final report

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Prepared by: Gavin Inglis

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

Bladestop – Phase 4 Final Report

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Abstract

This project is phase 4 in the development of Bladestop a bandsaw safety aid. It involves the redesign of the Bladestop mechanism and a testing campaign on 3 systems under simulated production conditions in order to confirm stopping times, distance and cutting depth estimations for different approaching speeds before plant installation. Following installation the saws will be monitored for reliability, downtime, wear and performance variation to identify potential issues before a wider roll-out starts.

The three saws were installed at Northern Coop Meat Producers, Gundagai Meat Processors and Australian Country Choice where they proved to be functional but with their limitations.

MAR recommend that these three saws continue to be used on site in light duty applications and that a further development project be established to allow further development of the Bladestop system. An application for this has been submitted to MLA.

Executive Summary

This project is Stage 4 in the development of Bladestop a bandsaw safety aid. It involves the redesign of the Bladestop mechanism and a testing campaign on 3 systems under simulated production conditions in order to confirm stopping times, distance and cutting depth estimations for different approaching speeds before plant installation. Following installation the saws will be monitored for reliability, downtime, wear and performance variation to identify potential issues before a wider roll-out starts.

Two prototype mechanisms were designed, fabricated and tested before a production ready mechanism was installed and commissioned on site. Several design iterations occurred throughout the project with the aim of making the system robust and reliable. The final design was installed on three saws these saws were commissioned at Northern Coop Meat Producers, Gundagai Meat Processors and Australian Country Choice where they proved to be functional but with their limitations. Specifically the current Bladestop Saw is only suitable for light duty operations where a running speed of 700rpm and blade tension of 70kg maximum are appropriate.

The ACC saw has been repaired and is currently being used in operation onsite in a light duty application.

MAR recommends an update of the current design be undertaken. This update would enable the saw to fulfil operational requirements identified for a heavy duty area, specifically allow for a higher blade tension and a higher blade speed as well as other design enhancements that have been identified to improve reliability and performance.

A development project for the redesign has been lodged with MLA and there is an estimated 6 month lead time for the development of the new machine. During this time the existing Bladestop machines remain available for use and evaluation and serve to protect bandsaw operators in light duty areas. MAR remains committed to supplying a robust and effective safety aid to bandsaws in all areas however regrettably there is a necessary delay while the redesign takes place to ensure that all operational requirements in all areas are met.

Contents

1 Background

The first production prototype Bladestop was installed at NCMC in December 2008. This unit operated successfully, but only on the basis of various on-going technical issues and faults that needed to be addressed by MAR via redesign of the mechanism.

In 2009, MLA funded an independent review of the current status technical and commercial viability of Bladestop. This recommended further development subject to various issues being addressed.

During 2010 Project P.PIP 260 was contracted by MLA and the redesign of the Bladestop system was commenced.

2 Project Objectives

The objectives for the Bladestop Phase 4 project were:

- The design and include in the next development stage a testing campaign for the next 3 systems under simulated production conditions before plant installation in order to confirm stopping times, distance and cutting depth estimations for different approaching speeds
- To closely monitor reliability, downtime, wear and performance variation of those 3 systems during the first months after installation, to identify potential issues before the wider roll-out starts.
- To consider the technical recommendations suggested by Invetech and, based on the results obtained from factory tests and in plant consistent monitoring, implement when appropriate.

3 Methodology

The above objectives will be achieved by completing the following milestones:

Milestone 1

Design new tensioner concept & trial

Milestone 2

Build 1st Prototype & trial

Milestone 3

Build 2nd Prototype & trial

Milestone 4 – Documentation

- Detailed drawings mechanical
- Electronics drawings
- Electronic layouts for dual microprocessor
- Microprocessor dual monitoring
- Training manuals
- Electrical layouts
- Testing documentation
- Risk Assessments
- Legal review

Milestone 5 - Upgrade the NCMC saw

Retrofit all the learning's from the above two installations to the NCMC saw.

Milestone 6 - Manufacture of 2nd system

This version will include all the latest improvements and modifications derived from development work to date.
Those include, but are not limited to:

- Mechanical design upgrades for commercial robustness
- Electrical design upgrades
- Water ingress protection
- Saw motor upgrades
- Microprocessor upgrades
- Coil tripping upgrades
- Firing circuit power transistor upgrades

Milestone 7 - Factory training & testing

The system will be subject to an intensive testing plan to simulate one year of being run. The following cycle will be repeated 250 times:

- Set up and turned on
- System runs for 20sec
- System is triggered (with sausage or similar)
- System is turned off
- Wash up with hose
- System is reset and turned on

Any occurrence will be recorded in a log book and issue addressed. Upon completion, it will be decided whether any modification must be implemented and/or if additional factory testing is required.
A representative from the site where this unit will be installed will be present during a full day in the last runs, to gain familiarity with the system and address any significant issue that may take place when it is installed on site.

GO / NO GO DECISION *

Project to proceed based on meeting between MLA Project Manager and MAR Project Manager

Milestone 8 - System installation in 2nd site

- Training of operators
- Training of maintenance staff

Milestone 9 – Onsite Testing

The system will be tested under normal operation for a period of at least 2 weeks. Any event or occurrence will be recorded in a log book, in order to document and address any potential issue. The plant will then report on the operating performance of the system prior to manufacturing the 3rd system.

GO / NO GO DECISION *

Project to proceed based on meeting between MLA Project Manager and MAR Project Manager

Milestone 10 – Manufacture of 3rd System

Upon review of results from tests, the 3rd unit will be manufactured, introducing all the suggested modifications. The design is meant to be frozen after this point and only minor adjustments will be expected upon testing of this unit.

Milestone 11 – Factory Training and Testing

The system will be subject to an intensive testing plan to simulate one year of being run.
The following cycle will be repeated 250 times:

- Set up and turned on
- System runs for 20sec
- System is triggered (with sausage or similar)
- System is turned off
- Wash up with hose
- System is reset and turned on

Any occurrence will be recorded in a log book and issue addressed. Upon completion, it will be decided whether any modification must be implemented and/or if additional factory testing is required.
A representative from the site where this unit will be installed will be present during a full day in the last runs, to gain familiarity with the system and address any significant issue that may take place when it is installed on site.

GO / NO GO DECISION *
Project to proceed based on meeting between MLA Project Manager and MAR Project Manager

Milestone 12 - System installation in 3rd site

- Training of operators
- Training of maintenance staff

Milestone 13 - On site testing

The system will be tested under normal operation for a period of at least 4 weeks. Any event or occurrence will be recorded in a log book, in order to document and address any potential issue. Upon satisfactory completion, results will be reviewed and it is expected a new roll out.

Milestone 14 - Industry Open Day

Hold an open day at one of the three sites

4 Results and Discussion

4.1 Mechanism Redesign

The Bladestop mechanism as it stood at the commencement of this project is shown below

