HARVESTING TECHNICAL NOTE

HTN04-10
2012

Improved Grapple Control using a Grapple Restraint

Summary

A simple low cost system was designed to restrain the free rotation of a swing yarder grapple and align the grapple tines for easy grappling of bunched or single trees. The grapple restraint was built and tested over a four-month development process during 2011 that eventually produced a robust design. The grapple restraint was then evaluated in a production study. Results showed that use of the restraint significantly reduced grappling time for bunched trees over haul distances of less than 150 m when a spotter was not used. At an average haul distance of 150 metres, it was estimated that using the restraint increased production by an extra 10 hauler cycles per day (an increase of 4.5%). At average hauler rates and returns this additional production would enable pay back of the capital cost of the restraint in about five weeks. The hauler operator noted that the restraint made the grapple easier to control, and given the choice the operator would prefer to continue to use the restraint for all grapple yarding operations.

Tony Evanson, Scion and Duncan Brown, Jensen Logging Ltd.

Introduction

Grapple yarding of trees is a desirable means of extracting both single tree stems and bunched wood because of the short loading (or “grapple time”) element of the haul cycle and the elimination of breaker-outs exposed to hazards.

In a grapple yarding operation the “Grapple” element of the yarder productive cycle is probably the most variable of all the element times due to:

- visibility of the grapple or the target tree to the operator or “spotter”;
- the distance of the target tree from the operator;
- the orientation of the target tree to the grapple tines and the yarder ropes (“extraction corridor”);
- whether trees are bunched or not;
- the slope of the ground the tree lies on;
- the profile of the extraction corridor (hauling from front face or back face); and
- the skill of the operator in manipulating the grapple.

The grappling phase involves locating the grapple on or against the tree in such a way that the grapple tines will be able to wrap around it. This is accomplished with control of two ropes, the main rope and tail rope (Figure 1). The grapple can be either lowered onto the tree, or dragged across it after overrunning the tree. The grapple is then closed using a tag or second main rope.

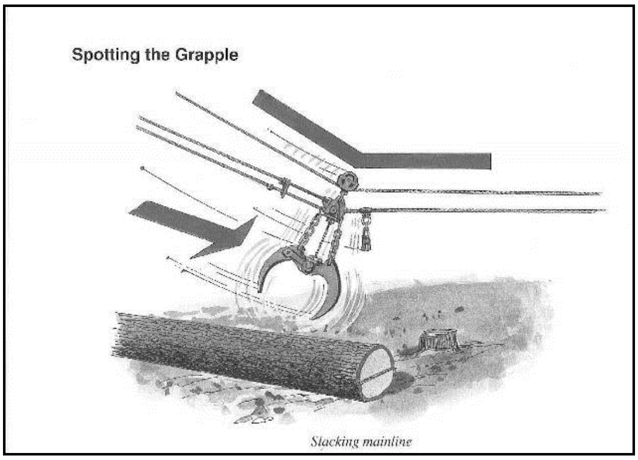

Figure 1: Spotting the grapple by slacking mainline to move grapple towards tail hold (Ref: WCB of British Columbia) [1]

Research into grapple yarding with swing yarders has identified a number of factors influencing productivity. An operator’s ability to grapple trees unaided is generally reduced with

increasing haul distance, and a "spotter" can be used as an operator's limits are reached. Grapple times are naturally longer with increasing haul distance because of the delays in communicating and implementing actions. This has been documented by Howard[2], who found that haul distance increased grappling time, even when a spotter was used. One study showed an average 30% increase in grapple time for haul distances over 150 m.

Grapples will rotate freely through 360 degrees, and of necessity grapples must rotate through at least 180 degrees to align with the tree's position. Aligning the grapple tines with a tree, with or without the aid of a spotter, can be a difficult task. Often, many years of experience are required before a grapple operator can become highly competent. Contractors in the past have solved this problem by shortening one of the hanger chains, and restraining one of the hanger chains (Figure 2) to align the grapple tines for extracting from bunches.

