final report

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Automatic Beef Carcase Splitter Stage 2

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EXECUTIVE SUMMARY

The aim of this project was to determine if the action of the existing hide pulling process installed in Ralph's Meat Company in Seymour, Victoria, can be sufficiently modified through alternative dressing and processing procedures to produce a suitable surface that when scanned by ultrasound, will generate images of sufficient quality for use in guiding an automatic splitting saw.

Tests were carried out during a normal week of production, concentrating on animals that had at least some fat coverage, as these were seen as most likely to provide a desirable result.

Ten major and one minor methods of altering the process with the existing upward hide puller were used with varying results. Tests were carried out using the existing hide puller to remove the hide in both the upward and downward directions.

Tests consisted of trialling the upward hide-puller with the roller in the standard position; in the highest position; and in the lowest position to simulate a downwards hide pulling motion. Alternative dressing procedures included removing the head, fleecing with knives and clearing different regions of the carcass. Sections on the hide were dressed away from the carcass prior to the hide puller to attempt to reduce the stresses of the hide pull. The air knives were used to help separate the hide from the carcass in an effort to reduce the plucking effect caused as the hide was removed.

The time to perform the pre-work and process a carcass for some tests was quite substantial and caused disruption to Ralph's processing chain. Some of the tests, particularly those simulating downward pulls, also caused significant carcass surface damage. At the request of the plant the number of carcasses required for each test was minimised if no improvement change was observed. The increased cycle time also meant that that excessive clearing occurred on some carcasses, while workers waited for the chain to index, possibly giving false improvements to some of the results.

Of the eleven tests carried out, some tests provided an intermittent improvement in the image produced by the ultrasound unit, but no test provided a clear improvement that could be relied on – even in a specific region. Some of the improvement differences may in fact be attributable to changes in carcass quality.

The conclusion for this report is that the existing upward hide puller and surrounding processes could not be modified sufficiently to generate ultrasound images that are useable for automatic carcass splitting. The results for the downwards hide-pull trials were questionable as due to the available equipment a downwards pull was simulated inadequately. For conclusive results a mechanical guide apparatus to maintain probe pressure on a carcass should be trialled at an alternative commercial site with a conventional downwards system. To use the robot system in its current location an alternative backbone sensor needs to be investigated.

1. INTRODUCTION

During the installation phase of PRTEC.007 – Automatic Beef Carcase Splitter it was found that the ultrasound images obtained from animals de-hided using an upward hide puller were of unsuitable quality. This was a major issue as the ultrasound images are analysed to provide position feedback for placement of the splitting saw during cutting.

Further investigation at the conclusion of that project showed that air pockets or "bubbles" are formed in the carcass muscle/ fat tissue during the hide pull process. Degraded ultrasound images are caused by the ultrasound signal not being able to penetrate the air bubble into the underlying tissue of interest below. Skinning an animal by hand proved to be a solution to the problem, but this is not a practical solution for an existing works situation.

It was proposed to return to Ralph's Meats where the commercial prototype was undergoing installation, to further investigate alternative de-hiding processes to explore if a usable image could be produced. This investigation is the basis of the current project (PRTEC.029 Automatic Beef Carcase Splitter– Stage 2) and is documented in this report.

2. TEST METHOD

The aim of this project is to determine if the action of the hide puller can be altered to enable the ultrasound system to capture usable images. To do this a variety of tests were conducted in the commercial environment using alternative dressing and hide-pulling methods to investigate any change that may occur in ultrasound image quality.

Alterations that were investigated with Ralph's existing hide pulling process involved:

- More pre-work before de-hiding using the upward hide puller
- Changes in the operation of the hide puller to simulate a downwards hide pulling motion with various pre-work procedures
- Further investigation of any pre-work dressing procedures/ hide puller angle/ standard hide pull combinations that could provide favourable ultrasound images.

Tests included processing the images using the existing ultrasound image processing computer, digital photographs for a record of the carcass features, and a visual review of the ultrasound images recorded during the carcass scan.

Trials were carried out over a week during normal production, with some interruption to the normal plant operations. Due to these interruptions some test were reduced in numbers to minimise the delays to production.

2.1 METHODS USED TO EVALUATE DATA

Each of the carcasses processed was evaluated by its condition, the type of animal being presented and the results obtained during the scan from the ultrasound.

