final report

Project code: P.PIP.0323 Tamim

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Date submitted: August 2013

PUBLISHED BY

Meat & Livestock Australia

Limited Locked Bag 991

JBS BEEF LOIN SAW MK II

This is an MLA Donor Company funded project.

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

JBS in conjunction with Scott, MLA and AMPC proposed to take the lessons learned from a previous project PIP.0271, ‘Beef loin saw’, which concentrated on developing a safe bandsaw device to process grass fed beef striploins, and develop a beef striploin saw Mark II and apply it across the broader grass and grain fed processing facilities. The MKII system was reverse engineered and manufactured, to allow for greater robustness and durability. The system was trialled and minor modifications were required to allow for the varying sizes of products and the device was proven to run, safer, with additional yield whilst maintaining throughput. The MKII has delivered the required improvements sought by all stakeholders and still retained at least the $4/head processing benefit of the MkI unit.

Executive summary

There are significant yield and operator safety issues associated with the manual processing methods for deboning beef striploins. In 2011, Scott Technology (Scott) in collaboration with JBS Australia (JBS), Meat and Livestock Australia (MLA) and the Australian Meat Processing Corporation (AMPC) developed a Striploin Saw MKI by modifying an existing bandsaw with a triangular cutting path (using three wheels) rather than the typical oval cutting path (using two wheels). This configuration allowed for the striploin to be cut at the best angle possible for meat recovery.

This MKI system was redesigned and a MKII system was developed to be trialled on larger grass and grain fed beef carcases at another JBS site (Brooklyn). The system was to process larger grass and grain fed beef whilst focusing on three key deliverables:

1. Operator safety.
2. Additional yield and revenue across the entire range of grass fed beef.
3. Maintain throughput capacity.

In addition to processing a larger range of carcase sizes, all of the learnings of the MKI were taken into consideration for the MkII design. These included; a simpler, lighter, safer and more compact solution from a footprint perspective. This unit was installed into the JBS site where production trials were undertaken.

During the trialling phase of the project, the system was installed into a secluded area in the JBS beef boning room for offline trialling. Operational staff received training on the safe operating procedures of the system and the maintenance staff were given a brief overview of the system's major components.

During the offline trials, minor system modifications were required. The handles and clamps were modified to ensure maximum grip of product and the laser light positions were tweaked to ensure accuracy of cuts. As a result of the modifications, the system operated safely at optimal speeds, with increased yield output and faster cycle times. Once all modifications were completed, the system was moved and installed into its final position in the production line.

The Striploin saw MKII proved it could process larger grass and grain fed product whilst ensuring operator safety, increasing yield and maintaining throughput capacity.

Since the conclusion of the MkI unit, Greenleaf Enterprises Pty Ltd has undertaken an independent cost benefit analysis and determined a $4 per head benefit in using the Scott Striploin saw when compared with manual table boning. The MkII has retained these benefits, if not slightly improved them.

	Table Boning	Scott's Loin Saw
Capital cost	$0	$98,000
Gross return Per head	$1.92	$4.05
Total costs Per head	$0.00	$0.06
Net Benefit Per head	$1.92	$3.99
Net Benefit / cobotic unit	N/A	$1,422,686
Annual Net Benefit for the plant	$687,201	$1,422,686
Pay back (months)	0.00	0.83
NPV	$4,103,483	$8,476,843

Figure 1: Extract from Greenleaf report (Beef Loin Deboning Saw_FINAL report 1-1-13)

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1 Background

There are significant yield and operator safety issues associated with the manual processing methods for deboning beef striploins. In 2011, Scott Technology (Scott) in collaboration with JBS Australia (JBS), Meat and Livestock Australia (MLA) and the Australian Meat Processing Corporation (AMPC) developed a Striploin Saw MKI by modifying an existing bandsaw with a triangular cutting path (using three wheels) rather than the typical oval cutting path (using two wheels). This configuration allowed for the loin to be cut at the best angle possible for meat recovery.

This new solution (Striploin Saw MKI) increased the yield obtained and resulted in a safer process. However, there were design issues with the MKI system; the machine was bulky and had minimal manoeuvrability. The lasers, used as cut references, were positioned in a way, which resulted in laser beams being projected onto nearby operational staff.

