final report

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Chine machine

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Abstract

Adapting the ATTEC Middle Machine for cutting rack barrels has been the main objective. Features have been added for automatic adjustment to wide size ranges of lamb barrels. The position control of the flap cut meets different customer specification by simple touch button computer control, allowing better yields. The chine bone is removed using powered circular knife blades, also with position adjustment to optimise yield. Important new features include a set of pre-cutting knives that separate the feather bone from the rack barrel and a set of guide plates that keep the eye muscle away from the spine during separation of the chine bone. The result is a clean and free from bone dust, ‘chineless’ pair of bone-in rack from each rack barrel, ready for finishing and packing or for further trimming to produce French racks. The main advantages include: (a) the capability to set the cut positions for best yield, (b) elimination of bone dust on the finished products; and (c) eliminating operator exposure to band-saw when such is used in the breakup of the rack barrel. The developed machine is currently in use in Australian plant capable of rates approaching 1,000 barrels/hour and ROI less than 18 months.

Executive summary

The rack barrel is the highest value lamb primal per unit of weight. The current process of cutting uses machines that perform the task by saw blades and many plants in Australia have an operator that uses a band saw to break up the barrel. The fist band saw action is a splitting operation on the band saw followed by cutting of the flap from each half of the rack barrel again using the band saw. The next cuts are the removal of the chine bone from the split piece and the rack piece may require a second pass in case the chine bone has not been fully removed in the first pass on the band saw. The process relies on operator judgement for accuracy of each cut and as a minimum 5 band saw actions are needed.

The starting point of this project was a production prototype machine, developed by ATTEC in Denmark. The machine required a barrel to be loaded at the in-feed on a motorised carrier and the carried moved the barrel through a series of powered knife blades. The barrel, when loaded was located on the carriers with the spine located to provide fixation whilst the barrel was being cut. A pair of blades removed the flaps on either side of the rack and a pair of blades set at chine bone cut angle to the vertical above the barrel separated the chine bone in two separate cutting actions one after the other. The machine was manually adjusted for different cut positions and rack sizes and the intended use required sorting of rack barrels or grading of lambs in specific range.

In this project new objectives were set to develop a more flexible machine, requiring less manual adjustment, with the machine capability to cut rack barrels from a wide size range of carcasses without the need for sorting. In particular machine adjustments on the flap cut were to be computerised and the removal of chine bone such performed to minimise trimming after the cuts were done on the machine. This meant that the machine capability needed to provide for the removal of feather bone as well as the spline giving a featherbone – chine bone free rack piece with the flap also removed in a manner that gives the best yield for the entire weight range of lambs in Australia.

The project started by analysing the features in rack primal pieces and the feature variability in relation to the cutting requirements. The analysis was used to define the way in which rack barrels from large and small carcasses may be places on the machine with the position of the flap cuts in an optimum location to give the best yield result for any production run. In addition the overall specification of the machine was determined using measurements performed on a significant number of barrels defining the machine geometry as well as the specific positioning of handling and cutting tools inside the machine.

The construction of the final machine required three iterations over a period of 24 months in order to reach the point when first trials could be performed. The final machine changes were made in the first half of 2011. Production runs that followed identified the need for additional features in the design of the

machine as well as changes to the loading and cycle start operation. Important additions, that could only be specified whilst the machine was put into use, cutting large volumes of rack barrels, were added with input from GM Scott. On completion of the work, the machine has been upgraded for production and has been in use to make specific range of cuts to meet the needs of customers.

The figure below illustrates the cuts, the machine in its current position in production and the resulting cuts.

Results at GM Scott, Cootamundra, NSW, Australia

The ATTEC middle machine was completed in August 2011 at GM Scott with the following capabilities:

(i) Removal of chine bone at better than 98% efficiency for all barrels in the range processed as observed over an 8 hour shifts
(ii) Separation of flap at best optimum position for yield for 100% of production.
(iii) Throughput in excess of 300 barrels/hour target, calculated at greater than 1,000 barrels per hour, limited only by the manual loading speed.
(iv) Elimination of over 3.8 million band saw action given a single 8 hour shift at 400 barrels/hour having significant OH&S benefits for the Australian industry.

Return on investment based on figures available is anticipated to be shorter than 18 months for an average operation at 400 barrels per hour on a single shift per day operation,

Contents

1. Background

In the 2005 ATTEC targeted a new market for machines within the lamb industry and with specific interest from New Zealand ATTEC designed and built a new machine for removal of chine bone and cutting flaps from a lamb rack barrel. The specific features of the machine giving specific cuts were manually adjustable for a given run and trial with the machine in New Zealand had been specific to the range of lambs in that country.

In 2008, a new initiative was set up with the Meat and Livestock Australia to undertake further developments taking advantage of the IP already established by ATTEC in the development of the machine in order to introduce the solution to Australia, meeting the specific requirements of the processors and the better processing capability of Australian lambs that have greater variability.

The rack barrel being the highest value lamb primal per unit of weight compared to the other lamb products has been the main focus, although the project has considered splitting and breakup of the whole barrel also, which will be subject of other supplementary reports. This report covers the progress and the technical achievements in the development of the Chine Machine only dealing with the replacement of the current process largely performed manually in Australia.

