Final Report

AUSTRALIAN MEAT PROCESSOR CORPORATION

Beef Carcase Orientation

Beef Carcase Orientation Study

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1.0 Executive Summary

One of the initial processing stages of a beef carcase is the carcase splitting process. Here, the carcases are split straight down the median plane resulting in two half-carcases or "sides". This splitting process introduces a unique problem for automated production processes which made controlling what side of the carcase is facing the processing equipment a challenge. This becomes an important variable since most sites only carry out processing operations on the medial or "cut" side of the carcase.

Presenting the carcase to the processing equipment in the incorrect orientation can result in efficiency losses which directly impact ROI for the processing site as they will need to pause the system while the orientation of the carcase is corrected by an operator. Hence, this project will involve developing a concept to enable orientation control of a beef carcase whilst maintaining control of its final position. A trial of this technology will be performed to assess its suitability for the industry.

The following stages were employed to achieve a positive outcome for the project: -

1) Conducting an initial study and review existing methods
2) Develop a range of concepts to enable carcase orientation
3) Develop tests to validate these concepts
4) Perform site testing on the best options

Our main objectives for this project were to develop a concept which can enable a hanging side of beef to be orientated as per our system requirements with the medial side presented to an automation cell, along with the fabrication of test apparatuses to enable factory and site testing. Both of these objectives were achieved successfully and learnings from each stage were recorded.

Our initial study began with research on existing techniques and also a brief on-site trial to understand the best points of contact on a carcase to enable rotation with minimal force applied. This allowed us to develop a concept design which was fabricated and tested on site to assess its feasibility and understand its operational success rate, as well as pointing out any weaknesses or disadvantages of using such a system when we encounter a variety of different carcase shapes and sizes. Some of the key findings from our study indicated that: -

- Standard carcase sizes have no issues with complying as a rotation is induced when being put though our system – 100% of standard carcases were turned successfully.
- The contact points on the carcase will vary in height when dealing with left and right carcase sides to ensure we have optimal contact between the carcase and our turning mechanism.
- Our final concept will need to take into account various design considerations to assist with inducing carcase rotation and controlling the orientation at the outfeed of our system, as well as dealing with carcases with have sections trimmed out (e.g. belly or brisket).

The next steps to remain in line with the goal is to develop a robust and reliable system will be to determine the maximum and minimum range of height variation required to ensure we catch the carcase in our stable regions. This analysis will contribute to an increased reliability in our system which we may choose to install on site.

2.0 Introduction

The aim of the project was to develop a concept to enable orientation of a beef carcase whilst maintaining control of the final position. A further trial of this concept will be conducted to prove the feasibility and functionality of the chosen concept in a site environment.

The testing will assist us to eliminate a high-risk variable for an automation cell –ensuring the carcase is presented with the cut side facing our processing equipment. From a ROI perspective, not being able to achieve high accuracy whilst carrying our orientation process can lead to a reduction in efficiency for an automation cell due to the requirement for an operator to enter the cell and correct the orientation whilst the system is paused.

3.0 Project Objectives

There are many barriers to adoption of new technologies within the red meat industry, including changes of processes and risk associated with all new technologies. In addition to this, a major barrier is the ROI of a system. Within the scope of an automated processing cell, the ROI of the system is heavily dependent on the accuracy of the system. If we have an inaccurate carcase orientation system, we have not met our objective of removing staff from a dangerous operation and also significantly increased the process time for the operation.

Without a means to automatically ensure a carcase is correctly oriented, processor sites will require a staff member allocated to visually confirm and then manually correct the orientation of the carcase before entering into an automated cell. Thus, automating this process and achieving accurate results can meet multiple goals identified within AMPC's 2020-2025 Strategic plan, including: -

1) Removing staff from dangerous operations, via hands-off processing.
2) Increasing safety and wellbeing, by reducing the high-risk nature or certain processing operations.
3) Attraction of people to the industry via demonstrating a wide range of technological operations.
4) Retention of people within the industry by improving working conditions.
5) Increasing carcase primal profitability through optimisation

To ensure we meet our accuracy and feasibility requirements for this task. The trials will begin initially with the study of carcase turning techniques, then move on to the design conceptualisation of a carcase turning mechanism and finally performing on site trials with a fabricated test rig to simulate the turning concept chosen

3.1 Project Methodology

This project will involve developing a concept to enable the orientation of a beef carcase while maintaining control of the final position. A trial of the technology will be performed to access its suitability for the industry, to enabling further beef side automation.

