final report

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Prepared by: Jeremy Corbett, Shaun Kelly, Merv Shirazi, Kavin Miranda
Scott Automation and Robotics

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Meat and Livestock Australia Limited
Locked Bag 1961
NORTH SYDNEY NSW 2059

Manual Measure Single Tower Primal Cutting System Demonstration Wagstaff Cranbourne Pty Ltd.

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Executive summary

The project was undertaken to provide a lamb primal processing solution for small to medium scale processors like Wagstaff Food Services. The project was originally based on the larger dual tower fully automated LEAP III system with a processing rate of 10 carcases per minute (CPM), making it ideal for larger processors/abbitoirs. This system was therefore designed to be modular, allowing the flexibility of adding an additional tower and x-ray system as the business grows. With the smaller scale production, this system's production rated is expected to be 5 CPM in its base configuration.

The Single Tower Primal (STP) system consists of,

- Manual measure system, this also for the cut points to be assigned by the operator
- Product clamping system
- Saws
- Outfeed conveyor

This set up allows for the system to sit within a much smaller footprint, ideal for small to medium sized abattoirs. Additionally, operator safety is placed at the forefront of the system's operation.

The STP system is currently installed and successfully commissioned to operate with lamb. The system has run for multiple weeks under supervision from Scott Engineers. Multiple issues were encountered during this stage, these include:

- Substantial variation in the type of product being presented to the system, i.e. the system was designed for lamb but was presented with mutton as this is the primary protein processed at Wagstaff
- Cut quality was also an issue during wet commissioning, this related to the earlier point of mutton being put through the system instead of lamb. Additionally the blades did slow and stall as they made their way through the product
- Insufficient control as the product moved along the chain led to issues around product stability during the cutting process, this resulted in the product not being held correctly in the clamps and the saw cutting the product at incorrect positions
- Substantial blade damage and wear was also noticed during the wet commissioning .
- Meat in the saddle was found to be deformed as the primals were cut and the saddle impacted the bounce board and the conveyor, the deformation of the eye meat meant that the quality of the cut was being reduced

Once rectified, resulted in a consistent cut quality that was of an acceptable standard. System throughput was reordered at up to 7 CPM which was a 40% improvement on the initially proposed 5 CPM production rate, this is contingent on the system receiving a consistent infeed of product.

An open day was held on site to demonstrate the system's capability to key decision makers in the red meat industry. During the demonstration over 100 carcases were put through the system, this gave the opportunity for the attendees to get a hands-on look at the system as a whole as well as the end product.

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1 Background

1.1 Project Background

1.1.1 Project Description

This project was undertaken to provide the red meat industry, particularly small to medium sized abattoirs with a primal system that is of a smaller footprint compared to the Scott LEAP system. The smaller system will be required to maintain a consistent cut quality without any compromises in operator safety.

As the STP will now use a manual measure system the x-ray system found in the LEAP system will no longer be required, drastically reducing the cost of implementation. The system will still be able to be upgraded to include an x-ray system to autonomously determine cut points.

This is particularly significant for smaller processors as they no longer need to immediately invest in an x-ray system and the system can also be upgraded to include a second tower to cope with higher production rates, increasing it to over 5 CPM.

This system is significant in the fact that the smaller footprint reduce the costs associated with integrating it into an existing production line. The system aims to provide the customer with a reliable system that improves the quality and consistency of yield.

The LEAP III system which provides a basis for the STP system has been evaluated to provide a benefit of $4.50-$5.60 per head. This was due to identifying precise cutting lines and processing efficiencies.

The overarching aims of this project are to:

- Prove the system's viability in in a production environment
- Determine the system's achievable production rate while under operating conditions
- Fine tune the system, to further improve product quality and yield
- Determine the system's ease of use with regards to integration into site specific policies and procedures, and an operator's ability to use the system unassisted.
- Minimise overall system downtime and efficiency by fine tuning sub-systems to be able to cope with small variation in product
- Determine any additional improvements that can be made to the system for future implementation

Assuming a lower capital cost than the LEAP III and a lower yield benefit due the system requiring manual system to determine cutting lines, instead of an x-ray system, a gross benefit of $1.41 per head has been estimated for the STP system. This lead to a payback within 1.3 to 1.8 years.

2 Project objectives

This project has resulted in a solution developed for the Australian market that is of a higher quality than the existing primal systems. This was carried out by installing the system at Wagstaff Cranbourne, an Australian red meat processor. This was done to prove and evaluate the system's viability and performance under a production load subject to variables based in reality.

The objectives undertaken during the course of the project include:

- The site installation and trial operation of the STP system with a manual measure system
- This system will be evaluated by the CBA
- An open day was held to demonstrate the system's capability to leaders in the red meat industries
- Finally, the system aims to further demonstrate the system to other processors, interested parties and/or potential customers to view the system in action at Wagstaff Cranbourne, post reasonable notice

3 Methodology

3.1 Design & Manufacture

The Single Tower Primal was designed and tested in New Zealand, before it was shipping to Australia for installation at the Wagstaff Cranbourne. This STP system was one of the first systems to be built that did not also include X-ray system. Since the X-ray system normally supplies the Primal system with the vital cut positions, modifications were made to allow cut positions to be fed from the operator instead. This new operator procedure is explained in greater detail in Section 3.5, The drawings of the main cutting station can be seen in Figure 1, 2 and 3.

