final report

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Kidney fat removal system at Peel Valley Exporters, Tamworth

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Executive summary

The Robotic Kidney Fat Removal system was installed and commissioned at Peel Valley Exporters during July and August 2009. There were a number of driving forces behind the development of the robotic system, these were:

- Removal of the kidney fat manually is a repetitive and dirty task involving many associated OH&S risks. These include repetitive strain injury and potential for back and shoulder injuries.
- Manual removal creates high potential for cross contamination from one carcass to the next.
- The speed that the carcasses travel on the chain requires a very competent operator to maintain concentration to ensure that the required sterilisation procedures are met.

It is felt that an automated system will be able to eliminate the OH&S and cross contamination issues as well as improve consistency and yield and reduce labour cost.
As will be seen through the body of this report the installed system achieves the objectives mentioned above with a significant improvement in the amount of fat removed when compared to manual operation and reduction in water consumed when compared to the existing system at CRF Colac. It is felt that those plants that invest in future Automated Kidney Fat Removal Systems will immediately see the benefits of achieving these objectives.

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1 Background

Removing the kidney fat manually is a repetitive and dirty task and has many associated OH&S risks when removing the kidney fat by hand or vacuum. These include repetitive strain injury and potential for back and shoulder injuries. The potential for cross contamination from one carcass to the next is high. The speed they travel on the chain requires a very competent operator to maintain concentration to ensure that the quality of the sterilisation procedures is met. The Automated Kidney Fat Removal System is automatically sterilized to comply with Food Safety Standards. The Automatic Kidney Fat Removal system will allow for reliable Fat removal and sterilisation of the vacuum tool.

Working with CRF and MLA, MAR assisted with commissioning of the first Robotic Kidney Fat Removal system originally installed by Food Science Australia with Meat & Livestock Australia. The Kidney Fat Removal Robot was the first Robot on an Australian Red Meat Processing Plant and the first of its kind in the world.

Although the system worked satisfactorily for a few months, after a little while small but continuous issues started impeding the seamless operation of the robot. It was made clear then that the first implementation was not ideal, and some basic components had not been properly tailored for the task in the first design integrated by Food Science Australia. This is not an unusual occurrence when new technologies are being developed.

The system as originally installed at CRF included the use of an ABB IRB 2400 industrial Robot System. The robot utilised in this system was deemed to be under rated for the application since MAR's initial involvement of the project.

In 2005 it was agreed that MAR would optimise the system where possible utilising the original robot. The system was improved by MAR to a point where the system had been operating in production for some time.

The above improvements did offer a system that operated continuously in production and that met production requirements (Fat Removal) for a large proportion of the processed lambs.

It became apparent and a requirement, however, that more fat needed to be removed from the carcasses, in particular from larger carcasses. To do this effectively the system as a minimum must operate with increased suction on the vacuum and will also require the robot to operate with higher load demands.

The following outlines the main improvements to be implemented into the new Kidney Fat removal system to be developed within this project;

- New IRB 4400 Robot system can offer a payload capacity of 60Kg (> 300% increase)
- Improved sensing technology (laser) and software to provide an increase in efficiency "Remove more Fat". This additional sensing will allow for carcass variations to be identified providing a platform to implement variable robot programming paths and speeds.
- Reduced footprint of system allowing system to fit within more plants
- Relocated Spray Tank to reduce cycle time and stress on components (hoses etc)
- Additional and improved guarding and safety system to be implemented
- New higher rated robot will offer the capacity of the system to operate with higher vacuum rates and increased efficiency and speed
- Cycle time improvements to meet plant production rates via sensing and utilising a robot system better suited to the task "Flexibility, Speed & Configuration"

Reliability and accuracy, along with processing speed are critical to the success and acceptance of this technology within the industry.

MLA and MAR have invested significantly in the development of the Robotic Kidney Fat Removal system and MAR is confident the system can meet requirements with the correct hardware installed and further development. To benefit all parties involved with this development to date and the industry as a whole, we should finalise this development and ensure the system meets the requirements demanded by the industry.

