

French Dressed Lamb Rack Preparation Robot Cell (Stage 1)

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Table of Contents

1.0 Executive Summary3

2.0 Introduction.....3

3.0 Project Objectives.....4

4.0 Methodology4

 4.1 Format of Abattoir Site Visit4

5.0 Project Outcomes5

 5.1 The Master User Requirements5

 5.2 Alternative Robot-based System7

 5.3 Automated Frenching Machine Budget Capital, Operating Costs and Cycle Time8

 5.4 Budget Capital Cost8

 5.5 Budget Repeat Machine Cost (singly)8

 5.6 Budget Repeat Machine Cost (built in a batch of 5x Machines)8

 5.7 Est. Machine Cycle Time8

 5.8 Estimated Machine Operating Cost.....8

 5.9 Overall Progress of the Project.....9

6.0 Conclusions/ Recommendations9

7.0 Appendices10

 7.1 Appendix 110

 7.2 Appendix 2.....11

 7.3 Appendix 3.....12

1.0 Executive Summary

In this Project Applied Robotics visited 3 selected abattoirs to gather their User Requirements for French Dressing Lamb Rib Racks and summarized them in a Functional Specifications for an Automated Lamb Rib Racks French Dressing Machine.

Basically, the Functional Specifications required:

- the Machine cycle time to French dressed a rack in 6 to 8 seconds each.
- the Machine must handle the product variability of rib count from 6 to 10, and rack sizes from lamb to mutton racks.
- the Machine must handle the user variability of Frenching lengths from 25mm to 100mm.
- the Machine must recover the off-cuts (intercostal) and not contribute to shelf-life reduction.
- the Machine must occupy a minimal foot-print.
- the Machine must have a payback between 12 and 18 months.

Using the above Functional Specifications, Applied Robotics has developed the basic “wire-stripper” concept that resulted from an AMPC year 2015 R&D project, into a design that strips the meat off all the ribs in a rack simultaneously, in the required cycle time, recovers the off-cuts and with the ability to automatically cope with both the product and user variations.

This resultant ideal Automated Lamb Rib Racks French Dressing Machine is a relative small, non-robotic machine, that uses a Vision System to “see” the rack size and the rib count in each infeeding rack, and uses servomotors to enable automatic adjustments to cope with the variables in each rack.

A near-final concept design for this Automated Lamb Rib Racks French Dressing Machine has been generated along with a budget for the Prototype cost to build, and the budget cost of Production Machines. Production Machines are estimated to have an under a 1-year payback.

The next step is to assess whether or not there is positive industry support to proceed to engineer and build a Prototype.

2.0 Introduction

A year ago, Applied Robotics was contracted by the AMPC (under AMPC Project 2014/1006) to create a new machine concept to automate the labour intensive task of preparing French dressed lamb rib racks. Applied Robotics created an innovative machine concept that was presented to attendees at an AMPC seminar in the North Sydney at the end of that year. As a result of the expression of interest in our new concept by the abattoir members, the AMPC has raised a small project for Applied Robotics to take this concept one further step forward in this current AMPC Project (PRP15-T01-16)/ (2016.1035)

In this current project Applied Robotics visited three potential abattoir users to have detailed discussions with them to define their Lamb Rack Frenching User Requirements, then this was then

condensed into a set of Functional Specifications for an ideal Automated Lamb Racks Frenching Machine.

Following that, Applied Robotics will use the Functional Specifications to design the ideal machine or robot cell to make automated lamb rack Frenching both economic and practical to use in an abattoir setting.

Basically, the Functional Specifications required:

1. the Machine cycle time to French dressed a rack in 6 to 8 seconds each.
2. the Machine must handle the product variability of rib count from 6 to 10, and rack sizes from lamb to mutton racks.
3. the Machine must handle the user variability of Frenching lengths from 25mm to 100mm.
4. the Machine must recover the off-cut (intercostal) and not contribute to shelf-life reduction.
5. the Machine must occupy a minimal foot-print.
6. the Machine must have a payback between 12 and 18 months.