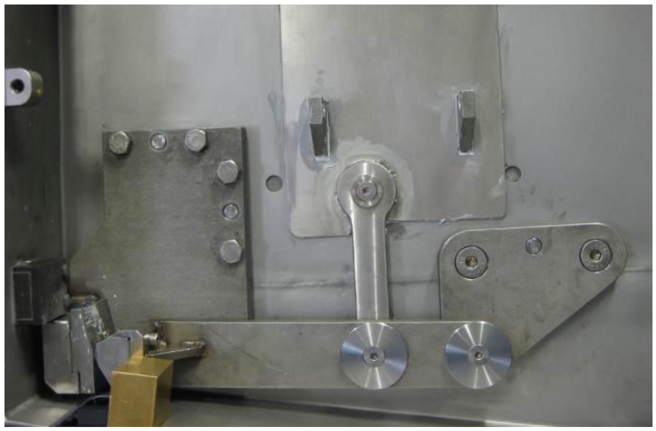

Fig. 1 Front view of Mechanism

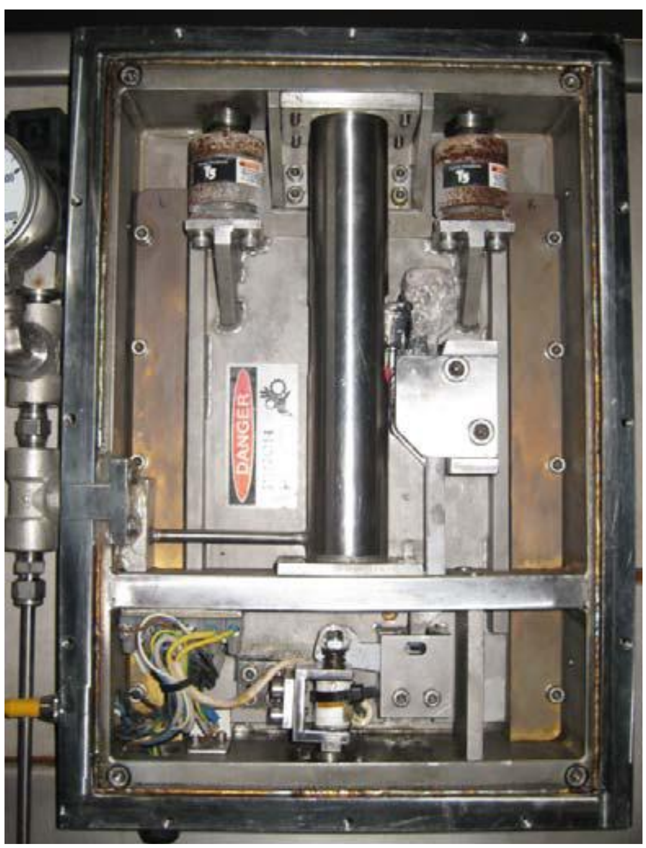

Fig. 2 Rear view of Mechanism

The criticisms of this system were that it was complex and contained a large number of parts, the latching mechanism was wearing and the system was very difficult to disassemble repair and reassemble so that the mechanism worked correctly again.

The new concept design saw the rear mounted gas strut and hydraulic latching mechanism removed and replaced by the front mounted spring tensioning and linear slide mechanism shown below.

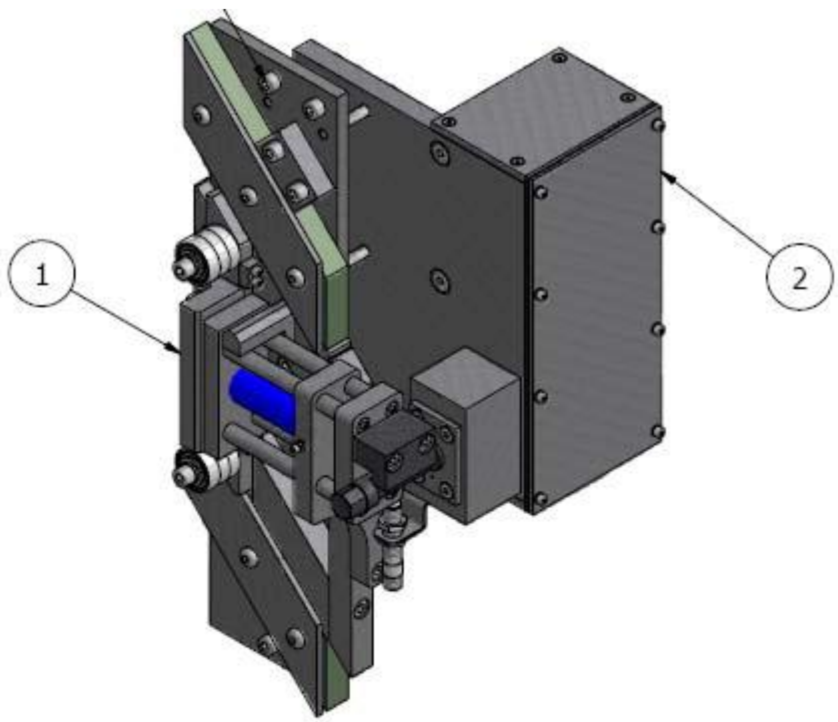

Fig. 3 Concept Design

4.2 First and Second Prototypes

The idea of the design is that the blade passes through the jaws shown as No.1 in the above diagram and runs over the roller bearings above and below the jaws. These bearings are mounted to linear slides shown in green above. As the mechanism is latched the linear slide moves the bearings to bring tension on the blade and the jaws are opened against the tension of the spring shown in blue above. The magnetic coil and release mechanism are located in the sealed box at the rear of the saw shown as the No. 2 in the above. When the mechanism trips the jaws close trapping the blade, and the linear slide and the bearing's move to release blade tension. This design was manufactured as the First Prototype and an image of this is shown below.

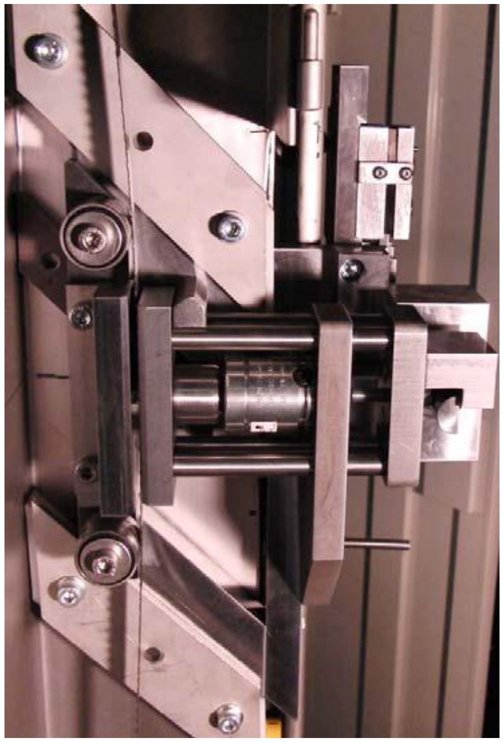

Fig.4 First Prototype mechanism

The concept proved to work well during initial trials restricting blade travel to 40 – 60 mm, which is well within the specified 150mm. However when conducting the 1000 trip test to ensure reliability at MAR a number of issues arose:

1) The linear slides showed signs of wear and lead to difficulties in latching the mechanism

2) The mechanisim consisted of a lot of individual components bolted together, these came loose with operation

3) Part of the mechanism has stainless steel rubbing on stainless steel which tended to bind up.

This lead a redesign and development of the second prototype which included the following upgrades:

- The rails were replaced by bearings that provided a sturdier and more reliable mechanism,

- Replacement of the gas strut used to provide the clamping force with Bellville Washers which were shown to have a much more horizontal compression verses force curve than the gas strut being used. This meant that the force provided during the clamping process did not decrease as significantly as the jaws closed.

- The Stainless steel block that was used to house the Bellville washers and the mechanism guide rods were made more structurally sound.
- A guard was added to prevent latching of the mechanism until it was in the retracted position eliminating possible mechanical damage.

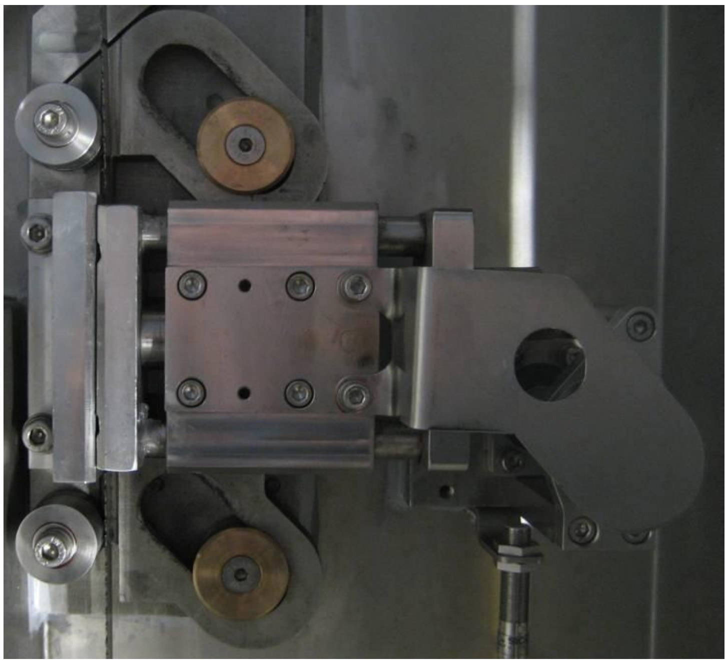

Fig.5 Second Prototype mechanism

4.3 NCMC Saw

This second protoype mechanism was fitted to the NCMC saw and put through the 1000 trip test at MAR. It performed well during these trials and stopped the blade with around 80mm run through and a depth of cut of less than 5 mm.
The saw was shipped to NCMC and used in production for a period of about 6 weeks. At this point there was an electrical issue preventing the operation of the operation of the saw. MAR attended site and tracked the issue to water that had ingressed a stop switch which caused interference with the electrical signals used for the Bladestop sensing circuits. This issue was rectified and prior to putting the saw back into production tests were conducted on the blade run through and cut depth when the Bladestop mechanism was activated. The blade run through had increased to around 100mm and the cut depth was greater than 5mm. Some mechanical adjustments were made but these failed to improve the results. The saw was returned to MAR in Sydney and further testing conducted. It became evident that the force that was being exerted on the blade by the jaws had decreased over the six week period ie the Bellville Washers were losing their strength over time.