1) Conducting an initial study and review existing methods
2) Develop a range of concepts to enable carcase orientation
3) Develop tests to validate these concepts
4) Perform site testing on the best options

4.0 Methodology

4.1 Trial Plan & Methodology

The site trials for carcase orientation study were conducted in two phases. The first phase was the carcase orientation technique study which involved a brief manual turning site trial. The next phase was the design, fabrication and site trails using our final concept.

- **Carcase Orientation Technique Study:** The purpose of these tests was to determine the best point of contact on the carcase to initiate rotation.
- **Carcase Rotation Trials:** These carcase rotation trials would involve site testing of our carcase rotation mechanism to determine its strengths and weaknesses. The goal would be to then optimise this mechanism to work with various carcase shapes and sizes

4.2 Carcase Orientation Study

The purpose of the carcase orientation study was to identify sections of the carcase which would work in our favour to induce a rotational motion in the carcase. These points would also be a major contributor to controlling the rest of the carcase.

4.2.1 Carcase Orientation - Methods Explored

Automated methods of carcase orientation are extremely rare to come across in the meat processing industry. The most common solution we find at most processor plants is to assign a staff member or ensure the operators carrying out the last manual process release the carcase in the correct orientation to be received by the automated system.

Thus, we needed to turn our attention to other industries in order to explore methods of object orientation control: **-**

- **Box Turning Peg/Roller:** A simple yet effective way to induce a rotation can be the use of a box turning peg or roller block method. Here, boxes are conveyed with one corner positioned to collide with a turning peg or roller mechanism. This catches the corner and induces a rotation in the box section. The stages of motion are as follows: **-**