Using the physical data gathered and utilising all the operational learnings of the initial Striploin Saw MKI project, a redesign of the system was to be undertaken to result in a MkII.

2 Project objectives

The technology and safety carriage used in the MKI loin saw was to be adapted to the MKII machine, with the main focus on:

1. Operator safety.
2. Additional yield and revenue across the entire range of grass fed beef.
3. Maintaining throughput capacity.

3 Methodology

3.1 Design evolution:

The learnings from the Striploin Saw MKI were incorporated in the design of the Striploin Saw MKII. Figures 1 & 2 below, summarise the comparison of the two designs and highlights the major design modifications.

3.1.1 MKI design:

The original MKI design encompassed a large amount of operational unknowns and in order to compensate for the unknowns, the design was arguably ‘over’ engineered. The initial design included hydraulic capabilities for aligning the product, large housings to secure the lasers, wide table tops to stabilise the product, large electrical cabinets to allow room for additional electrical upgrades and a long length span to allow processing of a wide variety of product sizes.

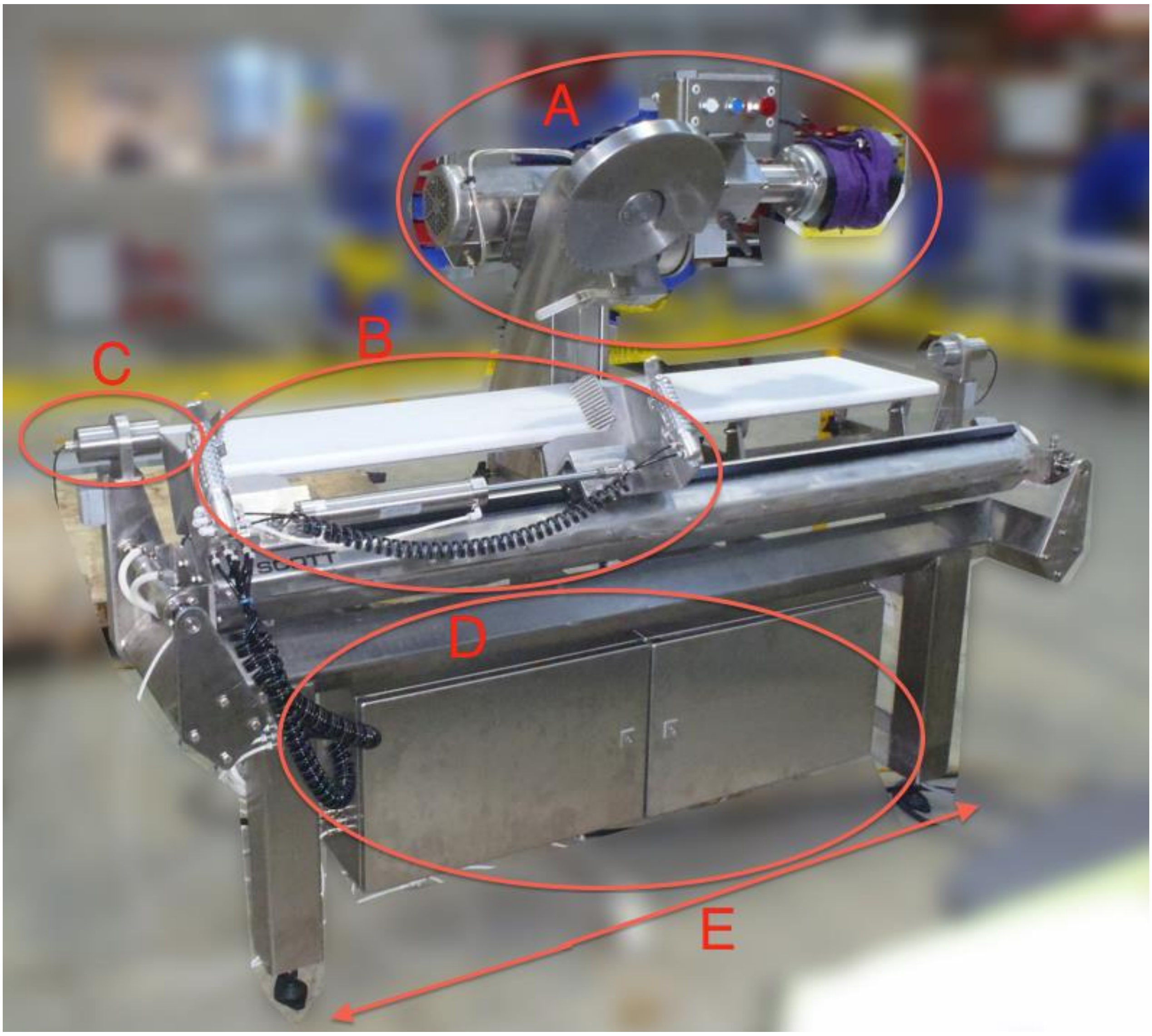

Figure 2 – Striploin Saw MKI design.

Table 1 – Overview of Striploin Saw MKI design features.

Item	Description	Design issue/correction
A	Circular Saw	The circular saw was originally installed to cut the rib bones simultaneously during loin separation process. This resulted in rib bones being thrown dangerously from the rear of the machine (by

		the circular saw) and as a result, the circular saw was removed.
B	Pneumatic ram	The handles were clamped and released pneumatically through the use of a foot pedal. The ram was later removed as it did not have enough stroke to be able to load larger product and it could not keep up with production flow (increased cycle time). The outcome was to have free moving clamps on linear rails.