At this point further research was conducted into the characteristics of suitably sized gas struts. Struts were finally sourced that had similar force - compression characteristics to those of the Bellville washers. This strut was larger in diameter than the Bellville washers that had been used and required remanufacture of the main block of the clamping mechanism. With the gas strut fitted and the new block manufactured the saw was tested at MAR, the run through achieved was approximately 40mm and cut depth approximately 2mm. With the achievement of these results the saw was sent back to NCMC and was put into production.

4.4 ACC Saw

Following the installation at NCMC several areas of the system were reassessed before design and manufacture of the second system began.

4.4.1 Front Mechanism

The gas strut used in the mechanism was reassessed and although the strut used in the NCMC saw was more than adequate for the job of clamping the blade a strut with a flatter force vs distance curve was procured to provide a more consistent force on the blade during activation. Incorporation of the new strut required a redesign of the front block/ housing of the mechanism and this along with the clamping jaws was designed to be more structurally sound. The mechanism installed in the ACC Bladestop is shown below.

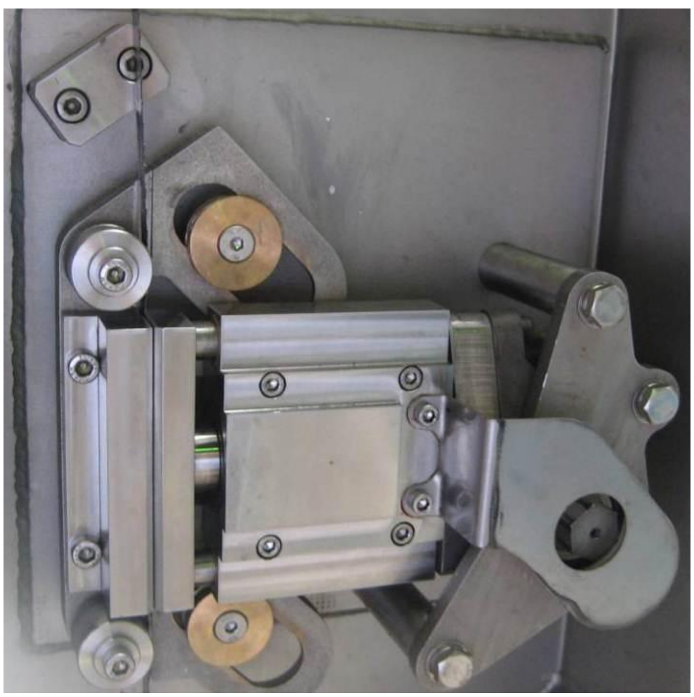

Fig. 6 Front side of ACC Bladestop mechanism

4.4.2 Back Mechanism

Following feedback with regard to the access and serviceability of the back half of the mechanism during installation and commissioning of the NCMC saw this area was also redesigned during the design and manufacture of the ACC saw. As can be seen from the images below the new design allows much easier access, enabling the whole mechanism to be removed from the housing if required. The new design also reduces the probability of ingress of water to the coil area and leakage of oil from this area.

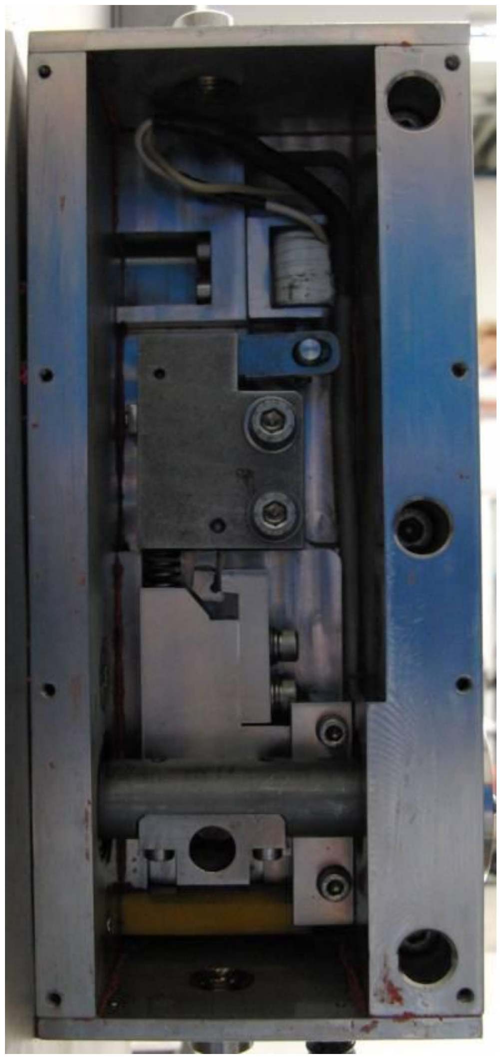

Fig. 7 View of the back half of the NCMC mechanism

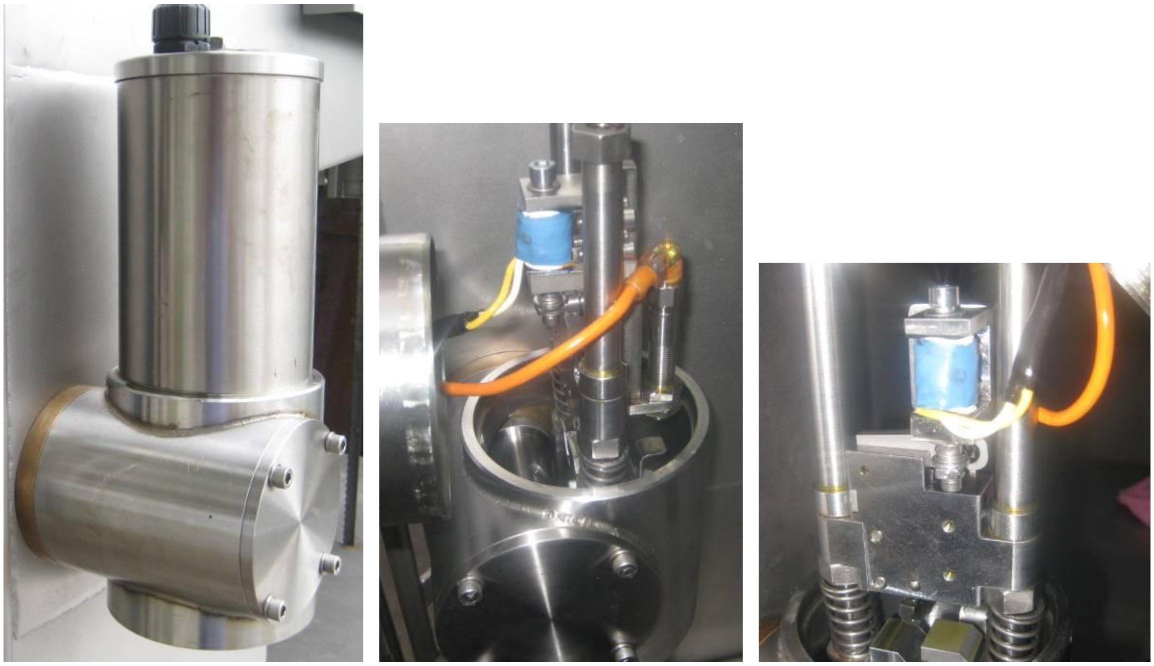

Fig. 8 Views of the inside and outside of the new back half of the Bladestop mechanism on the ACC Saw

Also as can be seen from the images in Fig. 8 the proximity sensor for the system has been moved out of the production environment and within the protected area of the back half of the mechanism with the coil.

4.4.3 Control Panel

Improvements were also made to the layout and accessibility of the electrical panel. The image below shows the improved electrical panel on the ACC saw.