3.0 Project Objectives

For this Project's Milestone 1, Applied Robotics visited three potential abattoir users to have detailed discussions with them to define their Lamb Rack Frenching User Requirements, then this was condensed into a set of Functional Specifications for an ideal Automated Lamb Racks Frenching Machine.

For this Project's Milestone 2, Applied Robotics used the Functional Specifications to design the ideal machine or robot cell to make automated lamb rack Frenching both economic and practical to use in an abattoir setting. This stage of work will entail the creation of an Automation Machine Concept that realizes the Functional Specs in a practical and engineered design. The performance specifications of this Automated Lamb Rack Frenching Machine will then be estimated, along with its cost to Prototype, and its cost to manufacture as a serial Production Machine.

For this Project's Milestone 3 Applied Robotics will write a Final Report.

4.0 Methodology

The author should provide a description of how the project was conducted, including experimental design(s), measurements, and statistical analysis.

4.1 Format of Abattoir Site Visit

The format of each abattoir site visit was:

1. firstly, to describe the machine concept that underpins the automation of this task,
2. secondly, to see the existing manual or mechanised process in operation and perhaps obtain a short video sequence of this operation, and
3. after that, to discuss ideally what a practical automatic system is expected to do and how it will best fit into their workspace i.e. to define their Lamb Rack Frenching User Requirements,

Lamb Rack Frenching User Requirements interview was based on the following questionnaire:

- A specification of the types of input, e.g. types such as full racks, half racks, single ribs, etc.
- The size range and the natural variability within each type e.g. lamb ribs, sheep ribs, etc.
- Different “styles” of French dressing? i.e. different ways of ribs meat removal e.g. expose entire bone, half bone, etc.
- Practical production through-put in products per hour.
- Manner of product infeed, i.e. in tubs, randomly on a conveyor, arrayed on a conveyor or in a magazine, etc.
- Manner of finished rib-racks outfeed, i.e. in tubs, randomly on a conveyor, arrayed on a conveyor or in a magazine, etc.
- Machine or Robot Cell placement requirements on processing floor?
- Machine or Robot Cell foot-print?
- Acceptable Operator manning level?
- Practical issues like ease of cleaning, user friendliness, etc. etc.
- Normal ROI for such machinery investments.

A rider was added that it will be obvious that the specification of a “dream machine” may cause it to be unrealistically complex, large and expensive. What was being sought is the User Requirements for a **practical** machine – indeed something that is technical simple and straight-forward to use, but still is able to make sufficient labour savings, will give the best ROI.

The three site visit reports are attached as Appendices 1, 2 & 3.

5.0 Project Outcomes

The three Lamb Rack Frenching User Requirements site visit reports were then condensed into a single Master Lamb Rack Frenching User Requirements, which was then translated into a set of Functional Specifications for an ideal Lamb Rack Frenching Machine.

5.1 The Master User Requirements

The summarised Master User Requirements are:

1. Input of full racks of lamb or mutton, 6 to 10 ribs (8 ribs average).
2. The size range of the rib rack is reflected in both the natural variability and the animal size. Lamb weights vary from 14kg to 35kg; mutton can weigh up to 65kg. So, typically, a rack can weigh between 250gm to 850gm.
3. There were two variations of the Frenching Process.

Process 1.

- Removal of the Cap (skin & fat layer) by cutting off by knife close to the ribs, and
- trimming off the split featherbone by knife (in one case the featherbone need not be removed as the whole spinal column was separated from the rib racks in a prior operation),
- manual-Frenching to remove the intercostal between the ribs using a sharp, thin-bladed knife making “U” cuts between ribs. In no case was there any further cleaning of the ribs.

Process 2.

- Removal of the Cap (skin & fat layer) by tearing off by hand, and
- Knife scoring the Frenching line across the rack and cutting off excess fat upper the to-be-Frenched rib section,
- manual-Frenching to remove the intercostal between the ribs using a sharp, thin-bladed knife making “U” cuts between ribs. In no case was there any further cleaning of the ribs.

In this case the featherbone need not be removed as the whole spinal column was separated from the rib racks in a prior operation.