C	Laser housing position	The laser housings were positioned on the extreme ends of the machine to allow for maximum exposure to both sides of the product surface. The positioning of the lasers had two (2) adverse effects. Firstly, with an empty table (no product sitting on the table top) the laser beam would continue down the room and hit other operators down the production line. Although the wavelength of the laser is not harmful, direct exposure to the human eye is not recommended. Secondly, the laser housings protruded out of the sides and increased the overall length of the machine. Limiting the machines positioning.
D	Electrical cabinet	The MKI system involved a large amount of electrical safety relay's and other safety devices. In order to house such a large amount of electrical equipment, a large electrical cabinet was required.
E	Overall length of the system	The overall length of the system was 2323mm and due to the room restrictions of the trial site, the machine could not be placed in its originally intended position and took up valuable floor space.

3.1.2 MKII design:

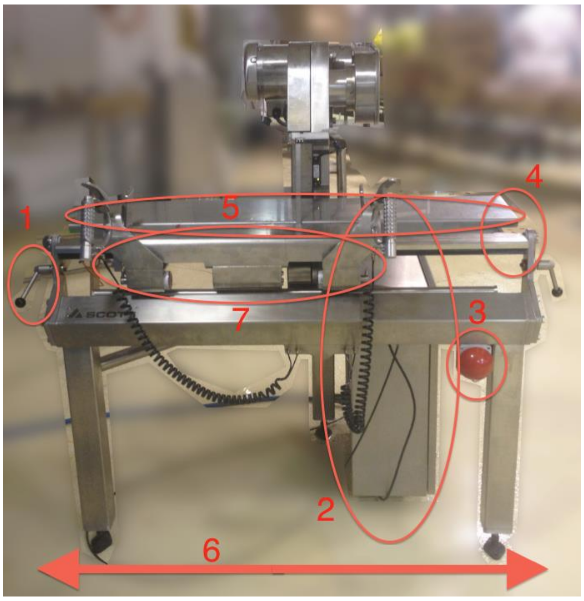

Figure 3 – Striploin Saw MKII design.

Table 2 - Overview of Striploin Saw MKII design features.

Item	Description	Design issue/correction
1	Easy turning table locks	This upgraded MKI's table angle adjustment, which was modified by tightening a small (hand lock) screw.
2	Smaller relocated electrical cabinet	MKI's electrical system involved a large array of electrical equipment, which was housed in two large cabinets. The MKII is designed to reduce the amount of electrical equipment required, whilst improving the safety of the system. This was implemented by converting several electrical interlocks to mechanical. Resulting in simpler troubleshooting and a smaller electrical cabinet.
3	Knee E-Stop	In the unlikely event of an emergency, the system can be stopped immediately (less than 2seconds), with the tap of the knee on the lower E-stop button, thus increasing the safety of the machine.
4	Laser housing	The MKI design had long, protruding laser housings on the extreme ends of the machine. This created unwanted length and projected laser lights onto other operators at either end of the machine. To correct these issues MKII's lasers are mounted at an angle, underneath the table. This corrects both issues simultaneously, as; A) the housings no longer protrude out of the sides (hence don't increase the overall length of the system) and B) the housing is angled in such a way that the laser light projects upwards at 30

