HARVESTING TECHNICAL NOTE

HTN08-04
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Economic Assessment of a Quick Coupler Mechanism

Summary

One of the highlights of the 2013 Elmia Wood forest harvesting demonstration was the Fiberdrive quick coupler developed by Fiberpac AB of Sweden. The Fiberdrive quick coupler allowed a base machine to change quickly and safely from a processor head to a log loading grapple in just a few seconds without the operator leaving the cab. The concept was investigated further to determine the economic advantages of introducing an automatic quick coupling mechanism into New Zealand steep country operations. The investigation showed that such a mechanism would have the most advantage where production of a mechanised processor was constrained by operational factors such as limited landing size or low yarder production. This report summarises a preliminary analysis of the potential advantages of using one base machine with a processor head and a loading grapple at various production levels (between 150 – 500 tonnes per day) to help improve machine utilisation. It is recommended that a quick coupler mechanism be developed that is suitable for large processor heads commonly used in steep country harvesting operations in New Zealand.

Spencer Hill, Scion

INTRODUCTION

The current Primary Growth Partnership Steep Land Harvesting Programme aims to improve harvesting productivity through a greater level of mechanisation. Steep country mechanised felling, bunching and processing has resulted in not only increased productivity, but also an increase in the number of machines in each harvesting operation [1, 2]. More machinery in each operation may increase harvesting costs if the operation is production constrained by factors such as limited landing size or low yarder productivity.

Figure 1: The Fiberdrive quick coupler demonstrated at Elmia Wood in 2013.

In 2013, a group of New Zealand forest managers and harvesting contractors visited Elmia Wood, the Swedish forest harvesting machinery demonstration, where one of the highlights was the Fiberdrive quick coupler developed by Fiberpac AB of Vislanda, Sweden (Figure 1). The Fiberdrive quick coupler was mounted on an SP Maskiner SP 561 LF processor head, and the operator changed from the processor to a log grapple in seconds without leaving the operator cab. The New Zealand contractors watching the demonstration saw the potential for reducing the number of logging machines required in steep country harvesting operations.

The Fiberdrive quick coupler mechanism is a hydraulically braked link with a rotator with eight hydraulic connectors, and one electrical contact for power supply. Power supply is via quick release built into the mount (Figure 2).

Figure 2: Fiberdrive attachment showing hydraulic couplers

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The hydraulic hoses are mounted in the centre of the rotator. The unit features wireless transmission of hydraulic set up information from the machine to the harvester head. The system can handle a maximum attachment weight of 2200 kg, which would make it suitable for the smaller end of the Waratah 600-series processors (models 616, 618 and 622), but not the larger model processors common in clearfell harvesting in New Zealand.

Subsequently, the FFR Technical Steering Team decided that further investigation was warranted. Discussions were progressed with Fiberpac AB to build a larger version of the Fiberdrive for New Zealand operations. Further investigation showed the Fiberdrive system would need to be redesigned to handle the heavier weight, larger oil flow requirements and continuous rotation of New Zealand clearfell-size processor heads.

Various New Zealand-based grapple processor manufacturers were approached to gauge their interest in either manufacturing the Fiberdrive system under licence in New Zealand or in designing a new quick coupler attachment. Southstar Equipment Ltd showed interest in further development of a quick coupler that would work specifically with Southstar logging attachments only.

An economic assessment was undertaken to determine the advantages of introducing an automatic quick coupling mechanism into New Zealand operations before doing any further development. Not all forests or forest harvest areas are suitable for high production operations given their operation-specific constraints. The question arose whether there is a place for a mechanism that allows fewer machines to operate a combination of logging attachments. In difficult areas where high production is constrained, it is necessary to determine the production rate at which the quick coupler improves harvesting profitability.

This report investigates the economic viability of the quick coupler mechanism and identifies the potential gains achievable where an excavator base machine is able to change attachments from a processor head to a felling head or to a grapple or to a bucket as opposed to using separate base machines for each of these functions.

METHOD TO ASSESS THE ADVANTAGE OF QUICK COUPLING

A spreadsheet model was developed to analyse the potential effect on logging system cost of introducing the quick coupler. The model predicted the amount of unutilised time for each piece of equipment in the operation over varying production levels in a standard steep country logging operation.