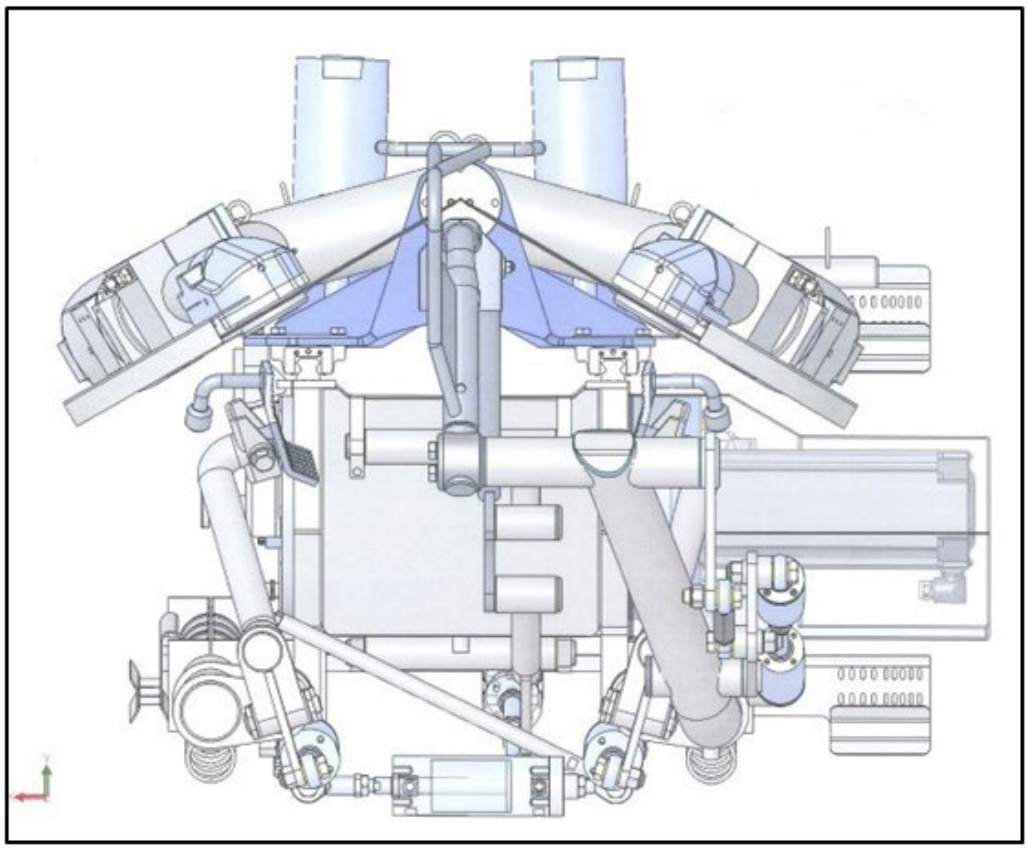

Fig. 1: Full Assembly

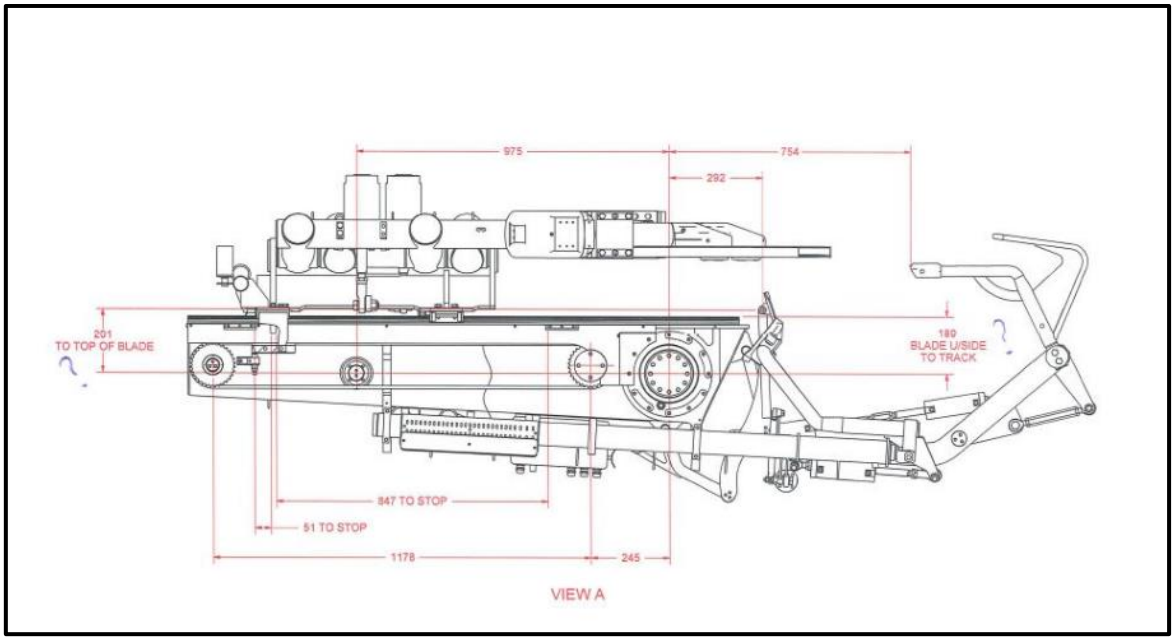

Fig. 2: Tower - Pivoting Carriage Assembly Side View

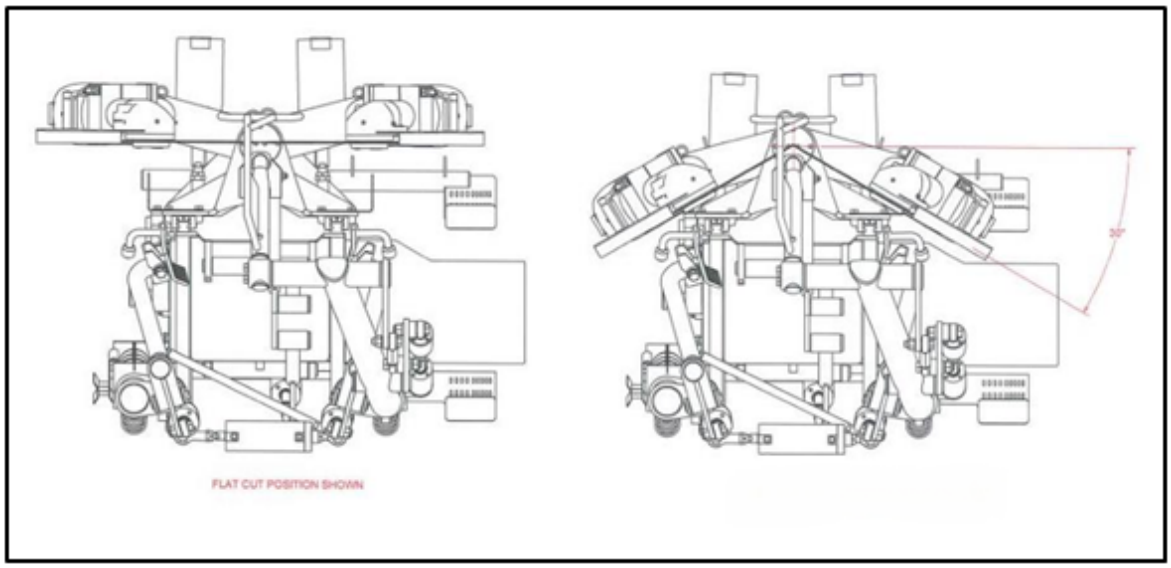

Fig. 3: Tower - Pivoting Carriage Assembly Front View

3.2 Installation

3.2.1 Preparing Site for Installation

Fig. 4: Original Site with New Concrete Slab (Grey), Third Chiller (red), DEXA Machine (Yellow) and Primal Tower (Green)

The original site at Wagstaff was limited in terms of its ability to accommodate both the DEXA system and the single tower primal. After extensive discussions with management, it was determined that the driveway along chiller 2 (See Figure 4) would be developed to accommodate:

1. A third chiller to assist with ensuring the meat is firm while being processed in the primal tower
2. Make room for the DEXA system that allows the primal system to accurately sense and locate cut locations along the carcass
3. Repurpose the remaining floor space for the primal tower system and primal processing/handling conveyors

The first step involved squaring the northern most potion of the facility, with the pouring of a new concrete slab along the entire length marked out in grey on Figure 4. Next a roof had to be built over the driveway to house the third chiller (marked in red on Figure 4).

