final report

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Evolution of Standalone Chine Machine to develop dual purpose lamb/mutton chine/flap chine machine

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Abstract

Over the past twelve years Meat and Livestock Australia and Scott Technology Australia (STA) have been developing solutions which align to a collective vision of an automated lamb boning room. As part of the middle machine system development a chine module has been developed. This chine module has the ability to be designed and configured as a standalone unit. After a preliminary independent cost benefit analysis by Greenleaf Enterprises it is apparent that a standalone offering provides a significant return to the Australian processing sector above existing alternatives.

For a dual mutton/lamb processing facility, purchasing a piece of equipment that then sits idle for a period of time (i.e. when the boning room is not processing lamb,) significantly reduces the viability of lamb specific equipment and can result in modern technology not being adopted by processing companies. The net result is that processing companies who process both lamb and mutton have difficulty justifying installing equipment that increase the yield return of lamb, which in return reduces the maximum potential for producers to be paid more for lamb supplied.

Prior to this project, the host processing site had recently trialled the Scott/MLA standalone chine machine with successful results. The trial had identified that whilst the system was able to process most products with excellent results, the size, shape and consistency of the mutton product extended past the capability of the machine.

At that time Scott, MLA and the host processing site identified an opportunity to further develop the Scott automated small stock processing equipment known as LEAP to be capable of processing mutton and extreme sized lamb. This would enable additional processing plants in Australia to adopt the equipment. Given the success of the chine module and that the first modules of the Scott LEAP middle machine (after the rack and loin are separated) is the removal of flaps followed by the chining of racks it was determined that a standalone flap and chine removal machine would provide many of the benefits associated with the Scott Middle machine such as yield retention, reduction in labour, removal of two bandsaw tasks as well as make significant progress towards a “mutton capable” LEAP middle machine.

Executive summary

Scott Automation and Robotics (Scott) and Meat and Livestock Australia (MLA) have recently developed a range of lower throughput, standalone, manually loaded machines based on the modules that operate within the LEAP solution. The intention with these developments is that they will allow processors with lower throughput or restricted capital budget to gain some of the benefit of the LEAP system whilst at the same time procuring modules that can at a later date be pieced together to form a fully integrated LEAP solution whilst reducing re-investment in hardware.

During an evaluation of the chine machine at the host processor (HP), HP identified that there would be benefit in incorporating the flap cutting station from the Scott middle machine. This new module design would be derived from the existing middle machine design, however it is not as straightforward as isolating the chine station. The chine station requires no vision and sensing however the flap station does.

This project aimed to expand the capabilities of the chine system into mutton whilst extracting and implementing the flap cutting station by developing standalone vision and sensing and increasing the flap station capability to process mutton and lamb simultaneously.

As a result of this project a flap and chine machine has been developed and trialled. Good results have been achieved across a wide range of lamb and mutton product however it has been found that the capability to process the full range of mutton shapes and sizes still requires some further development work.

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1 Background

Over the past twelve years Meat and Livestock Australia and Scott have been developing solutions which align to a collective vision of an automated lamb boning room. The solutions consist of an x-ray machine, a primal cutting machine, a middle machine, a forequarter system and hindquarter system (currently under development for Australian customers). As part of the middle machine system development a chine module has been developed. This chine module has since been extracted and configured as a standalone unit. A preliminary independent cost benefit analysis by Greenleaf Enterprises confirms that a standalone offerings provides a significant return to the Australian processing sector above existing alternatives and enables processors that run at a lower throughput or cannot justify the capital outlay for the fully automated system to achieve a portion of the benefit of the automated system at a lower cost.

For a dedicated lamb processing company the current Scott standalone chine machine offers an acceptable payback in its own right. For a dual mutton/lamb processing facility, purchasing a piece of equipment that then sits idle for a period of time (i.e. when the boning room is not processing lamb,) significantly reduces the viability of lamb specific equipment and can result in modern technology not being adopted by processing companies. The net result is that processing companies who process both lamb and mutton have difficulty justifying installing equipment that increase the yield return of lamb, which in return reduces the maximum potential for producers to be paid more for lamb supplied.

One way to encourage companies who process both lamb and mutton to install equipment that improves the return to producers on mutton is to understand how (and evolve) lamb specific yield improving processing equipment to also process mutton, and ultimately, if possible, also include the yield recovery of mutton as well. At the very least having a piece of equipment that can be utilised 100% of product time, even if no yield improvement to manual mutton boning, still results in significant operator health and safety when mutton boning.

During evaluation trials at The host processor (HP), HP have identified that they benefit from incorporating the flap cutting station from the Scott middle machine into a standalone module. This module can be derived from the middle machine, however it is not as straightforward as isolating the chine station. The chine station requires no vision and sensing however the flap station does.
As such this project will enable Scott to work with HP and MLA to expand the capabilities of the standalone chine system into mutton whilst extracting the flap cutting station, developing standalone vision and sensing and increasing the flap station capability to process mutton and lamb simultaneously.

An independent analysis previously completed by Greenleaf Enterprises identified a cost benefit analysis of the chinning systems on offer by BLM and Scott with the Scott system having a 0.18% yield loss and the BLM system a 0.51% yield loss, with this difference equating to $0.85 per head processed. As part of this project structure a similar cost benefit analysis was intended to be develop to validate the opportunity within the mutton product category plus removal of the flap.

Table 2: Preliminary results of Scott's chinning machine performance in production

Chining Yields - Scott's Prototype machine (Silverstream plant May 2012)								
Rack Grams	Left Rack Grams	Right rack grams	Chine - untrimmed	Chine post scraping	Left chine meat	Right chine meat	Avg weight/side	Yield loss
							0	0
	0	0	0	0	0	0	0	0
1870.5	**833.9**	**808.2**	**230.1**	**212.5**	**8.3**	**9.5**	**1872.1**	**3.3**
	65.932	75.859	24.425	21.767	2.831	2.586	911.900	4.819
	736	688	195	180	4	5	0	-25
	960	1028	312	289	15	16	2278	15
	224	340	117	109	11	11	2278	40
	44.58%	**43.21%**	**12.30%**	**11.36%**	**0.45%**	**0.51%**	**100%**	**0.18%**
	87.8%			**0.94%**	**0.95%**			

Figure 1-1 - excerpt from Greenleaf analysis

Table 3: Preliminary results of BLM chinning machine performance in production

	Chining Yields - BLM production machine (Silverstream plant May 2012)								
	Rack Grams	Left Rack Grams	Right rack grams	Chine - untrimmed	Chine post scraping	Left chine meat	Right chine meat	Avg weight/side	Yield loss
								0	0
sum		0	0	0	0	0	0	0	0
Avg	**2064.1**	**882.0**	**868.1**	**309.8**	**260.4**	**18.7**	**26.1**	**2059.9**	**10.6**
StDev		141.216	129.731	38.004	31.310	6.280	8.315	940.013	7.452
min		625	535	209	181	9	10	0	-2
max		1247	1184	380	336	34	44	2811	28
Diff		622	649	171	155	25	34	2811	30
		42.73%	**42.06%**	**15.01%**	**12.62%**	**0.90%**	**1.26%**	**100%**	**0.51%**
		84.8%			**2.39%**	**2.17%**			

Figure 1-2 - excerpt from Greenleaf analysis

The technology developed through conducting this research would be a standalone machine containing:

1. A chining module capable of processing both mutton and lamb.
2. A flap removal module with its own vision and sensing station capable of processing mutton and lamb.
3. The required mechanical and electrical connectivity to integrate the chine and flap removal into a single, integrated but standalone solution.