The current process of cutting uses machines that perform the task by saw blades and many plants in Australia have an operator that uses a band saw to breakup the barrel. The fist band saw action is a splitting operation on the bans saw followed by cutting of the flap from each half of the rack barrel again using the band saw. The next cuts are the removal of the chine bone from the split piece and the rack piece may require a second pass in case the chine bone has not been fully removed in the first pass on the band saw. The process relies on operator judgement for accuracy of each cut and as a minimum 5 band saw actions are needed.

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2. Project objectives

The main objectives for the Chine Machine development have been:

i) To extend the capabilities of the ATTEC Middle Machine developed earlier to meet the expectation of the Australian ovine processing sector
ii) To enhance the features on the machine for lower set up time
iii) To add features that allow automatic adjustment of the cut position
iv) To improve operator machine interfaces
v) To extend the range of lambs from those sizes typically seen in New Zealand to those that are processed throughout the seasons in Australia
vi) To make the machine capable of efficient production in an Australian plant proving capability and performance, with target speed of 300 barrels per hour with minimum or no bone dust, improved yield and OH&S.

Figure 1 Shows that ATTEC machine as originally designed as a wire frame drawing.

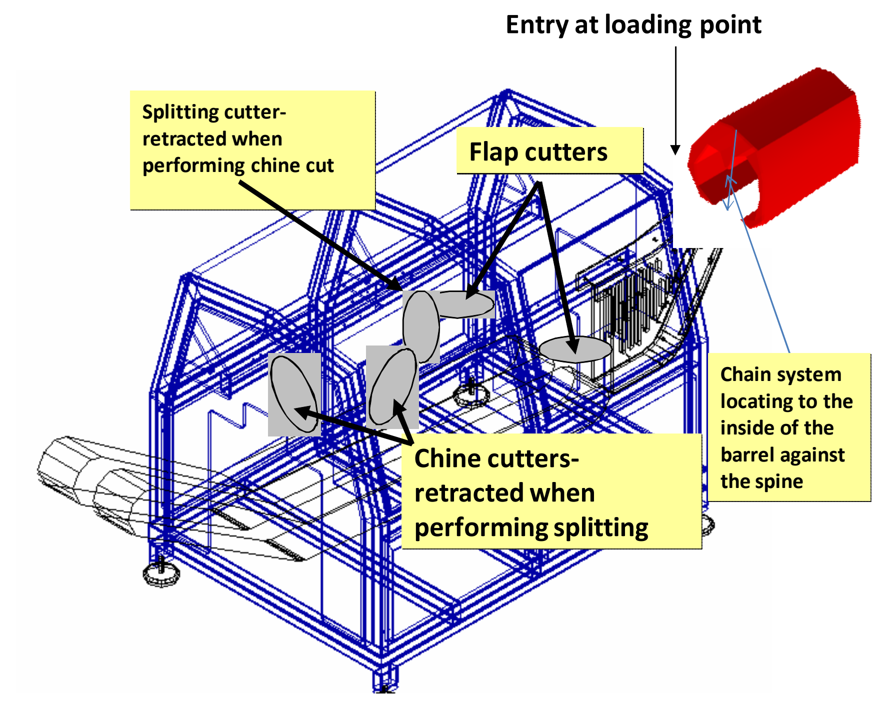


Figure 1: Schematics of the original ATTEC Middle machine

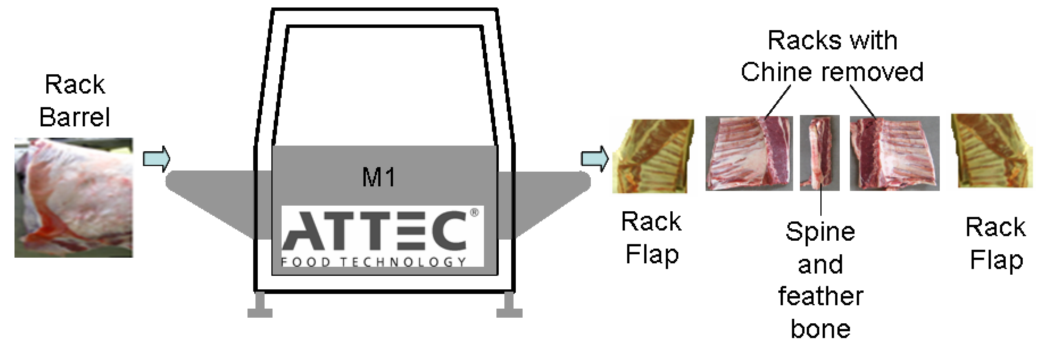
3. Methodology

The project methodology was defined to follow a process that allows machine features to be re-defined in such manner that meet the specification of the process of break up whilst accommodating the variability in the input product namely the rack barrel. The steps in the project have involved:

- Measurement of barrels and quantification of variables that influence the process of cutting,
- Definition of machine features that need redesign, but maintaining the basic features of the machine already developed by ATTEC and tested with narrow size range in New Zealand,
- Construction of the machine and testing to use the both existing features and new features that provide the adaptation to accommodate the range of lamb barrels in the production of rack products in Australia.
- Testing and improvements
- Modifications to finalise the machine for production.

Over the period of the development the ATTEC Middle machine has undergone several iterations of change and 2 shipments to Australia for trials at Midfield and GM Scott. The final shipment in early 2011 was followed by 3 visits by ATTEC, which provided the basis for the final production machine. Once the machine was in production it was possible to observe the performance and with further effort from BMC, GM Scott and ATTEC the machine reached its final stage of operation. The methodology planned at the outset of the project was adapted as it was clear in the course of the project that the features that achieve the final process efficiency could only be implemented by processing large volume of product in production.