The drawings below in Figures 5 and 6 show the plan of where the Single Primal Tower would be positioned and how it would integrate with the rest of the room.

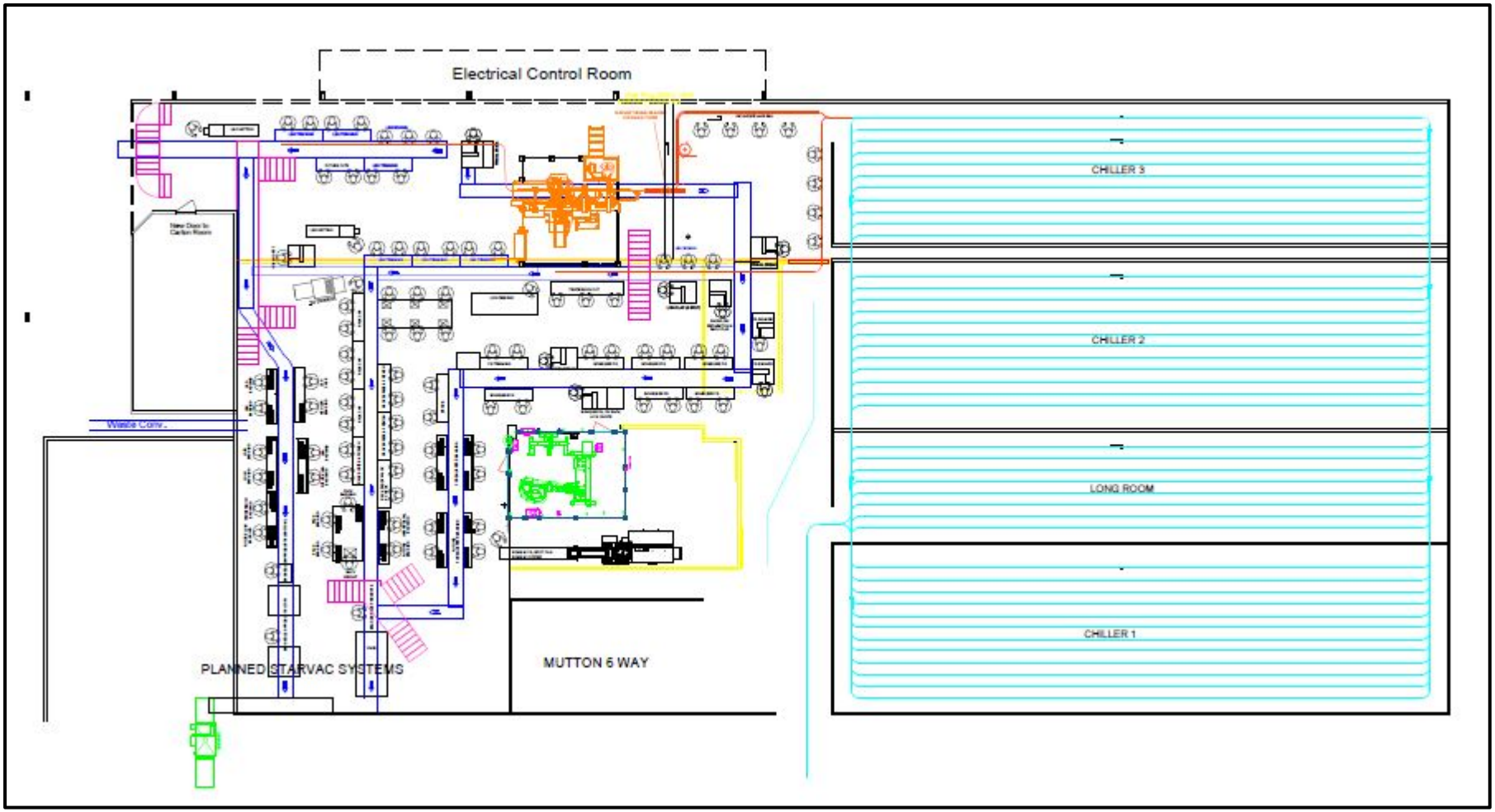

Fig. 5: Inside Layout of Wagstaff Plant, Single Tower Primal in Orange.