The base operation for the analysis model was a hauler, a processor and a loader. Three scenarios were developed, two that typified current operations and one scenario that examined the situation where a processing head and a grapple were able to be shared between one base machine.

The first scenario was based on dedicated equipment where additional equipment was added as production increased. The second scenario included the quick coupler which was assumed to cost $60,000 and analysed the impact of sharing logging attachments between bases to try and increase overall machine utilisation first, prior to adding machinery. The third scenario depicted the situation where an operation had equipment in place for high production but was harvesting a block that was less suited to high production. Therefore a key component of the model involved estimating equipment utilisation.

Table 1: Production rate assumptions for the various processes used in the model.

Process	Tonnes per hour
Feller buncher	60
Hauler extraction from un-bunched trees	30
Hauler extraction from bunched trees	60
Processor clearing chute, delimbing and cutting logs	60
Grapple loader fleeting, sorting and loading	30

The following assumptions were used in the model:

- Manpower was limited to 9 scheduled hours per day
- Where machines were used for more than 9 hours per day additional operators were costed in to the operation.
- Base machines could only share attachments if the combined utilisation was less than 12 hours total work per day.

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- A maximum 10 hour day was applied to loading equipment. Where a loader was required for more than 10 hours, additional equipment was added.

To predict utilisation the maximum production rates shown in Table 1 were used in the analysis. Where machinery was underutilised the percentage under-utilisation was used to reduce the variable cost of running the equipment (such as diesel and repairs and maintenance). This assumed that the machine would be switched off and not used. However since this rarely happens in reality and machinery tends to remain operating (in non-productive work) this assumption provided some conservatism in the model estimates. That is, the reduction in operating costs due to under-utilisation would in reality be less than estimated, and hence the benefits of increased utilisation by using the quick coupler could be higher than stated.

RESULTS OF ECONOMIC ANALYSIS

Scenario 1 depicts a standard grapple hauler operation with a dedicated processor, and enough machines were used to be capable of producing the specified volume. Scenario 2 depicts a grapple hauler with an excavator sharing a processor head and a grapple for loading. The third scenario shows the implications of a large production crew with a felling machine working in a low producing block.

Table 2 shows an example operation costing for a production level of 220 tonnes per day (Scenario 1).

Table 2: Daily cost for a system where separate bases are used for the processor and the loader.

Job Costing Summary Non-Optimised Processing and Loading					
MACHINERY		Units	Hrs	% Util	$/Day
	20T Excavator-Tailhold	1	2		$ 233
	24 Tonne Excavator	1	7.3	92%	$ 823
	4x4 Double Cab Work Ute	3	2		$ 260
	Hauler	0.9	7.3	92%	$ 1,352
	Processor	0.5	3.7	46%	$ 1,179
	Chainsaw	2	8		$ 78
LABOUR		7	8		$ 2,360
OVERHEADS					$ 566
BASIC UNIT RATE					$ 6,852
PROFIT					$ 685
TOTAL DAILY RATE REQUIRED					$ 7,537
INDICATIVE PRODUCTION					220
INDICATIVE RATE					$34.26

At 220 tonnes per day a loader fleeting, sorting and loading worked for 7.3 productive hours based on a productivity of 30 tonnes per hour, and was costed at the full daily rate ($823). The processor at a production level of 60 tonnes per hour operated for 3.7 productive hours per day (46% utilisation), and was also costed at the full daily rate ($1,179). This resulted in the overall on-truck logging rate of $34.26 per tonne.

In Scenario 2 the daily cost for a system where the same base was used for the processor and the loader was $6,909 per day (Table 3), and includes the additional cost of the quick coupler estimated to be $60,000.

Table 3: Daily cost for a system using a quick coupler to share the base machine between the processor and the loader.