Figure 2 gives the specific target for the Chine Machine, which was set during the project after considerable trials with the original machine and the second Middle Machine designed and built under this MLA project. The machine currently operating at GM Scott is the third version in this development.



Input: Rack Barrel   Output: 2 x Flaps, 2x Racks and 1x spine and feather bone in one piece

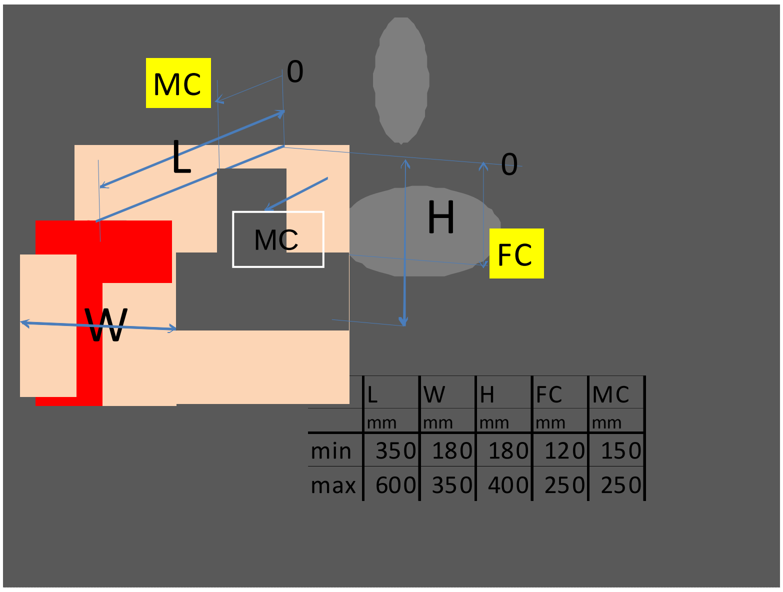
Figure 2: Chine Machine overview defined after several iterations that were followed in the methodology of the project.

4. Results and discussions

The project started by analysing the features in rack primal pieces and the feature variability in relation to the cutting requirements and specification of the Chine Machine. Trials were conducted with the existing machine leading to adaptations and definition of the specification of the design features for the machine to be built for Australia.

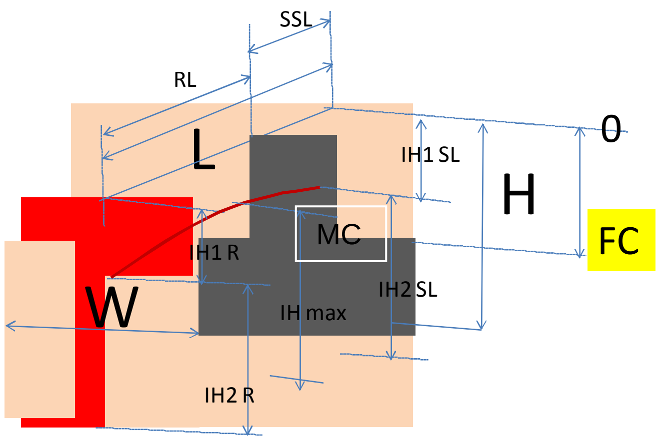
4.1. Anatomical measurement variability

The measurements give the variability of the middle primal and in particular the rack barrel. The results in Figure 3 show the measurements and the range of variability



	L mm	W mm	H mm	FC mm	MC mm
min	350	180	180	120	150
max	600	350	400	250	250

Summary (above)- Full data (below)



02/09/2008	Carcass Kg	Middle Kg	L	W	H	IH1 R	IH2 R	IH1 SL	IH2 SL	IH max	SSL	RL	FC
A	13.8	3.66	360	200	240	90	170	60	160	175	180	180	150
B	15.8	4.54	420	210	290	95	200	55	200	220	190	220	150
C	20.0	6.72	400	225	280	100	170	70	130	190	180	220	160
D	25.4	8.88	430	250	310	115	220	90	180	230	210	220	180
E - Mutton	30.2	10.26	470	280	350	130	220	80	150	260	210	260	180

Figure 3: Anatomical variation

The minimum and maximum dimensions are given whilst the range of the cut position relative to the zero position is also shown. FC is the position of the flap cut relative to the back of the carcass and MC is the position of the line of cut separating short-loin and rack relative to the zero point shown in Figure 3, which is from the leg-middle cut face.

4.2. Initial testing and benefits

The original ATTEC machine was tested for operational performance during the earlier period of the project to quantify potential benefits and to benchmark performance as well as to define the necessary changes to achieve the specifications for the Australian processors.

The trials with machine revealed important additions needed to the design of the chine bone removal mechanisms, even though little changes were needed for the separation of the flaps except for introduction of automatic devices for its adjustment to accommodate for the user requirements.

The operator interface was also to be modified to allow the users to specify desired offsets for optimising yield or meeting specific customer orders on a run by run basis.

The measurements and the analysis were also used to define the way in which barrel from large and small carcasses may be places on the machine with the position of the flap cuts in an optimum location to give the best yield result for any production run. In addition the overall specification of the machine was determined using measurements performed on a significant number of barrels defining the machine geometry as well as the specific positioning of handling and cutting tools inside the machine.