2 Project objectives

- MAR will implement the learning's from the CRF Fat sucker system and other MAR installations such as the Sani-Vac systems to substantially improve the Kidney Fat Removal "Fat Sucker" robot system functionality.
- The system to be developed will offer different challenges including animal breed, site restrictions, line speed, chain types, gambrel variations, animal feed, customer specification on fat removal, available space, access and process location..
- Developed a commercial solution adaptation to suit Peel Valley's specifications.
- Solution must also satisfy the speed and accuracy criteria's specified by the client
- Test and prove the solution at MAR in controlled environment as proof of concept prior to installation on-site
- Implement into Peel Valley's Tamworth plant a fully function robotic kidney fat removal system
- Commission and trial system to achieve specifications according to the contract with client
- Train Peel Valley's operation and maintenance staff to competency in maintaining and operating equipment.
- Provide a plan to improve the existing CRF system

3 Results and discussion

The Kidney Fat Removal System was installed and commissioned at Peel Valley Exporters in Tamworth during July and August 2009. The images in Fig. 1 and 2 show the installed system:

Fig.1

Fig. 2

The following are the main improvements that were made to the system following learning's from the CRF installation;

- An IRB 4600 Robot system was used. This offered a payload capacity of 60Kg, a greater than 300% increase on that used at CRF. This robot has allowed a more aggressive removal path, ensuring that the tool gets in around the rib cage without the robot torqueing out as has been experienced in previous installations.
- Improved piping and pump location, allowing more effective removal of fat from the system.
- Improved tool design and compliance.
- A new automated stabilisation bar that supports the back of the carcass as the robot is removing fat and is sterilized after each carcass.
- The system is installed adjacent to the Robotic Rear Sani Vac System allowing the carcass to travel directly from one system to another. This removes the need for safety mats at the exit of the Fat Removal System and the entry of the Sani Vac system as well as reducing the floor space required.
- Improved and easier to use controls.
- Improved guarding and safety system. The guarding used was a higher grade of Polycarbonate, which does not scratch as easily as that used at CRF. Additionally the method of securing the polycarbonate eliminates the securing of the sheets with bolts and hence avoids the cracking of the sheets experience at CRF.
- Improved laser sensing technology and software has allowed carcass variations to be identified and variable robot positioning and paths to be implemented.
- Reduced footprint of system which will allow the system to fit within more plants in the future
- Additional and improved guarding and safety system.
- Cycle time improvements to meet the plant production rates, this has been achieved via the improved sensing and utilising a robot system better suited to the task "Flexibility, Speed & Configuration".
- A 3 spring compliance mechanism was used in the tooling connection to the robot roll face, this provided full 360 degree compliance and improved system flexibility
- The spray tank was mounted on the fence at operational height, decreasing robot moves and increasing the time the robot has to work on the carcass.
- An 11% fat removal increase was achieved
- A 45% reduction in water consumption was achieved.

3.1. Fat Removal Comparison

3.1.1. Aim

To determine the increase in quantity of fat that has been removed due to robotic removal.

3.1.2. Method

The easiest way to quantify the increase in fat removed is to weigh the fat removed manually then weigh the additional removed by the robot. The issue is that in the process of robotically removing the fat, it becomes mixed with water and it was felt that regardless of how much water could be drained away prior to weighing this would provide an inaccurate result. It was decided that the best results would be obtained by:

1) Having an operator manually remove the fat and place it into a red floor bin.
2) Then manually remove any excess fat to simulate the standard of fat removal achieved using the robot.
3) Weigh the fat in each bin to determine the extra that is removed by the robot.

3.1.3. Results

The images below show the results achieved. The bin on the left contains the fat removed by the initial manual operation, the bin on the right contains the extra removed to simulate the results achieved using the robot.

Fig.3

The table below shows the results.

