final report

Project code: P.PSH.0304

Prepared by: David Hart

Dematec

Date submitted: February 2010

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Lamb rack frenching

This is an MLA Donor Company funded project.

Meat & Livestock Australia and the MLA Donor Company acknowledge the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Executive summary

Aims

To build upon the results obtained during the Milestone 5 trials, and optimise the automated lamb rack frenching process in terms of speed, repeatability, and quality of finish for assessment as a commercial production technique. From this to determine a projected process cost and an estimate of the capital cost for build of a prototype production machine.

Summary

Based on the two-pass boning knife technique developed during Milestone 5, a number of process improvements were made. Firstly, the process was modified to incorporate two pin array imprints of the meat, one slightly offset from the other, in order to obtain greater rib detection resolution and therefore more accurate trimming. Secondly, the base plate of the pin array was modified in order to obtain greater differentiation between pins which were displaced by bones, and pins which were not. Thirdly, a second cutting implement was added to the robot head, a double-sided blade, to perform the third cut on each rib sub-section. Finally, the process was sped up by reducing the robot path calculation time and increasing the robot travel speed.

It is now considered that the automation of the lamb rack frenching process has been proven with the nominated rib detection technique and robotic trimming arrangement. In order to develop a production machine the next aspect that must be considered is the loading, locating, and clamping of the lamb racks for consistent presentation to the automated frenching process. The development of the rack clamping system is outside the scope of this R&D activity and will be considered as an alternative project.

Contents

1 Introduction

In Milestone 5, several methods were trialled for the intercostal meat removal. Of these, a two-pass cutting technique using a Swibo boning knife demonstrated the most encouraging results, whereby the knife would slide along the side of each rib, allowing the flexibility of both the rib and the knife to place a sufficient degree of pressure on the rib during the cut. This approach has now been developed and optimised using a variety of strategies.

2 Double imprint of pin array

One of the difficulties encountered using the two-pass boning knife technique was that the accuracy of the bone location estimate is critical for the correct entry point of the knife; if the location is underestimated with respect to the centre of the bone, the knife will run into the bone. If, on the other hand, the location is overestimated, the knife will cut too far from the bone, resulting in a poor quality cut.

Since the pin array was already designed to achieve the optimal balance between spatial resolution and mechanical strength of the pins, simply increasing the density of pins was not a possibility. An alternative solution was then developed whereby two imprints of the meat are taken using the existing pin array, one imprint slightly displaced from the other. This effectively simulates a pin array with twice the density of pins, resulting in a two-fold increase in resolution. For testing purposes, this strategy was implemented by displacing the meat, as opposed to the pin array, however in a production setting it is likely that the pin array itself would be displaced. Results have demonstrated that this approach is successful, as the knife cuts are visibly more accurate.

3 Modification of pin array base plate

Previously, the base plate which supported the bones beneath the pin array was a solid plate made from alumium. Consequently, the pins would only be displaced by a distance equal to the thickness of the bone, as well as any fat underneath the bone. In the case where the bone was of minimal thickness, and there was little or no fat beneath the bone, this resulted in a minimal change in displacement of the pins above the bone. While this change in displacement was still detectable by ensuring the most favourable air pressure on the pin array, and optimal filter settings on the camera, the repeatability of this strategy was an issue.
Subsequently, an array of holes was drilled in the base plate such that the pins which did not strike the bone would pass through it, thus improving the signal-to-noise ratio by maximising the change in displacement of the pins which do strike the bone.

4 Addition of double sided blade

The next challenge was to successfully sever the interconnecting meat after the two side cuts had been performed. Since the boning knife is sharp on only one side, difficulties were encountered using it to perform the third cut. This was due to the fact that the resulting cut was unlikely to intersect properly with the first cut, in the case where the first cut was very close to the bone. The solution was to use a double-sided blade, thus allowing the sharp edges to push against the bone on each side with enough pressure to successfully sever the meat. The knife was then added to the robot head in such a way that it is interchangeable with the Swibo knife during the Frenching process, and the robot program was updated accordingly.

Figure 1 – Multiple knife configuration.

Results demonstrated that this approach is effective.

Figure 2 – Intercostal meat has been fully severed.

5 Reduced cycle time

The robot code was optimised in order to reduce the path calculation time and increase the robot travel speed. This resulted in a total movement time of approximately 12 seconds (for the 5 rib reduced size rack). Note that this time would be proportionally longer for the Frenching of a full lamb rack (approximately 20 seconds for an 8 rib rack). The Frenching cycle time could be further reduced using a faster robot; the testing had been performed using a second-hand welding robot which was not designed for high speed movement. At present, the cycle time for the rib detection component of the process is far longer than could be expected using up-to-date equipment. A serial interface between the robot and camera is presently used, resulting in a slow transfer of data. This time would be substantially reduced using an Ethernet interface. Additionally, the rib detection process will run in parallel to the Frenching process, and it is expected that the rib detection cycle time will be less than the Frenching cycle time.
Please refer to the accompanying spreadsheet for details on the estimated process cost savings based on the findings above.

6 Considerations for rack presentation fixtures

At present, the machine is capable of consistently Frenching a rack of lamb when fat is present. As described in the Milestone 5 report, the fat provides additional support to the meat such that the meat is less likely to slip beneath the bone during the second cut. In the case where no fat is present, the consistency of cuts is reduced. This problem is exacerbated when the bones are close together, since there is less support from the interconnecting meat. One solution to this problem is to provide support to the meat during the second cut by means of blowing compressed air onto it from the opposite direction to the movement of the knife. Preliminary trials have demonstrated that this improves the consistency of cuts in the described situation. Another problem encountered was that if no fat is present, the meat is likely to hang down from the rack after the first two cuts have been performed, resulting in reduced consistency of the third cut properly severing the meat. In order to provide support during the third cut, a pivoting cross-beam can be moved into place after the second cut. This approach was shown to be successful during a trial whereby a cross-beam was manually placed under the ribs during the third cut.
These items will need to be considered when designing the fixtures that retain and present the lamb racks to the automated frenching process.