4.3. Enhancements to the machine features

The main focus of the work in the tasks that continued at ATTEC were to make enhancements to the machine to accommodate for the range of lambs processed in Australia (15-32 Kg) as well as to introduce the mechanisms that give the required automation for ease of use and control of yield. Figure 4 shows an important change that introduces guides maintaining the position of the middle as it travels through the various stages of cutting to accommodate for the bigger size range.

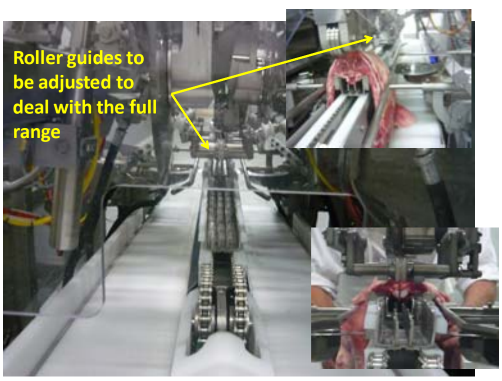


Figure 4. Trials and changes to deal with size range

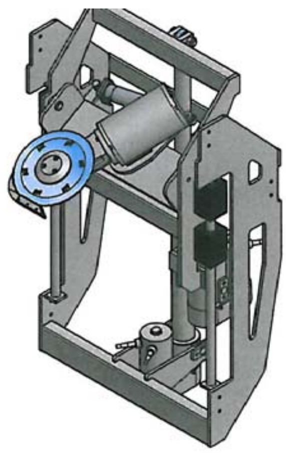
The design and build stages of the new ATTEC middle cutting also required features that would provide greater stability in holding the rack barrel whilst having the capability to adapt position to avoid jamming given the wider range of rack barrels from Australian lambs compared to those in New Zealand. The enhancements were listed as follows:

a) Modification to the in-feed section of the machine to allow fast manual loading and better location of the rack barrel at the time of loading and as the barrel is transported on the carrier into the machine.
b) Include a sensors and controls that allow automatic set up for different cut recipes to meet optimum yields for different customer specification.
c) Incorporate adjustments for the chine cutting allowing fine tuning by mechanical adjustment using operator judgement as the incorrect positioning of the chine blade cutters could result in collisions given the close proximity of the tip of the blade to the carrier.
d) Include pre-cutting knives to separate the feather bone prior to cutting the chine bone.
e) To add guides that keep the eye muscle away from the chine bone knife blades to avoid cut penetration into the meat as the chine bone is being separated from the rack.
f) Modify mechanical sections and guides to accommodate full range of sizes.

4.3.1 Flap cut mechanisms and controls

ATTEC designed provided a new arrangement for guides and flap cutting blades. The main features allow the guides to be part of the knife blade assembly and the controls allow the whole assembly to be positioned for a new cutting position with no manual intervention.

Figure 5(A) shows the new design and (B) the construction of the new features now fully tested in the new machine at GM Scott. Note that two changes were made whilst at GM Scott in relation to the flap cut. The first was the removal of the feature that placed the blade at



(A): 3D drawing of the flap cutting mechanism

(B): Construction of the flap cutting mechanisms assembled for trials

Figure 5: New features of the ATTEC machine for flap cutting

an angle relative to the side of the rack as these were not required (but may be added for processors that require it, and the second the blade diameter and direction of rotation were changed to allow the cutting to be performed to specification.

4.3.2 Chine bone removal

The chine cutting process has been a most demanding consideration of the project. After several months of observation, experimentation and trials with mechanisms a solution was realised for the process of separating the chine and the featherbone as one piece from the rack barrel.

The main challenges have been the restraining of the rack barrel after the removal of flaps and the control of separation to avoid soft-siding as well as over penetration into the eye muscle. Figure 6 gives the new approach for cutting where the feather bones and spine are to be separated from the racks as one piece.

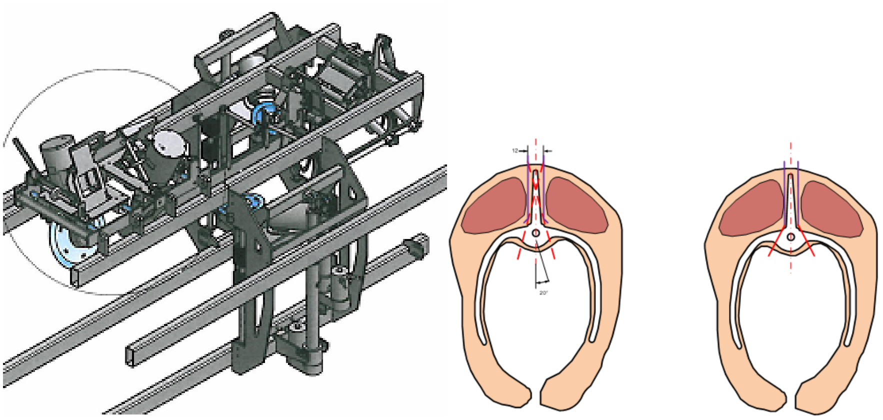


Figure 6. Arrangement for the chine removal mechanisms

Figure 7 shows the mechanisms that were designed for trials. Two cutters locate the featherbone on the rack barrel as it enters the machine separating the meat whilst parallel guides located immediately after each cutter (one guide on either side of the featherbones) move the meat back away allowing access for two other blades to cut the ribs close to the spine separating it from the rack barrel.