This was the result of a visual inspection of the animal as it left the hide puller. Air bubbles evident on the surface of the carcass, as well as the lack of surface fatty tissue have previously been identified as indicators that the ultrasound analysis system would not perform as desired. Looking down the carcass a rating of carcass damage was also given for the loin, forequarter, shoulder and neck.

After the trials were run, the recorded ultrasound images for each trial were reviewed and a rating of the quality of the image manually assessed.

This information was summarised in the following table :

No.	Comp Time	U/S Time	Hooks	Class	Animal Condition	Image at Lumbar	Image at Loin	Image at Shoulder	Image Overall For Splitting	Comments
10-1	10:04	9:56	ODD	A	LEAN /MED	POOR	POOR	POOR	UNUSABLE	Fat damage. Some had US images only.
10-2	10:07	10:08	MATCH	A	FAT	FAIR	POOR	POOR	UNUSABLE	Bruising. Could start to see some US images.
10-3	10:11	10:09	MATCH	A	LEAN	FAIR	POOR	POOR	UNUSABLE	Bruising. Damaged fat. US images neck only.
10-4	10:14	10:12	MATCH	YG	VERY LEAN	POOR	POOR	POOR	UNUSABLE	Heavy bruising. US slightly over to one side.
10-5	10:21	10:15	MATCH	A	VERY LEAN / RAZOR BACK	FAIR	POOR	POOR	UNUSABLE	Fat damage.

Table 2- 2 : Example of the manually assessed replayed ultrasound images

This information also records whether the rollers were matched or not. If the rollers were not matched, then the animal would tend to hang to one side and the ultrasound unit would commonly run to one side of the backbone. An assessment of the image was given for the Lumbar, Loin and Shoulder regions, as well as an overall rating on the quality of the ultrasound images. In addition the class of each carcass is also noted.

The class grades are:

V – Veal
A – Beef
B – Bull
Y – Yearling Beef
YS – Yearling Steer
YG – Young Beef
YGS – Young Steer
YP – Young Prime Beef
YPS – Young Prime Steer
PR – Prime Beef
PRS – Young Prime Steer
S – Ox (Female)
SS – Steer
C – Cow

A set of pictures of each carcass was also included to give a visual indication of the animal condition.

Image 2- 1 : Examples of still pictures taken of a carcass after it leave the hide puller

The images from the ultrasound were processed by a dedicated imaging computer used to track the backbone of the carcase. Each individual image was analysed to find the centre of the backbone. If the image was not of sufficiently good quality, then the image was rejected.

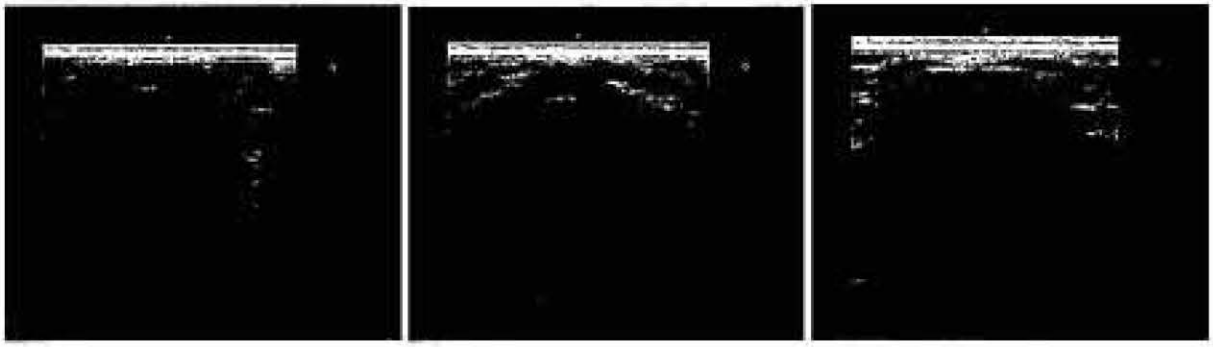

Image 2- 2 : Examples of "good quality" single ultrasound images suitable for processing

Image 2- 3 : Examples of poor ultrasound images rejected by the image processing computer

After the carcase had been scanned the individual ultrasound image frames were processed to form a representative carcass scan strip image with the analysed bone centres overlaid on the collated image. This "collated image" has been included for each animal and gives an indication of the desired cut path as analysed by the current system.