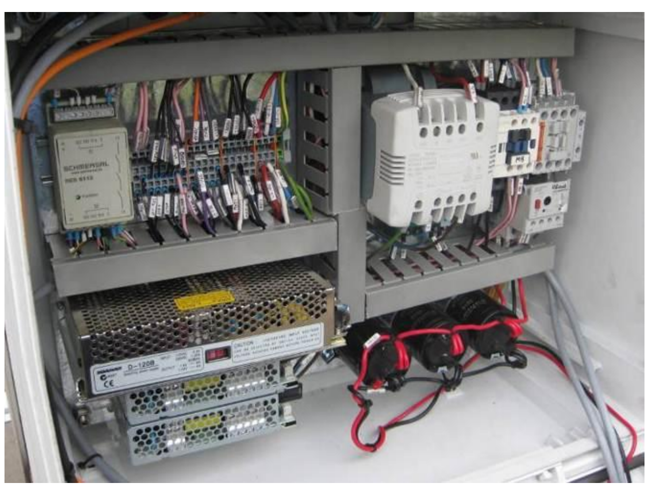

Fig.9 View of the electrical panel on the ACC saw.

4.4.4 Printed Circuit Board

Some minor component modifications were made were made to the Printed Circuit Board that controls the Bladestop mechanism to improve signal quality, the board is shown below during testing.

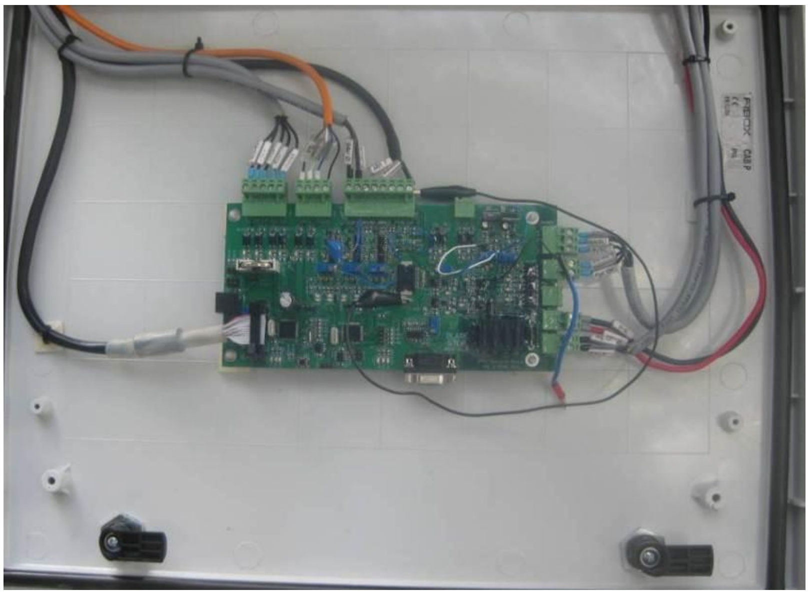

Fig.10 ACC Bladestop PCB mounted on the control panel door

With these modifications implemented the ACC saw underwent the 100 trip test and and further required testing as witnessed by MLA.
The images below show the paint and sausage tests conducted during the testing process. The run through, 25mm, and depth of cut, 3mm, were well within specification for the Bladestop project.

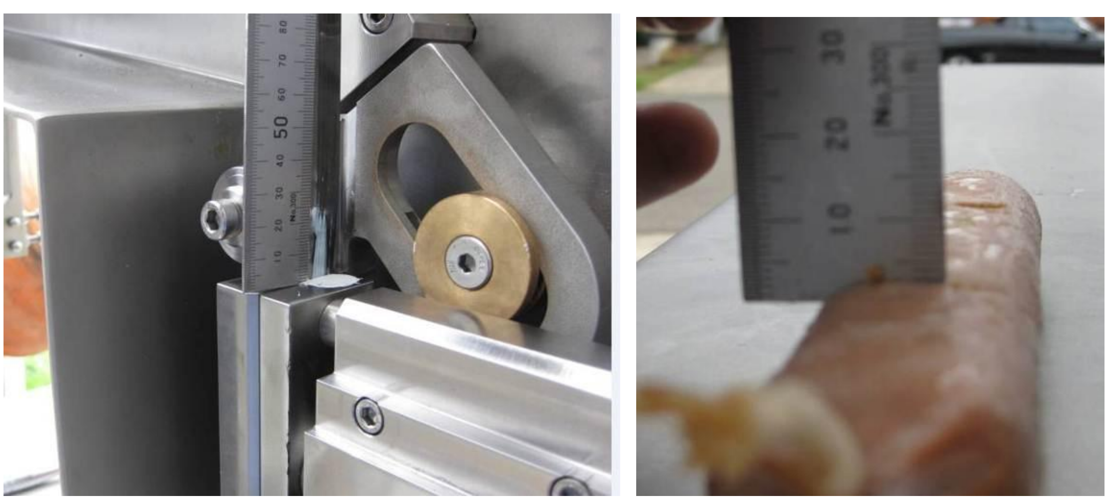

Fig.11 Sausage and paint run through test conducted with MLA on ACC at MAR's workshop

With this testing complete and approval from MLA the saw was sent to site and used in production as shown below.

 

Fig.12 Bladestop installed at ACC

4.5 GMP Saw

The upgrades that were implemented on the ACC were incorporated in the manufacture of the GMP saw with no further modifications. The required Factory Acceptance testing was performed on the saw and it was then sent to site.

4.6 Issues with installed saws

During the fabrication of the ACC and GMP saws NCMC experienced a number of issues with their saw, these included:

- Circuit board/electronics issues
- Stretched and broken bolts
- Difficulty in relatching after a trip
- Self, relatching after tripping

Several attempts were made to address these issues on site without success. This combined with the fact that further improvements had been made to the ACC and GMP systems the decision was made to return the saw to MAR and have these upgrades implemented on this saw also.
These upgrades were made and this saw was tested and displayed at Foodpro before being returned to site.

Other the ensuing months all saws experienced mechanical issues including:

- Blade alignment and tracking issues
- Stretched and broken bolts

- Broken latches
- Blade blunting caused by rubbing on bearings and clamp faces
- Meat build up and entrapment issues
- Bearing failure

As well as various electronic, board failure and water ingress issues. These issues were deemed unacceptable by MAR (and the processors) and a major design review was under taken to establish the causes of these issues.

4.7 Design Review and modifications

The main issues identified during the design review were:

- Meat and saw dust entrapment
- Bearing issues
- Ability to over cock the mechanism
- Overloading causing bolts to stretch over time and latch failure
- Solenoid misalignment

The sections below describe the resolutions to these issues.

4.7.1 Entrapment

Meat entrapment is an issue that was been eliminated by welding up all visible gaps on the BladeStop mechanism and saw flywheels.
The bottom flywheel had previously had a strip of wire tack welded to it to inhibit the saw blade from jumping forward when the BladeStop mechanism was actuated. This is now fully welded to prevent any entrapment. Wheel scrapers were also added to prevent meat build up on the wheels.