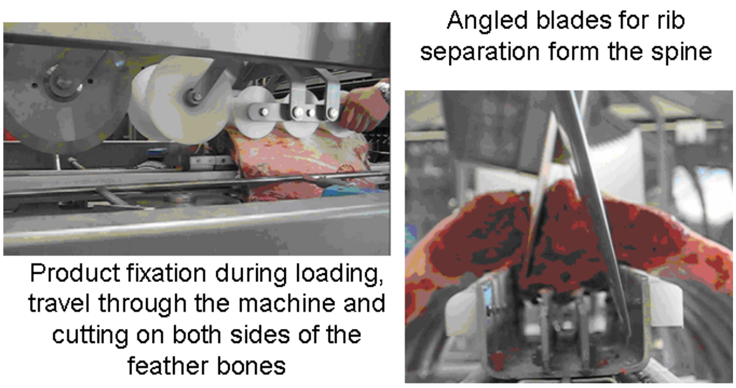
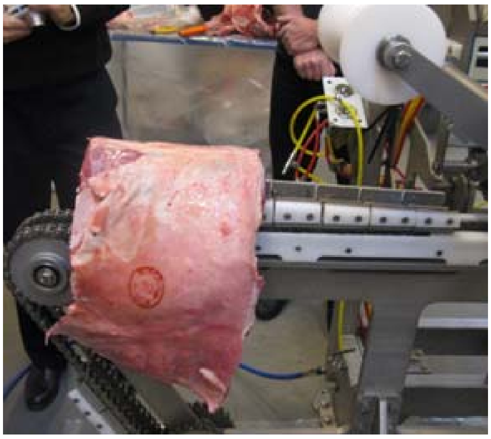


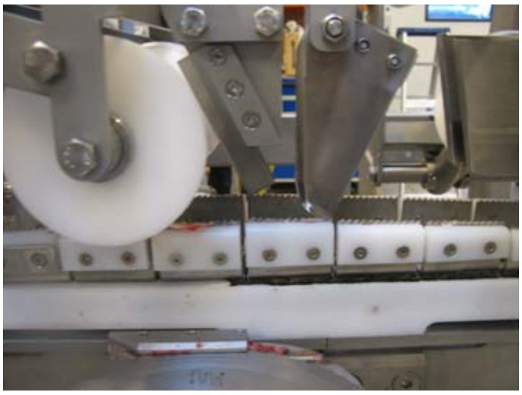
Figure 7. Construction of machine with new mechanisms and trials for chine removal

The trials provided the basis for the design features to be incorporated in the construction of the final machine for flap and chine cutting. The features are shown in Figure 8, which include a twin cutter enhancements and addition of guides to bring the barrel after the twin feather bone cut is made to the rib cutting powered blades.

(A) Guides for holding Rack barrel in the chine machine.



(B) Rack barrel loaded at entry



(C) Twin feather bone pre-cut and plough Cut in front before chine cutting

(D) Guides and rib cutting blade for chine removal

Figure 8: Enhancements of the ATTEC machine for chine cutting.

Figure 9 shows the results of the chining and flap cutting on the pieces that were cut during an MLA review meeting in Denmark with representatives from Australian processors.

It is important to state that the resulting pieces were cut well and in addition to good yield there was no evidence of bone dust on the chine cut surfaces.

(A) Rack barrel cut made during MLA visit on Flap and Chine test machine

(B) Whole chine removed from the Rack barrel with no bone dust on the cut surfaces

Figure 9. Chine removal using improved features.

Slight slippage (Figure 10) of the cut pieces in the test machine was responsible for a minor undercutting of the ribs towards the end of a cut on one side or the barrel. The changes introduced later at GM Scott when larger numbers were cut have made significant improvements tom eliminate this issue.

The flap cut performed on the Rack barrel caused slight bone chipping and the removal of one of the guides that brought the flap in line with the cut along the full length of the barrel seemed to cure this during trials. It was later discovered at GM Scott that the cause of the chipping at the end of the flap cut was related to the movement of the rack and matters related to the cutter blade. The matter was resolved by improvements made at GM Scott.

Production runs identified the need for additional features in the design of the machine as well as changes to the loading and cycle start operation. Important additions, that could only be specified whilst the machine was put in use to cut large volumes of rack barrels were added with input from GM Scott. On completion of the installation, the machine at GM Scott has been upgraded for production and has been in use to make specific range of cuts to meet the needs of GM Scott customers.

4.4. Chine Machine for the Australian market

Prior to the start of this project the ATTEC middle cutting machine was designed to perform several lamb cuts on the barrel in one machine. In particular, the machine which was already developed by ATTEC before the start of the project included features that would allow flap, chine and split cuts on a whole or part lamb barrel to be performed.

This project revealed limitations of the original approach and significantly greater effort has been required to define, design and build the machines that would satisfy the needs of the Australian market.

New machine modules were defined as standalone units and the Chine Machine designed was fully reviewed and constructed as a standalone unit. Figure 10 presents the overview of the main machine as constructed and delivered to GM Scott today.