Figure 2: A simple chain restraint, holding the tines in a desired position for grappling bunched wood

A series of projects was initiated by Future Forests Research Ltd (FFR) in 2010 with the aim of improving productivity and reducing costs through the use of improved harvesting technologies. A number of studies had reported productivity gains through bunching for grapple extraction, and through feeding or presenting to the grapple by excavator. Commonly these gains were largely achieved by grappling more pieces[3] rather than reducing cycle time. It was recognised that there was potential for other improvements to come through the addition of cameras to the carriage, or rigging (Kerry Hill, pers. comm.) and/or constructing a carriage with remote controlled rotation or hydraulic opening and closing[4].

In contrast to these other more complex grapple control methods, research efforts were made to improve on the simple low-cost chain restraint that grapple logging contractors had used in the past to improve grappling in either bunched or excavator-presented wood.

This project aimed to improve the productivity of the extraction phase of cable logging through the development of an improved grapple/carriage control system to reduce the "grapple" time element of the production cycle.

Development Process

From initial discussions with a Rotorua cable logging contractor, Duncan Brown of Jensen Logging Ltd, it was decided that there was sufficient interest in the concept to begin designing a system. A new Micron grapple was used to test the system (Figure 3).

Figure 3: The Micron grapple used for testing. Arrows show the grapple attachment point to the haul back rigging and control principle for the prototype restraint system

It was proposed that a simple, spring-based system for aligning grapple tines might have merit. Various chain and spring assemblies were constructed and tested. Often these failed when subjected to the vibration and forces involved. Initial designs were based on a double restraint using 600 mm 75 kg springs, protective pipe, galvanised chains and shackles.

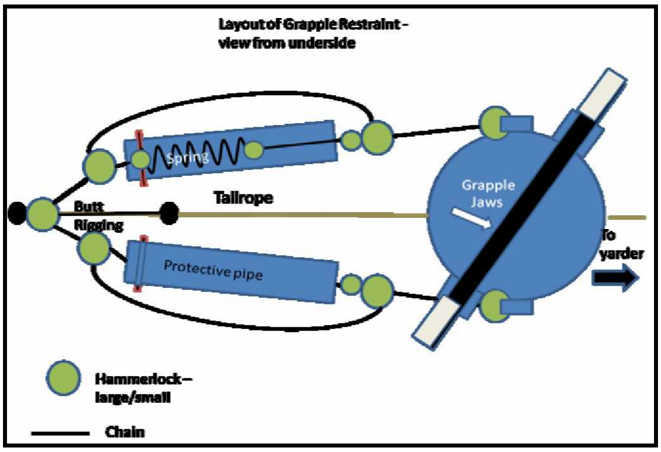

Figure 4: The layout of the prototype grapple restraint system (V3)

The next design involved thicker-walled pipe, 13 mm high-tensile chain and 10 to 13 mm hammerlocks. The grapple tine angle was set through having different lengths of chain (Figure 4).

The springs were intended to return the grapple to the desired alignment during outhaul. The springs were set to stretch sufficiently to allow the grapple to rotate through 180 degrees. The looping chains parallel to the pipes were intended to prevent over-stretching of the springs, and to take the full force of grapple rotation on inhaul and during grappling. The restraint chains were attached to the large rings supporting the grapple hanger chains.

The design was improved through the addition of two attachment plates (Figure 5) which were designed and built by Jensen Logging Ltd. The plates, when welded to the rotating assembly, enabled the tines to be set at any one of four angles. The restraint chains could then be of equal length.

Damage to the springs, although partly protected by the steel pipes, was difficult to avoid given the harsh terrain of the logging site.

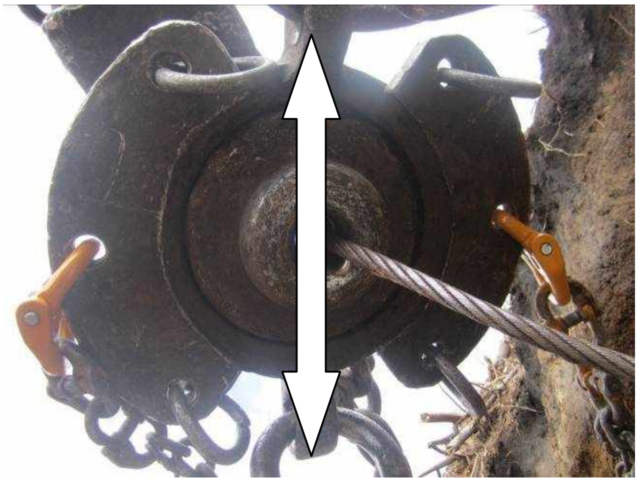

Figure 5: The location of the attached plates. The hammerlocks are attached so the grapple tines (arrows) are parallel to the ropes

The 1.2 m (90 mm diameter) steel pipes were damaged by the grapple tines, which also damaged the springs. The fitting of pipes of 7.5 mm gauge thickness enabled the removal of some of the chain and also made the system more robust (Figure 6).

