HARVESTING TECHNICAL NOTE

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2014

Alpine Grapple Carriage – From Prototype to Production

Summary

The development of the Alpine Grapple carriage from the prototype to the current production model is described. Developments included structural changes as well as the addition of a camera/GPS unit. Time study techniques were used to establish whether the addition of a camera to the carriage would improve productivity. In a study of a Harvestline hauler using the Alpine Grapple in a eucalyptus clearfelling operation showed that for a given haul distance the combination of camera image and GPS information enabled a faster outhaul time than when a human spotter was used. No overall difference was apparent for grapple time however. There were indications of reduced grapple times using the camera when grapple yarding a difficult gully area in which visibility to the spotter may have been limited by vegetation. Other data from the same operation, where a spotter was used prior to the addition of a camera, suggested a longer drop and grapple time for 'front face' extraction compared to 'back face' extraction, which was visible to the hauler operator.

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INTRODUCTION

Development of an improved grapple/carriage control system was initiated through the FFR Harvesting programme, specifically, the Alpine Grapple Carriage, designed by Alpine Shovel Yarders Inc. of South Africa [1]. The grapple was designed to run on either two-drum haulers in a running skyline configuration or on three-drum haulers in a slack line configuration. Earlier work in the project involved the evaluation of the prototype Alpine Grapple carriage (designated prototype AGC-3) [2] in a swing yarder operation in the Bay of Plenty. Figure 1 shows the production model Alpine Grapple carriage with "Power Grapple" (AGC-3).

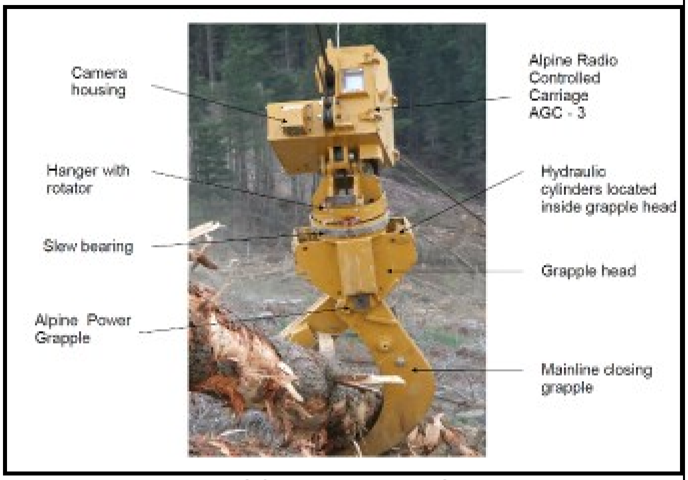

Figure 1. AGC-3 with Power Grapple

This report summarises the development of the Alpine Grapple to its present production model status and trials with the first production model working in New Zealand operations. A study was initiated to test whether installation of a camera/GPS unit had any effect on hauler productivity in terms of reduced work-cycle time.

DEVELOPMENT PROCESS

Following the first trials of the prototype Alpine grapple in New Zealand reported previously[2] it was trialled at several tower hauler, swing yarder and Harvestline operations in the East Coast region of the North Island. These trials took place from late 2012 to early 2013 for short periods of one to four days. Two of the three operations were able to achieve "acceptable" production levels (Brett Vincent pers.com). Some barriers to introduction of the grapple carriage were identified and these included both technical and operational issues.

Technical issues included: the "basic" nature of the hauler cab controls, which made grapple use difficult; the design of the grapple itself, which precluded the timely opening of the grapple following a "miss" on the target log; and line-of-sight communication issues whereby the operator could not always view the grapple and the target log using the camera. Operational issues included: the skill level of the hauler operator; operator reluctance to try new technology; and the need for the crew to

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maintain high production levels during the trial period.

Further developments of the Alpine Grapple were then undertaken which included structural changes as well as the addition of a camera/GPS unit. Information on the prototype development process was supplied by Alpine Shovel Yarders Inc. (Table 1).