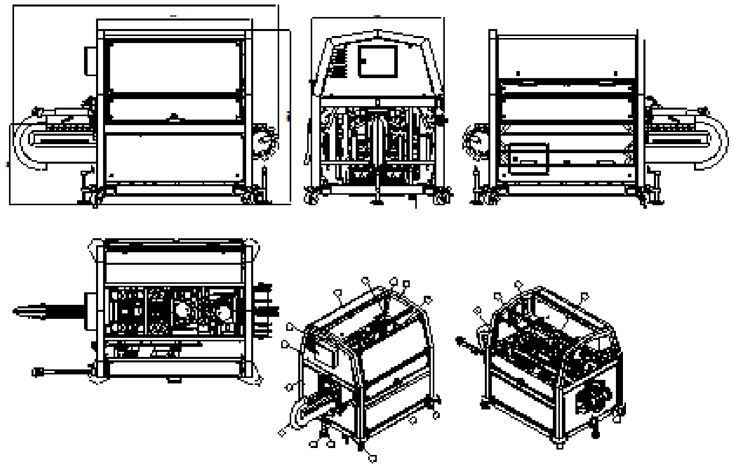


Figure 10. ATTEC Chine machine

The new machine modules and component features have undergone significant change from the original ATTEC design in order to provide capability for the range of sizes Ovine carcasses, whilst maintaining modularity in the components for better operation and service. The following sections present the features in the final machine.

4.4.1 The main carrier section

The main carrier has a universal design. It comprises a central section which locates the spine when loaded at the entry to the machine. The carriers also meet the hygiene requirements and are easily cleaned by the in-built CIP system within the body of the machine. See Figure 11 for the design of the carrier

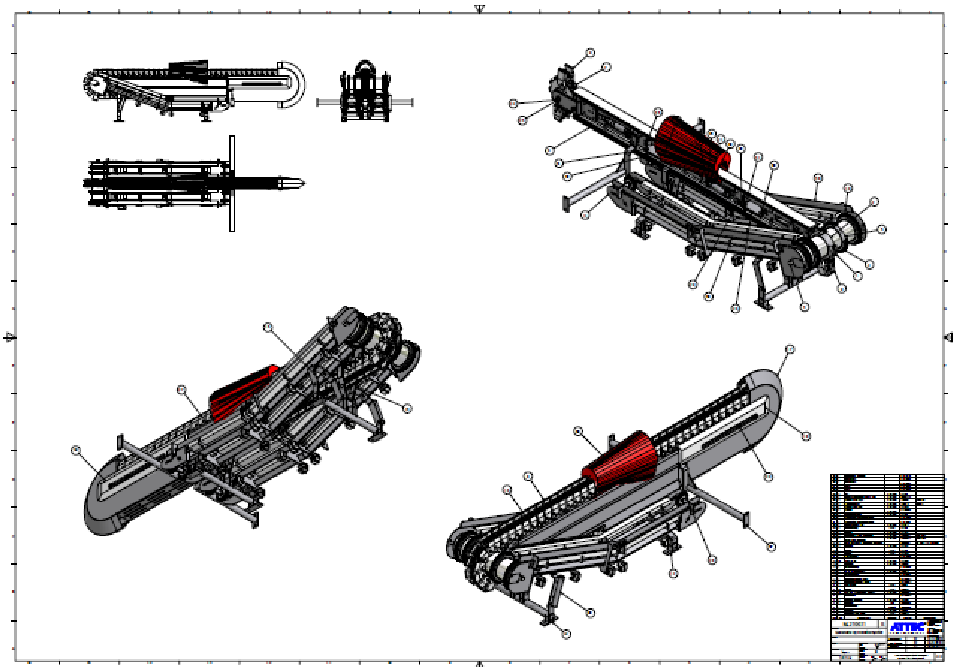


Figure 11. The main carrier for barrels modified for stability and firm grip

The carrier has a set of conveyors that collect and carry the cut flap and middle pieces out of the machine as may be viewed in Figure 11. Note that this assembly has undergone a major upgrade both in features and specification for fabrication compared with the original ATTEC Middle Machine.

4.4.2 Hold down rollers

To retain position and attitude of the barrel as it travels on the carrier through the machine, whilst being cut, a series of modular hold down rollers have been designed, which provide a major enhancement over the previous method of holding. Figure 12 presents the elements of the design for the hold down sections. Note that the rollers at the end of the shaft are free to move up and down, accommodating for the size variability in the ovine range, whilst giving a firm hold to avoid movement during cutting.

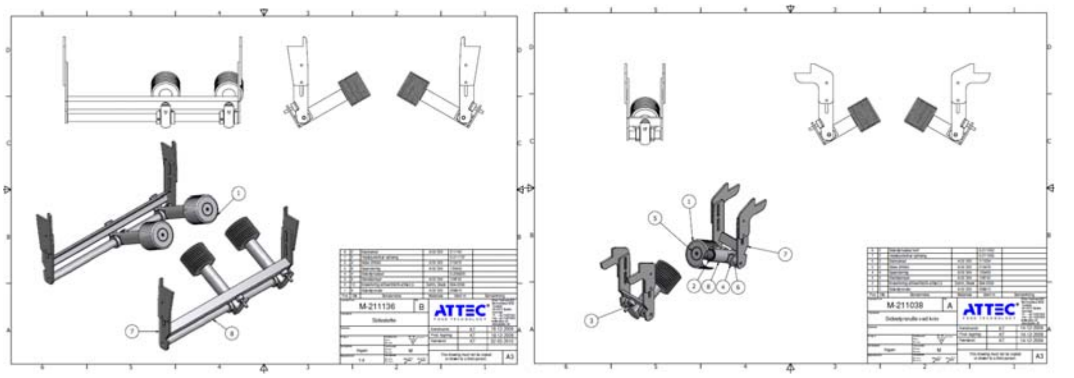


Figure 12. Hold down section

4.4.3 Flap cutting module

The design of the flap cutting brackets, vertical and tilt adjustment, drives and blade assembly is presented by Figure 13. Note that the tilt adjustment is an option and only needed in specific circumstances. The final machine at GM Scott did not require this as user experience revealed. Also the guides that manoeuvre the flap section between the blades are part of the blade adjustment brackets keeps the blade close to the point of grasp on the flap at the time the barrel passes through the blades. This is an important feature allowing adjustment to the full range of carcasses, whilst avoiding rib splinters or chipping during cutting.