1. Different “styles” of French dressing: The length of the ribs out from the “eye” is cut as a bank from 25mm to 100mm long (the rib ends are trimmed squarely to the required length by bandsaw). The cleaned part of the rib could be 25mm to 100mm long, in other words, the 25mm to 100mm long ribs after bandsaw cutting are not necessarily always Frenched right up to the eye. The “eye” must not be cut.
2. Production through-put in products per hour varied from 9 rack/min to 19 rack/min.
3. Specifically, the manners of operation were:
 - Off the Main Boning Line, the Bandsaw Operators supplies the Rib Racks. 4x Frenching Operators carry out the entire manual-Frenching process on 50% of the racks. The Frenching Operator rate then is just under 1 minute/rack/Operator. When all 8 racks are to be Frenched, other upstream operators are utilised to de-Cap and remove the Featherbone, so the 4x Frenching Operators can then handle all 8 rack/min. Otherwise, 8x Frenching Operators will do everything.
 - Off the Main Boning Line, the Bandsaw Operators supplies the Rib Racks. 4x Operators cut off the Cap and Featherbone, 12x Frenching Operators operating the semi-automatic Water-Frenching machines. The Frenching Operator rate then is 0.63 min/rack/Operator.
 - Off the Main Boning Line from the Bandsaw Operators: 2x Operators De-cap by tearing off, 1x Operator Marking, 3x Frenching. Marking is the process of making a cut across the top of the rib rack and cutting away the fat immediately above the ribs to be Frenched.
4. For manual Frenching the space occupied by a set of 4x Operators is a bench of about 2m x 1.25m.
5. After Frenching, the finished racks are conveyed directly to the Cryovac Vacuum Packer, for size sorting, individual wrapping/bagging (with or without a soaker pad), and then fed into the Vacuum Packer. The conveyor transport of the rack stream to the Cryovac Vacuum Packer is preferred, as with binning, any time delay and further manual handling is detrimental to shelf-life.

- 6. Normal ROI for such machinery investments ranged from 12 to 24 months. The average all-up annual cost per operator is similar to the Australian industry average of \$70k to 80k pa.

The processors all know of the availability of Water-Frenching machines, but they are adverse to the reduced shelf-life (30 days for Water Frenched compared to 90 days for Manual Frenched), and the intercostals/trimming is wasted. Water Frenching shelf-life can be enhanced by the use of a “cold charge” process, but this is an additional process that can be “tricky” to perfect.

Therefore, they see an automated non-water Frenching option as highly desirable. They confirm it as a “holy grail” of their industry.

5.2 Alternative Robot-based System

The requirement to strip all the ribs on each rack simultaneously, and in an economic and compact manner, has dictated that a Frenching Station is designed to carry out that function, and a Vision Station to measure the rib pitch distance apart for each incoming Rack. Beyond that, the remaining functions is the infeed and outfeed of the Racks.

The option exists to employ a robot with a universal rack-sized robot gripper, and an on-board vision system to identify the position and orientation of each incoming Rack in order to pick it up for loading first into the Vision Station and then into the Frenching Station.

However, since it is a required preparation condition that an Operator de-caps, etc. one Rack at a time, this Operator may as well be utilized to also load his output in a neat manner onto the infeed conveyor for the Frenching System, and save the considerable cost and space of a loading robot and another vision system.