		degrees, refer to figure 3 below.
5	Table material	The table top material was upgraded to a stainless steel to increase the durability of the material and to allow easier cleaning.
6	Overall Length	The overall length of the machine was reduced, by relocating the laser housings and reducing the table top length. The length of the MKII was reduced to 1490mm, a reduction of 800mm compared to the MKI.
7	Carriage system	The MKI initially incorporated a pneumatic clamping system which, clamped the product with the press of a foot pedal. This was proven to be slow and cumbersome and was replaced with free moving clamps mounted onto a linear rail. The free moving clamp system was enhanced in the MKII with the addition of a free moving carriage. This carriage supports the weight of the loaded product and allows the operator to easily transfer the product through the cutting process. As the carriage support moves with the product through the cut process, it mitigates the friction between the table and the product, hence reducing cycle time.

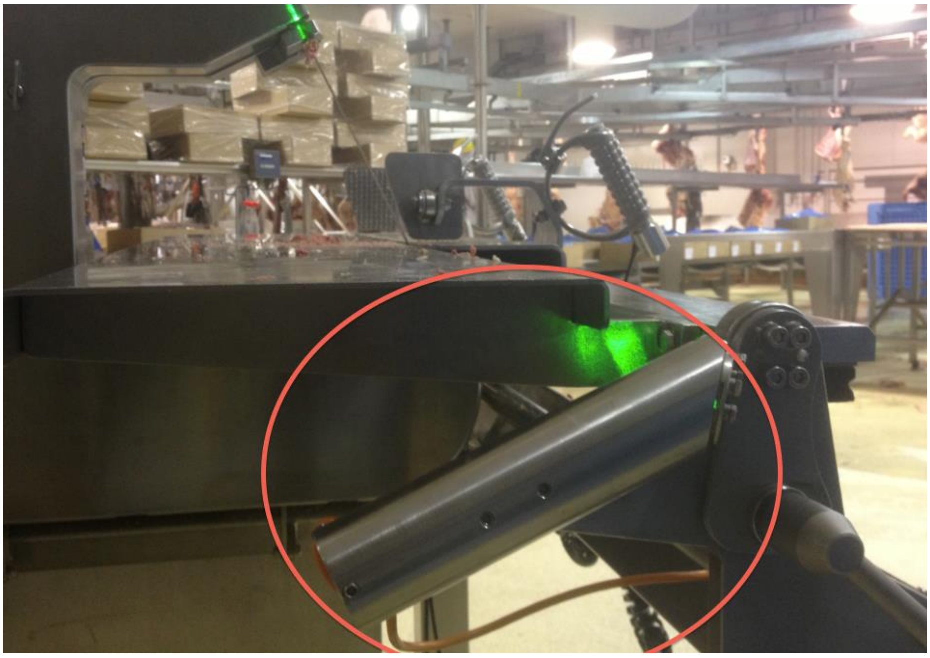

Figure 4 – Laser housing location and angle.