Figure 6: The Version 3 restraint, showing the attachment to the grapple itself

The final version of the restraint (Version 4) used the pipes themselves as tensioners (Figure 7).

HARVESTING TECHNICAL NOTE

HTN04-10
2012

Figure 7: The final version of the restraint (V4).

At this stage, the system (Figure 8) was considered sufficiently robust to be evaluated to establish if there was measurable improvement in grappling time. The final cost of the restraint system was approximately $1500.

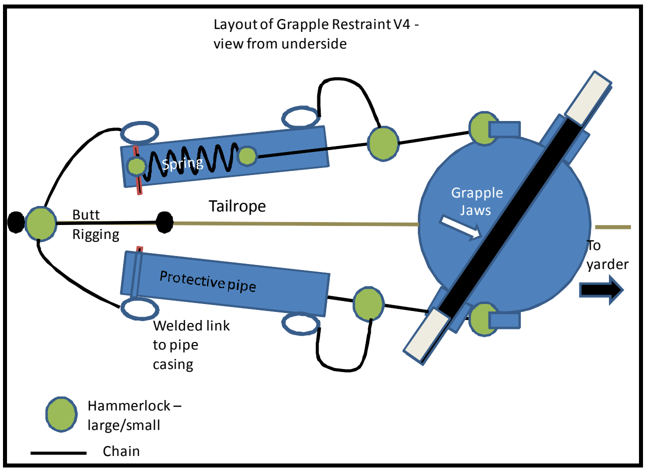

Figure 8: The layout of the prototype grapple restraint system (V4)

Feedback from both the contractor and the hauler operator was positive. The restraint made grappling of bunched trees both easier and faster. This effect was apparent both with and without the use of a spotter.

Study Area and Method

The grapple restraint was used in a Madill 120 grapple yarding operation. The hauler was rigged with a Micron MC88H Yarding Grapple (88 inch or 224 cm when opened) which had been modified by Active Equipment for double-purchase operation (Figure 9).

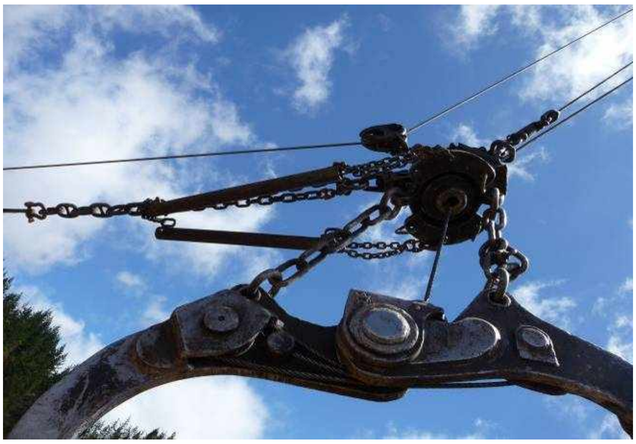

Figure 9: The Mark 4 Prototype grapple restraint fitted during the field evaluation

The evaluation took place in a clearfell operation located in Poronui Station close to the Kaimanawa Forest Park in the North Island. The unmanaged stand had an estimated extracted piece size of 1.3m^3. Where terrain permitted, trees to be extracted had been bunched by excavator into continuous rows for grapple yarder extraction (Figure 10).

Figure 10: Trees bunched for extraction by grapple yarder.

Time study methods were used to evaluate differences in grappling time, with and without the use of the restraint. Video recordings were made of the grapple's operation and times were measured directly from the recordings. Haul distance was measured using a laser rangefinder. A total of 107 observations were collected over a two day period, 42 cycles using the grapple restraint and 65 without the restraint.

The grapple time element started when the grapple tines first touched the trees to be extracted, and finished when the tree/s started to move after being grappled. All grappling times recorded related to grappling from bunched trees, which were in turn aligned perpendicular to the haul ropes. The grapple restraint was set so the grapple tines were parallel to the haul ropes, and perpendicular to the trees being grappled.