A vision system will need to be developed to enable the flap station to know where the eye meat muscle and spinal cord are located. This research was required as current Scott automated systems are only built for lamb and this project intends to allow flexibility through be capable of processing both lamb and mutton. Additionally, semi-automated systems using laser measuring systems (where the middle section is placed manually) to ascertain cut points.

2 Project objectives

Using the Scott standalone lamb chinning machine, Scott, a host processor and MLA are able to evaluate the majority of challenges facing the machine when processing mutton and understand the what work is required to enable both the following to occur:

1. Modify the existing chine system to enable the processing of both mutton and lamb.
2. Develop a standalone vision and sensing system to enable the flap removal station to operate as a standalone piece of equipment from the current middle machine.
3. Develop the flap cutting station to process mutton.
4. Integrate the developed and upgraded components into a single standalone piece of equipment that can process flaps and chine removal.
5. Redesign the lamb machine for mutton processing, with an increase in mutton yield recovery, but no loss in lamb yield recovery (but retain operator safety)
6. Fine tune the resulting integrated system for both mutton and lamb yield improvement.

The project output will be a modified Scott's standalone chine boning machine with the capacity to accommodate Australian mutton processing requirements to a standard representative of a typical Australian export meat processing plant plus a new standalone flap removal station capable of processing lamb and mutton to a standard representative of a typical Australian export meat processing plant.

3 Methodology

3.1 Concept and detailed designs

Using the Standalone Lamb Chine Bone Saw (LCBS) as a base, a new standalone and modular (expandable) rack and loin processing system was developed. Critically, the new system had to be capable of processing a wide range of lamb and mutton product. The system was to replace many of the processing tasks typically conducted manually on a bandsaw. These include:

- Loin flap cut to length
- Rack rib/flap cut to length
- Rack chine removal (CFO)

The proposed advantages of such a Lamb Flap Chine Machine (LFCM) would be:

- Improved yield and product consistency due to high precision flap/rib cuts on both racks and loins.
- Vastly improved yield and product presentation of CFO products due to proven performance of the Standalone Lamb Chine Machine.
- Reduced sawdust contamination, due to abolition of bandsaws.
- Reduced OH&S risks, due to abolition of bandsaw tasks.
- Optimised labour utilisation, the LFCM will be able to conduct flap and CFO on up to 16 parts per minute.

In addition the design would include improvements identified for the original LCBS during the course of its trial and demonstration at the host facility. These are the additional challenges presented by the LFCM and site requirements:

- The need to make the machine modular and expandable to facilitate increased automation in the future.
- Requirement to make the machine "mobile", easy to transport, install and move for cleaning.
- Footprint restrictions that prevent the existing Scott middle machine format from being replicated.
- These requirements lean toward structurally integrated guarding, similar to that used in the LCBS.
- The current LCBS is not configured to allow easy transfer of product and waste to an external conveyor system, this was to be rectified.
- The added complexity of the system and the need for the flexibility to incorporate future additional modules requires the introduction of an HMI screen which will allow the operator to input and update (live) the desired product specifications.
- Cleaning capability needed to be improved based on feedback from the LCBS trials.
- A revised safety system and assessment was necessary.
- A single operator can easily load the current LCBS at 6 parts per minute (racks only). Tests where the operator had to load 12 parts per minute (which would be the case when loading both racks and loins at 6 carcasses per minute) were only successful if all the parts were presented to the operator in the correct orientation. To achieve even higher throughputs than this a second operator may be needed.
- Due to the multiple processes being conducted in a small area and on the same product chain, the original LCBS configuration of a "floating" (suspended on pneumatic cylinders) product chain (which allows the system to account for product variation) would no longer be viable. Therefore, the product chain would have to remain rigid and instead each of the processing modules had to become "floating".

A specification document was prepared in collaboration with The host processor (HP). This specification document detailed:

- Overall assembly drawings of the LFCM,
- The original floor plan of the boning room,
- The floor plan showing the proposed location and conveyors for the LFCM,
- A machine overview describing the functions of various components of the machine,
- Product output / production specifications,
- Description of raw input product, Human Machine Interface, Supporting Services and Infrastructure to be provided or otherwise considered by site (including estimated costings),
- Product out-feed conveyor details
- Equipment Specifications and list of proprietary component suppliers,
- Guarding and Safety requirements
- Description of Acceptance Criteria and Testing,
- Requirements for Training,
- Other site input.

The specification document has been included as Appendix A.

A series of trials using the LCBS and measurements at site were used to detail the machine design for manufacture.

3.2 Build and Factory Testing

3.2.1 Build stage 1

The machine build and testing was conducted in the Scott Dunedin workshop in collaboration with Australian design and technical input.

The main machine build components were:

1. Mechanical fabrication, assembly, reticulation and plumbing
2. Electrical wiring
3. Machine control programming
4. Vision and sensing
5. Systems integration

Build Stage Images

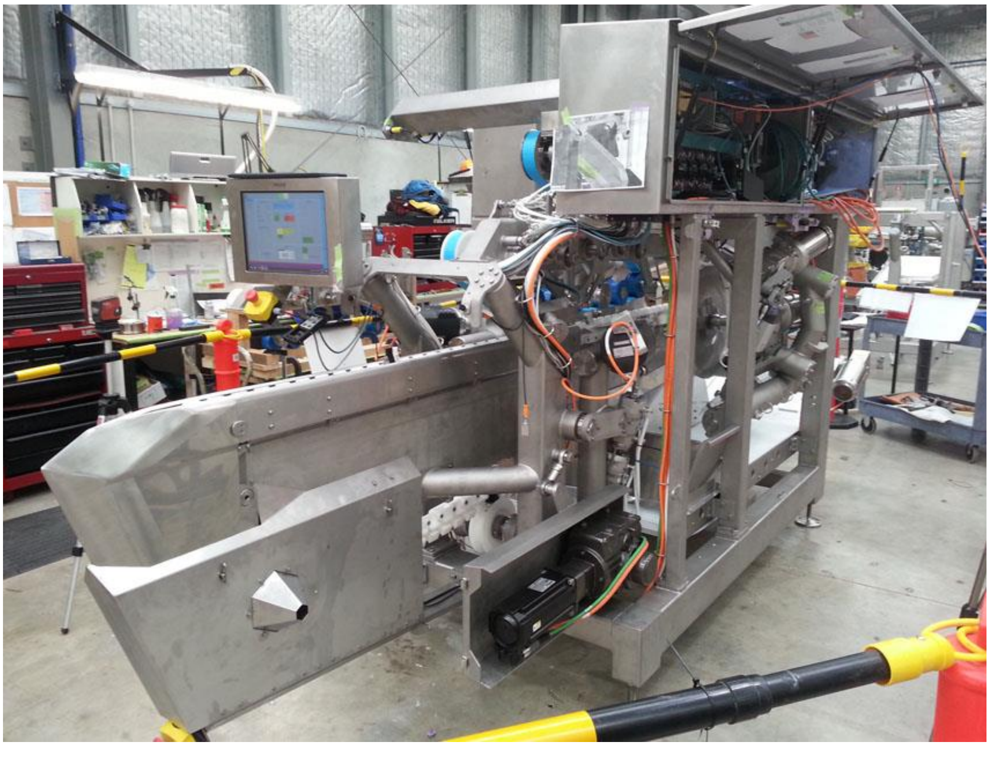


Figure 3-1 - Load station and operator interface during build

Figure 3-2 - Outfeed interface

Figure 3-3 - operator interface

Figure 3-4 - Control cabinet and reticulation

The machine trialling consisted of two stages:

1. Dry cycle testing

Dry cycle testing involved the manual step through of each actuator and sensor to ensure the signal processing and mechanical linkages were operating to specification and that the designed machine function and interlocks were operating correctly. It is possible to pick up any geometrical interferences brought about through motion or forced interlock failures at this time

Dry cycle also allows the testing of all the machine safety interlock features and a re-assessment of the safety design for the machine.

Dry cycling then operates the machine in its normal processing cycle without product present. This ensures that all machine functions have been integrated together correctly and allows a first view of the system dynamics.

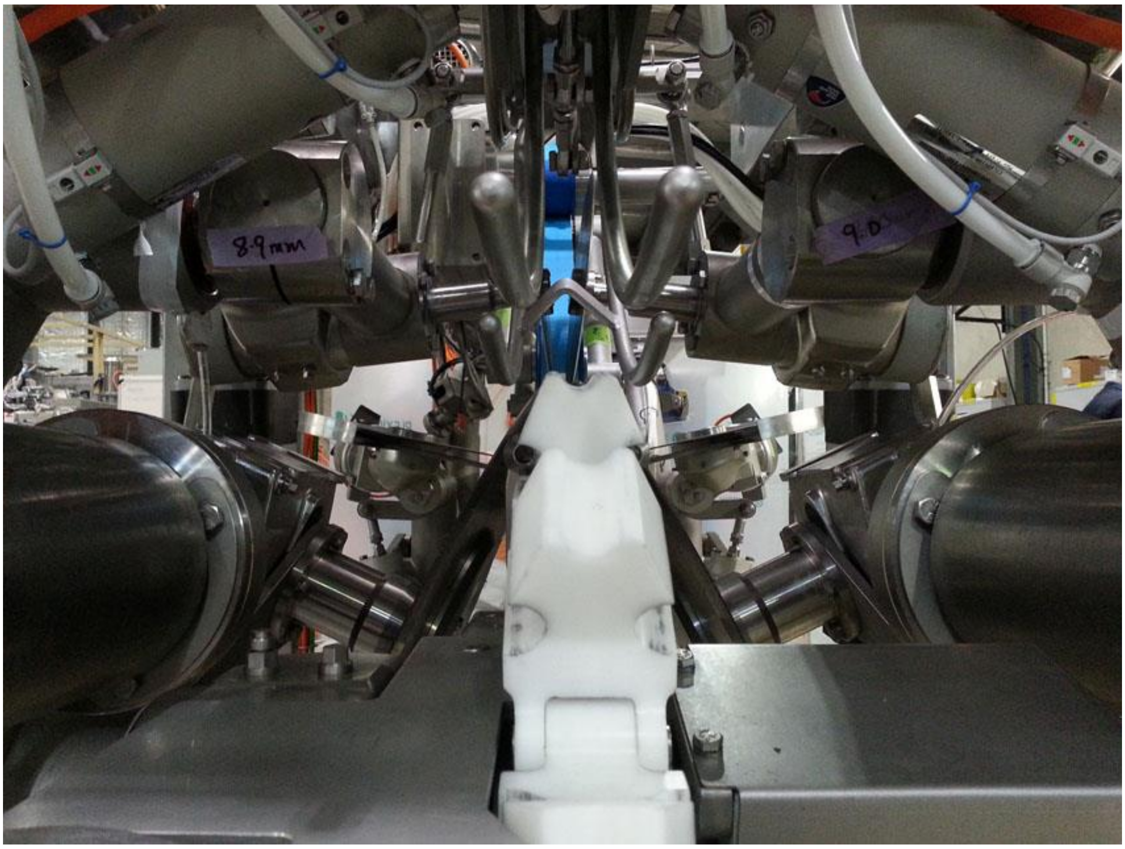


Figure 3-5 - Main product transfer

Figure 3-6 - Chine cutting station and Flap cutting station

Figure 3-7 - Chine cutting station

Dry cycling was completed successfully.

3.2.2 Scott factory customer product trials

Product was sourced from host processor International Export site and shipped to Dunedin as chilled boxed saddles to factory trial the machine. There were a range of lamb and mutton products and pre-process conditions. These included saddle product that had the brisket cut off center, excessive kidney fat as well as product where the aorta was left attached to the saddle. The functions that were satisfactorily demonstrated include:

- ☑ Manual loading
- ☑ On the fly vision system
- ☑ Single chain and pushers through flap and chine station
- ☑ Overhead retaining belt through flap station
- ☑ Guarding
- ☑ Flap cutting
- ☑ Chine cutting – except products that lift the station 20mm and over
- ☑ Clearing of chine bones
- ☑ Delivery of cut portions
- ☑ Controls enclosure, cooling and wash down protection

3.2.3 Issue Realisation

During the trialling with product it was realised that there was a “toe-in” issue with the blades on larger spine product generating an incorrect cut. This appeared to be an inherent issue with the way the chine station was designed based on the principals as they were understood in the LEAP middle system and lamb chine bone saw. The fundamental principal is shown below where the blades need to move as the product size and shape varies.