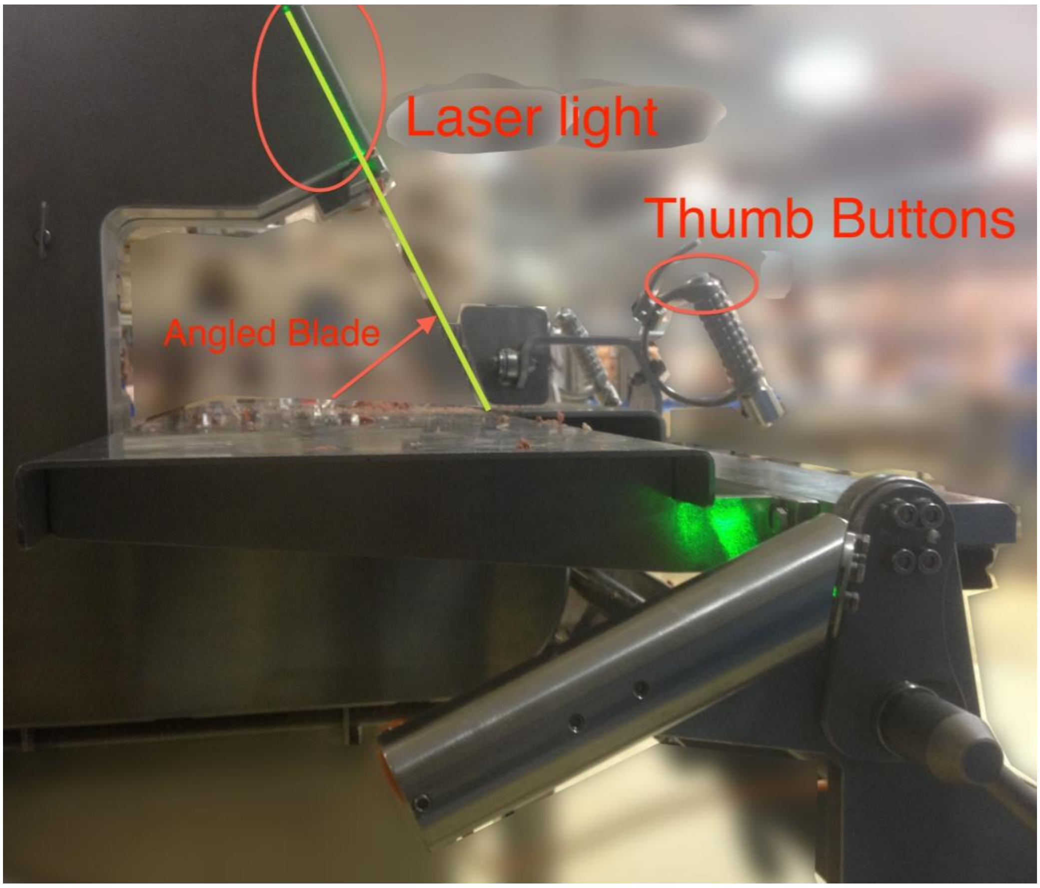

Figure 5 - Detailed view of key system features.

3.2 Installation, Commissioning and Training

The Striploin Saw MKII was delivered to site and after AQIS checks, was installed in an isolated area of the boning room. Operational and engineering staff were invited to view the machine whilst it was being commissioned. This afforded staff the opportunity to: A) see the system run for the first time and B) ask any technical questions relating to the operation of the system and/or it's many features.

Figure 6 – JBS staff reviewing the Striploin Saw MKII.

After the system was commissioned a brief demonstration of the system and all its features was given to all attending staff. The (preselected) operators of the system were then brought to the system for one-on-one training with Scott personnel. The operators were shown the safe operating procedure of the system and provided with the routine checks they would be required to undergo. The operators were also guided through the troubleshooting steps, which included; safety resets, power outages, equipment faults, replacing blades and general fault finding. Once the operators were informed and trained, the trialling phase was commenced.

3.3 Production Trialling & modifications

As the yield and cycle times of the system are heavily operator dependent, the operators were given three (3) days to familiarise themselves with the day-to-day use of the system. The production data throughout the first six (6) days, including the initial 3 days was recorded and tabled in section 4.2,

Table 5. The results indicated a linear relationship between the cycle times and the operator's time spent using the system.

3.3.1 Challenges overcome

3.3.1.1 Clamping

Table 3 - overview of clamping issue.

Issue	**Some products were not being clamped securely.**
Cause	Product with the spinal bones still protruding from the loin were unable to be clamped by the existing clamps. The bone would stop the clamp making contact with the 'meaty' surface.
Solution	Cut off an angle of the clamps to allow the clamps to make contact with the 'meaty' section of the product.

Figure 7 – Protruding spinal bone clashing with clamps.