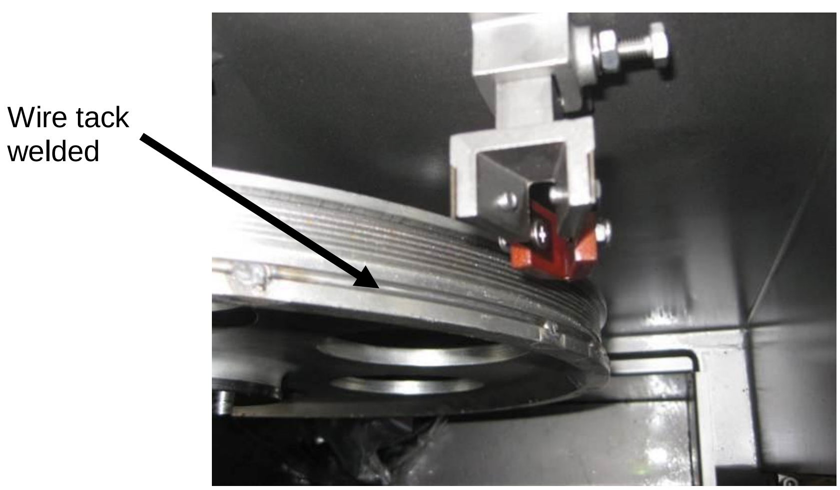

Fig.13 Previous tack welding of wire

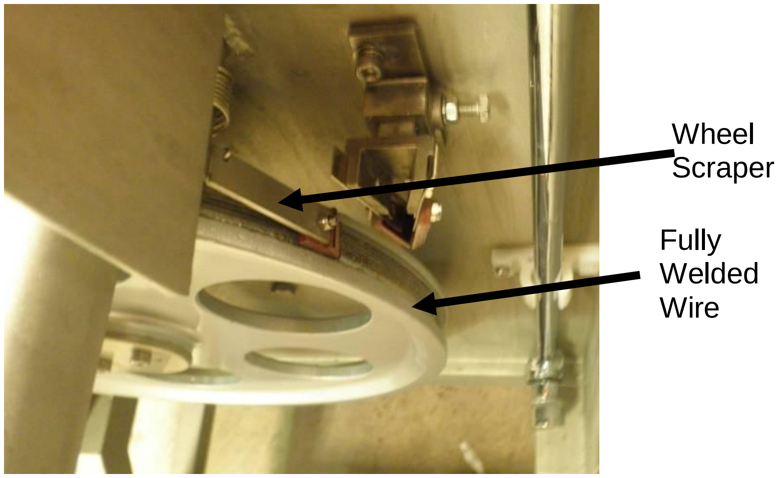

Fig 14: Welded wire and wheel scrapers

The mechanical stops that had previously been fastened on with bolts only left a gap for entrapment around it's edge. These gaps have now been welded (see Fig15) to prevent the chance of any meat build up.

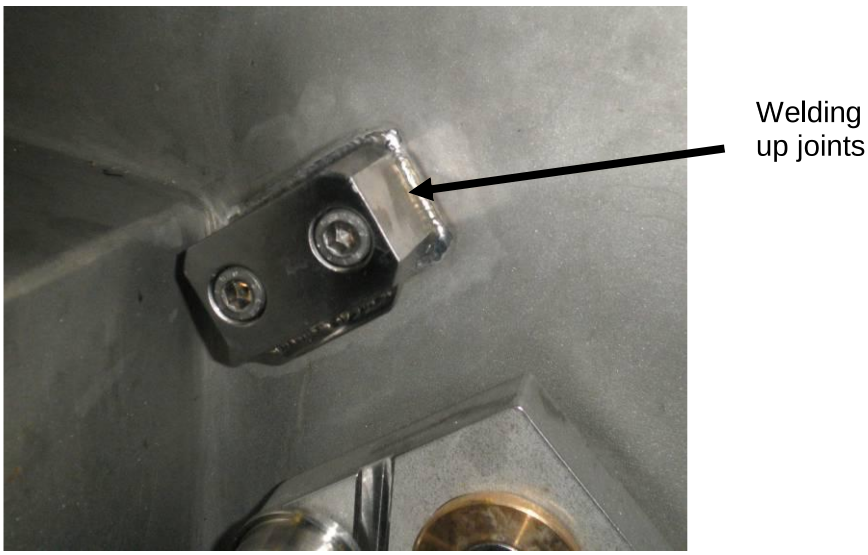

Fig 15: Welded up joints on plate support

4.7.2 Blade Running Bearings

The bearings in the previous design were failing due to a number of reasons:

1) Over heating from high running speeds
2) Corrosion due to the wash down
3) Minimum load not being achieved

The following changes were made to rectify these issues:

- The bearings have been upgraded in size to meet the high speed requirements of the blade.
- One bearing is now being used instead of 3 to meet the minimum load requirements.
- The bearing sleeve has been changed to a completely sealed design to prevent water and chemical ingress.
- The bearings are now a food grade stainless steel bearing which is lubricated with a food grade of grease and sealed

It is felt that these design changes will dramatically increase the performance and lifetime of the bearings.

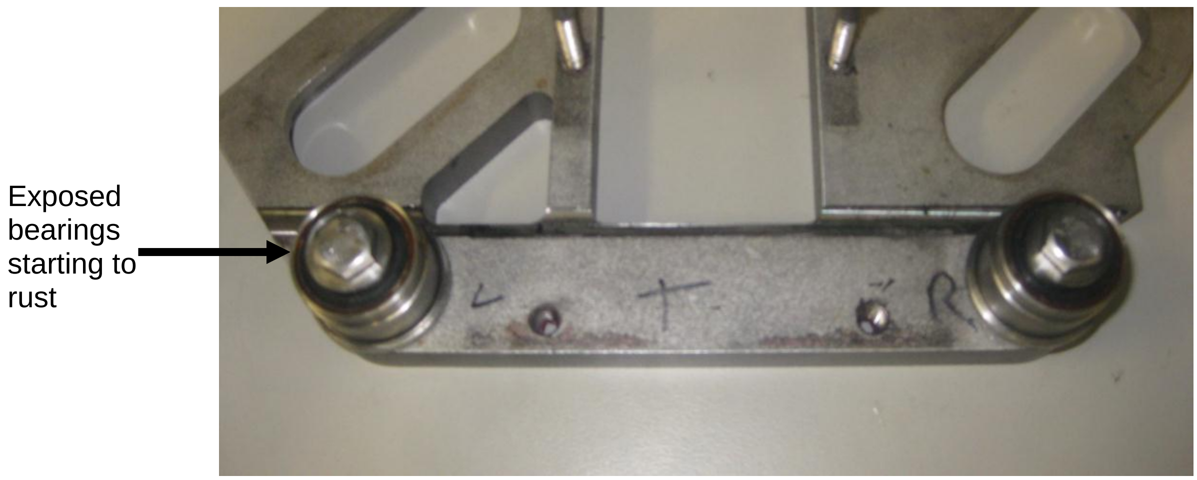

Fig.16 Previous Bearing Sleeve Design

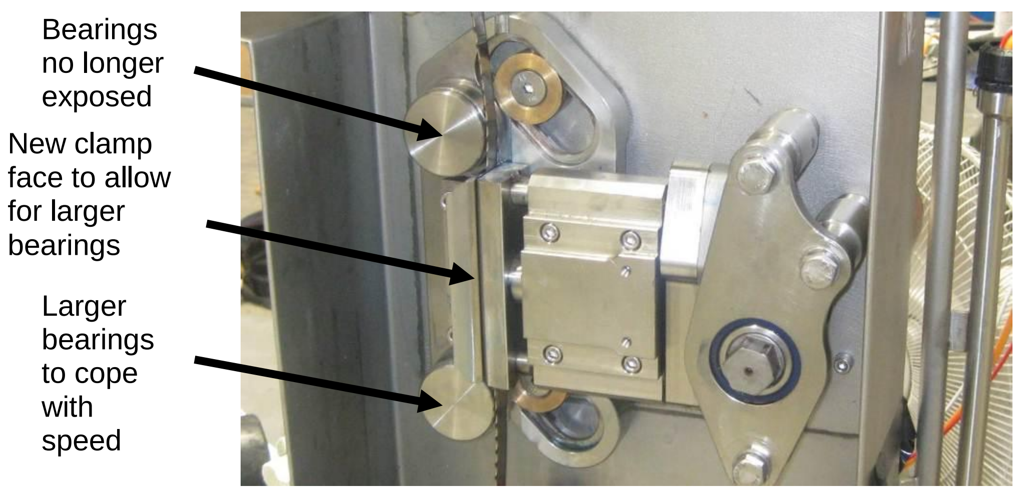

Fig.17 New Bearing Design

4.7.3 Over Cocking Prevention

Over cocking when using BladeStop has lead to the following issue:

1) Damage and failure of the latching fingers

The following change has been made to eliminate this issue:

- The newly designed mechanism now mechanically bottoms out inside the rear housing compartment.
- The latching fingers have adequate clearance meaning they cannot physically be over cocked to a point which might damage them.

4.7.4 Blade Cutting into Clamping Faces

On the previous design the blade was found to be cutting into the clamping faces while running after the mechanism had been cocked (clamping faces held open) for a period of time. This was due to the following issues:

1) Bolts on the clamping face stretching from being overloaded
2) Unbalanced loads caused by an offset between the gas spring position and the latching mechanism.

The following changes were made to rectify these issues:

- Lowering of the front part of the mechanism by 15 mm to align the gas spring with the point of contact on the latching mechanism.