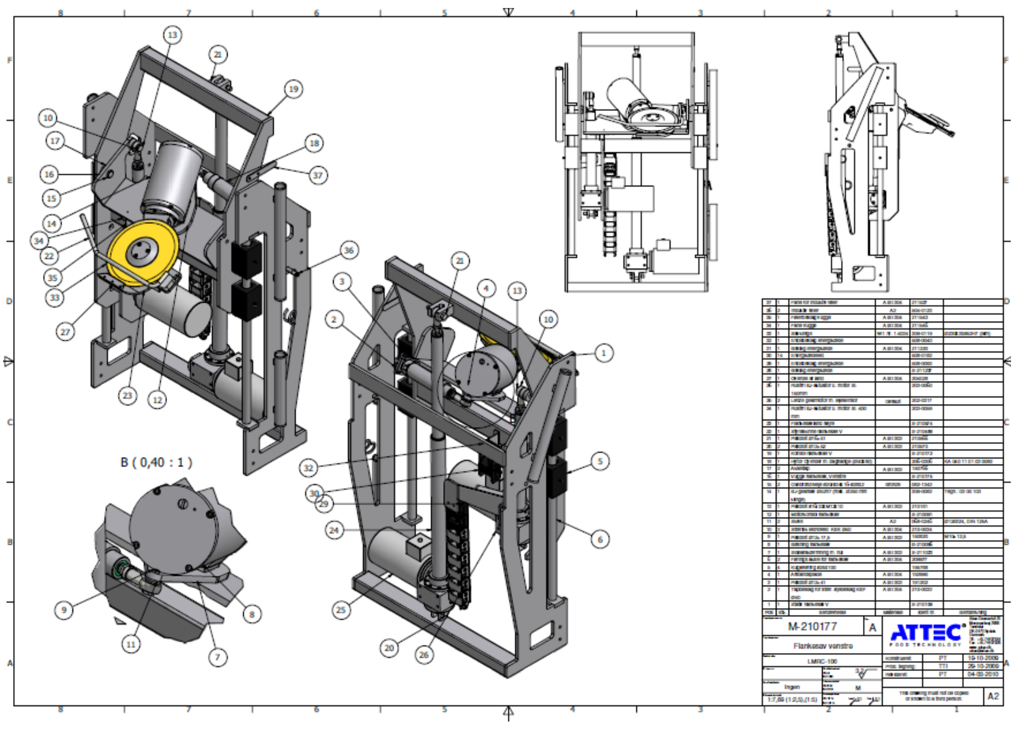


Figure 13. Flap blade assembly

4.4.4 Featherbone separation

To achieve separation of the featherbone in the flap and chine machine, a new blade pair section integrated in a roller hold subassembly (Figure 14) have been designed and added to the construction.

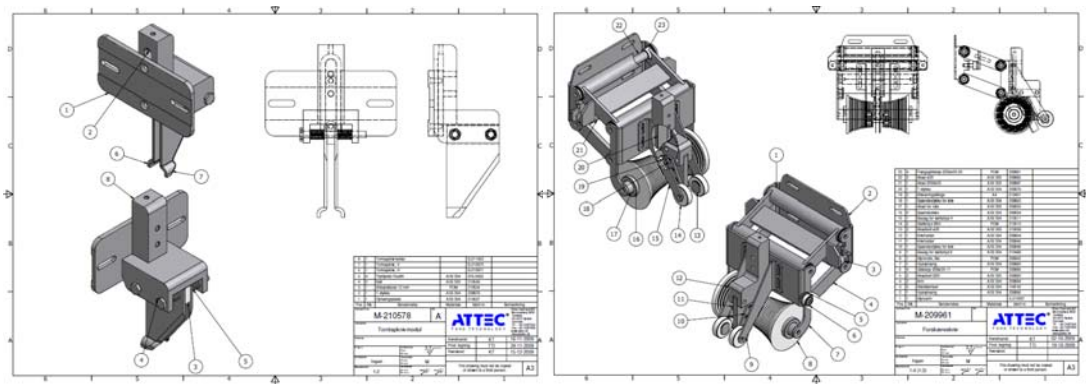


Figure 14. Featherbone blade section (right) and featherbone separation module (left)

The blade pair is such arranged to separate the main muscle in the back of the rack barrel from the feather bone. With the use of static guides the meat is to be moved away from the feather bone is a manner that allows a pair of blades (see next section) either side the chine to cut through and completely separate the chine bone from the rack barrel.

4.4.5 Chine blade assembly

Figure 15 shows the general assembly of the blades and associated drives for chine removal. The 3D drawing shows the assembly for both pairs of blades in the chine machine.

Note that the brackets and fittings around the blade drive assembly allow it to be adjusted as part of a set up procedure, giving users the possibility to optimise the cut positions for specific runs if such is desired. In the range of the barrels specified the setting would be in a fixed optimum position at the time of commissioning.