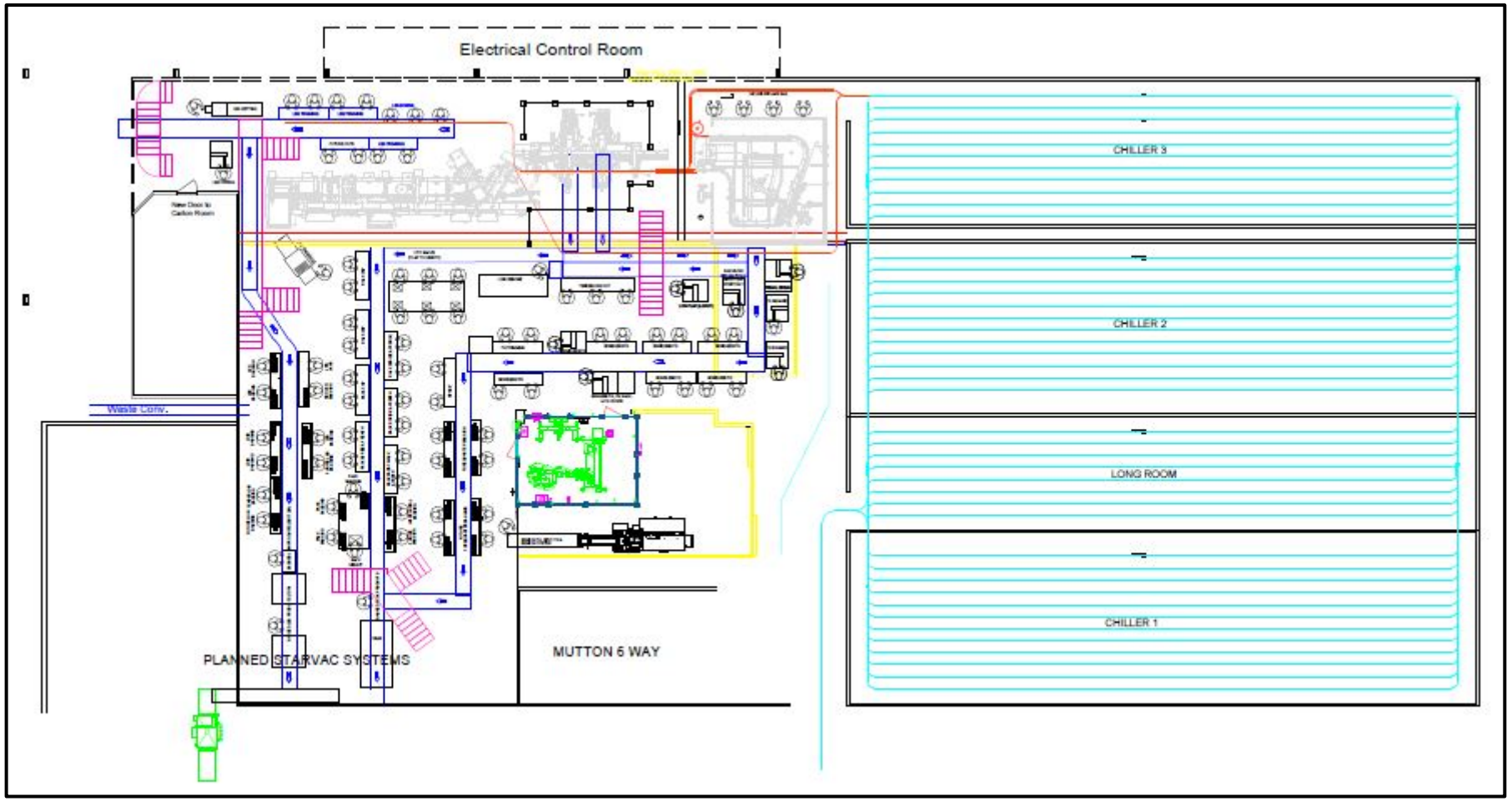

Fig. 6: Integration of DEXA Single Tower and Dual Tower and Middle Machine Linked with the Forequarter Machine

The larger components of the Single Tower Primal were placed in their designated area (See Figure 7), before the rest of the ceiling and walls were constructed around them (See Figures 7, 8, 9 & 10).

Fig. 7: Primal Tower components placed in their designated location

Fig. 8: Chiller 3 being constructed

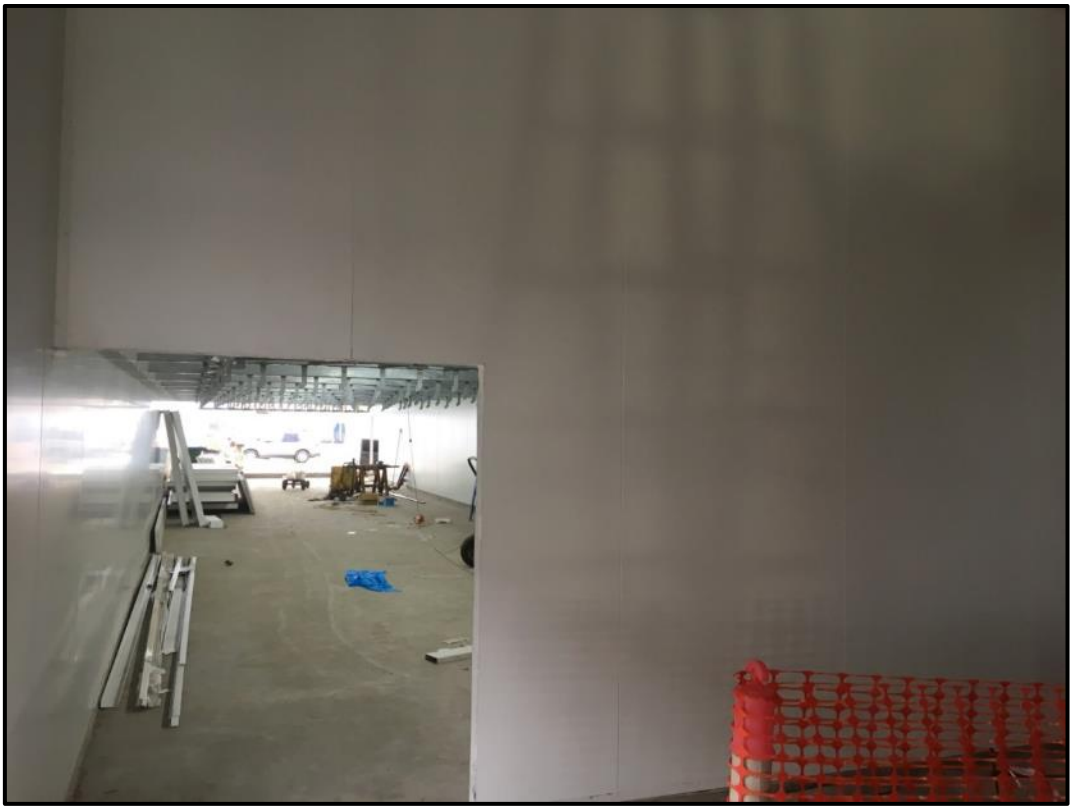

Fig. 9: Chiller 3 and Proposed Location of DEXA Machine (Behind Wall)

Fig. 10: Celling and Wall Constructed Around Primal Tower Components

3.2.2 Mechanical Installation

Mechanical installation required large sections of the machine to be lifted and bolted together. The large machine sections create shorter and simpler assembly (See Figure 11). However, moving large sections around inside a cool room can be quite difficult. Positioning the machine within the room correctly is important, so that it integrates smoothly with the chain conveyors.

Fig. 11: Overhead transfer being moved into position

3.2.3 Electrical Installation

A large amount of wiring was run from the machine to the new electrical room. Neatness and labelling of the wiring is critical for trouble shooting and further add-ins in the future.

Fig. 12: Overhead Electrical Tray and Duct

Fig. 13: Control Panel Front Side

3.3 Device testing

Once the machine was assembled and wired each device was tested individually. Servo devices were homed to provide them with their absolute position relative to the machine and calibrated to perform efficiently in the expected environment (see Figure 14). Pneumatic devices were tuned to prevent excess wear and interlocks were programmed to prevent machine damage when in operation.