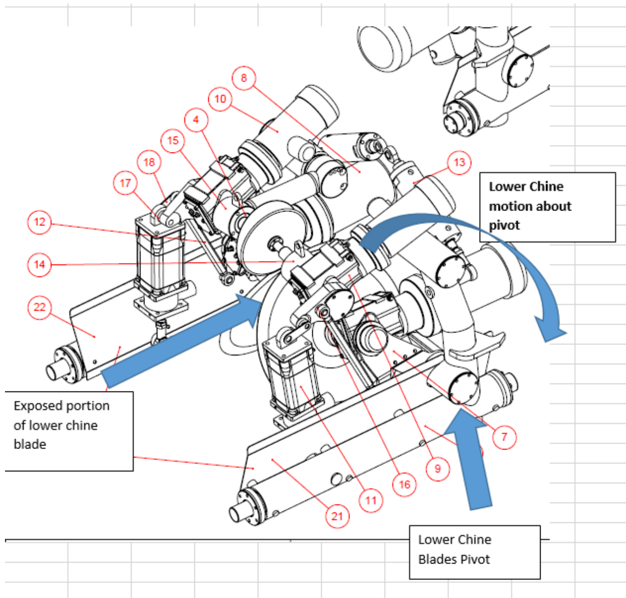


Figure 3-8 - Chine cutting station overall assembly

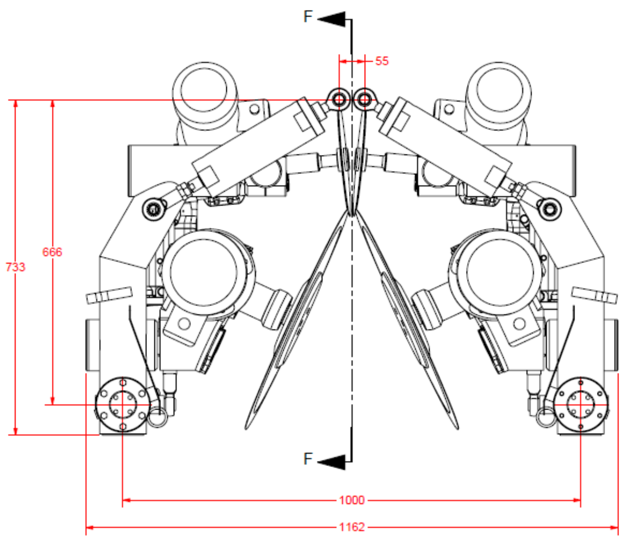


Figure 3-9 - Chine cutting end view

In this design the blade angle changes slightly with the movement in the assembly which was supposed to mimic the effect that is experienced in the LEAP and LCBS where the conveyor can deflect to accommodate product variation.

3.2.4 Description of Chine Station Toe-In Issue

It had become clear that the “Toe-In” of the lower chine blades for the devised geometry reduced to 0 for a product of a spine dimension of 20mm larger than the minimum product specification. The upper product specification needed to be 30mm larger than the minimum. Theoretically a positive toe-in is required – it is the equivalent of a positive rack as typically required for cutting.

Trials were done which displayed products at 15mm cut well down the length of the spine and products at over 20mm cutting poorly. The station “climbed” excessively.

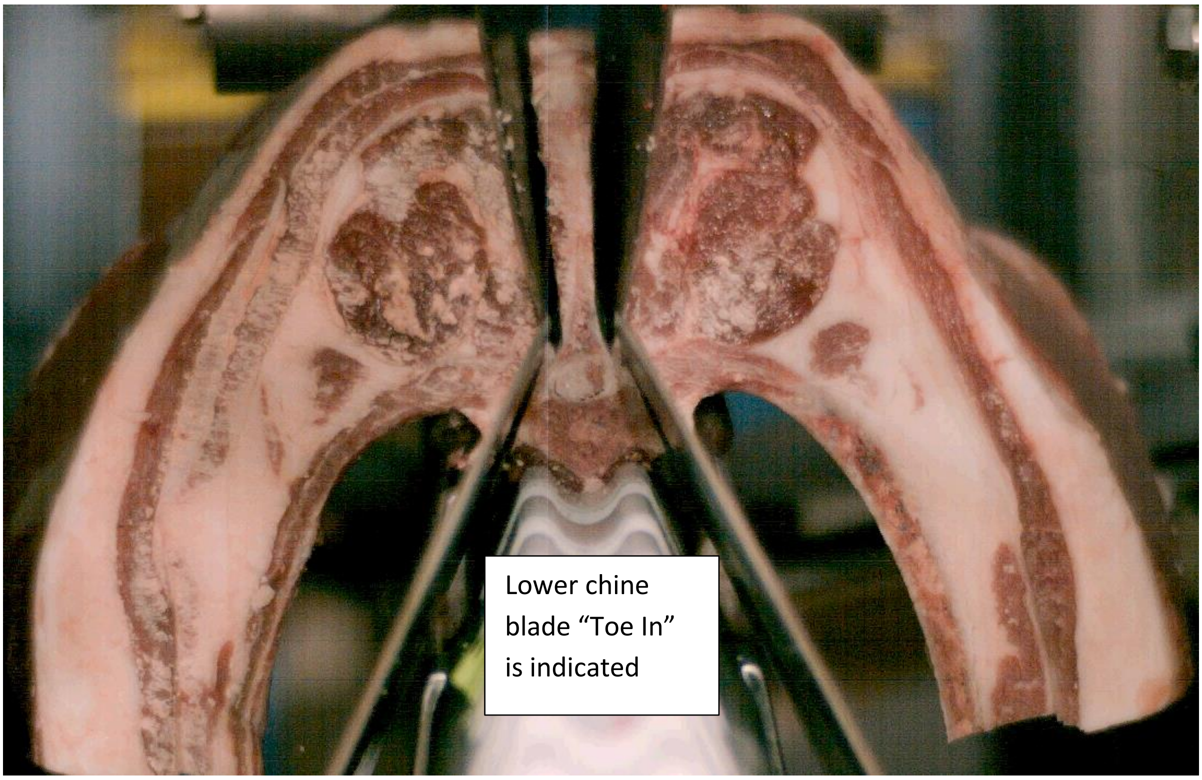


Figure 3-10 - Chine blade "toe-in" issue - end view

Figure 3-11 - Chine to-in issue

The images above of the product with ideally a 20mm lift shows the toe-in is lost and the station rode up to 44mm. The product has also lifted. The chined rack is poor, as evidenced by the meat thickening (yield loss) on the chine bone.

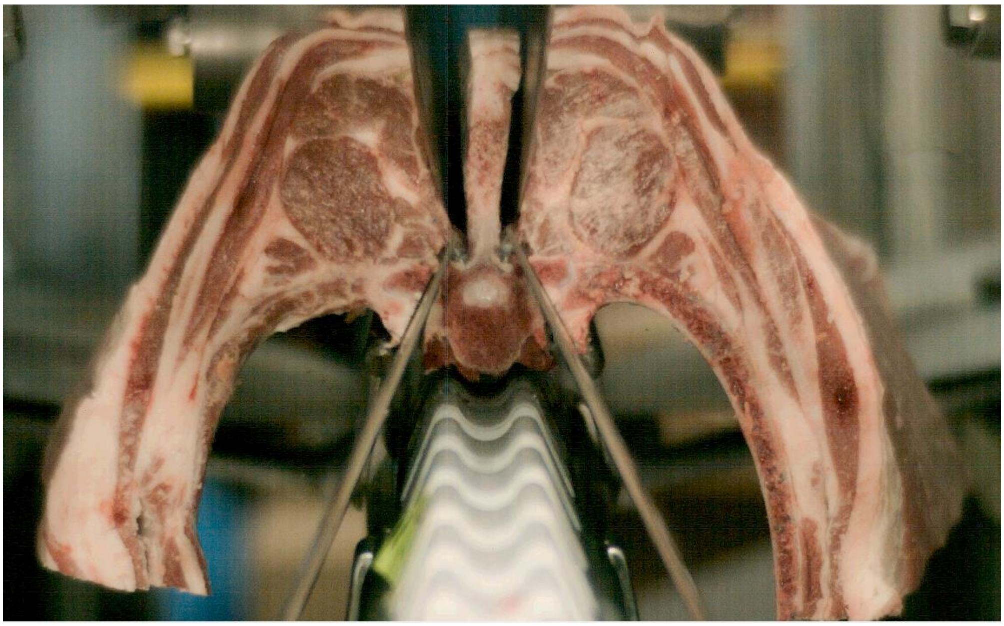


Figure 3-12 - Chine - blade angle and movement

Figure 3-13 - Chine to-in issue lost yield

Figure 3-14 - Yield loss due to toe-in issue

Figure 3-15 - Chine to-in issue lost yield measure

3.3 Build and Factory Testing Stage 2

3.3.1 Design to address issues identified in first stage factory trials

The chine station of the flap chine project has blades which float to "self-adjust" for variation of the rack spine.