Test	Quantity of carcasses in Test	First Manually Removed (Kg)	Excess Manually Removed (kg)	Total Removed (Kg)	Total Removed (Kg/Carcass)	Simulated Robot effectiveness over manual
1	38	5.85	0.7	6.55	0.17	10.69%
2	42	6.3	0.75	7.05	0.17	10.64%

3.1.4. Conclusion

As can be seen from the above table the percentage increase in fat removed is an average of 10.67% over the two samples taken, thus providing a substantial benefit to the producer over a 12 month period.

3.2. Water consumption calculation/comparison

3.2.1. Aim

To determine what water saving have been achieved by the Kidney Fat Removal System installed at PVE over that installed at CRF.

3.2.2. Method

The system contains four areas where water is consumed, there are:

1) Vacuum Nozzle
2) Sterilization Spray tank
3) Stabilization bar sterilization
4) Receiver tank extra spray

The water that drains from each of these areas was captured into large bins as shown below:

Fig. 4

3.2.3. Results

The table below shows the results. The system was running at 520 carcasses/hr or cycle time of 6.9 seconds, the figures in the table are based on the vacuum nozzle be sterilised for 0.5 sec every 4th carcass.

Item	Description	Test time (min)	Volume Measure (L)	Flow Rate (L/min)	Flow Rate (L/hr)
1	Vacuum Nozzle	30	200	6.67	400
2	Receiver Tank Extra Spray	8	10	1.25	75
3	Sterilization Spray Tank	30	40	1.33	80
4	Stabilization Bar Sterilization	30	54	1.80	108
			Totals	**11.05**	**663**

3.2.4. Conclusion

The results above can be compared with the water consumption figures from CRF which estimate that the water discharge into the auger at the end of the process is 20 litres/min or approximately 1200 litres/hr. Hence saving of approximately 45% in water consumption have been achieved in the new system at PVE.

3.3. Carcass Stabilisation

Stabilisation of the carcass was deemed necessary since during site visits it had been observed that if the carcass was disturbed as it moved along the rail ie by an operator pulling kidney fat out, that the plastic gambrel holding the carcass had a tendency to 'skip' ahead of the chain dog that was guiding it or to rotate. These occurrences would create issues for the robot as it attempts to track the carcass according to chain speed and for the tool/robot if the carcass was to rotate during the fat removal process.

A stabilisation bars were designed and trialled on site with a view to inhibiting the carcass from spinning and the plastic gambrel from moving ahead of the dog. The aim of the bars were to 'lock' the gambrel to prevent spin and to apply enough force to retain the gambrel so that the action of the Fat Removal tool did not cause the gambrel to 'skip' ahead of the chain dog but allows the chain dog to move it forward at chain speed. An image of the bars is shown below in Fig.5. This image is taken from below the rail looking up. In this image it can be seen that three stainless steel stabilisation bars have been added. The two out side bars have been added with a view to inhibit the gambrel from spinning and the stainless bar against which the gambrel hook is rubbing in the centre of the image is the bar that has been added to prevent the gambrel from skipping ahead.

Fig.5

Fig.6

Fig.6 above shows the lead in on the bars as the gambrels approach the processing zone.

As commissioning of the system progressed it was found that further stabilization was required. This was due to the fact that, on some carcasses, the operation of the robot/nozzle would push the carcass outside the robot operating zone and some fat would be missed. A stabilization bar was added to support the carcass from. This is shown below in figure 7. This stabilization system in fact consists of two bars and a mechanism rotates and sanitizes the bar after each carcass has passed through the cell. Sanitization was necessary to avoid any chance of cross contamination since the system was before final inspection of the carcasses and may not be required for all plants depending on the location of the system with respect to final inspection.

Fig 7.

Fig.7 Above shows the rub bar mechanism installed to prevent excessive sway of carcass as robot removes fat.