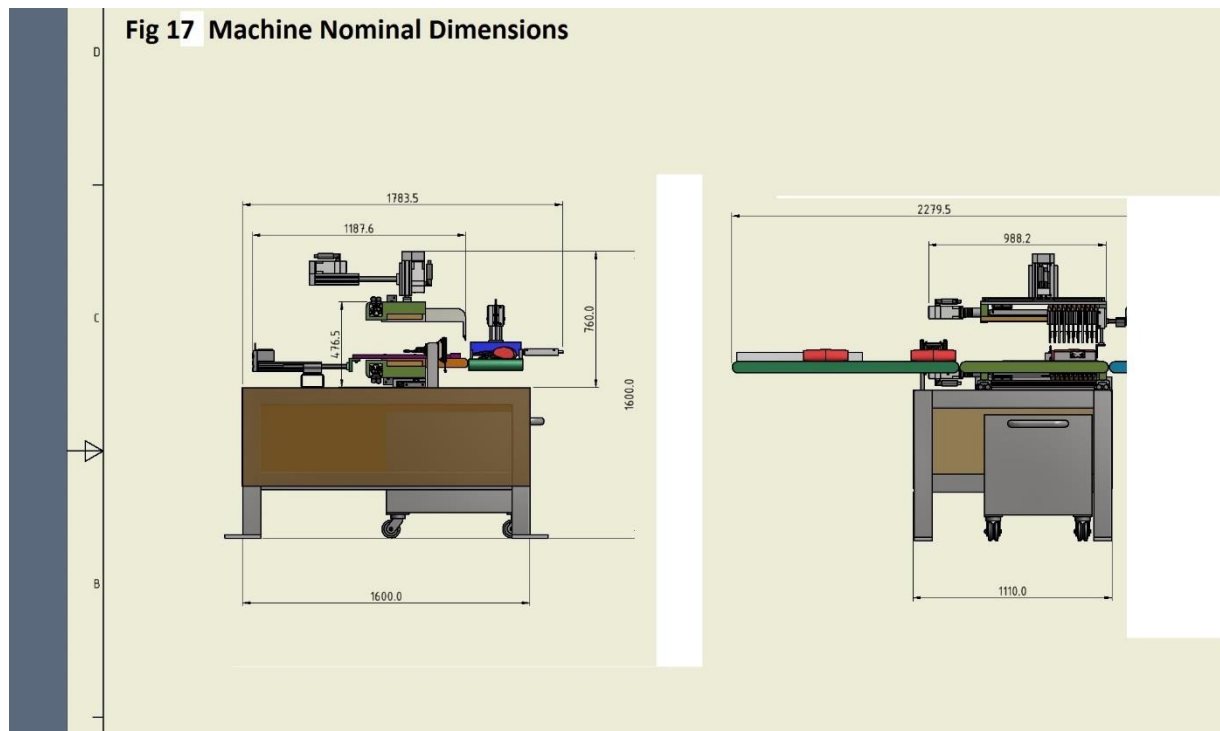


Fig 17 shows the nominal dimensions of the non-robotic Automated Lamb Racks French Dressing Machine.



5.3 Automated Frenching Machine Budget Capital, Operating Costs and Cycle Time

The Automatic Lamb Racks Frenching Dressing Machine described above (includes the 1m long Infeed Conveyor but not the Outfeed Conveyor), is now estimated, at a budget level, for the following costs:

5.4 Budget Capital Cost

- Prototype Development Cost. The budget cost to design and build a Production Prototype of the above described non-robotic Machine in “abattoir-friendly” form, is \$640,000.00 + GST.
- Field Trials Cost. The cost to conduct a field trial of the Production Prototype will obviously depend on the location and length of the trials. We should be thinking of a \$50k allowance.

5.5 Budget Repeat Machine Cost (singly)

The budget cost to build a Repeat of the above described non-robotic Machine, is \$430,000.00 + GST, ex-factory.

5.6 Budget Repeat Machine Cost (built in a batch of 5x Machines)

The budget cost to build a repeat batch 5x of the above described non-robotic Machine, is \$300,000.00 + GST, each Machine, ex-factory.

5.7 Est. Machine Cycle Time

The cycle time elements of the functional sequence:

• Rack infeed & outfeed Back-Stops Adjust for Incoming Rack)	2 seconds	(while Top Claws & Bases, and
• Rack Push into Pre-set Back-Stops	1 seconds	
• Top Claws Enters Rack examining Next rack)	1 seconds	(upstream Vision System is
• Top Claws Draws Back to Cleans Ribs	1 seconds	
• Top Claws Retract	1 second	
• Cleaned Rack Ejected Forward to Conveyor perform their mutual cleaning function)	2 second	(while Top Claws and Back-Stop
Total Est. Cycle Time	8 seconds	

While an 8 seconds cycle time will be adequate, a 6 seconds cycle time would be ideal. Perhaps, during the development of the Prototype such an improvement can be made.