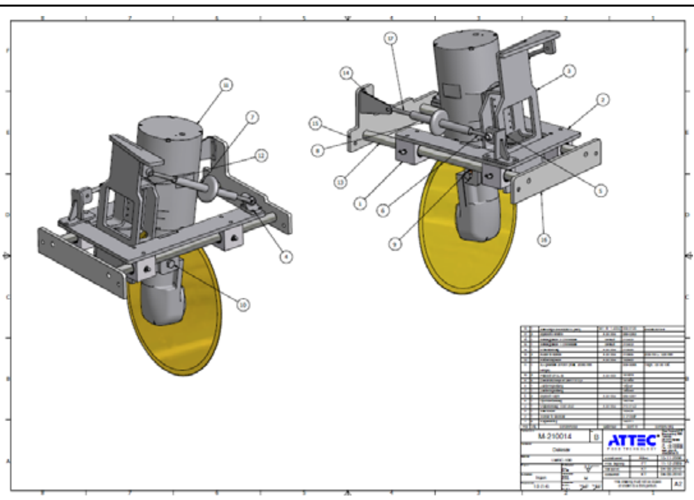


Figure 15. Chine removal blade-drive assembly

4.5. Machine build and shipment

The construction of the machine was concluded and delivered for initial trials to GM Scott site at Cootamundra in early 2011. The machine in its final form prior to delivery is shown in Figure 16.

Figure 17. Photographs of Chine Machine prior to shipment

4.6. Installation and trials

The ATTEC Chine machine delivered to GM Scott was installed and operated to meet Woolworth cut specification. In the early period of trials two specific issues were identified:

1. The cutting of the chine bone was considered inaccurate for a significant number of rack barrels,
2. The ribs closest to the shoulder face of the barrel showed signs of chipping, with the consequences of leaky bags of French racks in vacuum packs.

Considerable effort has been spent to resolve the above, requiring effort on the part of BMC and GM Scott in addition to the ATTEC team from Denmark.

Two specific features were added to the machine on an experimental basis:

a) New holding device to locate the rack by pin attachment in the spinal cord cavity so that the rack position on the carrier is maintained from the point of loading station to through the end of the last cut on the rack as it travels through the machine. This resulted in more precise separation of the chine bone, giving much better yield and consistency in the range and variability of lambs.

b) The direction of the blade was altered as well as the type of blade used ensuring stability of the rack whilst cutting through the flap thus avoiding rib chipping.

Once the above alterations were made, testing proved that the machine was ready for production.

4.7. Production trials

Following the trials the chine machine was used on 5 consecutive days, with approximately 8,000 rack barrels cut.

The efficiency of the machine was tested by arranging to load the machine as fast as possible. The main finding is that the machine can be loaded by a trained operator in less than 3 seconds. Specific test run were conducted by having a number of rack barrels accumulated and loading them successively one after the other for cycle time calculation. The estimated throughput capability of the machine was estimated at 1,000 barrels per hour. During peak situations with the machine in operation speeds of 500 per hour were observed during normal operation. This is a major achievement of the project as it is possible to work the machine at the speed of the person loading it.

For smaller barrels and with some barrels from de-formed or miss-shaped carcasses, the resulting racks with chine bone removed were closely observed to see how well the spine had been removed. In the specific production run of one shift less than 2% of the racks needed rework putting the chine bone removal process capability at 98%. The time to rework the pieces was estimated at less than 5 minutes for a whole day’s production. The observations on Thursday 1st September 2011 put this capability at 99.5% with much fewer barrels needing re-work.

The quality of the resulting French racks was considered far better than ever achievable on a band saw.

The flap cutting process resulted in no chips on the ribs and all cuts were according to specification at 60 mm as requested by the customer. On average this is a 10mm gain on bone in racks giving better yield in finished products.

The chine machine places a distance between cutting blades removing the flap and the chine bone, which is removed in one whole piece. The band saw actions producing the same results as the chine machine require the splitting of the rack (1), cutting the ribs to separate the flap from both sides of the rack barrel after splitting (2 and 3) removal of chine bone from each rack after cutting the flap (4 and 5). On occasion there is a need for a 6 and 7 band saw cuts to remove any remaining chine bone on the rack piece, but ignoring these finishing cuts there are 5 band saw actions that are eliminated by the machine, thus reducing risk of injury to a band saw operator carrying out such a task. At 400 barrels per hour, 8 hours per day, 5 days per week and 48 weeks a year, the number of band saw actions eliminated is over 3.8 million.

Figure 17. Chine and Flap cuts at GM Scott

The Chine machine uses knife blades eliminating bone dust on the product giving better quality and shelf life. (see Figure 17).

The ATTEC Chine machine is in daily use at GM Scott cutting to the Woolworths specification.

5. Concluding remarks

The ATTEC middle machine project with MLA is considered complete in featuring the following capabilities:

(v) Removal of chine bone at better than 98% efficiency for all barrels in the range processed over four 8 hour shifts and providing significant yield gain.
(vi) Separation of flap at best optimum position for yield for 100% of production
(vii) Throughput in excess of what is needed and calculated at a maximum beyond 1,000 barrels per hour.

Return on investment based on figures available is anticipated to be shorter than 18 months for an average operation at 400 lambs per hour on a single shift.

The machine removes contact between the operators and band saw for production of bone in racks and French racks from whole rack barrels. The estimated band saw action for an operation that cuts 400 barrels per hour is in excess of 3.8 million per year. This has a significant impact on OH&S benefits for the Australian industry.