Job Costing Summary Multi Functional Processor/Loader Base					
MACHINERY		Units	Hrs	% Util	$/Day
	20T Excavator-Tailhold	1	2		$ 233
	24 Tonne Excavator with Quick Coupler	1	7.3	92%	$ 806
	4x4 Double Cab Work Ute	3	2		$ 260
	Hauler	0.9	7.3	92%	$ 1,352
	Processor	0.5	3.7	46%	$ 625
	Chainsaw	2	8		$ 78
LABOUR		7	8		$ 2,360
OVERHEADS					$ 566
BASIC UNIT RATE					$ 6,281
PROFIT					$ 628
TOTAL DAILY RATE REQUIRED					$ 6,909
INDICATIVE PRODUCTION					220
INDICATIVE RATE					$31.40

At 220 tonnes per day, based on productivity of 30 tonnes per hour, a loader fleeting, sorting and loading worked for 7.3 productive hours per day. The processor at a production level of 60 tonnes per hour operated for 3.7 productive hours per day. The base machine worked for 11.0 productive hours (7.3 hours loading and 3.7 hours processing). The combined daily cost for the base machine, quick coupler, grapple and processor head was $1,431 ($806 plus $625). This resulted in the overall on-truck logging rate of $31.40 per tonne. Therefore, at this production level, using a dedicated processor (Scenario 1) cost an additional $2.86 per tonne compared to sharing base machines using a quick coupler mechanism (Scenario 2).

Scenario 3, a system where separate bases were used for the processor and the loader and another machine was used as a feller buncher is shown in Table 4.

At 220 tonnes per day, a loader fleeting, sorting and loading operated for 7.3 hours based on productivity of 30 tonnes per hour. A dedicated processor at a

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production level of 60 tonnes per hour operated for 3.7 productive hours. The feller buncher, based on productivity of 60 tonnes per hour, also operated for 3.7 productive hours. The hauler operated for only 3.7 hours due to the higher productivity of extracting bunched trees. At the daily production rate of 220 tonnes, this resulted in an overall logging rate of $42.42 per tonne.

Table 4: Daily cost for a system where separate bases are used for the processor, the loader and the feller buncher.

Job Costing Summary Non-Optimised Processing and Loading and Mechanical Falling					
MACHINERY		**Units**	**Hrs**	**% Util**	**$/Day**
	Climbmax Feller Buncher	1	8	46%	$ 1,551
	20T Excavator-Tailhold	1	2		$ 233
	24 Tonne Excavator	1	7.3	92%	$ 823
	4x4 Double Cab Work Ute	4	2		$ 286
	Hauler	0.5	3.7	46%	$ 1,006
	Processor	0.5	3.7	46%	$ 1,179
	Chainsaw	2	8		$ 78
LABOUR		8	8		$ 2,680
OVERHEADS					$ 647
BASIC UNIT RATE					$ 8,484
PROFIT					$ 848
TOTAL DAILY RATE REQUIRED					$ 9,332
INDICATIVE PRODUCTION					220
INDICATIVE RATE					$42.42

The model was used to predict the logging rate required (in $/tonne) for the three scenarios over production rates ranging from 150 tonnes per day to 500 tonnes per day (Figure 3).

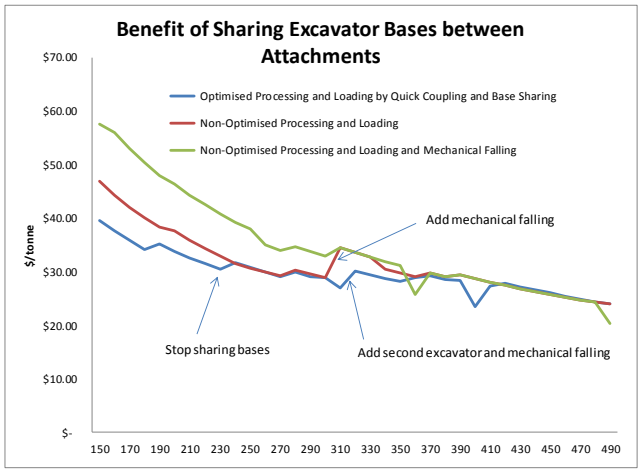

Figure 3: Logging cost ($/t) over varying production rates for Scenario 1 (red) , Scenario 2 (blue) and Scenario 3 (green).

Scenario 1 (the red line in Figure 3) shows the operation with no base sharing where new equipment is taken on when required. As new equipment is added there is a spike in cost due to it not being fully utilised.

Scenario 2 (the blue line) shows the operation using a quick coupler mechanism to share the base machine between the processor and the loader.

Scenario 3 (the green line in Figure 3) shows the operation with the feller buncher, suitable for high production.