Table 1. Alpine Grapple prototype development process

Version	Description
AGC-1	Light, hanging-type grapple, total weight 450kg, designed for a 2 drum yarder
AGC-3 Prototype	NZ version, hydraulic rotator, NZ Johnson hanging-type grapple fitted for convenience (no freight from SA). Weight of carriage 530kg. Dimensions (mm) 750x565x420. Total weight 1.32 tonnes.
AGC-2	Fitted with an Alpine Power Grapple, lighter version of AGC-3 and suited to Harvestline/Madill 071 size machines. The non-hanging Power Grapple has 500kg of grapple-opening force which is applied to the main rope.
AGC-3 Final version	Carriage weight 800kg. Dimensions (mm) 800x650x420. Johnson hanging-type Grapple (Y76H) specifications: Weight 790kg. Jaw opening tip-to-tip of 1.93m.
AGC-3 Power Grapple	Power Grapple weight 700kg. Total weight of Carriage and Grapple is 1.5 Tonnes. Jaw opening tip-to-tip of 1.9m.
Alpine Power Grapple (APG)	Jaws closed by the main rope but opened by hydraulic rams. The APG will not open on a back face where more than 500kg of pull on the main rope is required.

The method of operation of the AGC-3 prototype using the Johnson grapple is given in Table 2.

Table 2. Pick up operating method AGC-3 Final Version (hanging Johnson grapple)

Step	Description
1	Stop over the target log
2	Lower the grapple (maintain the gap between carriage and grapple)
3	Haulback Clamp to "ON"
4	Wait 2sec
5	Release Main rope tension slightly
6	Main rope Clamp to "OFF"
7	Pull Main rope slowly to close the grapple
8	Hold the main rope
9	Main rope Clamp to "ON"
10	Release Main rope tension slightly
11	Haulback Clamp to "OFF"
12	Ahead on Main rope, brake Haulback, haul in the log

The method of operation for the AGC-3 with the Power Grapple is given in Table 3.

Table 3. Pick up operating method AGC-3 Power Grapple

Step	Description
1	Stop over the target log
2	Lower the grapple
3	Release Main rope tension slightly if necessary
4	Main rope Clamp to "OFF"
5	Pull Main rope slowly to close the grapple
6	Ahead on Main rope, brake Haulback, haul in the log

A summary of the issues arising from early field testing of the AGC-3 prototype in New Zealand and the corrective actions undertaken is given in Table 4.

Table 4. Identified AGC-3 prototype deficiencies

Deficiency	Corrective Action
Bolts vibrating loose	Increased bolt size, use of lock-washers.
Broken slew motor mounts	Reduced slew pressure. Use of relief valves.
Slew ring jamming	Stock slew ring used, slew ring is now protected.
Grapple closing rope housing cuts the closing line	Mounting re-designed and safety rope fitted.
Oil leakage	Oil tank construction change and baffles installed.
Hydraulic pump shaft – excessive movement	Changes to mounting plus spacers used
Electronics board failure due to grapple impact	Grapple can no longer impact the carriage causing shock vibration
Camera printed circuit (PC) board failure/ water damage	Grapple can no longer impact the carriage causing shock vibration. Camera PC board secured with larger bolts.
Requirement for additional structural change to fit a camera	Modular camera unit fitted. Mounting integrated into the carriage structure
No provision for safety rope connection (closing line breakage)	Carriage has safety rope attachment points.
The grapple opens very slowly	Patented powered opening system developed
Poor access to the battery, difficulty with charging from the hauler	Re-designed battery access. Use of two battery packs.

Some of the key changes are illustrated in Figures 2 to 7 overleaf. Owing to the nature of the deficiencies identified and the number of changes made, not all the changes have been included.

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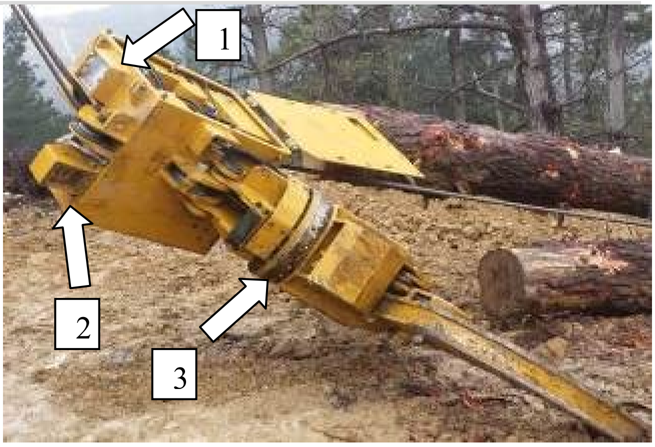