Rework was required to develop a new design and build effectively constructing a whole new station – right back to the bypass pivot. The result is as per figure below.

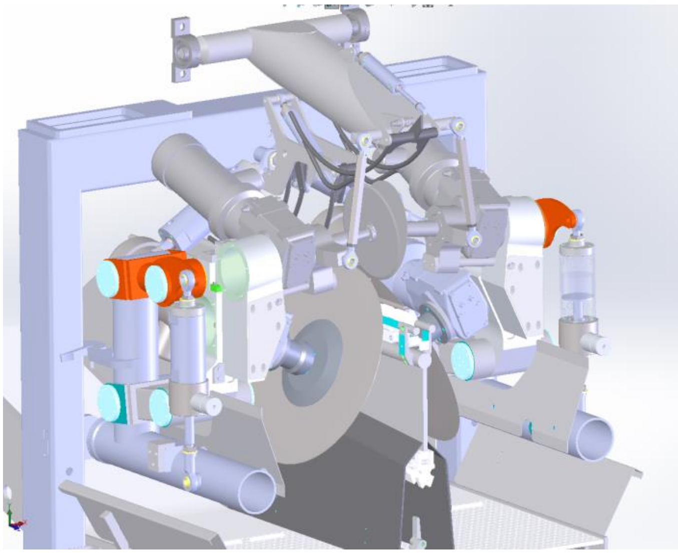


Figure 3-16 - Design changes to rectify toe-in geometry issue

The vertical height axis is now achieved with a parallelogram principle which ensures that there is no angular change to the blades assembly; therefore toe-in is maintained throughout the vertical axis range. The parallelogram design includes links and pivots as shown in the figure below.

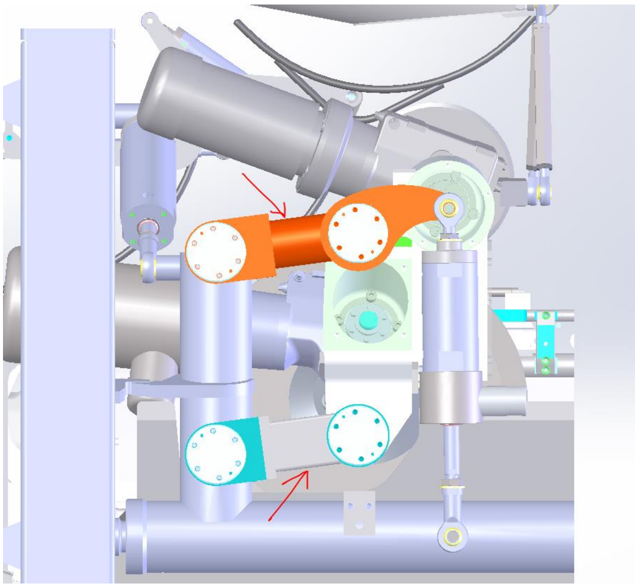


Figure 3-17 - Parallelogram principal

The two figures below show how the toe-in is maintained at the minimum and maximum height of the blade assembly.

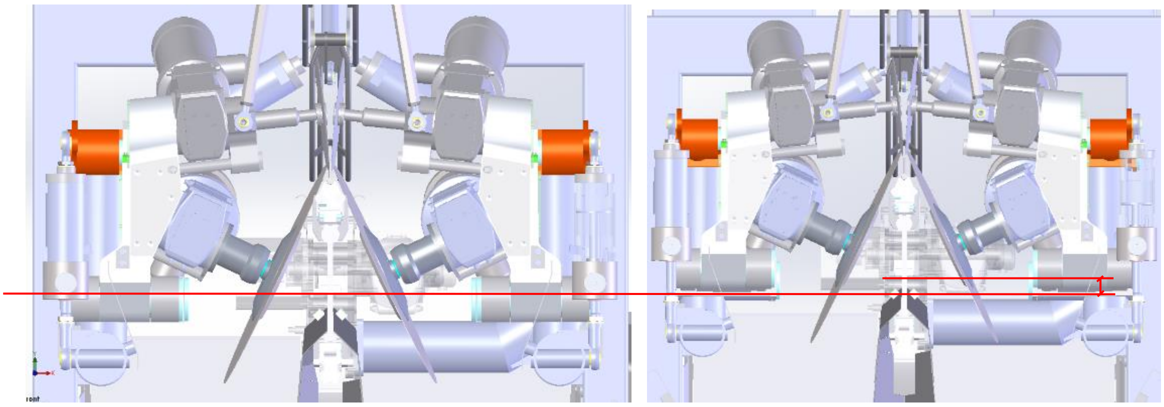


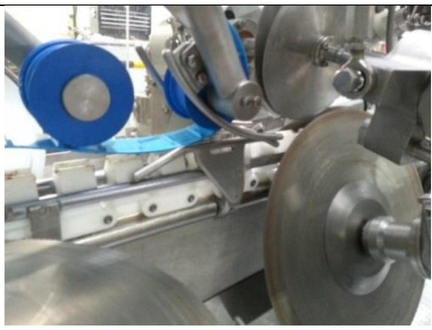
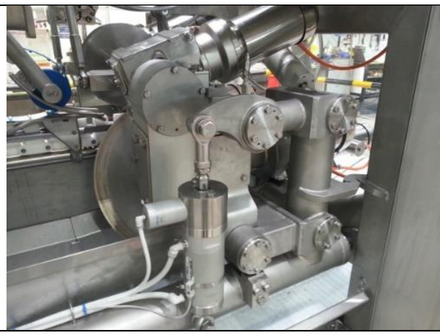
Figure 3-18 - Min and max blade height

3.3.2 Build stage 2

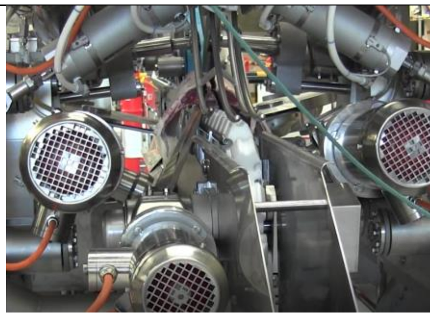
On completion of the re-design the system was re-fabricated and assembled.


Front/Right

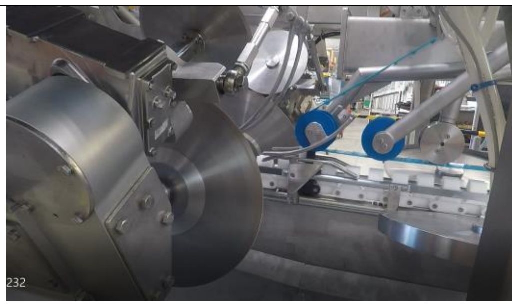

Front/Left



Floating chine station


Side view


Front view


Flap and Chine Stations


Loin Bypass Mode

3.3.3 Product trailing stage 2

The solution was able to eradicate the toe-in issue causing the cut “runoff” on the racks as shown in Figure 3-19 and the resulting cut remains on the cut line through the length of the rack as shown in Figure 3-20.