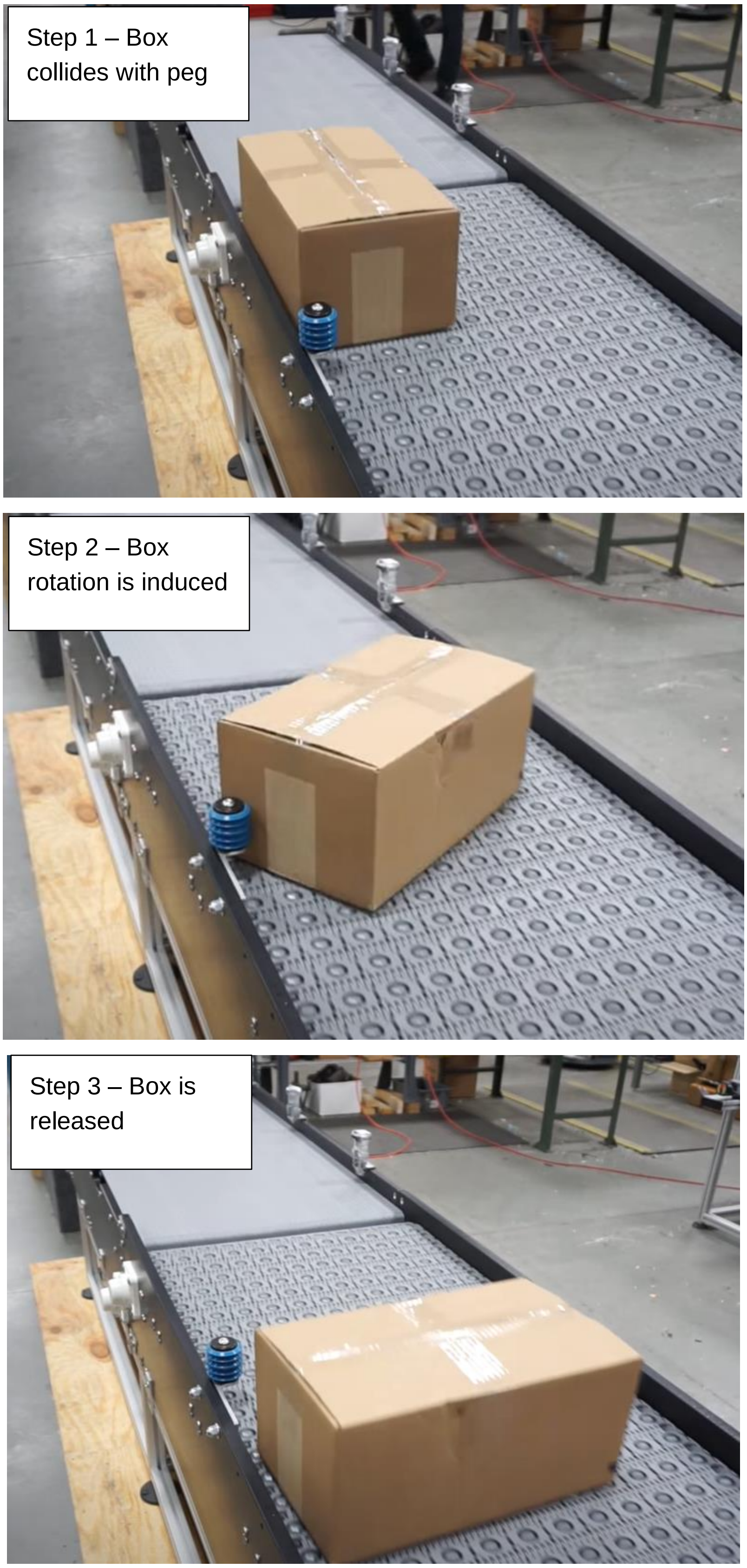

Figure 1: Box Turning Peg Concept

- **Box Flip Plate:** In this method the carton is first conveyed up to a flip plate stopper, the flip plat then rotates along with the carton to re-orientate it. The stages of motion are as follows: -

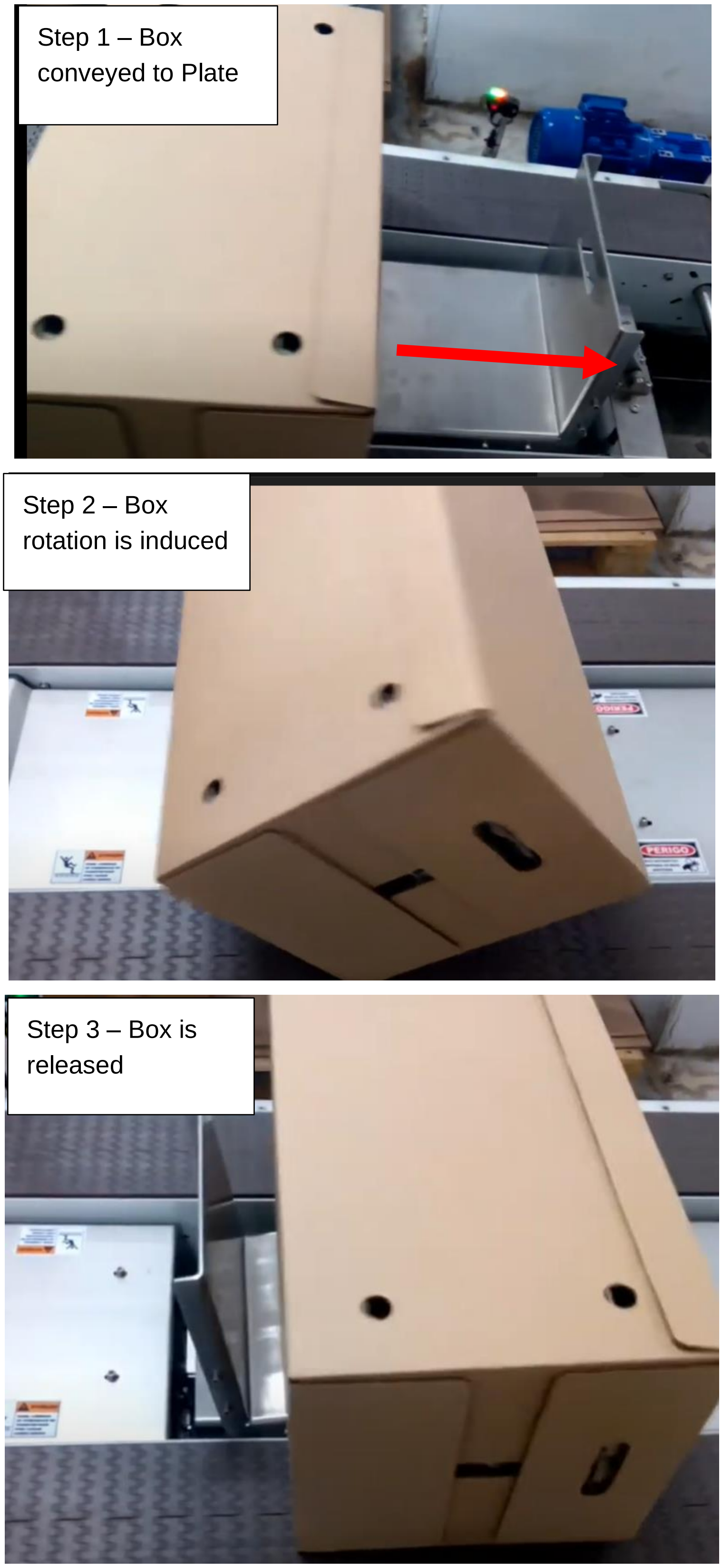

Figure 2: Box Flip Plate Concept

- **Actuated Bump Turn System:** This method of rotation is very similar to the turning peg system, however, it includes an actuator to assist with inducing the rotational motion on the cartons.