Fig. 14: Primal carriage being homed and tested.

3.4 Dry cycling

After the individual devices have been tested, the entire system is activation. Dry cycling is where the machine is cycle tested without product. Each automatic cycle is triggered and the operations of all devices are tested in their typical product cutting sequences. The dry cycling for the Manual Load machine differs from X-ray primal in that it still requires an operator to give the cut positions to the machine.

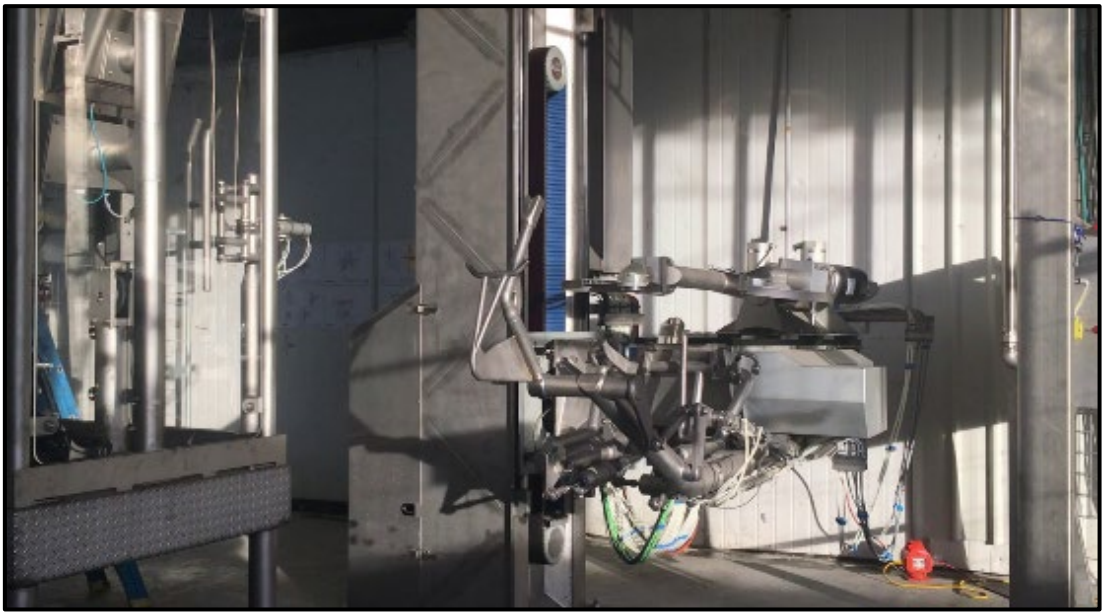

Fig. 15: Primal dry cycling with the room still open to the outside

3.5 First product trials

Before the machine could begin cutting, it was thoroughly cleaned (See Figure 16). Machine hygiene is very important in a meat processing environment which is why the machine mainly comprises of high grade stainless steel.

Fig. 16: Machine being cleaned and prepared for trial.

The first product trials occurred in June 2018 (see Figure 17). The first product was cut using single step mode, where each action sequence is triggered step by step on operator command. This allowed more control and safety of the machine in operation. The machine has the capabilities to remember its last step, so in the case of a fault the machine can be stopped, electrically isolated, fixed and restarted back to its last step or position.

Fig. 17: First product manually lifted onto machine meat rail as at 31/06/2018.

Instead of using X-ray to calculate cut positions, a measuring device is directed into rib cage by the operator. There are three cut positions, in first cut position the operator aims to align the laser between the 4th and 5th rib (See Figure 18).

Fig. 18: Manual measuring station targeting FQ ribs with laser projection.

4 Results

4.1 Commissioning

4.1.1 Room integration delays

Wet commissioning was halted in July 2018 while the customer finished the room construction and the safety fencing was installed. Wet commissioning commenced briefly in May 2019 with the room completed, but still product infeed and outfeed chains were not implemented. Commissioning was only able to be completed end of June 2019 after the product rails were completed by the customer.

Fig. 19: Fencing installation on the 21/9/2018 with the infeed and outfeed product rails still missing.

Fig. 20: Machine integrated in room in full production as at 15/07/2019.

4.1.2 Product sizes

Product sizes presented to the machine were a challenge not anticipated in the original design. The machine specification is designed to cut lamb, however the product at Wagstaff often consist mostly of large Mutton. Mutton tends to have a higher bone density and mass than lamb, and because of this causes much higher stresses to be put on the primal cutting blades.

The blades tended to stall mid-cut in the larger product, so a second VFD was added to power the two saw blades individually giving a higher level of control and cutting torque.

4.1.3 Cut quality

Cut quality was a concern initially during wet commissioning due to product movement, product size, sequencing and blade profiles. Cut quality improved drastically with addition of new motor blade drives (VFD) and fresh sets of blades and also optimising software.

Fig. 21: Good FQ cut quality

Fig. 22: HQ cut with a small amount of 'pasting' from the blades

4.1.4 Product stability and control

Product stability within the single tower primal was a challenge that was faced during wet commissioning. Some minor machine modifications to the clamp surfaces as well as rub rail adjustments were required to ensure product stability was satisfactory across the range of product sizes.