5.8 Estimated Machine Operating Cost

- Electricity usage: 20 amps per phase, 3 phase.
- Compressed air consumption: 100L per minute, 6 bar, clean factory compressed air.
- Operator attendance: 10%? of the operating time.

5.9 Overall Progress of the Project

This Milestone 12 Report is on time and according to budget.

6.0 Conclusions/ Recommendations

The market research in the manner of a User Requirements interviews has elicited a set of Lamb Racks Frenching dressing requirements data that has enabled Applied Robotics to develop a Machine Concept that appears to answer the Australian abattoirs' needs in one of the more labour intensive operations in the boning line.

This Machine Concept has been advanced to the stage of a nominal machine design, in order to give the reader an in depth appreciation of its functionality, and technology.

In addition, the cost to Prototype and to build Production Units have been estimated.

Basically, the Functional Specifications required that:

- the Machine cycle time to French dressed a rack in 6 to 8 seconds each. *It is currently estimated at an 8 seconds cycle time.*
- the Machine must handle the product variability of rib count from 6 to 10, and rack sizes from lamb to mutton racks. *The Machine will utilize a Vision System to scan each incoming rack and then automatically adjusts the Frenching mechanisms to suit that rack's dimensions.*
- the Machine must handle the user variability of Frenching lengths from 25mm to 100mm. *A Frenching distance range of 20mm to 120mm is selectable on the operator HMI.*
- the Machine must recover the off-cut (intercostal) and not contribute to shelf-life reduction. *All off-cuts are collected in a trolley bin at the underside of the Machine.*
- the Machine must occupy a minimal foot-print. *The Machine's footprint is about that of the bench currently used by 4x Operators.*
- the Machine must have a payback between 12 and 18 months. *Cost estimates show that a Production Machine will have under a 1-year payback.*

It is recommended that the next step is to engineer and build a Prototype.

However, before this can happen, we must confirm that there is support for such an Automated Lamb Racks French Dressing Machine from the Australian abattoir community.

The best way to establish support is for potential users to evaluate this Machine Concept, technically, operationally and commercially, and if a commitment can be got from them, then the Machine Concept will warrant further advancement.

Maybe there is an AMPC initiative to promote and support the evaluation of the Automated Lamb Rack French-Dressing Machine by potential users.

7.0 Appendices

The three confidential abattoir site visit interview reports are attached as appendices.

7.1 Appendix 1

Re: French Dressing Lambs Rib Racks Robot Cell: Functional Specifications Discussions Report:

Interview 1: Manildra Meats P/L,
572 Temora Rd,
Cootamundra 2590,
NSW.

Contact: Len Jones, CEO (mob: 0408 628990)
Matt Flynn, Grading Room Manager (mob: 0458628995)

Date: 4th December, 2015.

Discussions were held with lamb processing operators to determination of the Functional Specifications for a French-dressing Lamp Racks Automated Machine or Robot Cell. The Functional Specifications will define the operational parameters of the ideal Automated Machine or Robot Cell to make it both economic and practical to use in a real-world abattoir setting.

At Manildra Meats site at Cootamundra, Len Jones & Matt Flynn answered my questions. They use Manual-Frenching but was not able to shown me around their processing room as processing was not in operation at the time of my visit, so Matt Flynn demonstrated the manual process to me.

The Functional Specification discussions encompassed the factors as follow:

- The types of input: full racks of lamb or mutton, 8 to 10 ribs (8 ribs average).
- The size range and the natural variability: lamb weights vary from 14kg to 28kg.
- The French-dressed Rack Making Process: 1. Removal of the Cap by cutting off and cutting off the featherbone by knife, 2. manual-Frenching to remove the intercostal off and between the ribs.
- Different “styles” of French dressing: The length of the ribs out from the “eye” could be from 50mm to 100mm long (ribs are trimmed squarely to various length by bandsaw), the cleaned part of the rib could be 50mm to 100mm long, in other words, the ribs are not necessarily always Frenched up to the eye. The “eye” must not be cut.
- Production through-put in products per hour: 4.5 lamb/min. or 9 rack/min. (In the near future this rate will be upgraded to 5.5 to 6 lamb/min.)
- Manner of Operation: Off the Main Boning Line, the Bandsaw Operators supplies the Rib Racks. 4x Frenching Operators carry out the entire manual-Frenching process on 50% of the racks. The Frenching Operator rate then is just under 1 minute/rack/Operator. When all 8 racks are to be Frenched, other upstream operators are utilised to de-Cap and remove the Featherbone, so the 4x Frenching Operators can then handle all 8 rack/min. Otherwise, 8 Frenching Operators will do everything.
- The 4x Operators occupy a bench space of about 2.5m x 1.5m.
- They see an automated non-water process is highly desirable. They confirm it is a “holy grail” of their industry.
- They know about Water-Frenching machines, but they do not like the reduced shelf-life (30 days for Water compared to 90 days for Manual), and the intercostal is wasted. (Trimmings is \$4.50 to \$5/kg, while Intercostal is \$11/kg).