A second "collated image" has also been included for each animal in the results. These show the rejected images during the scan. A rejected ultrasound image frame is shown as a black horizontal line. As the number of rejected images increases, then the confidence in an accurate cut decreases. Once more than 10-15% of images are rejected, then the cutting path is unusable.

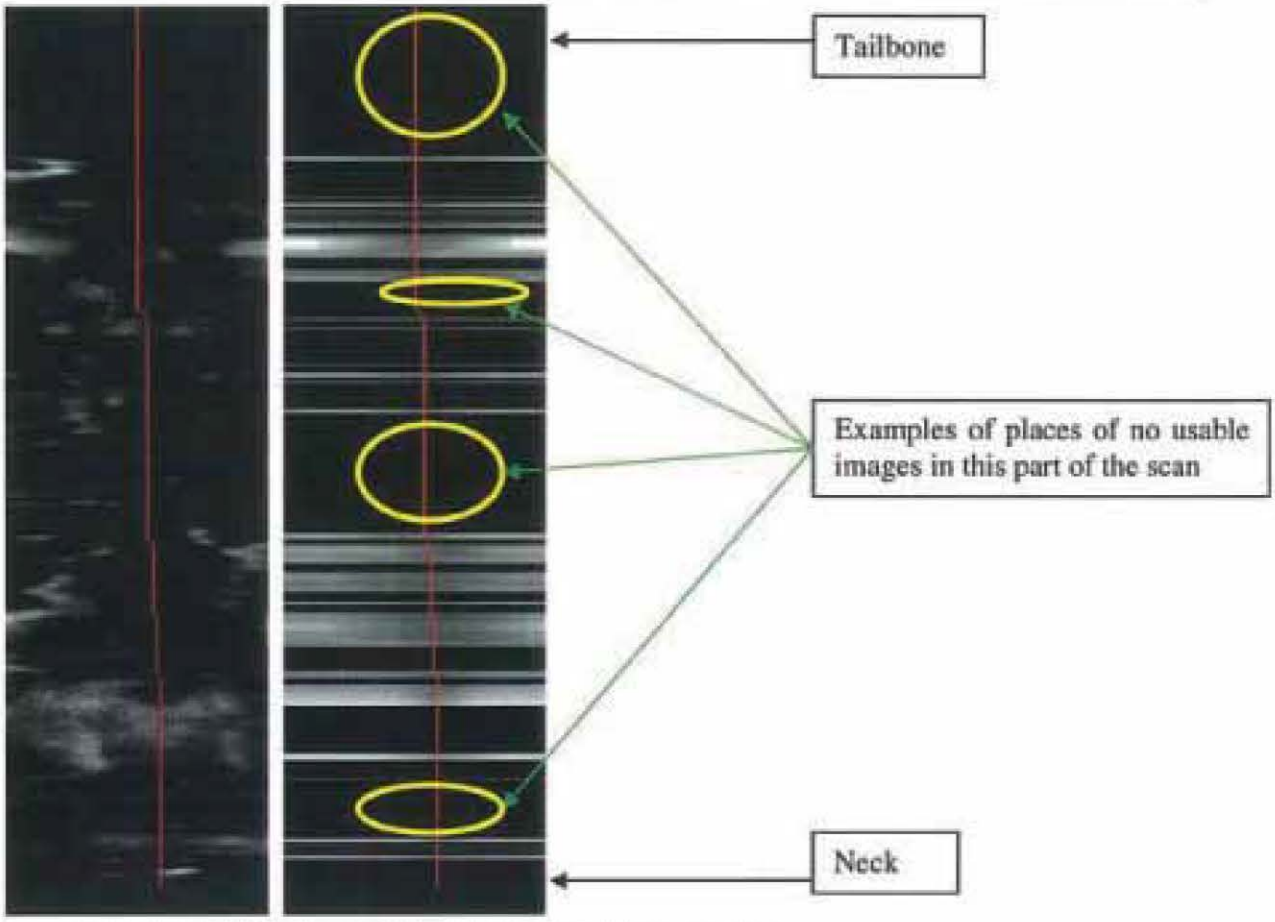

Image 2- 4: Examples of compiled ultrasound images in strip format

During the scan the ultrasound image was recorded on a video tape and played back at a later date. As the scan was reviewed a subjective opinion of the image was given. If the image looked good, but the image processing rejected too many images, then modification to the image processing software may have been able to be considered.