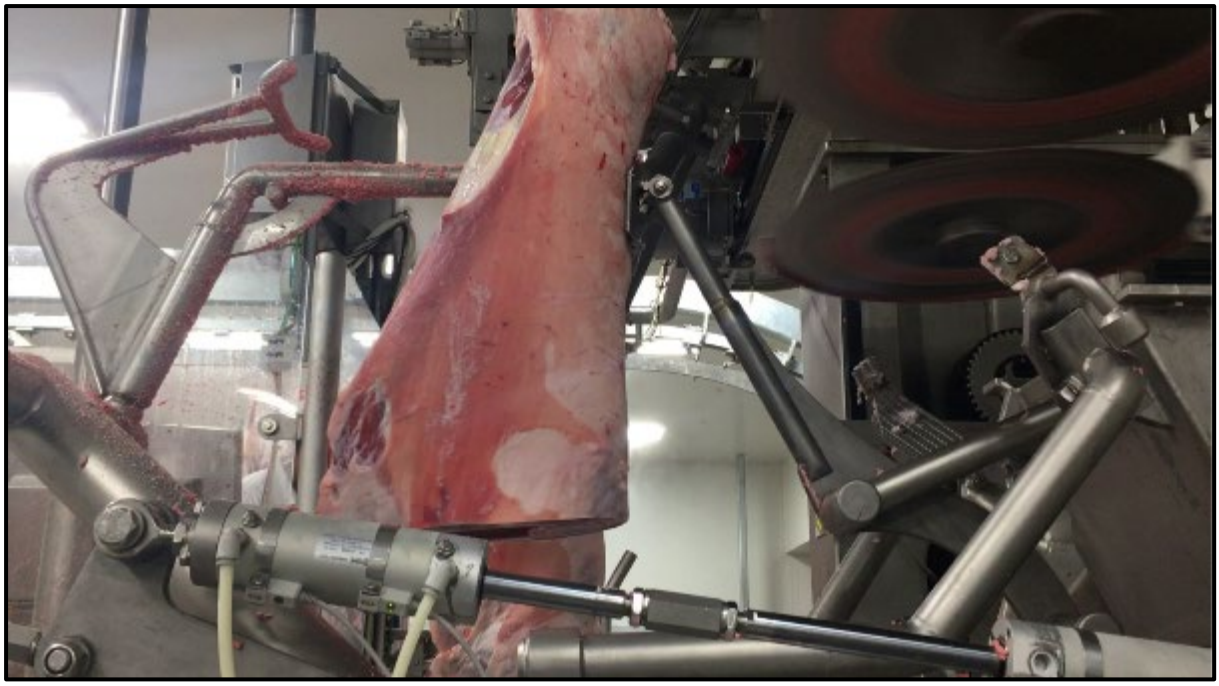

Fig. 23: Product clamped and primal saws about to perform HQ cut

4.1.5 Blade issues

Blade issues presented during wet commissioning. We had three blade failures within the first 3 weeks of production. The failures are still being investigated but it is believed there are multiple factors that may be causing a higher number of premature failures than expected. Some of these issues being investigated include;

- Out of specification product being put through the machine
- Blade contact with stainless steel gambrels in carcase chest cavity
- Product stability and movement during cutting putting large bending forces onto blade

Three blade types were trialled during commissioning;

1. Courier Sharpening - Version D Blades

   Courier Sharpening Blades are manufactured in Hastings, New Zealand and have a blunter edge to them than other manufacturers, making them typically more robust, but often at a sacrifice to cut quality. The thicker edge also requires more energy to pierce through the product, which can result in blades stalling in the cut or product being pushed forward under the resultant cutting forces.

2. BE Blades

   Be blades are manufactured in Germany and are standard on our Primal and Middle Lamb processing machines. These are a high quality blade with a fine tooth pitch and fine tapered edge. Due to the fine edge they produce cleaner cuts, with less bone chipping and saw dust. They also cut with less torque required by the motor and gearboxes. The drawback is that with a fine edge they can be prone to cracking and failure, and are not suitable for rough service.

3. Courier Sharpening - Version G Blades

A third blade profile was trialled at Wagstaff. These blades are a compromise between the Courier Sharpening Version D and the BE blades. With a moderate blade thickness they provide good cut quality with a stronger blade edge.

Fig. 24: Blade fracture on BE Blade, with section of dulled teeth prior indicating likely cause of fracture was contact with metal object

Currently Courier Sharpening blades are installed and in use, as the Manual Measure Single Tower Primal does not have the same level of product stability the Dual Tower primal has the product movement and size of the customers product results in an extremely rough service environment for the blades. The Courier sharpening blades with the thicker edge is more suited for this environment.

4.1.5.1 Cycle modifications based on customer feedback

The auto cycle was modified based on customer feedback to lower the saddles down to the product conveyor instead of dropping them as was designed as it was found the saddle eye-meat was being deformed due to the impact of the saddle onto the bounce board and conveyor.

On adjusting this routine it was found that due to the primal carriage having to raise and lower every cycle, the servo drives had to dump a huge amount of extra generated energy through the braking resistor. The resistor was not initially designed for this duty cycle of work and in order to facilitate this new routine it was upgraded from a 400W shunt resistor to a 1.5kW shunt resistor.

Fig. 25: 400W Shunt resistor that was overheating with the new cycle modifications

4.1.6 Additional improvements

The manual measure station devices were inspected regularly and it was found after a period of one month continuous daily use and wash-downs the cabling and field I/O module was having some intermittent issues. The field I/O module was moved to a cabinet location in order to protect it for long term use.

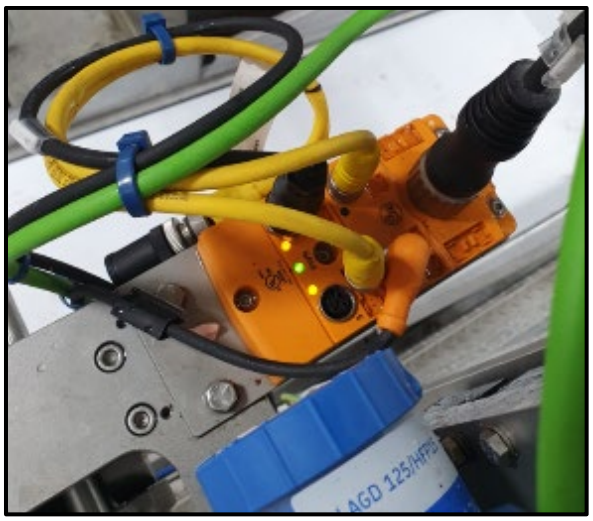

Fig. 26: Field I/O module that was repositioned.

5 Discussion

5.1 Evaluate system performance

5.1.1 Cut Quality

The cut quality of the machine has been consistently good since wet commissioning completed. Issues did arise with quality briefly, but this was addressed with new sets of blades.

Fig. 27: Good quality FQ cut

5.1.2 Machine Reliability

Staff have been able to troubleshoot and resolve all faults on the machine during day to day operation. A remote connection was set up to allow remote support from Scott technicians for major breakdown support, though this has not been required as of yet.

5.1.3 Machine Throughput

The machine operates well above the designed throughput, with the machine typically averaging around 5.3 carcases per minute (seven CPM with two cuts enabled and the machine being fed continuously by the operators. This is a 40% improvement over the designed throughput of five CPM).

The customer is happy with the machine throughput, and is typically limited by the room capacity and operators rather than machine performance.

The machine has been cutting on average 1718 carcases per day on days it is being used.