- After Frenching, for US export, the output is conveyed directly to the Pack-off Operators who divides into 4x weight ranges, adds a soaker pad, wraps 1.25 times with a plastic sheet of “clear bone guard”, before bagging and feeding into the Cryovac Vacuum Packer (individually in a plastic bag).
- After Frenching, for the local market, the output is conveyed directly to the Pack-off Operators who bags it before feeding into the Cryovac Vacuum Packer (individually in a plastic bag).
- Export to local ration is 50/50.
- Binning is avoided as this generates heating which deteriorates shelf-life. Manual handling also deteriorates shelf-life.
- Normal ROI for such machinery investments is up to 24 months.
- Staff turnover is 20% on floor.
- They are interested to participate in a French-dressing PIP project.

7.2 Appendix 2

Re: French Dressing Lambs Rib Racks Robot Cell: Functional Specifications Discussions Report:

Interview 2: JBS Australia P/L,
30 Industry Park Drive,
Brooklyn 3012,
Victoria.

Contact: Sean Naden, Operations Manager (mob: 0411 643544)
Mark Kelly, Production Manager (mob: 0448 005337)

Date: 14th December, 2015.

Discussions were held with lamb processing operators to determination of the Functional Specifications for a French-dressing Lamp Racks Automated Machine or Robot Cell. The Functional Specifications will define the operational parameters of the ideal Automated Machine or Robot Cell to make it both economic and practical to use in a real-world abattoir setting.

At JBS Australia P/L’s site at Brooklyn, Sean Naden & Mark Kelly answered my questions. They use Water-Frenching but was not able to shown me around their processing room as processing was not in operation at the time of my visit.

The Functional Specification discussions encompassed the factors as follow:

- The types of input: full racks of lamb or mutton, 6 to 10 ribs (8 ribs average).
- The size range and the natural variability: lamb weights vary from 14kg to 35kg, and mutton can weigh up to 65kg for each carcass. Sometimes other carcasses such goat’s racks are also processed. Mutton & goats are not common.
- Beforehand, the lamb carcass is split into two halves, and then each half is cut into a Hind section, a Mid-section and the Fore-quarters. From the Mid-section the Rib Racks are cut by the bandsaw operators.
- The French–dressed Rack Making Process: 1. Removal of the Cap by cutting off and cutting off the featherbone by knife, 2. Water-Frenching to remove the intercostal off and between the ribs.
- Different “styles” of French dressing: The length of the ribs out from the “eye” could be from 25mm to 100mm long (ribs are trimmed squarely to various length by bandsaw), the cleaned

part of the rib could be 25mm to 100mm long, in other words, the ribs are not necessarily always Frenched up to the eye. The “eye” must not be cut.