3. TEST RESULTS

The following tests were conducted:

Test 1: Standard hide pull with the head removed;
Test 2: Standard hide pull with the head removed and fleece during pull;
Test 3: Standard hide pull with the head removed, clear the shoulder area and fleece during the pull;
Test 4: Standard hide pull with the head removed, clear the shoulder area and flanks, fleece during the pull;
Test 5: Hide pull roller in highest position, remove the head and fleece during the pull;
Test 6: Hide pull roller in highest position, remove the head, clear the shoulder area and fleece during the pull;
Test 7: Hide pull roller in the highest position, head removed, clear shoulder, clear flank areas and fleece during pull;
Test 8: Downward hide pull with the roller in the lowest position;
Test 9: Downward hide pull with the roller in the lowest position and fleece during the pull;
Test 10: Downward hide pull with the roller in the lowest position, clear the rump area and fleece during the hide pull;
Test 11: Standard hide pull with the head removed and change dressing procedures or angle of pull.

It should be noted that dressing the animals for tests 4, 5, 6 and 7 took considerable time and caused significant disruption to processing as the delay was more than was expected during these tests. The plant requested a halt to test 6, midway through the sample of 10 animals. Considering that there was no considerable change observed in test results to that point, the number of animals required for each subsequent test was reduced. The number of animals for tests 8, 9 and 10 was also reduced to 5 for each test.

3.1 TEST 1 – STANDARD HIDE PULL – HEAD REMOVED

3.1.1 DESRIPTION OF MODIFIED PROCESS

Figure 1 : Images during the hide removal - head removed

The hide was cut above the head to relieve the stresses on the carcass that would normally occur as the hide is torn or pulled off around the shape of the skull. The head was skinned as normal by hand prior to arriving at the hide puller.

3.1.2 RESULTS

Eleven animals were scanned in this trial :

Results from animals 1, 2, 3, 4, 8 and 9 were totally unusable and showed no potential for use in an ultrasound guided automated cut.

Animals 5, 6 and 7 were marginally better, but the scan showed little or no potential for improvement.

Only animals 10 and 11 showed minor promise of improvement in the quality of the ultrasound scan, but the scan quality was still too poor to use as is.

All 11 animals had scans that were not usable for the automated cutting process.

3.1.3 CONCLUSION

From the results , there appears to be no improvement of the ultrasound scan by removing the head compared to a standard hide pull.

3.2 TEST 2 – STANDARD HIDE PULL – HEAD REMOVED & FLEECE DURING PULL

3.2.1 DESRIPTION OF MODIFIED PROCESS

Figure 2: Images during the hide removal - Fleecing during hide removal

An air knife was used to relieve as much tension as possible while the hide was being removed from the body as the hide puller moved up the carcass. The air knife processing was concentrated at the separation point of the carcass and hide.

Around the head was cleared and processed as in test 1.

3.2.2 RESULTS

Ten animals were scanned in this trial

Only results from animal 8 showed minor promise of a potentially usable ultrasound scan, but the image was still unusable as is.

All other animals were totally unusable and showed no potential for use in an ultrasound guided automated cut.

3.2.3 CONCLUSION

From the results , there appears to be no improvement of the ultrasound scan by adding fleecing with air knives compared to a normal hide pull.

3.3 TEST 3 – STANDARD HIDE PULL – HEAD REMOVED, CLEAR SHOULDER AREA PRIOR TO PULL & FLEECE DURING PULL

3.3.1 DESRIPTION OF MODIFIED PROCESS

Figure 3: Images during the hide removal - shoulder cleared prior to hide pull

Prior to the carcass entering the hide puller the hide was knifed (with a skinning knife) away from the carcass around the shoulders. This was to help reduce the stresses applied to the carcass during the hide pull.

Air knives were again used to help separate the hide from the carcass, as in test 2. Around the head was cleared and processed as in test 1.

3.3.2 RESULTS

Ten animals were scanned in this trial

None of the animals scanned showed any potentially usable ultrasound images.

3.3.3 CONCLUSION

Clearing the shoulder and head and adding air knife fleecing didn't help improve the ultrasound image quality.