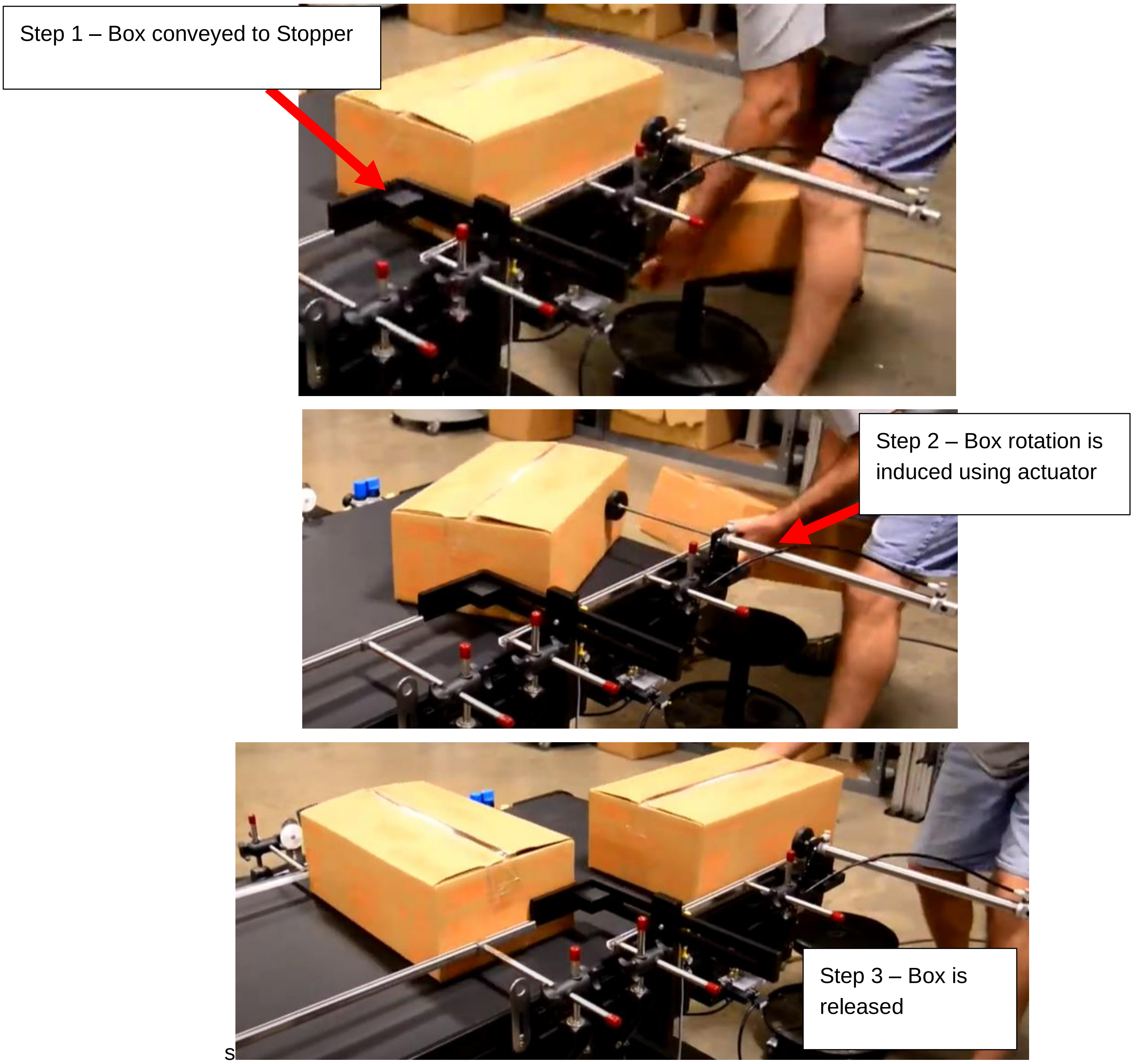

Figure 3: Actuated Bump Turn Concept

A concept turner was developed for a beef carcase. However, we would need to gather more data on how reliable this concept will be in inducing a rotational motion on the carcase. Thus, the design conceptualisation of what this system could look like for a site trial, as well as the subsequent fabrication could begin.