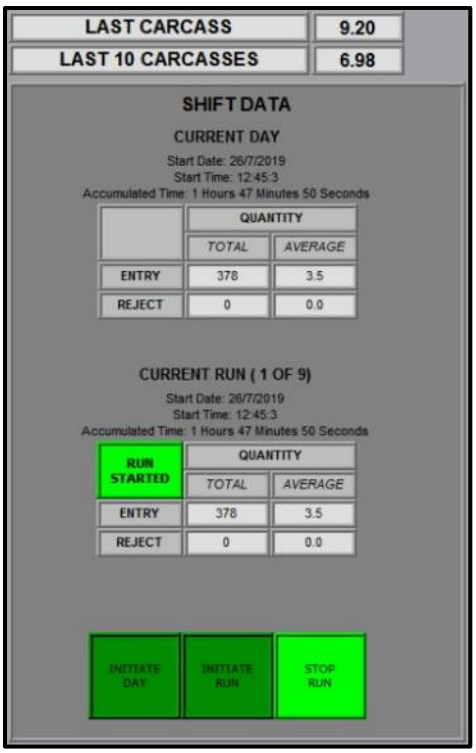

Fig. 28: Throughput statistics as displayed on HMI screen giving real-time information on machine performance.

The LEAP III (primal) system on which this technology is based has been extensively evaluated via independent ex ante and ex post cost/benefit analyses. Benefits of between $4.50 - $5.60 per head through precise cutting lines and processing efficiencies were identified.

Assuming a lower capital cost than the LEAP III, with a corresponding lower yield benefit without x-ray visioning, $1.41/head gross benefits have been estimated, giving a payback of 1.3 to 1.8 years.

Through the inferences and insights from the LEAP III project MLA and Scott Automation & Robotics have completed the development and construction of a new small stock module titled The Leap Manual Measure Single Tower Lamb Primal System.

The system was designed to cut a lamb carcass into its first three primals (Forequarter, Middle and Hindquarter) and operates using a manual laser sensing system, which has an estimated production rate of 5 CPM on average. This is subject to the input feed rate into the system.

Practical implications for the red meat industry include the ability for smaller processors to introduce a Manual Measure Single Tower System to their site without having to immediately invest in an X-Ray system. There is potential for processors to add an x-ray module replacing the manual measuring station, and/or add a second tower to increase throughput to over 5 CPM.

Additional work/research into understanding how well the system is coping with variation in the size and type of feedstock.

Due to the large variation in product found on site work was done to ensure the system can process carcasses at consistant quality. Factors that contributed to this included the further optimisation of the system, this included changes made to the system to ensure the saddle eye meat was not deformed as it impacted the bounce board.

Due to the system's reliance on a manual measure system, opterators on all shifts had to be trained to accurately "mark" cut lines with minimal delay to ensure throughput is consistant. This was a key aspect in the system's performance as it has a direct relation to cut quality and cycle time.

The following objectives successfully met during each phase of the project:

- The site installation and trial operation of the STP system with a manual measure system. This objective was successfully achieved in early project Milestones, and was contingent on insuring a successful outcome of the proceeding objectives.
- This system will be evaluated by the CBA
- An open day was held to demonstrate the system's capability to leaders in the red meat industries. During the open day over 100 head of lamb was processed by the system inform of a number of key leaders in the red meat industry. The guests had the opportunity to interact with the system and see firsthand the quality in yield and consistency provided by the system despite the inherent biological variation in feed stock.
- Finally, the system aims to further demonstrate the system to other processors, interested parties and/or potential customers to view the system in action at Wagstaff Cranbourne, post reasonable notice. This is an ongoing objective for the project. Additionally, Scott has providing ongoing support for the system as this serves as a way to further investigate how well the system copes with various in product, operator, etc. over a longer period of time.

Finally the overarching outcomes achieved during the course of this project are as follows,

1. The successful installation of the Manual Measure STP system at Wagstaff Cranbourne
2. Commissioning and testing the system under a production load
3. An industry demonstration day showcasing the system's capabilities

5.2 Open Day

5.2.1 Attendees

Attendees included representatives from Lean Projects, JBS, Scott Automation, Ararat Neat Exports, Gathercole, Colac, Ryan Meat Company, Midfield Meats, Kilcoy Pastoral Company, MLA, McPhee Bros and AMG.

Fig. 29: Scott Automation presenting their information on Red Meat Automation

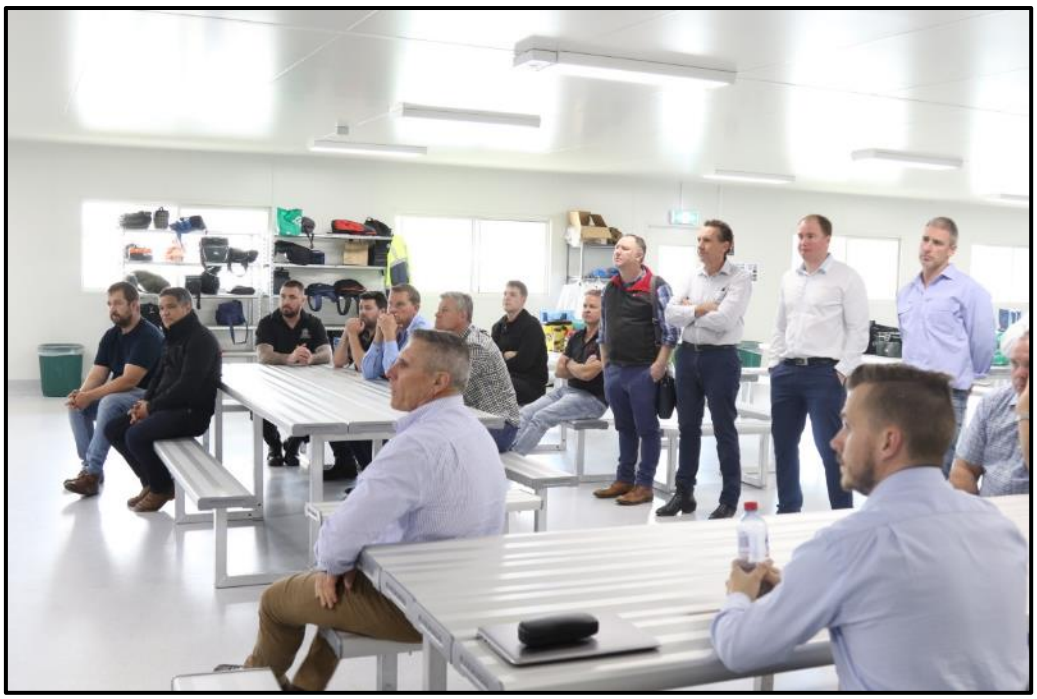

Fig. 30: Attendees watching the Presentation

5.2.2 Programme schedule:

The programme was as follows, Thursday 12/12/2019:

- 1:30 – Presentation on Manual Measure Single Tower Primal in Australian lamb processing, Wagstaff's experience, vision for the technology & wider industry adoption.
- 2pm – Demonstration of Manual Measure Technology for precision lamb cutting
- 2:30pm - Closing remarks and refreshments

5.2.3 Summary of presentation information

- Introduction to Scott Automation and their collaboration with the Meat and Livestock Australia.
- Work involved in processing different cuts of meat
- How DEXA operates and optimizes red meat yield
- Available meat processing machines and their advantages
- BladeStop and other packaging machines

5.2.4 Demonstration of Single Tower Primal

Over 100 lambs were ran through the Single Tower Primal in front of the audience. The machine's settings were changed between 2 and 3 cut positions via HMI. The guests were able to clearly see the machine operation and the operator's interaction with the machine.