Figure 2. Beta prototype Alpine grapple – using a Johnson 80-inch grapple

Figure 5. Re-designed grapple and carriage showing antenna (1), camera box (2), and stock-supplied rotator (3)

Figure 3. Broken mounts (1) on grapple slew motor

Figure 6. Re-designed grapple and carriage showing enclosure for powered opening rams (4) and box construction grapple (5)

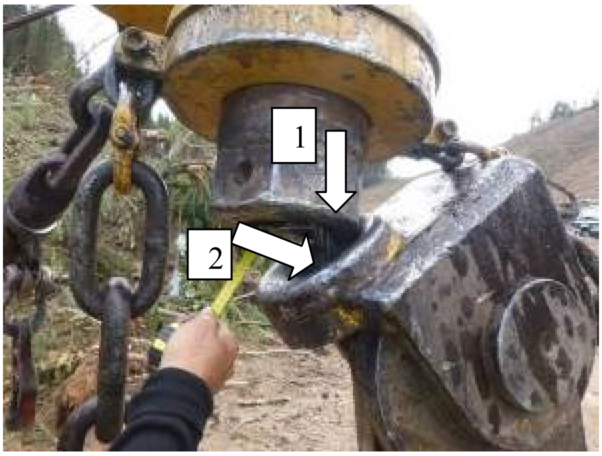

Figure 4. Sharp edges (1) cut the closing line (2) on the Johnson grapple

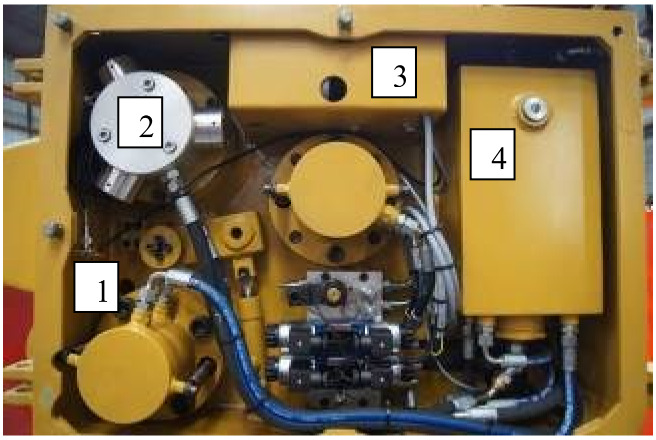

Figure 7. Re-designed internal layout showing flexible antenna (1), pump (2), accessible battery compartment (3), and oil tank filling point (4)

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TRIAL METHOD

The first production-model Alpine Grapple (with rotation) was delivered in April 2013. The grapple was subsequently modified by fitting a more robust set of grapple tines and modifying the grapple housing, which was found to restrict the opening of the grapple to its widest extent.

A camera/GPS unit supplied by DC Repairs Ltd [3] was fitted to a production model Alpine Grapple carriage. The effect on hauler productivity of fitting a camera to the grapple was quantified using time study techniques.

Study Location

The study was undertaken in a mature eucalyptus plantation located in Waione Forest, Lake Rotoiti in the Bay of Plenty, central North Island, being clearfelled by Complete Logging Ltd. A 2-drum Harvestline hauler using the Alpine Grapple and a mobile tail hold was extracting the manually-felled eucalypt trees.

Stand and Terrain Information

Average tree volume was estimated at 0.4 m^3. Slopes were steep and concave in shape. The "U" shaped profile setting had an average haul distance of approximately 180 m. Haul distance data were not collected each cycle.

All time-study data were collected from "U"-shaped terrain profiles. The felled trees that were close to a steep gully at 150 m were often obscured by vegetation and were also often invisible to the spotter.

Data Collection

The hauler operation was recorded using video and time study data were extracted from the video. Grapple time data were collected from haul cycles before and after the introduction of the grapple camera.