With the mechanism aligned properly the bolts are no longer over loaded. In changing the position of the front part of the mechanism, the cover plate and three mounting shafts were changed to allow for the movement as depicted in Fig.18 and 19.

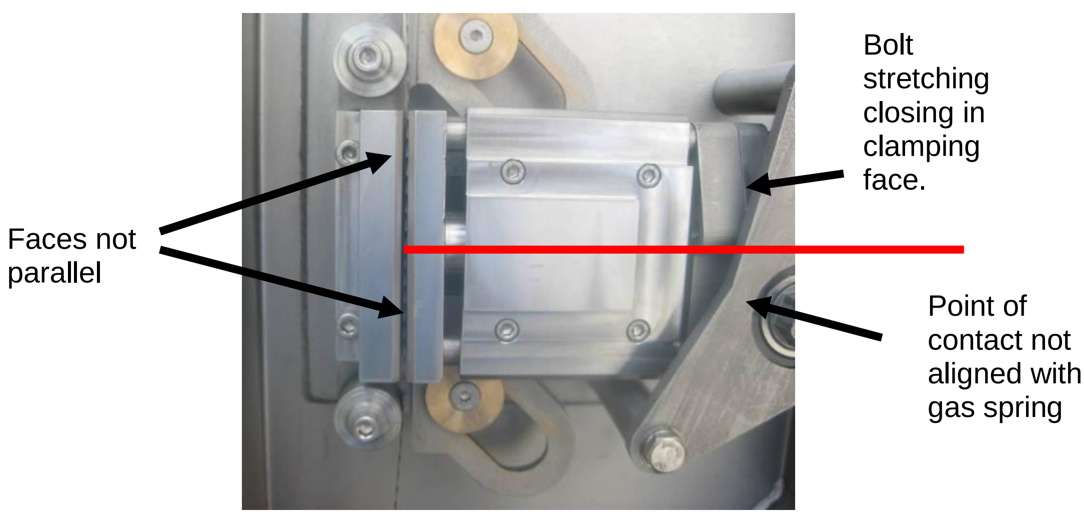

Fig.18 Old Mechanism

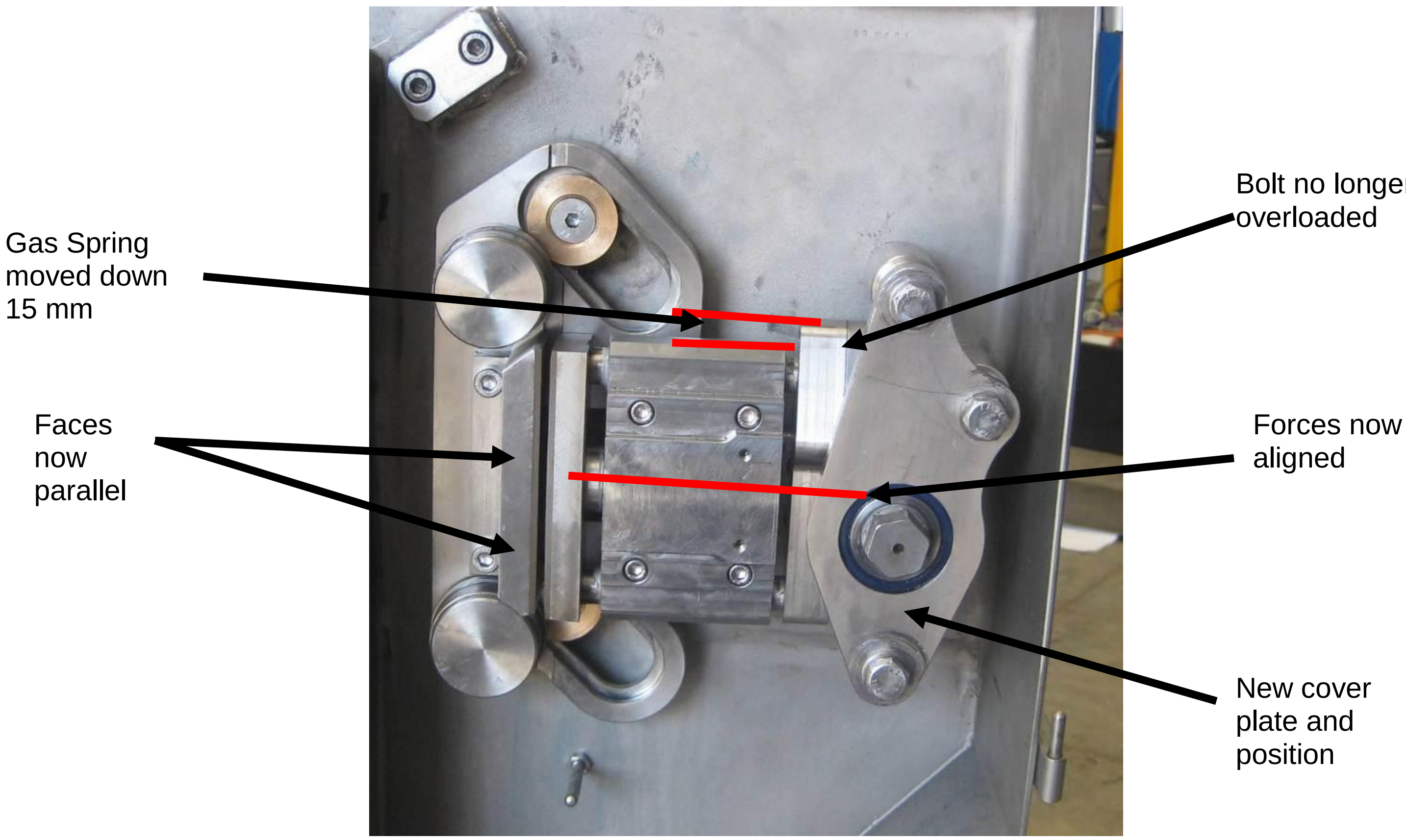

Fig.19 Changes to align the cocking forces

4.7.5 Blade Tension Relieved

The design was modified so that there is minimum tension on the blade after tripping. The aim of this was to decrease the driving force on the blade from the bottom motor driven fly wheel when the mechanism was tripped. The clamping block was shortened to allow the clamping faces to be repositioned and a new sliding mounting plate was needed to allow for this a modified movement. This is shown in the image below.

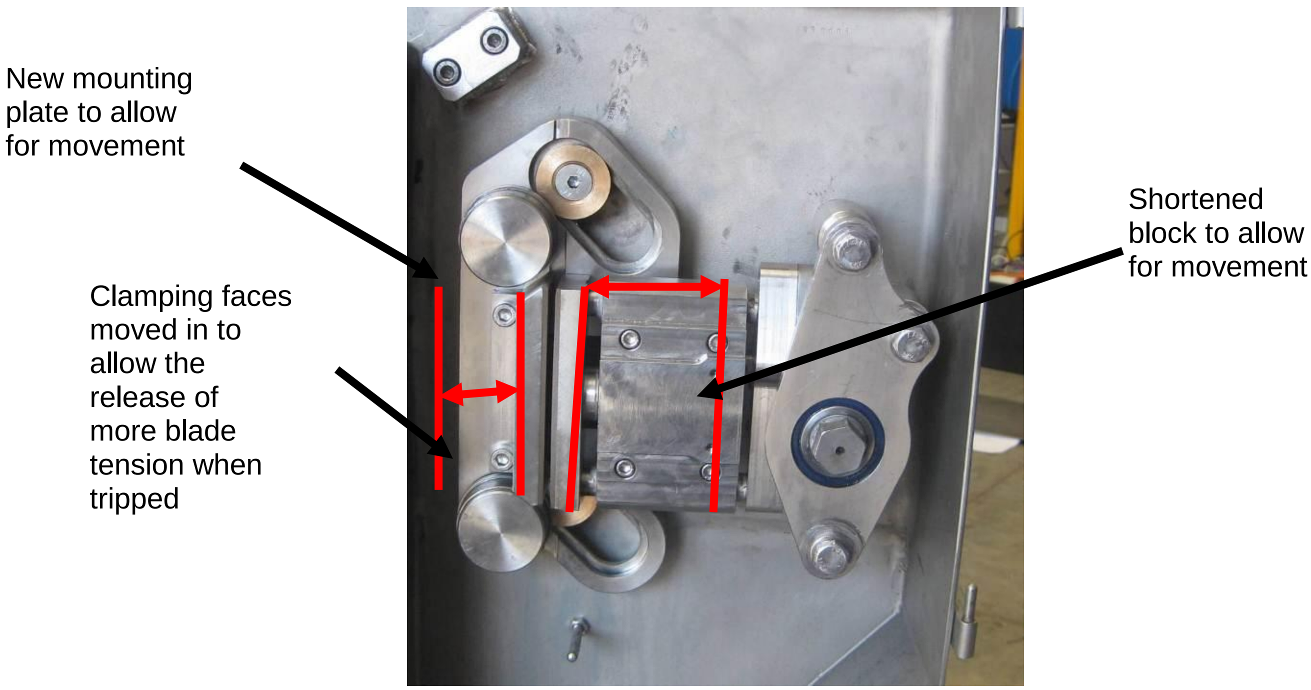

Fig.20 Changes to remove more tension in the blade

4.7.6 Failure of Cocking Fork Bolts

The bolts at the bottom of the oil filled compartment connecting to the main shaft have failed. This was due to the following reason:

1) Forces from the gas spring over loading the bolts

This issue was been resolved by using grade 12.9 black steel bolts which meet the maximum load requirements of this mechanism.