3.4 TEST 4 – STANDARD HIDE PULL – HEAD REMOVED, CLEAR SHOULDER AND FLANK AREAS PRIOR TO PULL & FLEECE DURING PULL

3.4.1 DESRIPTION OF MODIFIED PROCESS

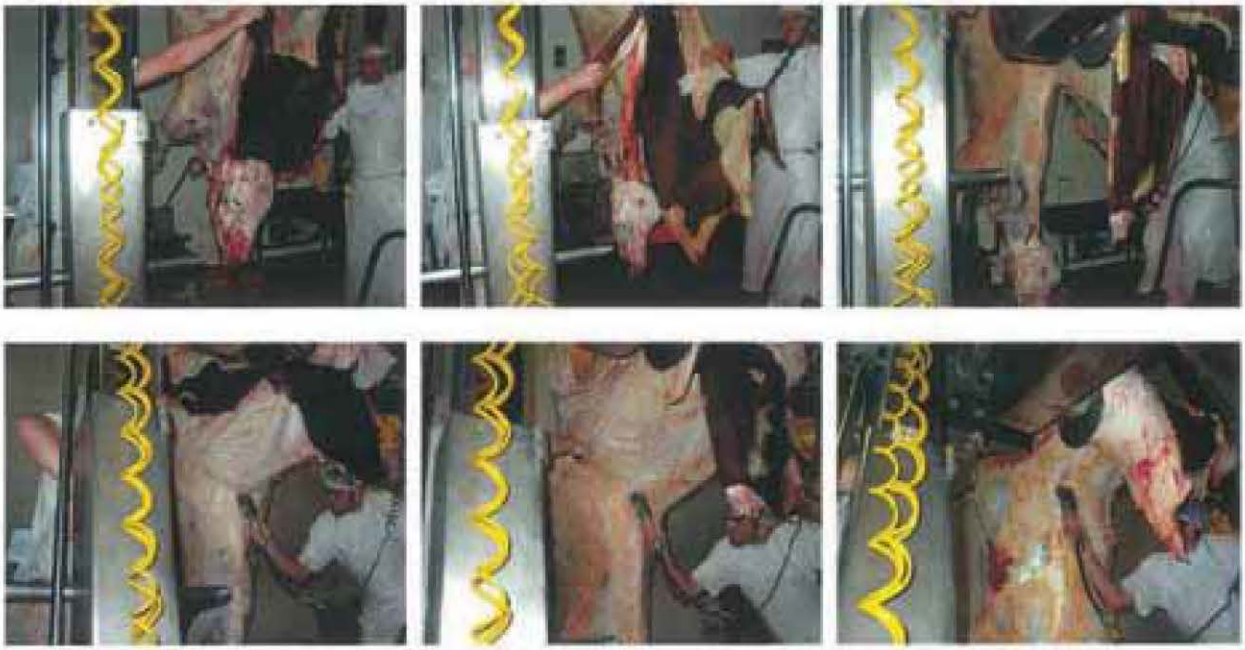

Figure 4: Images during the hide removal - clearing shoulder and flanks prior to hide pull

At a trimming station prior to the hide puller, the flanks were cleared to help reduce stresses at the top of the carcass during the hide pull.

Prior to the carcass entering the hide puller the hide was knifed (with a skinning knife) away from around the shoulders as in test 3. Air knives were again used to help separate the hide from the carcass, as in test 2. Around the head was cleared and processed as in test 1.

3.4.2 RESULTS

Ten animals were scanned in this trial

Animals 1, 3, 4, 5, 6, 7 and 9 showed minor increased ultrasound scan quality in the mid back to shoulder region, but the number of scan images accepted by the image processing computer was still too low.

The manual review of the ultrasound images showed that - for the majority of the scans – the lumbar region images were better than the rest of the scan, but the images were still not suitable for image processing.

3.4.3 CONCLUSION

Clearing the shoulder and the flanks of a carcass helps to improve the quality of the ultrasound image, but not to a minimum level required for automatic cutting.

3.5 TEST 5 – ROLLER REMAINING IN HIGHEST POSITION DURING PULL – HEAD REMOVED & FLEECE DURING PULL

3.5.1 DESRIPTION OF MODIFIED PROCESS

Figure 5: Images during the hide removal - Standard pull with roller in highest position

The roller of the hide puller was placed in as high as position as possible and a standard hide pull was performed. This was done to try and change the angle of the stresses involved in the hide pull.