This analysis of quick coupling technology only covered the processor and loader. However, the use of the quick coupler could extend to the feller buncher and a bucket for minor earthworks (such as deadman installation), providing an opportunity to maximise utilisation of other machines at lower daily production rates.

THE BUSINESS CASE FOR QUICK COUPLERS

The analysis showed there is a very good case for using one base machine to share attachments when cable logging production rates are less than 220 tonnes per day. The quick coupling mechanism will increase the utilisation of the base machine and result in logging rate savings of more than 2.86 per tonne (Figure 4). At an estimated purchase price of $60,000 for a quick coupling mechanism the payback period would be less than six months.

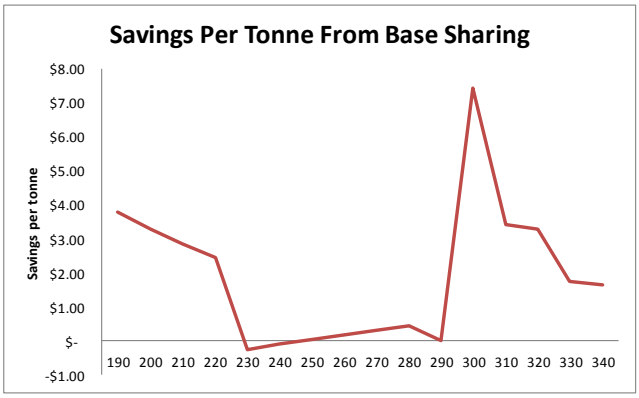

Figure 4: Comparison of savings ($/tonne) between Scenario 1 and Scenario 2.

At production rates between 230 and 290 tonnes per day the average savings were much less. Once daily production levels reached 400 tonnes per day there were few advantages in sharing base machines as all

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machines in the logging system reached 80% utilisation.

The quick coupling mechanism enables fast and safe changeover of logging attachments, such as a processor head, a loading grapple, a felling head and a bucket (for road and landing construction). The specifications for development of a quick coupling mechanism should include requirements for changeover of attachments without the operator leaving the cab and to ensure no contaminants enter the hydraulic system during changeover.

Processors on cable landings are becoming more and more popular for safety and cost reasons however these are often underutilised in crews producing less than 300 tonnes per day. The FFR productivity benchmarking database has shown that New Zealand hauler operations on average produce 200-210 tonnes per day [3&4]. Therefore having the ability to change attachments means the underutilised base machines can perform other functions such as truck loading, sorting, stacking or earthworks (if required).

OTHER COUPLING MECHANISMS

There are a number of manufacturers making mechanical couplers with quick release hydraulic connectors where the operator must leave the cab of the base machine to complete the changeover. However few companies make automatic quick coupling mechanisms whereby the hydraulic hoses are connected automatically during the changeover process.

Figure 5: Engcon Automatic hydraulic quick coupler

Two Swedish companies, Oilquick AB and Engcon International (Figure 5) specialise in automated hydraulic coupling mechanisms. Liebherr from Germany is another company that manufactures automated hydraulic coupling mechanisms (Figure 6). None of these companies currently manufacture a quick coupler suitable to carry a processor head commonly used in New Zealand. For example, Engcon couplers (distributed in New Zealand by Doherty Engineered Attachments Ltd) have a hydraulic oil flow limit of 120 litres per minute. Processing heads typically used in New Zealand require flow rates of 360 litres per minute. Further development is therefore required.

Figure 6: Liebherr automatic hydraulic quick coupler

CONCLUSION

The savings possible when using a quick coupler to share base machines at a production rate below 220 tonnes per day exceeded $2.80 per tonne. This highlights the potential of the quick coupler in lower production hauler operations in New Zealand.

Every forest in New Zealand has difficult harvest areas that preclude high production being achieved. Therefore sharing base machines by using quick coupler technology would be advantageous even for large forest owners. The benefits would accrue mainly for owners of small forests (<100 ha) where, due to operational constraints, daily logging production is commonly less than 220 tonnes.

Operations not involving mechanised felling, which result in lower hauler productivity due to no bunching, would also benefit from base sharing using the quick coupler mechanism.

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It is strongly recommended that further development be undertaken of a quick coupler mechanism that is suitable for large processor heads commonly used in the New Zealand logging industry, based on the results of this analysis.

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