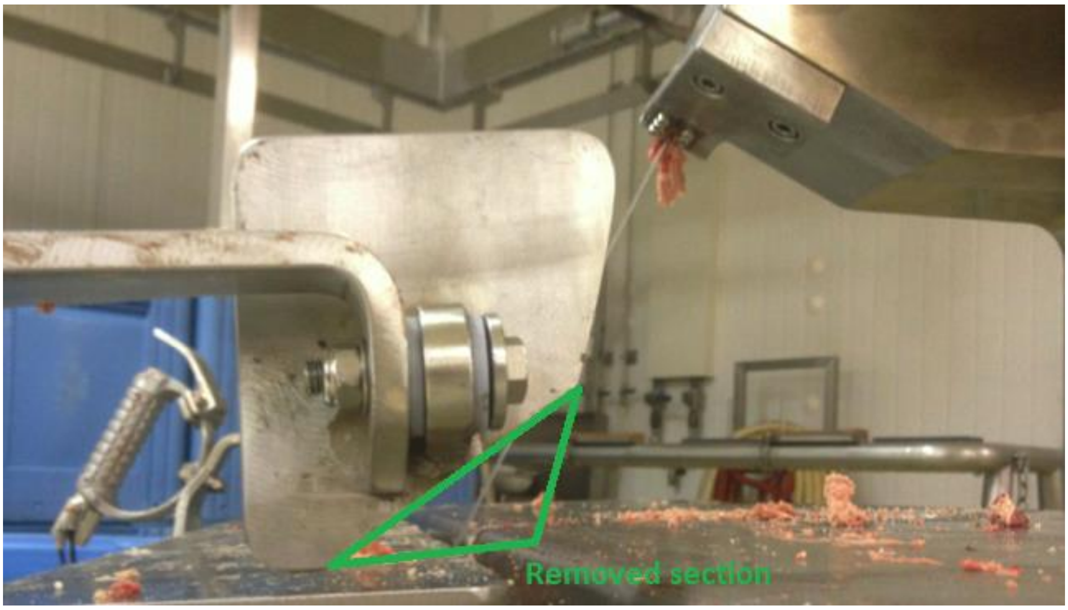

Figure 8 – Removed section of clamps.

Figure 9 – Spinal bone no longer clashing with clamps.

3.3.1.2 Heavy Carriage

Table 4 - Overview of carriage issues.

Issue	Slow movement of transfer carriage causing increased cycle time.
Cause	The linear support carriage in between the clamps, which supports the middle section of

	the Striploin was heavy and restricts the speed of the cutting process.
Solution	There were blockages in the pressurised containers, which were the self-lubricating modules underneath the carriageway. Once the nozzles of the containers were cleared, the carriage way moved with minimal required force.

Figure 10 – Support carriage circled.

3.4 Operator Training

The operators were trained in the basic operations of the system; turning the system on, engaging the bandsaw, clamping product and disengaging the bandsaw. However, the non-uniformity of the products, make the yield outcome of the process highly operator dependent. The operator must learn to align the product with the laser line, clamp the product and move through the cut with a certain amount of accuracy.

After a short period of time, the operators start to better understand the capabilities of the machine and develop visual cues and processes, which allow them to adjust their processing techniques to the varying product sizes and specs. As they become proficient with the use of the machine, the process cycle times decrease and the yield increases.

Figure 11 - Operation staff training.

4 Results and Discussion

4.1 Operator Safety

With occupational health and safety (OH&S) a key driver for the project, the redesign had to ensure that the operator's safety would not be compromised in anyway. The safety features of the original Striploin Saw MKI were upgraded and simplified. For example, the safety E-stop button size was increased and the location of the e-stop moved to knee height. Due to the nature of the process, it is safer to have the ability to e-stop the machine without moving ones hands towards the direction of the blade.

The key safety feature of this system is the pneumatic handles with depressible thumb buttons. To engage the bandsaw, both the thumb buttons had to be pressed. This feature ensured that both hands (of the operator) were to be constantly placed on the handles when the saw was engaged.

4.2 Yield and Throughput

Being an operator-centric process, as the operator(s) gained experience with machine, the yield and throughput increased. The yield was measured visually by the boning floor supervisor, with the result being either:

1. **Bad** - low yield - will need reprocessing.
2. **Average** – Average yield - room for improvement, requires reprocessing down the line.
3. **Good** – Good yield - doesn't require re processing.

A detailed yield analysis of the Striploin Saw can be found in the MLA final report titled P.PIP.0271 – Beef Loin Saw. An external yield analysis has yet to be concluded for the MKII system.

The target cycle time, to maintain throughput, was 17 sec. This was the current processing time, without the Striploin Saw MKII device. As the operator(s)'s experience with the machine increased the cycle times decreased as they became more proficient with the use of the machine.

The relationship between; time spent using the machine, cycle time and yield can be seen in table 5, this is further illustrated in figure 9.

Table 5 – Results of yield and cycle time data.