A trainee spotter, with only 10 days' experience worked in conjunction with the hauler operator. The spotter was located on the back face, about 80 m downhill from the mobile tail hold and a similar distance from the haul lines. The hauler operator had previous experience of the use of a prototype Alpine Grapple while it was being tested.

Time study data using the spotter only were collected first (in June 2013), several weeks following delivery of the Alpine Grapple to the operation.

A camera was then fitted to the Alpine Grapple four weeks' after the collection of the spotter-only data. The camera-only and camera-and-spotter data were collected another four weeks later in late August/early September 2013.

The hauler cycle time elements for the Harvestline hauler operation working in eucalypt clearfell are described in Table 5.

Table 5. Cycle-time element description

Element	Details
Outhaul	Starts: When the carriage begins to move from the yarder out to the breakout zone. Finishes: When the horizontal movement of the carriage stops and the carriage begins to drop vertically towards the target tree.
Drop	Starts: When the horizontal movement of the carriage stops and the carriage begins to drop vertically towards the target tree. Finishes: When the grapple carriage contacts the ground or the target tree.
Grapple	Starts: When the grapple carriage contacts the ground or the target tree. Finishes: When the tree begins to move. The hauler usually gives an inhaul signal prior to inhaul but this can be some seconds before the tree begins to move.
Drop and Grapple	Starts: When the horizontal movement of the carriage stops and the carriage begins to drop vertically towards the target tree. Finishes: When the tree begins to move. The hauler usually gives an inhaul signal prior to inhaul but this can be some seconds before the tree begins to move.

Grapple element start times could not be observed due to the vegetation present so the drop and grapple times were combined. Drop time was excluded from the analysis of this dataset.

Non-time elements recorded are given in Table 6.

Table 6. Non-time element description

Element	Details
Back face	The far face furthest from the hauler. In the operator's line of sight.
Gully	The zone of greatest drop distance. Between the back face and front face. Out of the operator's line of sight.
Front face	The near face, closest to the hauler. Frequently out of the operator's line of sight.
Spotter	Where a spotter was used to spot the target tree. Terrain shape and the location of the spotter close to the tailhold meant that spotter line of sight was restricted to the front face and only limited visibility of the gully and back face.
Camera	The camera was fitted to the grapple carriage.

The number of cycles for each type of data and work method are given in Table 7.

Table 7. Method, type and amount of data collected

Type of data and date of data collection	Work Method		
	Front face	Back face	Front and Back face
Camera-only (28.8.2013 – 6.9.2013)	-	-	43
Spotter-only (25.6.2013 & 26.6.2013)	47	43	-
Camera and Spotter (28.8.2013 – 6.9.2013)	-	-	16

The time-study data were analysed by testing for significant differences (P>0.05) between element mean values for different camera/spotter/haul direction configurations.

TRIAL RESULTS

Analysis of Spotter-only Data

Grapple Time and Drop and Grapple Time

Prior to the addition of the camera, data was collected when a spotter was used. The spotter was involved in the front-face grappling procedure because the operator had no line-of-sight view of the target tree. In contrast, the back-face trees were in full view of the hauler operator who could quickly manipulate them resulting in shorter "drop" times.

Results suggested that the need for communication between the spotter and hauler operator meant that the drop and grapple time was longer on average and was more variable for 'front face' extraction compared to 'back face' extraction (Figure 8).

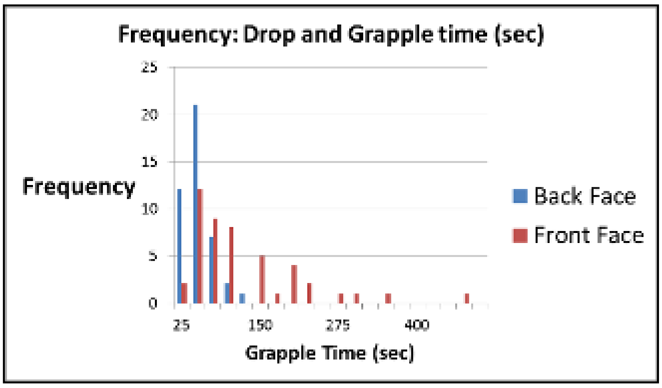

Figure 8. Comparison of the Drop and Grapple time for Front-face and Back-face grappling

Camera-only vs Camera-and-Spotter Data Analysis

Outhaul Time

Outhaul time appeared to be longer when a spotter was used (Figure 9). This result suggested that the use of the camera/GPS unit contributed to a faster outhaul to a target tree.