This change will see the lifespan of these bolts significantly increase.

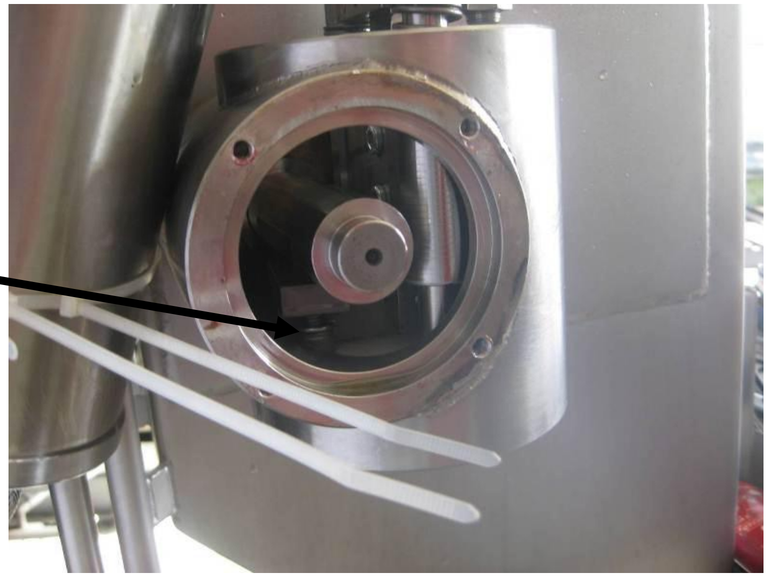

Fig.21 Overloaded Bolts

4.7.7 Second Stage Finger Latch Failure

The second stage finger latch (figure 22) had failed while on site. During the design review the following issues have been identified as the cause:

1) Stress applied by the gas spring is nearing the yield stress of the material
2) Faces on the latch are not completely flat from the manufacturing process used causing a point load to one side

The following changes have been made to rectify these issues:

- Increased material thickness at critical points to reduce loading of the material and subsequent failures
- The manufacturing procedure has changed to a more capable process to improve the integrity of the part.

It is felt that these changes will significantly increase the lifespan of the 2nd stage finger latch.

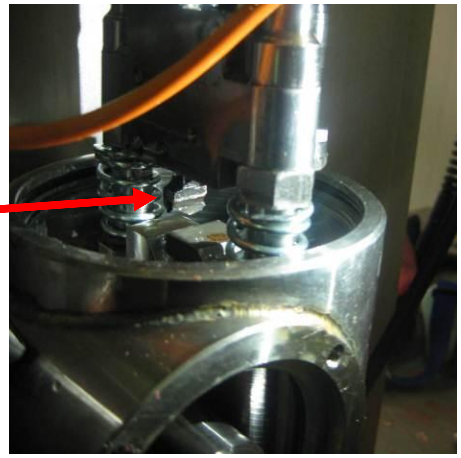

Fig.22: Broken stage two finger latch

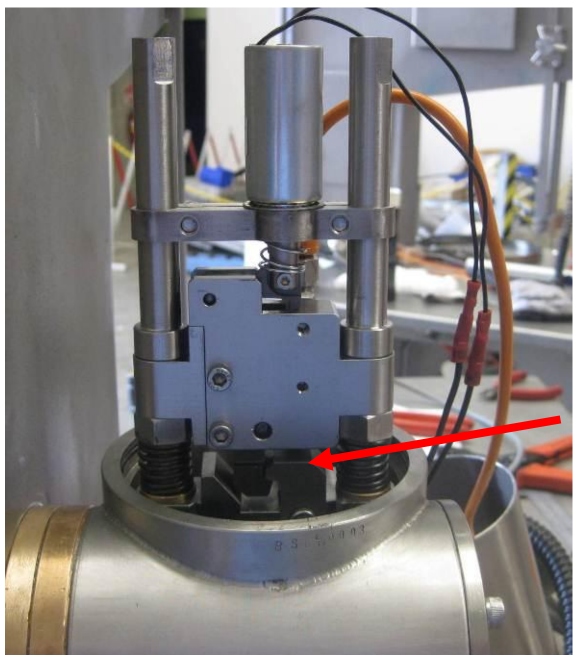

Fig.23 New stage two finger latch

4.7.8 Electrical Design Changes

The overall electrical design has been kept the same. The only change made is a new solenoid. The previous solenoid required modifications to adapt it to the tripping mechanism, this made it unsuitable for a production machine. The old solenoid required mounting to one side which resulted in misaligned forces that damaged the mounting bolt arrangement. A new solenoid has been sourced that requires no modification, improving reliability and serviceability.

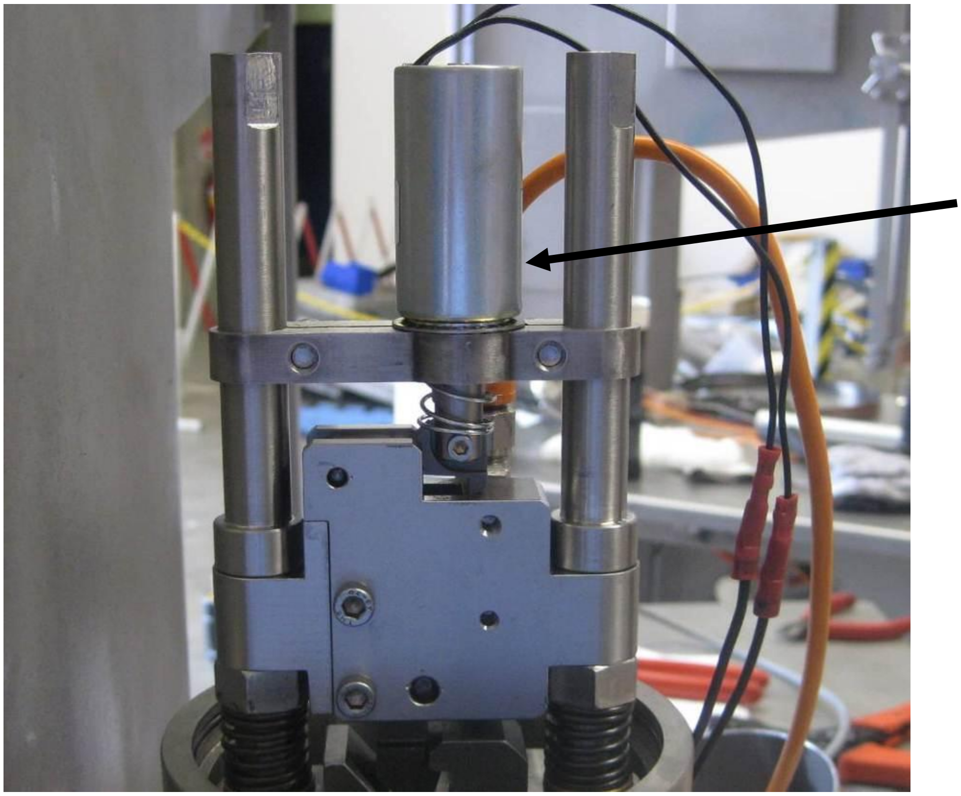

Fig.24 New Solenoid

4.8 Reinstallation of saws on site

These improvements were progressively rolled out to the three saws during November/December 2011.