Air knives were again used to help separate the hide from the carcass, as in test 2. Around the head was cleared and processed as in test 1.

3.5.2 RESULTS

Ten animals were scanned in this trial .
All of these animals were deemed to have moderate fat coverage.

All of the scans, except for animals 5 and 9, showed improved ultrasound image quality around the tailbone and upper lumbar region according to the image processing computer. The replayed image assessment confirmed that a lesser number of scans were better in this region, but still of not of good enough quality for image processing.

Only animal 10 showed enough potential to be used for automatic cutting however the scan barely reached the minimum level required of a useable "good quality" scan. None of the other 9 carcass scans was suitable for automatic cutting.

3.5.3 CONCLUSION

Fleecing during the hide pull appears to help improve the quality of the image around the tailbone and upper lumber sections of the scan - but that may have been due to the quality of the animal.

Fleecing during the hide pull with the roller in the highest position does not give a confirmed benefit to the quality of the scanned ultrasound image.

3.6 TEST 6 – ROLLER REMAINING IN HIGHEST POSITION DURING PULL – HEAD REMOVED, CLEAR SHOULDER PRIOR TO HIDE PULL & FLEECE DURING PULL

3.6.1 DESRIPTION OF MODIFIED PROCESS

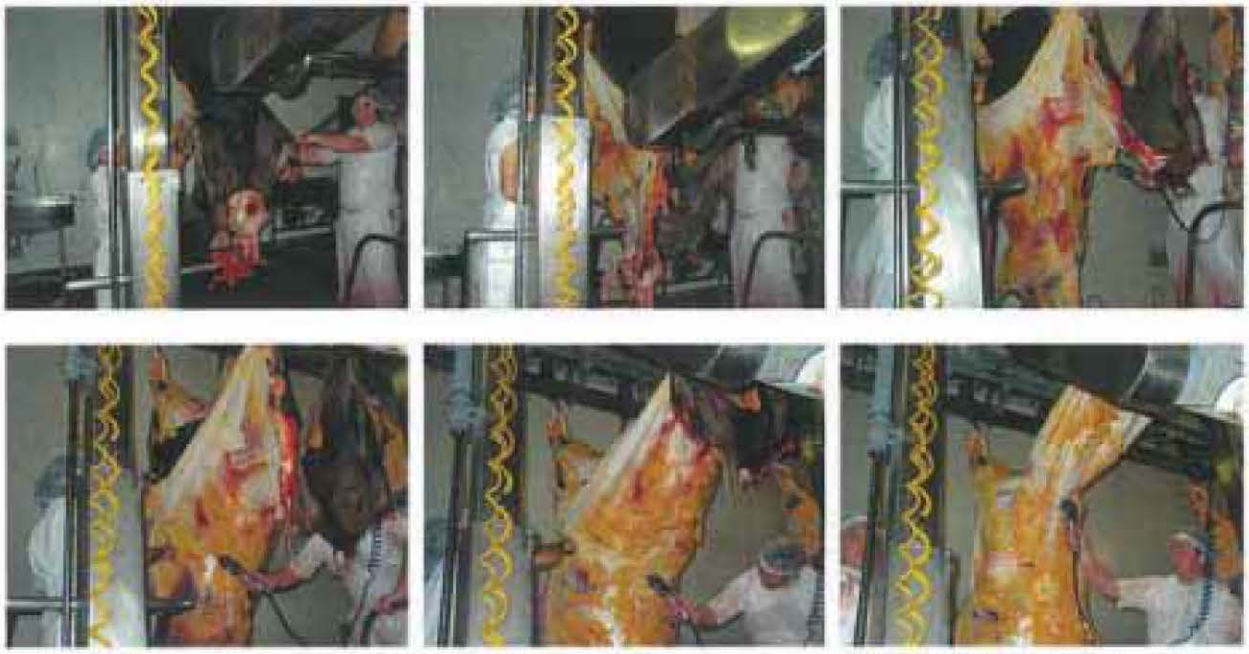

Figure 6: Images during the hide removal - Standard pull with roller in highest position with shoulder cleared

The area around the shoulder was cleared prior to the hide pull to help reduce the initial process stresses.

The roller of the hide puller was placed in as high as position as possible as for test 5. Air knives were again used to help separate the hide from the carcass, as in test 2. Around the head was cleared and processed as for test 1.