Results of Evaluation

Summary of Grapple Time with No Spotter

For short haul distances (less than 150 m) no spotter was used and 68 observations were made. Of the observations without the use of a spotter, 41 were with no grapple restraint, and 27 were with the restraint (Table 1).

Table 1: Grapple times with no spotter

	Without Restraint	With Restraint
Number of Observations	41	27
Average time (sec)	13.6	9.8
Minimum	4.3	4.0
Maximum	32.0	23.0
Haul distance range (m)	66 – 108	53 - 204

Figure 11 shows the range of values for grapple times without the spotter. Differences between the averages were significant at the p>0.05 level. The times using the restraint showed a tighter cluster and fewer long grapple times.

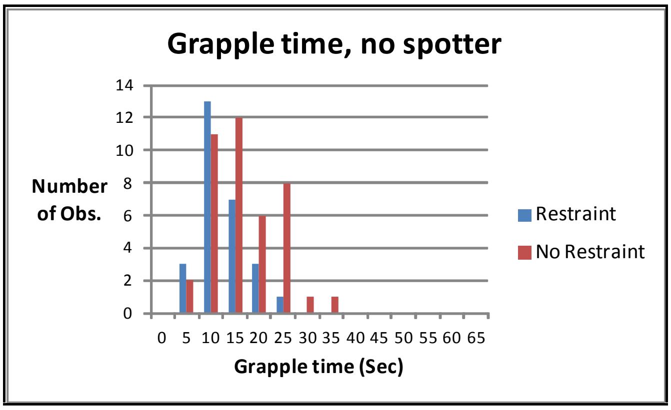

Figure 11: Frequency distribution of grapple times – no spotter

With no spotter, average grapple time with the restraint was 28% faster than without the restraint.

Summary of Grapple Time with a Spotter

For haul distances greater than 150 metres, a spotter was used and 39 observations were made (Table 2).

Table 2: Grapple times with a spotter

	Without Restraint	With Restraint
Number of Observations	24	15
Average time (sec)	18.7	15.7
Minimum	7.0	7.8
Maximum	40.8	27.2
Haul distance range (m)	190 - 203	240

When a spotter was used, average grapple time with the restraint was 16% faster than without the restraint. Figure 12 shows the range of values for grapple times with the use of a spotter.

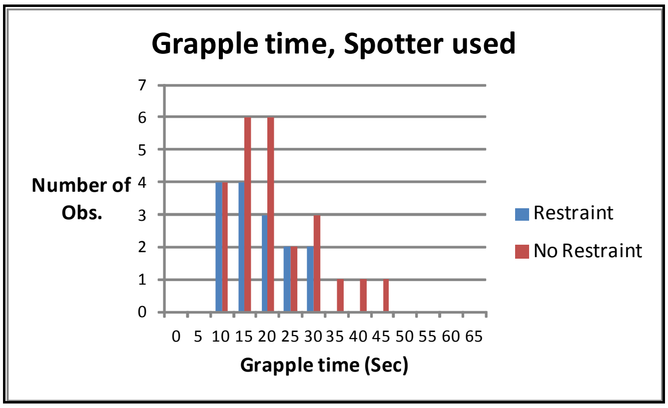

Figure 12: Frequency distribution of grapple times – with spotter

Differences were not significant at the p>0.05 level, indicating that the data were too variable to show any advantage offered by the restraint. Despite this, in the contractor's opinion the restraint was still advantageous when a spotter was used.

Effect of Haul Distance / Use of Spotter

A comparison between grapple times with the use of the restraint and without showed that there was an evident effect from increased haul distance where use of a spotter was required (Figure 13).