Day	Average Cycle time (seconds)	Average Yield Rating Green = Good Amber = Average Red = Bad
1	45	Red
2	35	Red
3	29	Amber
4	23	Amber
5	20	Green
6	17	Green

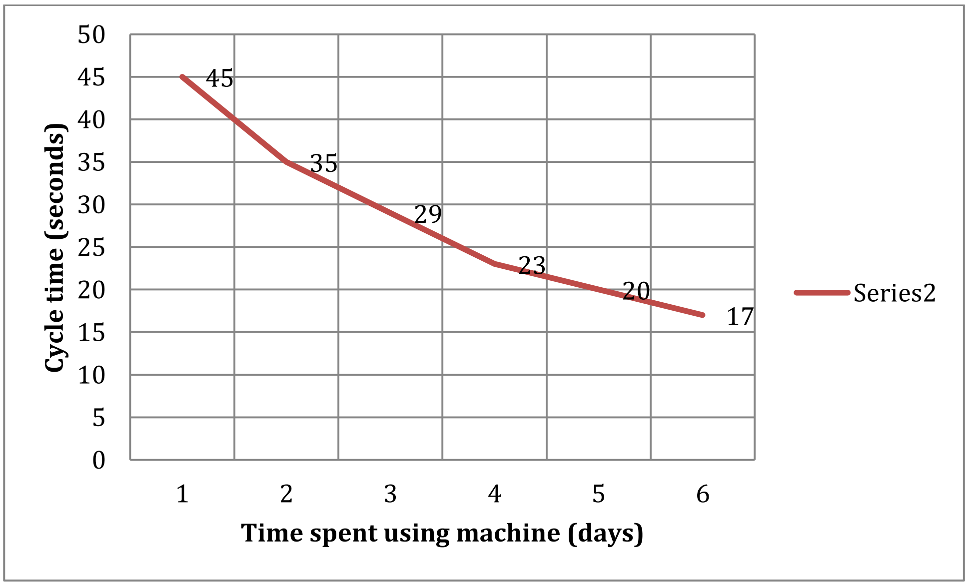

Figure 12 – Graph of Cycle time vs. average time spent with Striploin Saw MKII.

4.3 Cost Benefit Analysis

Greenleaf Enterprises Pty. Ltd. was independently engaged by MLA at the conclusion of the MkI design. The following is an extract from the Executive Summary of the Greenleaf report titled “Beef Loin Deboning Saw_FINAL report 1-1-13”.

There are significant yield and operator safety issues associated with current processing methods for deboning beef loins. The angle of cut is critical to achieving optimal yields. Whilst companies have experienced improved yields using trial make-shift saws they have involved operators working in close proximity to bandsaw blades. No commercial solution exists that removes direct interaction of operator with the saw while maintaining improved yields because the large variance in beef bone to meat ratio results in unacceptably large yield variations.

This cost-benefit study reviewed the performance of the prototype Scott loin de-boning system, the in-house loin saw (Generic Loin Saw) and table boning against side chain boning which was used as the baseline for comparisons within this study.

Trials conducted during the study demonstrated savings summarised in Figure [13]. Removal of vertebra using either a generic or Scott saw delivered improvements in yield over both table boning and chain boning.

	Table Boning	Scott's Loin Saw
Capital cost	$0	$98,000
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Net Benefit / cobotic unit	N/A	$1,422,686
Annual Net Benefit for the plant	$687,201	$1,422,686
Pay back (months)	0.00	0.83
NPV	$4,103,483	$8,476,843

Figure 13: Greenleaf CBA summary table.

5 Moving forward

The Striploin saw MKII verified that the learnings gained and technologies used in the Striploin Saw MKI could be adapted to the MKII machine. Furthermore, the Striploin Mark II delivers:

Increased operator safety, yield benefits and increased revenue across the entire range of grass and grain fed beef whilst maintaining throughput at capacity. The Striploin Saw MKII demonstrated that is a viable solution for the meat industry and can safely and efficiently process large grass fed beef.

With the nature of the process being highly operator dependent, the next evolution of the Striploin Saw needs to remove this dependency by having automated loading and cutting features. This would require further research in sensing techniques with the focus on the ability to correctly identify product features.

6 Appendices

6.1 Appendix A

6.1.1 Table of items