Figure 3-19 - Toe-in causing runn-off

Figure 3-20 - Resulting cut remains consistent for the full length of the chine

The machine was fully commissioned and approved for shipping.

3.4 Site Installation

The machine was shipped and arrived on site at host processors site with a Scott technician on site to assist in removal from container, unpacking and reassembly of machine.

Scott technicians were present on site for the final assembly of the machine and to ensure the machine was moved safely into place. Scott technicians then conducted initial setup and blade tuning.

Approximately 200 product were run through the machine during the setup with a number of issues realised and by and large resolved. The issues included:

- A number of small HMI issues, Safety enhancements, dimensional differences from HMI input to actual cuts and a review of saw dust generation on the product.
- Additional emergency stops were added and an operator area emergency stop was relocated.

A remote change was made to the blade speed to match that of the LCBS machine.

Most issues were resolved in the first installation week plus a return visit by a Scott technician with assistance remotely from NZ Engineers.

Saw dust generation remained with the knowledge that the blades would bed in over a short period. It was determined that the development machine did not generate saw dust and blades were swapped for a test. The new blades on the development machine did generate saw dust but at a reduced level to the new blades on the new machine proving that the blades are the source of the saw dust. It was noted that there is also a small RPM (40 rpm) difference for the 530mm saws between the LFCM and LCBS.

Figure 3-21 - Unloading at host site

Figure 3-22 - Unloading at host site

Figure 3-23 - Testing location (On transport Skid)

3.5 Site commissioning and testing

The commissioning of the machine was performed over a number of site visits each with challenges surrounding the machine function and product variation.

The first challenge discovered related to the lower chine blades stalling. This was rectified by replacing the drive module in late September.

The infeed rails were found to be too shallow for the largest product as the product spine sat on the conveyor and was dragged in by the conveyor rather than the transfer pegs. This was temporarily alleviated by adding 10mm round bar to the infeed rails. New guide rails were subsequently manufactured and installed.

During late September an offline product run was held where good volumes were passed through the machine whilst located to the side of production in a room adjacent to the production room. This allowed vision tuning to be undertaken on the product (25-30kg Product).

The machine was then relocated into the production line for further trials in late September. Larger product was put through the machine with a number of different flap length cuts.

It was found that the shorter cut lengths of around 35mm generated a curve in the ribs on the length of the cut due to the camming action of the saw. The camming is performed to have the saw move to have the eye meat to rib end length at the FQ and loin ends similar. To reduce this curvature, the angle of the blades is currently changed, but this generates a chiselling of the ribs. The current system cannot completely negate both of these product cut characteristics during cutting.

During the 35mm product runs the sawdust on the product was not removed. This showed the vision system could not detect the eye meat sufficiently generating poor flap cut lengths. The product is readied on band saws adjacent to the flap chine machine and the manual operation of wiping away the saw dust is not considered an operation that can or should be performed by the operators by HP.

Training has been completed for operators and maintenance staff with sign off performed by Scott and HP staff.

3.6 Site Issues resolution

3.6.1 Chine blades stalling

The first site visit in the production environment revealed issues where the chine blades would stall in the product.

This was resolved by exchanging a failing drive module.

3.6.2 Infeed rails suitability for larger product

The variation in small to large product also presented an issue on the infeed of the system where the product would not seat correctly, as the rib arches were larger than the infeed guide rails and the spine tended to ride the conveyor rather than the rails. This also presented issues as the conveyor moved the product rather than the pegs on the conveyor and saw the product out of synchronisation with the cutting stations. Temporary rails were fitted to raise the product to ensure that the product was transported along the rails by the conveyor pegs. New permanent fit guide rails have been manufactured but have not yet been fitted.

3.6.3 Chine cutting off centre

Product occasionally chined off centre.

If the brisket is cut off centre the rack product is biased on the infeed conveyor. This bias remains as the product enters the system and is secured by the top support belt. There is little movement in the product after the product is secured between the upper and lower belt. This allows the chine to cut off centre (incomplete chine removal). This was unresolved but infrequent.

3.6.4 Flap length cutting inconsistently

There were a number of issues identified in the flap cut station but were all inter related

The flap cut length was inconsistent taken from the eye muscle at the forequarter end. This was found to stem from the sawdust/pasting on the eye muscle area generated by the upstream saw cuts. The sawdust inhibits the vision system taking a clean reference point for making blade position adjustments. The product preparation for this machine is performed on band saws generating sawdust. The sawdust issue is still unresolved.

If the sawdust is manually cleaned from the product, the forequarter end of the product dimensional cuts from eye muscle to rib end are generally within the machine build specifications of ±5mm from target. With the machine set to 75mm cut length the in spec cut over 100 product was >95%.

Machine settings reduced to 35mm cut length realised an issue primarily with the larger product through the machine.

The cut through the length of the product was not consistent when measured from eye muscle to rib end at both ends of the product.

This issue was improve by camming the saws so that they moved up and down as the product passed through at a set programmed ratio. With the variation in product size and the set ratio to reposition the saws as the product passed through it proved to not be controlled against the product.

The larger product also made evident another issue where the setting of the camming ratio led to chiselling (not square) of the rib ends and also generating an arc along the rib rack making this product unsalable. This is due to the mechanics of the machine and could not be resolved through adjustments to existing hardware.

3.6.5 Other issues

The size of product attempted to be passed into the machine is physically too large for the machine entry point in some instances

3.7 Items still for determination

On completion of resolving the issues identified in the above mentioned commissioning visits the machine was able to be run in line with production and a significant quantity of product was able to be processed through the machine. This has enabled a thorough understanding of the effectiveness of the designed solution to achieve the project objectives.

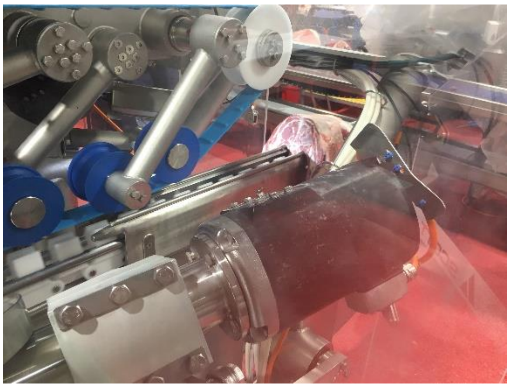
It has been learned from this that there are a handful of unforeseen shortcomings with the selected design that prevent the machine from reaching a desired performance level. These are listed below.

These learning’s have provided a clear understanding of what design changes would be required to improve the performance of the machine to achieve a level of return that would justify capital expenditure for a machine of this ilk.

Scott, MLA and the host processor are now establishing what would be required to complete this further development. Together Scott, MLA and the host processor will review what the best path forward is with the knowledge of what further development is required.