3.4. Fat Removal tool modifications

Modifications to the initial tool design taken from CRF were required during the commissioning phase, these were:

- A right angle was added to the non working end of tool to reduce the strain on the flexible hose,
- An additional lip was added to working nozzle of the tool to assist in the initial separation of fat from rib area.
- Solid guide bars were added along both sides of tooling, this enabled the tooling to enter the carcass without the hot pipes coming into contact with the skin and leaving black scorch marks on pipes. This system also reduces cross contamination and provides better cleaning of tooling.

3.5. Fat Removal from the system

During initial commissioning the plant experienced issues with transporting the fat away from the removal system. This was caused by the congealing of the Kidney fat in the ball screw of the rendering conveyor which runs at an incline. This was over come by the installation of tanks at the out feed of the fat removal system which are emptied at the end of each shift. In addition a fine hot spray was added to the vacuum tank to prevent the fat from congealing in the bends leading into the diaphragm pump. A float sensor was added to the tank to alert operators in case of a blockage and prevent the system filling up with fat.

3.6. Vaccum System issues

During the commissioning issues were experienced with the Kentmaster vacuum system in which the systems impeller was damaged. The issue was found to be a manufacturing fault where the impeller cowling was incorrectly fitted. The impeller was replaced the fitting of the cowling rectified and no further issues have been experienced with the vacuum system.

4 Success in achieving project objectives

As can be seen in the before and after shot in Figure 8 below the system is very successful in removing the Kidney Fat. This can be compared with a carcass that has had the Kidney Fat removed manually shown in Figure 9 below. It can be seen that the amount of fat removed has increased (by almost 11%), the point to note here is that the robot will perform this standard of operation repeatedly all day, providing a significant yield increase to the producer, while manual removal is far less consistent.