4.3 Design Conceptualisation & Fabrication

Based on the results gathered from our initial carcase orientation study, as well as our research on various orientation control mechanisms, we were able to develop a carcase orientation control trial concept. This concept could later be tested on site to assess its feasibility. The data gathered during our initial study showed us our critical points of contact to allow for maximum control on the carcase.

From this study, a trialling assembly was designed and fabricated for tests to be performed on-site. This trialling assembly enabled beef carcase sides to be loaded, and moved through the turning mechanism assembly (simulating an overhead chain for continuous process flow). The mechanics of the trialling assembly were adjustable to allow different configurations and mechanical arrangements to be trialled, and speeds were controlled via electrical drives to allow the speed of carcase motion to be controlled.

4.4 Site Trials

During our site trials we were able to successfully setup our trial configuration. Our goal throughout these trials was to try to rotate a range of different carcase shapes and sizes so that we could determine what the strengths and weaknesses of our turning concept would be in this application.

Our first goal was to determine which side of the carcase should be facing the mechanism to give optimal performance – the ‘skin’ (lateral) face, or the ‘cut’ (medial) face of the beef carcase side.

- **Carcase Skin Side:** We found that as the carcase approached the turning mechanism with its skin side, due to the curvature of this surface the carcase did not engage with the mechanism properly and therefore did not turn the carcase reliably.
- **Carcase Cut Side:** In this orientation, the carcase successfully engaged the mechanism in a consistent manner

Once the preferred approach orientation was determined, we could continue to trial our turning mechanism with a wider sample set, starting with similar or more common carcase shapes and then moving on to unique carcases which have sections cut out due to QA requirements or carcases that are abnormally small/long.

4.4.1 Standard Carcases

The standard carcases on site were mainly within a similar height and width range. They also did not have any abnormalities (i.e. sections cut out, large length and width variances etc.).

From the 17 consecutive trials that were conducted on both left hand and right-handed carcases (Leg leading and leg trailing) we saw a 100% success rate inducing a rotation on the carcases; however, we were also able to highlight some risks with the carcase rotation process. These were mitigated by implementing mechanical guides and adjusting the speeds of the system.

Overall, the standard carcases were able to give us a good understanding of how our turning mechanism works and what its weaknesses were. We saw that the turning mechanism was able to consistently induce a rotation on the carcase and were also able to highlight issues such as carcase orientation. The next phase would be to trial with carcases of different sizes and other unique abnormalities such as sections cut out from the body due to quality control requirements.

4.4.2 Unique Carcases

The next phase of the trial involved testing with unique carcases that had sections cut out of them due to quality control protocols. Here we were able to see some failures whilst attempting to inducing the rotational motion onto the carcases. Once the root cause of these failures was determined, we were able to once again implement a mechanical solution to mitigate the risk.

Another issue we experienced whilst working on the unique carcases was that the longer carcases would impact the turning mechanism at different sections relative to shorter carcases, thus a solution to address the height variations of different carcases entering our system will need to be developed.

5.0 Conclusions / Recommendations

Based on the results gathered on site, we saw that for common carcase shapes, it would be sufficient to have the turning mechanism at a fixed height. There is however a need to account for unique carcase shapes and heights by giving our mechanism some means for dynamic height adjustment.

Having the carcase oriented with the cut face facing the assembly helped more than having the skin side facing the conveyor as per results from our initial trial on site. Having the curved skin side presented to the assembly created issues with the curved face not engaging the turning mechanism in a consistent manner.

During testing, our four key findings include: -

1) Standard carcase sizes are most reliable when it comes to inducing the rotation on the carcases.
2) In order to reliably rotate the carcase and ensure we meet the carcase at our ideal contact points. This may require some automated height adjustability for this system in its final concept. This is to compensate for carcases of different lengths.
3) An increase in contact surface area between our turning mechanism and the carcase also increases the reliability when processing carcases of unique shapes.
4) A control mechanism will be required on the outfeed side of our turning system to ensure the carcase settles appropriately after completing its rotation cycle.

The next step is to determine the maximum and minimum range of height variation required to ensure we catch the carcase in our stable regions, with the view to develop a prototype which can be trialled on a processor site.