Images showing unresolved issues

 **75mm reference point not taken from eye meat by vision system**	 **Product arches not sitting on the infeed guide. Spine riding the conveyor**
Image 1	**Image 2**
 **The fat and aorta ride the conveyor rather than the rails – This is an extreme example**	 **The fat and aorta ride the conveyor rather than the rails – This is an extreme example**
Image 3	**Image 4**

 **The fat and aorta ride the conveyor rather than the rails – This is representative of the norm.**	 **Infeed rails raised to attempt to support the product off the chain.**
Image 5	**Image 6**
 **Result of chine off centre due to rolled product on infeed – Note the eye meat dimension**	 **10mm round bar Infeed rails fitted - Trial**
Image 7	**Image 8**

 **Brisket cut off centre skewing the product**	 **Machine in production location**
Image 9	**Image 10**
 **Machine in production location showing conveyors on outfeed**	 **Spares on site**
Image 11	**Image 12**

Whilst the machine still has outstanding issues statistical data sets have been analysed only for the purpose of machine improvement. A series of measurement data and analysis to aid in issue identification and resolution has been captured over a few hundred product.

4 Results

4.1 Site preparation

4.1.1 Room readiness

The room was prepared for the machine to be located in the final production location.

This included transforming a pre-existing storage location in the production room to a food grade suitable production environment space, installation of three phase power supply capable of supplying sufficient current to run the machine, installation of instrument quality compressed air to the required specification to run the machine, installation of Ethernet (and associated services) for data transfer/remote access plus the build and install of a number of cut product conveyors to the location of the machine to take product from the machine outfeed back to the main processing line so that operators could continue with further processing and product could continuously flow through the boning room to the packaging area.

4.1.2 Spares package

It was identified as part of establishing this project that for successful commissioning and operation of the machinery in production without introducing significant risk associated with machine breakdown or stoppages, any machine components that are either at high risk of becoming damaged in case of a machine fault or that would introduce significant downtime based on the lead time (availability) should be stocked at site.

A list of all available parts was identified, evaluated and a selection was made in consultation with Host Processor maintenance department. Parts that were identified as mission critical and/or long lead time were procured/manufactured and delivered to the Host Processor by SCOTT.

4.2 Flap & Chine machine commissioned

Figure 4-1 - Testing location (On transport Skid)

The Flap & Chine machine was successfully installed and commissioned. The machine was initially installed in a space adjacent to the processing room so that initial setup and tuning could be performed without disrupting production.

At this time the machine was retained on a transport skid to enable the movement within the work area as well as transport to the processing room when tuning had been completed.

The machine was moved into the processing room on completion of the trialling and integrated into the production line so that production trials could be conducted.

The machine was tuned and commissioned and Scott and HP staff agreed on the machine conditional acceptance of commissioning allowing the machine to move to product trialling.

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SITE ACCEPTANCE TEST – SIGNOFF

Company:	[redacted]		
Address:	Lot 11 Yarrandale Rd, Dubbo NSW 2830		
Project Number:	12080 (275)		
Project Type:	GS GI IS II (PLC) PM S R		
Project Description:	Standalone Flap Chine machine		
Company Contact:	[redacted] (Plant Manager), [redacted] (Maint. Manager)		
Phone:	[redacted]	**Mobile:**	
Email:	[redacted]		

Date Completed:	3/11/2017
Warranty Period:	12 Months
SCOTT Engineer/s:	[redacted]

	Criteria for SAT	
Installed	(Yes) No N/A	Requires feet to be fitted when in final location
Commissioned	(Yes) No N/A	Yes – Off line. Final location tests to be performed and any required adjustments to be made by SCOTT. (Estimated June 2018)
Site Safety Risk Review	(Yes) No N/A	Reviewed with Fletcher's. Additional e-stops fitted and validated
In Production	Yes (No) N/A	Available for production.
Performance Criteria Met	(Yes) No N/A	
Documentation	(Yes) No N/A	With machine. Electrical Drawing update to be provided
Maintenance Agreement	Yes (No) N/A	
Follow-up	(Yes) No N/A	New 530mm blades may take a few weeks to bed in to reduce the saw dust (pasting) Spare parts to be selected and procured
Signed (Customer)	[signature]	(Conditional sign off per above)
Date	4-1-2018	
Signed (SCOTT)	[signature] IAN GRIMLEY	
Date	5/1/18	

SCOTT Automation & Robotics Pty Ltd

- Robotic solutions
- Consulting & front end engineering
- Automation & control systems
- Software & supervisory systems
- Sensing & vision
- 24HR / 365 day service

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Figure 4-2 - Conditional acceptance agreement

4.2.1 Unresolved Issues

The machine was trialled in production and it was found with a significant number of product put through the machine that some additional issues exist on various products within the range of typical production. These issues are listed below.

Deficiency	Cause	Potential solutions	Results/Expected results
Flap cut location from Forequarter eye muscle to rib	Saw dust	• Scrape sawdust off by operator or mechanical means. • Change upstream cutting technology	Manual removal proven to improve vision
Eye muscle to rib end forequarter dimension the same as eye muscle to rib end loin dimension	Assumption that eye muscle ratio is the same FQ to loin on all product	• Additional camera • Use a different method to determine eye muscle location (prediction model) (Both require eye muscle saw dust to be removed)	• Expected that two cameras able to determine FQ to loin ratio • Expected that alternate vision calculation method may be more accurate
Curvature in flap cut and chiselling of rib ends	Existing mechanical arrangement with larger product	Change mechanical set up to allow more positional control over the flap station blades	Expected that the removal of the flap accuracy is improved and chiselling is reduced
Product bias on infeed conveyor	Brisket cut off centre (Primary cause)	Brisket cut accuracy improvements	
Product being taken into system by conveyor and not pegs	Rails not suitable to larger product with fats etc. still on	Change rails	Product will ride on the rails and not the conveyor
Large product cannot enter the machine	Opening size	Review opening against product spec	

Table 4-1 - Unresolved issues

5 Discussion

5.1 Resulting Flap & Chine machine

Developed in this project is a “Standalone Flap & Chine” removal machine that is founded on the flap and chine components of the standard Scott Middle Machine. It is intended that the internal workings of the machine can at a later date be transplanted into a fully automated Middle Machine reducing re-investment and minimising hardware redundancy.

The machine is manually loaded with lamb and mutton middles, rack saddles or loin pairs and processes them by cutting of flaps to an operator selected specification and remove the chine bone resulting in two CFO racks. Once loaded onto the product transfer (chain) the machine transfers the middles through the flap and chine station. Cut flaps and racks fall to the product conveyor and the chine bones come off the end of the machine. The machine also processes loins and whole middles which necessitate that the chine station must move away from the product and allow it to bypass. The chine station involves two upper blades and two lower blades setup such that cuts are made adjacent to the feather bone and through the intercostal joint.

The station vertically self-adjusts both upper and lower chine blades to the product size by gauging off the root of the feather bone with the upper chine blades. The system is counterbalanced to limit the “weight” of the station. The flap chine machine development has been through design, build and commissioning in which a number of products have been run.