4.8.1 NCMC Saw

The NCMC saw was the first saw reinstalled in early November. An issue arose shortly after installation with the self relatching of the mechanism after tripping. The spring's, that can be seen at the bottom of Fig. 24, which had been installed to prevent this from occurring, were replaced with hydraulic dampers. These dampers were installed at NCMC at the end of November and onsite training with a new training presentation and manuals was given to maintenance and operators during the week of the 28th of November 2011 with the MAR technician remaining on site for the week to ensure correct saw operation and provide production support. Since this point the saw has been running in production. There has been the occasional relatching issue but maintenance on site are able to overcome this and it has not caused any large disruptions to production.

4.8.2 GMP Saw

The GMP saw was the third saw recommissioned. It was sent to site the week before Christmas 2011, operators were trained and the saw put into production there were issues with false tripping and the blade jumping out of the jaws during clamping, these issues were not able to be resolved before the Christmas break.
MAR returned to site the week of the 9th of January 2012 and the issues experienced prior to Christmas were resolved. The saw was put into production following this and has been running in production since this time. In late January the saw was moved to a heavier duty cutting position and it was found that the blade was twisting due to the increased force required to cut the harder bones. The saw was removed from this position and returned to the lighter duty operation of cutting lamb chops where it has remained since this date. The Bladestop received its first reported activation preventing a serious injury during the week of 19/3/12. The image below shows the graze received following Bladestop activation.

Fig.24 Graze received following first reported Bladestop Activation preventing a serious injury

4.8.3 ACC Saw

The ACC saw was shipped to site during the first week of December 2011. Onsite training was conducted with the operators and maintenance staff during the week of the 5th of December 2011 and the saw was put into production. An issue arose with the PCB shortly after installation which resulted in false tripping of the Bladestop mechanism. A new board was sent up from Sydney with upgraded software installed to eliminate the false tripping. The new board was installed and the saw was put back into production. There were a number for mechanical issues and perceived electrical issues that followed.

There was concern on site after the saw was put back into production that the operator had to touch the saw with more force when performing the daily test that he had in the past to get the saw to trip and hence that the system was not working correctly. This is not the case, the conductivity of a person will vary from day to day and person to person depending on a number of factors all of which will be negated if the skin is cut. This variance in sensitivity to the daily test does not affect the operation of the of the Bladestop system. Regardless of this, software modifications were made to the system to overcome this issue and MAR attended site with a view to remaining on site to support the saw in production. At this point the armband for the Bladestop was damaged and ACC were unable to find the spare that had been supplied with the saw. A new armband was sent from Sydney and the saw was out of operation while thus occurred.

Following the installation of the new PCB both prior to Christmas and during January there were a number of issues with relatching the mechanism and the saw was taken out of production on a number of occasions due to this. As with the GMP saw ACC had moved the saw to a heavier duty cutting position and were finding issues with the blade twisting as the harder bones were pushed through the blade. To overcome this the tension on the blade was significantly increased. This had the effect of making the Bladestop mechanism difficult to latch because the tighter blade was not allowing the mechanism to fall naturally, under gravity, to the required latching position. A guide shown in Fig. 25 below had been installed in an attempt to ensure that the mechanism was in the correct position before latching was possible. Attempting to latch the mechanism with it out of position causes the two latching faces/lips (shown in Fig.26 below) to slip over each other and damage the edges of these faces. Repeated attempts at latching will cause further damage and induce stresses in the mechanism that will cause damage to other components in the mechanism. This has occurred twice at ACC. In early February MAR replaced damaged parts onsite and the saw went back into production in the heavy duty location and with the higher tension on the blade. Within two weeks the same issue had occurred and MAR made the decision to remove the saw from site and bring it back to MAR Sydney to investigate the issue further.

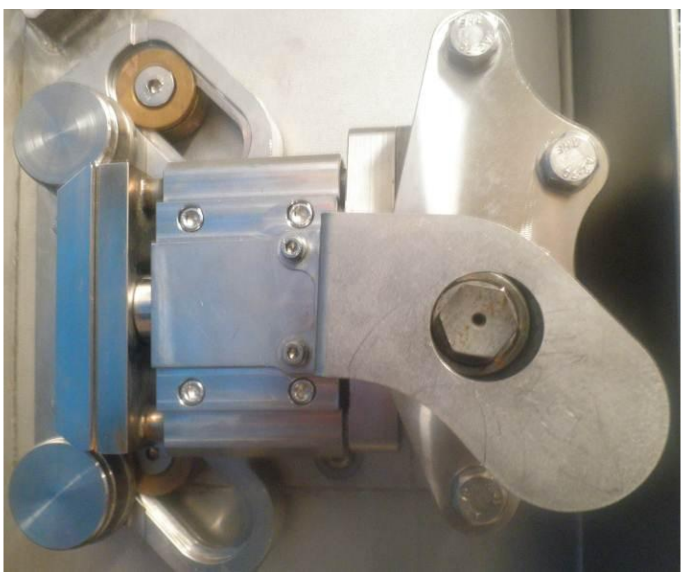

Fig.25 Image showing guide for latching

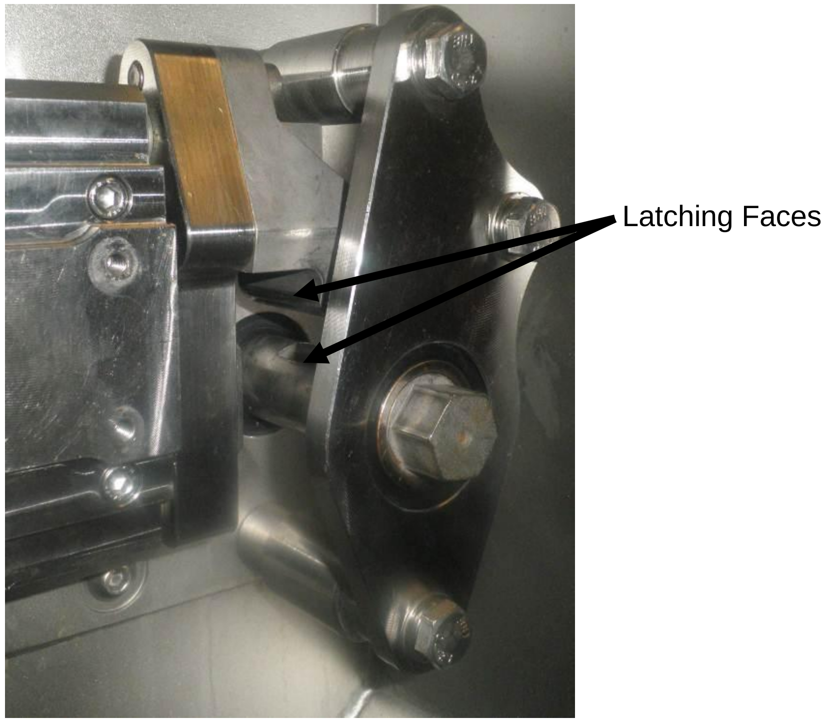

Fig.25 Image showing latching faces

5 Conclusions and Recommendations

It is evident from the experiences at the three sites and the discussion above that the current version of Bladestop is functional but has its limitations. Specifically the current Bladestop Saw is only suitable for light duty operations where a running speed of 700rpm and blade tension of 70kg maximum are appropriate.
Discussions between MAR and MLA have initiated the following actions to move the Bladestop development forward:

- The $13,000 in the project for Milestone 14 – Industry Open Day, has been used to partially fund the repair of the ACC saw and return it to site for operation in a light duty area. The remainder of the cost the reinstallation, re-commissioning, and support of the machine in production was borne by MAR.

- A plan to update the current design to fulfil operational requirements identified for a heavy duty area, specifically allow for a higher blade tension and a higher blade speed as well as other design enhancements that have been identified to improve reliability and performance.

A development project for the redesign has been lodged with MLA and there is an estimated 6 month lead time for the development of the new machine. During this time the existing Bladestop machines remain available for use and evaluation and serve to protect bandsaw operators in light duty areas. MAR remains committed to supplying a robust and effective safety aid to bandsaws in all areas however regrettably there is a necessary delay while the redesign takes place to ensure that all operational requirements in all areas are met.