- The 25mm short racks is called “baby-Frenching”.
- The rack weigh varies from 250gm to 850gm.
- Production through-put in products per hour: 9.5 lamb/min. or 19 rack/min.
- Manner of Operation: Off the Main Boning Line, the Bandsaw Operators supplies the Rib Racks. 4x Operators cut off the Cap and Featherbone, 12x Frenching Operators operating the semi-automatic Water-Frenching machines. The Frenching Operator rate then is 0.63 min/rack/Operator.
- The Water-Frenching process (by WASSCO or McClarens (from Hastings, NZ) now uses chlorinated water which lengthens the product shelf-life. With chlorinated water the product shelf-life is extended to 13 weeks (similar to that for the manual Frenching process), however, the use of Water-Frenching requires a “tricky” special “cold-charge” process post-Frenching to retain shelf-life. The intercostal is retrieved.
- In the Water-Frenching process each machine employs an Operator to handle the Racks in/out of the machine.
- They see an automated non-water process is highly desirable (nationally and internationally). They confirm it is a “holy grail” of their industry.
- After Frenching, the output is conveyed directly to the Pack-off Operator who adds a soaker pad before feeding into the Cryovac Vacuum Packer (individually in a plastic bag). The soaker pad can be avoided if water is not used.
- Binning is avoided as this generates heating which deteriorates shelf-life. Manual handling also deteriorates shelf-life.
- Normal ROI for such machinery investments is up to 12 months.
- They are interested to participate in a French-dressing PIP project.

7.3 Appendix 3

Re: French Dressing Lambs Rib Racks Robot Cell: Functional Specifications Discussions Report:

Interview 3: Australian Lamb Company,
30 – 34 Strazlecki St,
Sunshine West 3020,
Victoria.

Contact: Murray Miller, Innovation Manager (mob: 0427 081739)
Jason McPhail, Production Manager
Chris Houghton, Supervisor (mob:042 5780015)

Date: 15th December, 2015

Discussions were held with lamb processing operators to determination of the Functional Specifications for a French-dressing Lamp Racks Automated Machine or Robot Cell. The Functional Specifications will define the operational parameters of the ideal Automated Machine or Robot Cell to make it both economic and practical to use in a real-world abattoir setting.

At Australian Lamb Company site at Sunshine West, Chris Houghton answered my questionnaire and then showed me around the processing room to see the rack-getting and Frenching process.

The Functional Specification discussions encompassed the factors as follow:

- The types of input: full racks of lamb or mutton, 6 to 10 ribs (8 ribs average). The rack weight will vary from 12 oz. to 32 oz.
- The size range and the natural variability: lamb weights vary from 14kg to 35kg, and mutton can weigh up to 65kg for each carcass.
- The French-dressed Rack Making Process: 1. Removal of the Cap by ripping off, 2. Marking the Cut Line & Remove excess fat by knife, 3. Cut away the meat between the ribs with a narrow sharp knife making “U” turns, 4. Clean meat off sides of Rack with knife. The underside of the rack is un-touched.
- Note that the featherbone has already been removed when the lamb carcass is split – 2x halves plus the Featherbone strip (automatically by a pair of tapered knives) See Video Sequence.
- Different “styles” of French dressing: The length of the ribs from the “eye” could be from 25mm to 100mm long (ribs trimmed to length squarely by bandsaw), the cleaned rib could be 25mm to 100mm, in other words, the ribs are not necessarily always cleaned right up to the eye. The “eye” must not be cut.
- Production through-put in products per hour: 6.5 lamb/min. or 13 rack/min.
- Manner of Operation: Off the Main Boning Line from the Bandsaw Operators: 2x Operators De-cap, 1x Operator Mark, 3x Frenching. Marking is the process of making a cut across the top of the rib rack and cutting away the fat immediately above the rib rack. See video.
- The output is tubbed, and then loaded onto a Check-weigh and Sorting Conveyor which sorts the Racks into 7x weight grades (12oz min. to 32oz max.)
- The post-Frenching manner of finish: each rack is wrapped in a sheet or plastic, put into the Cryovac bag and onto the Cryovac conveyor by 2x Operators. A separate Cryovac Loading Operator attends the Cryovac machine. See video.
- Processing time interval: from entry of chilled side of lamb to the Cryovac – 2 hours.
- They don’t use water-Frenching due to its shortened shelf life. (Not so much of an issue if the racks were to be frozen).
- Robot Cell foot-print: Current Frenching table space about 3m x 2m.
- Normal ROI for such machinery investments: A managing decision. \$70k to \$80k per operator all-up sounds about right.
- They are interested to participate in a French-dressing PIP project.
- Subjectively, the Frenching operation looks to be a significant part of the entire process.