Fig. 31: Guests inspecting the cut product

Fig. 32: Guests inspecting the cut product

Fig. 33: Guests inspecting the cut product

Fig. 34: A guest viewing the machine in operation

Fig. 35: The operator moving the laser to different cut positions

Fig. 36: The operator selecting the number of cuts

6 Conclusions/recommendations

With regards to future R&D one important issue in commissioning of this system at Wagstaff was processing the large mutton, blades were failing when was in touch of very large muttons but after system optimisation this problem got less and less. The current system is now capable of cutting these large mutton sizes, however it may impacts the blade's life especially the new thinner blade technology. Further work can be done on this aspect of the system's design to improve blade life and in turn decrease system downtime.

Further work can be conducted on the carriage and gripping points which will be important in ensuring the system can handle, large lamb/mutton carcasses. This will build and expand on the system's current scope (only processing lamb), allowing the processor to seamlessly handle changeover in product type and size.

Practical applications of the project's insights and implications to the red meat industry follow from the handover of the machine to the customer on the 8th of July 2019. The handover was facilitated over a week long period where a Scott Engineer was on site full time and available to assist if there any issues arose. Some incremental improvements were made over this period to improve reliability and cut quality, further enhancing the value proposition this bring to small scale red meat processors.

Fig. 37: Cut product (Saddles, FQ's) being fed out of machine on conveyors

The machine operates well above the designed throughput, with the machine typically averaging around 5.3 carcases per minute (seven carcases per CPM with two cuts enabled and the machine being fed continuously by the operators. This is a 40% improvement over the designed throughput of five CPM).

The system is currently limited, typically by the room capacity and operators rather than machine performance. The machine has been cutting on average 1718 carcases per day on days it is being used.

6.1 Machine Reliability

Post implementation staff have been able to troubleshoot and resolve all faults on the machine during day to day operation. A remote connection was set up to allow remote support from Scott technicians for major breakdown support, though this has not been required as of yet.

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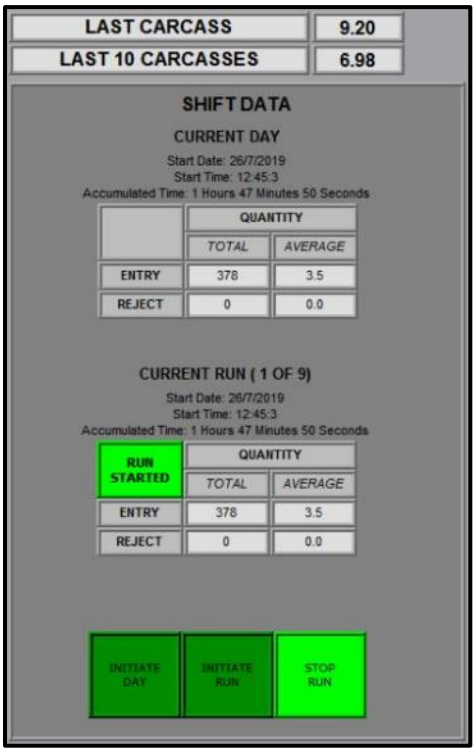

Fig. 38: Throughput statistics as displayed on HMI screen giving real-time information on machine

6.3 Training

Key focus was placed on ensuring the safe and reliable operation of the system; this was achieved through development and adoption of policies and procedures communicated through a comprehensive operator training materials. This allows the customer to gain full value from the project's findings

6.3.1 Manuals & Training Material

- Operation manual

The operator manual for the manual measure single tower primal has been delivered to the customer. A hard copy of this document as handed to the customer is shown in Figure 27.

- Cleaning manual

The cleaning procedure is included in the operations manual and details safe cleaning procedures for the machine.

- Training material

The training manual for the manual measure single tower primal has been included with the deliverable of this document. The document number is JA13439-TRM-220-02. A hard copy of this document as handed to the customer is shown in Figure 27.

- Checklists and spare parts lists

Check lists and Spare parts lists were handed to the customer from our service department at handover. Examples of check lists are shown in operator and instruction manual. A separate list of recommended spare parts submitted to Wagstaff as well.

Fig. 39: Operator and training manual, materials for system

6.3.2 Conduct training for on-site staff

Training was performed over three separate days with eight different employees at Wagstaff. Two supervisors where given a higher level of training and understanding with the intension that they be capable of troubleshooting the machine and providing basic system operation training to new operators.

7 Key messages

The Single Tower Primal System Cell has been successfully installed and commissioned to operate with lamb. The system has run for weeks with continuous monitoring of Scott team including the fine-tuning of details, optimised with speed and cut accuracy. The system is designed for processing 5 carcasses per minutes with two and three cuts and all these are delivered at commissioning stage. Accounting for a lower capital cost and a lower yield benefit compared to the Scott LEAP III, an estimated economic gain of approximately $1.41 per carcass has been estimated. This puts the system's payback period between as little as 1.3 to 1.8 years.

Two operators have been trained who are capable of running the cell unassisted. As mentioned earlier the system has been designed around ensuring operator safety while enhancing product quality and consistency. The operator's safety provides the processor with social benefit that minimises risk brought on by repetitive work and handling in close proximity to hazardous equipment.

Regardless of some of the hurdles faced in this project, the system is performing reliably in cycle time and accuracy and improving red meat yield for the customer. It is hoped than more of these systems can be utilised by other small scale abattoirs in the future.

As part of this project at the completion and handover stage of the manual measure single tower system to client all training and documentation packages have been delivered.

The open day was a great success, with the presentation demonstrating the improvements a Single Tower Primal can make to small / medium scale productions.

As part of this final report, Scott has prepared a video of open day presentation which has submitted with this report.