16 Redesigned Front Hock Flicking mechanism

The new design has flipper arms that actuate from under the gambrel and between the two hocks sliding along the underneath of the gambrel to remove the hocks. This Hock Flipper ran in production, but experienced issues with control of the hocks after they were removed from the gambrel.

4 Success in Achieving Objectives

The project has successfully achieved the following objectives. It has successfully integrated

- Carcase handling & stabilisation equipment
- Sensing technology
- A Robot for Neck washing and Rear Hock Tipping
- A Cell Safety System

Issues were experienced however with the

- Linear guided saw for Hock cutting and the thinking now is that this will be replaced with a dual hock cutter
- Chain synchronization

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

MAR is currently working with Peel Valley to rectify the issues with chain synchronisation and hock cutting tooling. Potential benifits to be achieved by utilization and continued development of the Robotic Front Hock Cut, Hind Hock Tip and Neck Wash System are as follows:

- 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 processes improves accuracy and repeatability over manual systems
  - Improved sensing technology (laser) and software allows carcase variations to be identified providing a platform to implement variable robot positioning and paths.
- Labour cost:
  - The system will replace 2 units of labour per shift.
- Line Speed:
  - The system can operate at line speed >10 carcases/min.
- Species:
  - The System is suitable for use in lamb, sheep and goat processing
- Yield gain:
  - The system has achieved a yield gain through the elimination of the Neck Tipping process
  - The System minimises waste product through;
    - improved cutting line accuracy
    - greater cutting line consistency

Production levels at plants such as Peel Valley 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.

6 Conclusions and Recommendations

As can be seen from the discussion above the installation of the Robotic Front Hock Cut, Rear Hock Tip and Neck Wash System has suffered from issues throughout the commissioning phase of the project and the system is currently not being used in production.
A different approach to the Hock Cutting process has been put forward by Peel Valley, and MAR are in discussions with Peel Valley about integrating the proposed tooling with the existing cell.
Upgrades to the chains on site are also being discussed with a view to rectifying the synchronization issues.