3.6.2 RESULTS

Dressing the animals for tests 4 and 5 caused the plant to be held up longer than was predicted. During test 6 it was requested by the plant to halt testing for that day after animal 6. Considering that there was no observed change in test results to that point, the number of tests was reduced.

Six animals were scanned in this trial
These animals were deemed to have a mixed quality of fat coverage.

Animals 3, 4 and 5 showed an overall improvement of scanned image quality, but the improvement was still not acceptable for full scan image processing. Replaying the ultrasound images confirmed that the image was improved, but mainly in the region of the tailbone and lumbar regions.

Animals 1 and 5 were considered to have a protruding backbone, which should prevent any good image being obtained from the ultrasound unit.

3.6.3 CONCLUSION

Fleecing of the animal, combined with increased pre-work for the hide puller (clearing head and shoulders), may increase the quality of the scan for some carcases - but not all – and the increase in quality is still not sufficient for reliable scans.

3.7 TEST 7 – ROLLER REMAINING IN HIGHEST POSITION DURING PULL – HEAD REMOVED, CLEAR SHOULDER AND FLANK PRIOR TO HIDE PULL & FLEECE DURING PULL

3.7.1 DESRIPTION OF MODIFIED PROCESS

Due the similarity of processing with tests 5 and 6, no still pictures were taken during the processing of test 7.

The areas around the shoulder and the flanks were cleared prior to the hide pull to help reduce the pulling stresses.

The roller of the hide puller was placed in the highest position possible as for test 5. Air knives were again used to help separate the hide from the carcass, as in test 2. Around the head was cleared and processed as for test 1.

3.7.2 RESULTS

Due to the time taken to dress the carcasses prior to the hide puller for this and the previous 3 tests, it was requested by the plant to reduce this test to a very minimal number of animals. Two animals of medium quality were used for this test.

Two animals were scanned in this trial

Although both animals had the desired amount of fat cover required for the ultrasound unit to work correctly, neither scan produced enough "good quality" ultrasound image frames to be useful for automatic cutting.

Reviewing the ultrasound images manually confirmed that the scan was not suitable for cutting.

3.7.3 CONCLUSION

Combining the results from this test and the previous tests, it could be said that fleecing can improve the quality of the ultrasound scan in some cases, but not consistently.

Fleecing with considerable amounts of pre-work to clear the hide does not improve the quality of the ultrasound image.

3.8 TEST 8 – DOWNWARD HIDE PULL (ROLLER REMAINING IN LOWEST POSITION)

3.8.1 DESRIPTION OF MODIFIED PROCESS

Figure 7: Downward hide pull

The roller was placed in the lowest practical position to pull the hide from the carcass starting at the tail and ending at the head.

The hide was pulled off the head during this process.

No special fleecing was performed during this test.

3.8.2 RESULTS

Due to the length of time taken for pre-work during these tests and the time required to perform the trials the plant requested that the number of animals for each test be reduced for this day of testing. The number of animals for tests 8, 9 and 10 was consequently reduced to 5 animals for each test.

Using the upward hide puller to do a downward hide pull also caused some carcass surface damage resulting in the carcase being downgraded. This was another reason the plant requested the number of animals used in tests 8, 9 and 10 be reduced.

5 animals were scanned in this trial

Animals 2, 3, and 5 showed intermittent improvement in the quality of the scan in differing sections of the carcass. The manual review of the ultrasound images later assessed that these images may still have been of questionable quality.

3.8.3 CONCLUSION

Using the upward hide puller to do a downward hide pull with no additional separation assistance did not substantially increase the quality of the ultrasound scan.

3.9 TEST 9 – DOWNWARD HIDE PULL – FLEECE DURING PULL

3.9.1 DESRIPTION OF MODIFIED PROCESS

Figure 8: Downward hide pull - fleece during pull

The roller was placed in the lowest practical position as for test 8.

Air knives were used to help separate the hide from the carcass during the hide pull to reduce processing stresses.

3.9.2 RESULTS

Five animals were scanned in this trial.

All 5 carcase scans showed a reduction in the number of processed scan images from the previous test.

None of the scans could be used in any way for automatic cutting.

3.9.3 CONCLUSION

Adding air knives to help with fleecing during the downward hide pull did not improve the quality of the ultrasound images. It could be suggested from the data that the fleecing may have made the images worse.