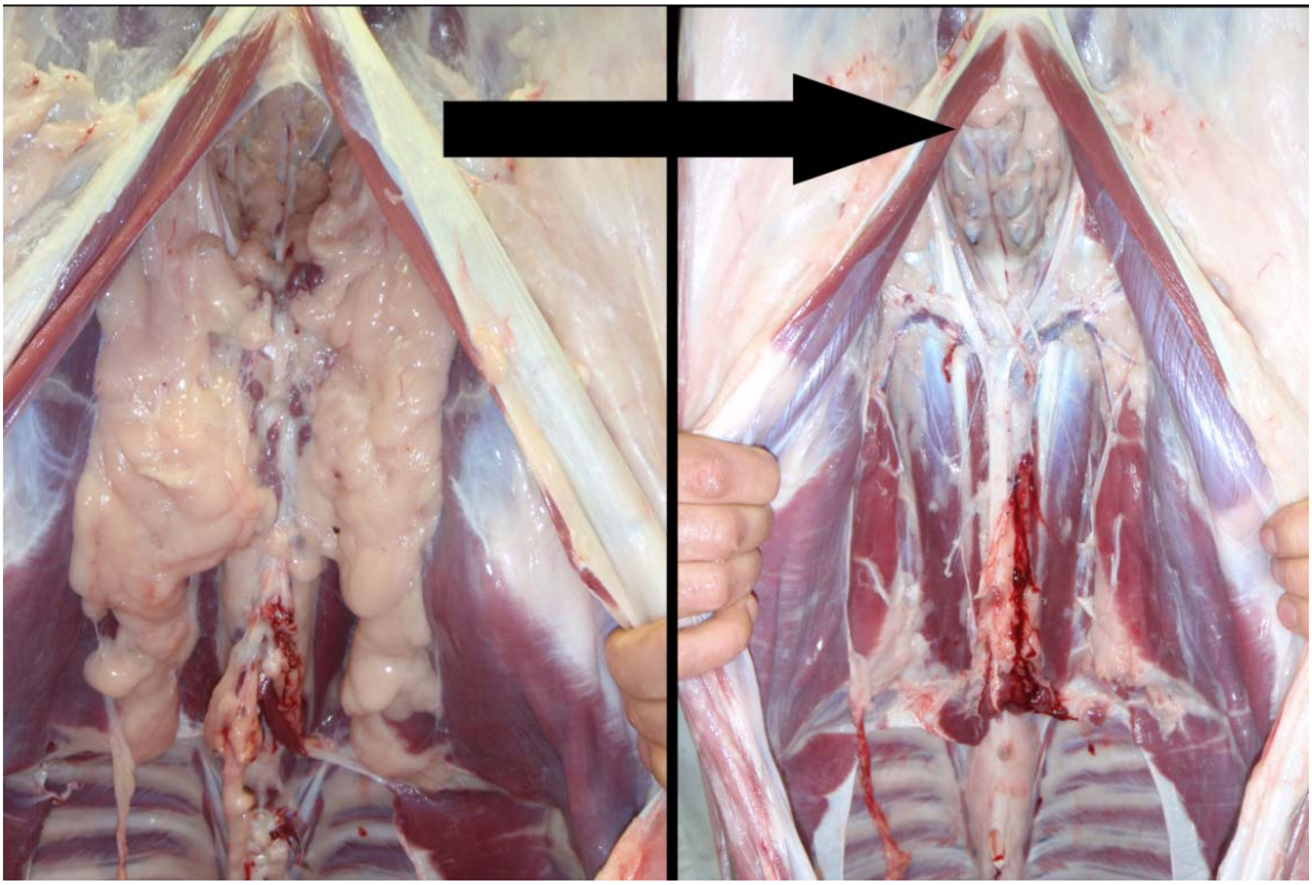

Fig 8.

Fig 9.

Swab tests were performed by PVE Quality Assurance and the results were acceptable for then to allow the system to go into full production.
The system was completed on budget and ahead of schedule, production starting on the 1st of August and sign off occurring on the 31st of August, signifying the commencement of the warranty period.

5 Impact on meat and livestock industry- now and in 5 years time

Benefits to be achieved by utilization and continued development of the Robotic Kidney Fat Removal System include:

- Improvements in OH&S;
    - Elimination of risk of operator strain injury from the size, weight and repetitive tasking
    - Elimination of dangerous operational practices
- Consistency;
    - Robotic mounting and control of the fat removal process improves accuracy and repeatability over manual removal systems
    - Improved sensing technology (laser) and software to provide an increase in efficiency "Remove more Fat". This improved sensing allows carcass variations to be identified providing a platform to implement variable robot positioning and paths.
- Improved yield through;
    - Improved yield payback by ensuring more kidney fat is removed consistently for every carcass prior to weighing
    - flexibility of system to change path specifications upon requests
- Labour cost:
    - The system will replace 1 unit of labour per shift.
- Line Speed:
    - The system can operate at line speed >10 carcasses/min.
- Efficiency:
    - Less rework required in boning room to remove Kidney Fat after chilling
- Hygiene:
    - Microbiological tests prove reduced contamination compared with manual operations
- Species:
    - The Kidney Fat Removal System is suitable for use in lamb, sheep and goat processing

Reliability and accuracy, along with processing speed which are critical to the success and acceptance of this technology have been achieved throughout this project.
Production levels at plants such as Peel Valley justifies the investment in a robotic system and the recent inclination for Australian processing plants to participate in robotic developments shows the trend the industry is following towards further automation. This is fuelled by acute shortages in labour supply, which will likely get worse in the future.

6 Conclusions and recommendations

It is evident from the images shown throughout this report that the system is very much a success and MAR would recommend adoption of this system in further plants.
MAR recommend upgrading the existing at CRF to meet the new standards and will be offering a package for CRF to consider. The improvements to the CRF system should include:

- Increasing robot to an ABB IRB 4600
- Mounting spray tank on fence at operation height
- Moving vacuum system closer to robot and out feed directly below tank
- Adding a right angle piece to the end of the tool to reduce stress on flexible pipe and save weekly replacement
- Add 360 degree compliance to rollface mount
- Add fine hot spray to tank (currently CRF pump extra water through tooling)
- Upgraded sensing.