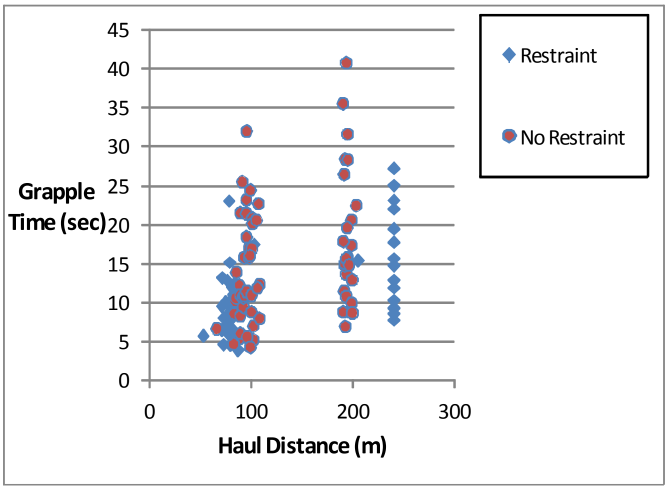

Figure 13: Grapple time vs. haul distance, with and without the use of the restraint

Without the use of the grapple restraint, longer haul distances with the use of a spotter resulted in a wider variation of grapple times and a 38% increase in average grapple times from 100 m to 200 m haul distance (+5.1 sec).

Differences between the average grapple times at 100 m and 200 m (no restraint) were not however statistically significant at the p>0.05 level.

When the restraint was used, there was a similar increase in average grapple time (+5.9 sec) with increased haul distance and use of the spotter.

Trees Extracted Per Haul

For all cycles, an average 1.4 pieces per cycle were extracted. Using the restraint, an average 1.5 pieces/haul were extracted. Without the restraint an average 1.3 pieces was extracted per haul. The averages were not significantly different at the p>0.05 level. When the grapple restraint was used there was approximately 20% more hauls with greater than two pieces extracted per haul (excluding lost pieces with and without the use of a spotter).

Effect of a Grapple Restraint System on Yarder Daily Production

A sample of inhaul and outhaul times was taken from the video recorded of the study to estimate hauler cycle time at 150 metres haul distance.

This time was matched with average grapple time values (Table 3) to give a daily production estimate (based on six productive hours per day).

Table 3: Standard factors used for production estimates

Element	Average Value
Swing and drop	11.6 sec
Outhaul	23.4 sec
Grapple	12.3/16.5 sec
Inhaul	45.5 sec
Pieces/haul	1.4
Piece size	1.3 m^3

With use of the grapple restraint, the estimated cycle time was 1.55 minutes resulting in 38.7 cycles per hour or 232 cycles per day. Without the restraint the cycle time was calculated to be 1.62 minutes, resulting in 37.0 cycles per hour, or 222 cycles per day.

Therefore with the use of the restraint, an extra ten cycles per day was gained, or a 4.5% increase in daily production. This equated to an extra 18 m^3 per day (10 cycles x 1.4 pieces/haul x 1.3 m^3 piece size).

At an estimated rate of $32/tonne[5] the increase in daily cash flow through the use of the grapple restraint was estimated to be $576. Assuming a 10% profit margin on daily cash flow this investment of approximately $1500 would have a payback period for the contractor of about five weeks.

Conclusions

The use of a grapple restraint with a grapple swing yarder extracting bunched wood resulted in a significant reduction in average grapple time at shorter haul distances when a spotter was not required.

When offered the choice of using the grapple restraint or not, the operator was emphatic: he would use it because it made the grapple more controllable. The contractor also stated that this ease of control also applied when a spotter was used.

Further Information and Acknowledgements

A copy of the design specifications and a full list of parts for this grapple restraint is available by contacting Tony Evanson at tony.evanson@scionresearch.com, (phone 07 343 5458).

The assistance and cooperation of Duncan Brown of Jensen Logging and Russell Brown, hauler operator is appreciated. Also acknowledged is the contribution to the project of Ian McElroy and Paul Milliken of Scion.

References

1. Workers' Compensation Board of British Columbia, *Grapple yarder and Super-Snorkel handbook*: Workers' Compensation Board of British Columbia. (1992).
2. Howard, A.F., *Production equations for grapple yarding in Coastal British Columbia.* Western Journal of Applied Forestry, Vol 6 (1), pp. 7-10. (1991).
3. Evanson, T., and Amishev, D., *A steep country excavator feller-buncher.* Harvesting Technical Note, No. 3 (2). Future Forest Research: Rotorua, New Zealand. (2010).
4. Eagle Carriage & Machine Inc., 12 December]; Available from: www.eaglecarriage.com.
5. Visser, R., *2010 benchmarking of harvesting cost and productivity.* Harvesting Technical Note, Vol 3, No. 10. Future Forests Research: Rotorua. (2011).