3.10 TEST 10 – DOWNWARD HIDE PULL – CLEAR AROUND RUMP PRIOR TO PULL & FLEECE DURING PULL

3.10.1 DESRIPTION OF MODIFIED PROCESS

Figure 9: Downward hide pull - rump cleared

The hide was cleared from the rump area at a station prior to the hide pull. This was done to reduce any initial stresses during the process.

The roller was placed in the lowest practical position as for test 8. Air knives were used to help separate the hide from the carcass during the hide pull as for test 9.

3.10.2 RESULTS

Five animals were scanned in this trial .

All 5 carcase scans showed a reduction in the number of useable ultrasound scan frames, similar to the results found in test 9.

None of the scans could be used in any way for automatic cutting.

3.10.3 CONCLUSION

Helping the downward hide pull by clearing around the rump prior to the hide pull does not improve the quality of the ultrasound images.

3.11 TEST 11– STANDARD HIDE PULL WITH CHANGED DRESSING PROCEDURES

3.11.1 DESRIPTION OF MODIFIED PROCESS

This test was included in an effort to develop any promising results of the prior ten tests.

None of the tests showed a substantial improvement to the normal upward hide pull being used in the plant.

In an attempt to see if more gathered images may give a usable result, the downward vertical travel scanning speed was reduced from 90mm/sec to 60mm/sec.

By reducing the vertical speed of the ultrasound probe it was hoped to generate the effect of gathering more ultrasound images for the same distance travelled, and possibly allow more time for the ultrasound head to push the sub-surface air bubbles out of the way and allow a better image to be obtained.

3.11.2 RESULTS

Four animals were scanned in this trial

Animals 3 and 4 showed some increase in the number of scans accepted by the imaging computer, even though these carcasses had reduced fat cover.

None of the scans produced any consistent improvement in scanning quality, and none of the scans could be used for automatic cutting.

3.11.3 CONCLUSION

Slowing the scan speed down on an animal skinned using a standard upward hide pull does not allow the quality of the ultrasound images to improve enough to use with automatic cutting.

4. OVERALL CONCLUSIONS

This report concludes that in some tests conducted there is a slight improvement in image quality for the ultrasound image analysis system, but this improvement is neither consistent over a whole carcass scan, nor consistent over a number of bodies in a particular test.

Results showed no improvement from the standard upward hide pull for:

- Removing the head
- Fleecing with knives
- Clearing the shoulder.

Clearing the flanks in addition to the three steps above did improve the ultrasound image quality, however not to the minimum required for the automatic cutting process. The improvement difference may be attributable to the change in carcass quality.

Tests 5, 6 and 7 used alternate dressing procedures for an upward hide-pull with the hide-pull roller in its highest position. In general the image quality improved over results from tests 1 through 4, however carcass quality cannot be ruled out as the major factor. Results showed fleecing improved the quality around the lumbar and tailbone regions with clearing at the shoulder and flank regions also showing improvement. Unfortunately the improvement is neither consistent or of sufficient quality for automatic cutting.

These results may also have been affected by excess clearing of the carcass at stations before the hide-pull. Performing the specific hide pull operation required by the tests took some time and consequently workers at earlier stages along the process continued to clear while waiting for the chain to index. The longer a test took to prepare and process, the greater the amount of clearing that occurred in addition to what was specified and required.

None of the simulated downwards hide-pull showed improvement in ultrasound image quality. Severe damage occurred to the carcass fat covering resulting in reduced carcass quality. The downwards hide-pull trials poorly simulated the requirements of a conventional downwards system and for conclusive results a mechanical guide system to maintain probe pressure on a carcass should be trialled at an alternative commercial site.

Reducing the speed of the scan also did not help improve the quality of the overall carcass scan.

Using air knives to help fleece the animal did not help increase the quality of the carcass surface and in some cases may have attributed to a degraded surface for scanning. The operators were not accustomed to the use of air knives for fleecing the hide during the hide pulling operation. This also contributed to the poor quality carcass finish.

Based on the results of these trials project staff believe it is unlikely that alternative dressing procedures and alterations to the upward hide-pull will generate ultrasound images suitable for use to guide an automatic splitting saw.

Recommendations for this project are:

- Conventional downwards hide pulling trials
- Investigate an alternate backbone sensor for existing splitting saw system.