It is suggested that the spotter may have slowed the carriage outhaul because his view of the target tree relative to the grapple carriage was impaired owing to his location, leading him to be conservative about stopping the carriage in time to manoeuvre closer to the tree. From the graph, it appears that this time difference can be estimated at an average of 10 seconds.

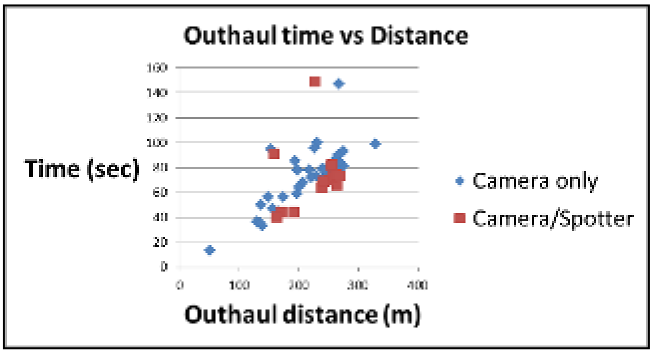

Figure 9. Comparison of outhaul times, Camera-only vs Camera-and-Spotter data

Grapple Time

Grapple time did not appear to differ between camera-only vs camera-and-spotter operation when grappling off the back face (Figure 10). The back face was visible to the operator. There were indications of reduced grapple times from the data-point distribution (Figure 9). Using the camera when grapple yarding a difficult gully area at 150m haul distance, where visibility to the spotter may have been limited by vegetation, may have resulted in shorter grapple times, but there were insufficient data to be definitive.

There were indications of reduced grapple times using the camera in a difficult gully area.

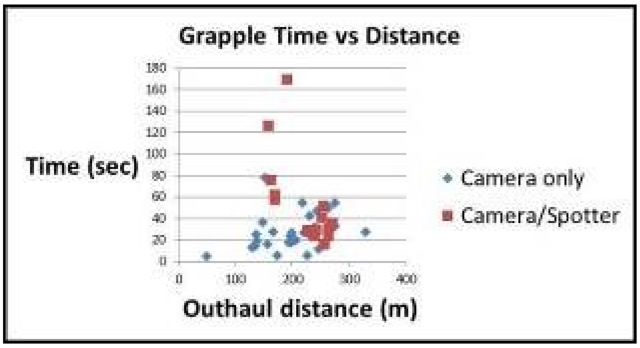

Figure 10. Comparison of grapple times, Camera-only vs Camera-and-Spotter data.

Calculations made after the time study showed that reducing the average productive cycle by only two seconds (based on a 3.5 min estimated cycle time and an extraction cost of $2000/day over a 24 months period) could reduce costs sufficiently to pay for camera installation. If a reduction in outhaul time of ten seconds per cycle was achieved through camera use (as suggested in Figure 8), an effective reduction of average cycle time of eight seconds could be achievable and this would contribute to improved harvesting system productivity.

CONCLUSIONS

Some of the barriers to introduction of the prototype grapple carriage were identified including technical and operational issues. Further developments of the Alpine Grapple were then undertaken which included structural changes as well as the addition of a camera/GPS unit.

The effect on hauler productivity of fitting a camera to the Alpine Grapple carriage was quantified using time study techniques.

Results of the comparison of the time taken to complete the outhaul and grapple elements of the hauler cycle with and without the fitted camera showed that outhaul times appeared to be faster when using the camera/GPS unit only compared to using both camera and a spotter. Grapple time was also quicker for the camera-only operation compared to the camera-and-spotter combination in instances where vegetation may have obscured the spotter's view.

There was insufficient data to be definitive about the effect of camera use on grapple carriage operation. It is recommended that a further trial be undertaken under more controlled conditions.

ACKNOWLEDGEMENTS

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