The basic building blocks of the machine are as follows:

Flap Station

Inputs:

1. Rack saddles (see product specifications for further details)
2. Cut specification selection.
3. 2D vision used to determine the eye meat width

Outputs:

1. Flap onto outfeed product conveyor
2. Rack saddle (flap off) remains on the main feed chain

The Flap station consists of the following key components:

Transfers:

- Main acetal conveyor
- Overhead stabilisation conveyor

Stations:

- Loading station
- 2D camera vision station
- Flap removal station

Product Conveyors

- Flaps would eject onto two flat conveyor belts that run the length of the machine common with the CFO racks and chine bone. These belts converge at the outfeed end of the machine.

Chine Station

Inputs:

1. Rack saddle flap off (Ex flap station)

Outputs:

1. CFO rack onto outfeed product conveyor
2. Chine bone onto outfeed product conveyor

The Chine station consists of the following key components:

Transfers:

- Balanced acetal conveyor

Stations:

- Chine removal station

Product Conveyors

- CFO racks would eject onto two flat conveyor belts that run the length of the machine common with the flaps and chine bones. These belts converge at the outfeed end of the machine.

5.1.1 Specific outcomes

In achievement of milestone 5 the standalone manually loaded flap and chine removal machine was shipped and commissioned as far as is practical for the Host Processor product variation given the design used. The site has been successfully altered to accommodate the machine being run in-line with production, the required support services have been installed and the mission critical spare parts have been delivered to site.

The flap and chine machine has subsequently been removed from the main production line and the Scott standalone chine machine re-instated pending a decision by Scott, MLA and the host processor on what next steps should be pursued. Initial meetings with the host processor indicate that there is still a desire to both complete further development of the machine to make it suitable however an understanding of the required investment is necessary to understand if this out ways the benefit in completing the further development.

Scott, MLA and the host processor are determined to make a decision on next steps however given the status of the current project it is recommended that milestone 6 – Cost Benefit Analysis not be completed at this time. Milestone 6 was designed for an independent audit by Greenleaf enterprises PL to evaluate the cost in relation to the benefit of the flap and chine machine. However completing this analysis while the machine still requires further development would not provide data that is useful to Scott, MLA, the host processor or industry as a whole.

6 Conclusions/recommendations

In concluding this project the following has been completed.

The required mechanical and electrical connectivity to integrate the chine and flap removal into a single integrated but standalone solution has been implemented.

The Flap and Chine machine has been developed for lamb and mutton and commissioned within the host processor facility.

It has been found through further product trialling that the machine is not able to process the full range of lamb and mutton product at the host processor site to an acceptable standard.

Further development has been identified to resolve the remaining issues and a decision is pending on how or if to complete this additional development work.

It is recommended that milestone 6 – CBA analysis is not completed while the machine still requires further development.

7 Key messages

7.1 Milestone 6 - CBA

As there are still unresolved issues with processing the full range of lamb and mutton product at the host processor site it is recommended that milestone 6 – CBA analysis is not completed.

7.2 Further development

A decision needs to be made on if and how to proceed with completing the remaining development required to address the issues that have been identified and remain unresolved from this project.

The key issues and related developments are summarised in the table below:

Issue: Solution	Work required
1. Saw dust/paste Obscured eye meat	
Enhance vision analysis robustness with coping with partly obscured eye meat with the exploration of the capability of neural networks	Vision analysis development, dry commissioning and validation
2. Rib length at the loin end of the rack and non perpendicular rib cut angle (the chisel) or perpendicular but longitudinal curve in ribs cut	
Add camera and vision analysis to the loin end of the rack and vision analysis to obtain ideal rib length measured off the loin end eye meat and associated camming down software	
	Design
	Mechanical, Electrical, PLC and Vision design
	Build
	Hardware (incl Camera, cable and servo kit) and assembly
Add servo electric actuator to "tilt" axis, both sides (in place of the two, each side, series cylinders) and in association with the loin camera, optimise the "camming" of both tilt and height axis along the longitudinal axis	**Design**
	Mechanical, Electrical, PLC and Vision design
	Build
	Hardware (incl Elec cylinders, cables, mounting and drive) and assembly
3. Overall	
	General shipping incl machine to/from Scott workshop
	Install new rails for product guidance
	Commission at Scott factory (Sydney)
	Commission at Fletcher Int'l
	Ongoing tuning and support
4. Cost benefit and final report	CBA and final report carry over from current project

8 Bibliography

Philip Green – Greenleaf Enterprises PL, 2014. *Lamb chining technology comparison – final report*. MLA A.TEC.0104.

9 Appendix

9.1 Flap & Chine specification document excerpt

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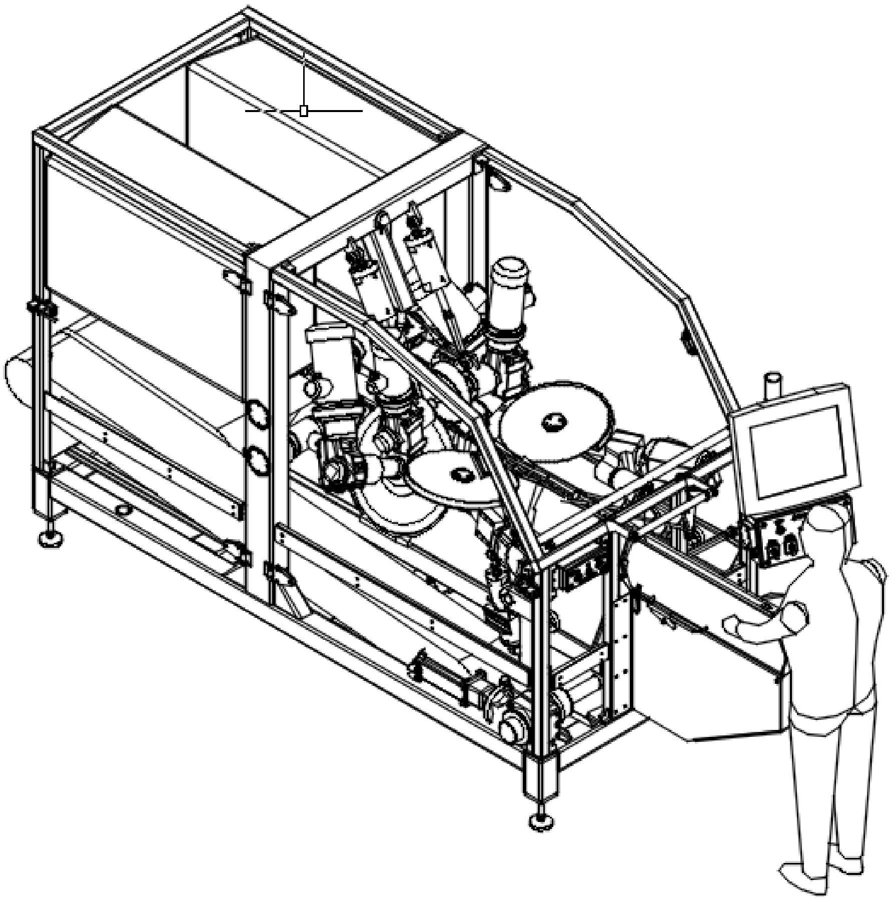
Scott Standalone Chine and Flap Machine



Filename: Scott Standalone Chine and Flap Specification

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Revision Date: 28th June 2016

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