HARVESTING TECHNICAL NOTE

HTN04-04
2011

Developing a Multi-function Hauler: A Feasibility Study

Summary

Few of the estimated 300+ haulers in New Zealand have implemented the yarding technologies developed in European haulers over the last 15 years, such as electro-hydraulic control, remote control, semi-automation, or integration of functions. This study investigated the feasibility of installing a boom/arm and grapple or processor operating from the hauler. This would allow the hauler to clear the landing chute, eliminating the need for a separate loader, or to either delimb or process stems from the stockpile of landed stems. Discussions were held with equipment manufacturers and design engineers regarding retrofitting an integrated knuckle-boom loader/processor to existing haulers in New Zealand. These highlighted some engineering issues that could be overcome. It was considered essential that any interference to the yarding cycle be eliminated through the use of radio-controlled chokers and remote controlled or automated carriages in conjunction with the development of an integrated loader/processor with the yarder. Future harvesting research will focus on further development of intelligent yarders and carriages through mechatronics, automation, and teleoperation. Such changes would necessitate thorough investigation of harvest systems design and application of ergonomics.

Dzhamal Amishev, Scion

Introduction

The New Zealand forestry sector has identified steep country harvesting as the key bottleneck in achieving greater profitability in forestry. Harvesting methods on steep terrain in New Zealand, using cable logging, differ in several respects from those in other regions in the world due to the nature of *Pinus radiata* and the features of New Zealand's terrain. Present cable logging methods however have changed little in 50 years.

A research programme has been initiated by Future Forests Research (FFR) to enable improved productivity and reduced costs through the use of improved harvesting technologies. Part of this programme involves improving efficiencies of existing haulers in New Zealand. Potential developments include integrating functions of the cable hauler to utilise existing production delay (during automated "out-haul", "hook-on" and "break-out" phases of the cycle) and spare engine capacity of the yarder during this idle time.

The objective of this study was to assess the feasibility of developing a multi-function yarder through installation of a boom/arm and grapple or processor on to a hauler. This could be used to either undertake existing functions (such as clearing the yarder chute, or loading trucks) eliminating the need for a separate loader, or to introduce new processing capability to the landing to delimb and/or process stems from the stockpile. This project evaluated existing hauler machine utilisation and investigated the feasibility of using spare hauler engine capacity for handling logs. The potential to retrofit machine capability to existing yarder equipment was a key part of the investigation.

Figure 1. A typical tower yarder skid layout.

Study Method

Literature on cable yarding technology was reviewed and available technological developments in the logging industry were investigated and summarised. Discussions on the feasibility of installing additional functions to a hauler were held with forestry equipment manufacturers and design engineers.

Results

Literature Review

Hauler Systems

Hauler logging systems in New Zealand can be divided into either fixed tower yarders (Figure 1) or swing yarders. Most haulers were manufactured in North America and adapted to work in New Zealand conditions. Their numbers have increased substantially over the last 25 years from 82 in 1985[2], to 165 in 2002[3] to more than 300 today (Rien Visser, pers. comm.).

Mobile haulers with knuckle-boom loaders have been trialled in New Zealand in the past. A Timbermaster, “lightweight” mobile skyline hauler was evaluated to assess its characteristics and operating potential for New Zealand (LIRA Machinery Evaluation, 1977). An important feature of the unit was the Swedish Cranab 5000 hydraulic knuckle-boom crane which was used to clear trees landed in front of the hauler and for loading 6-metre pulpwood directly onto multi-lift bunks for transport.

This small hauler was equipped with a 7.6m fabricated steel tower, secured by three manually winched guy ropes and had a maximum line pull of 4.0 tonnes. The Cranab model 5000 was a hydraulic loader with 140^{o} swing and fully rotating grapple with a lifting capacity of 6 kNm. The operator’s cab was at the rear of the machine with the Cranab mounted on the cab roof. Visibility of the main and tail rope drums was poor and the operator’s position was generally quite cramped.

On most cycles carriage outhaul could not be started until the tree lengths were lifted clear from in front of the hauler using the crane. Once stems were delimbed and cut to length, the crane stacked them directly on bunks located behind the hauler, or into a stockpile if no bunk was available. It was concluded that the interference between the crane operation and the hauling cycle had a substantial effect on the daily output. The skill and competence of the operator in using the crane was crucial for the success of the operation. These machines have not been used since, and in a discussion with Morbark Pacific Ltd, the New Zealand distributor, the main reasons stated were its small size and low productivity.

The feasibility of integration of functions is based on two fundamental assumptions: that the hauler operator has spare time and that the hauler has available power.

Machine Utilisation

Machine utilisation values for yarders were found to be positively correlated with longer average haul distances, minimal downhill logging, use of mobile tail holds and larger harvest setting areas [13]. Productive time from time studies, shift level data and predicted values from regression models was found to range from 53% to 81% of total scheduled time (i.e. machine utilisation of 53-81%). This “productive time” included the production cycle elements such as hook-on and unhook which could be considered as delays in terms of hauler engine capacity utilisation. These figures indicated that hauler engine capacity may not be fully utilised up to 50% of the time.

Mechanical Power

Originally, mechanical gears transmitted power from an engine to the winches which required shifting and braking operations[5]. In Europe in 1972, a new development was introduced where all winches were powered hydraulically [14]. Advantages of this solution were:

- infinitely variable gearing;
- high horsepower with low weight ratio of hydraulic components; and
- simplification of the man - machine interface design due to multi-function control.

Integration of Functions

This development also provided the platform for integration of yarder technology such as winches, power supply, and the yarder tower on a wheeled or tracked carrier – the development of the mobile tower yarder. In 1979, the Austrian state forests added a boom to a truck-mounted tower yarder (Figure 2) to which either a grapple or a processor could be attached.

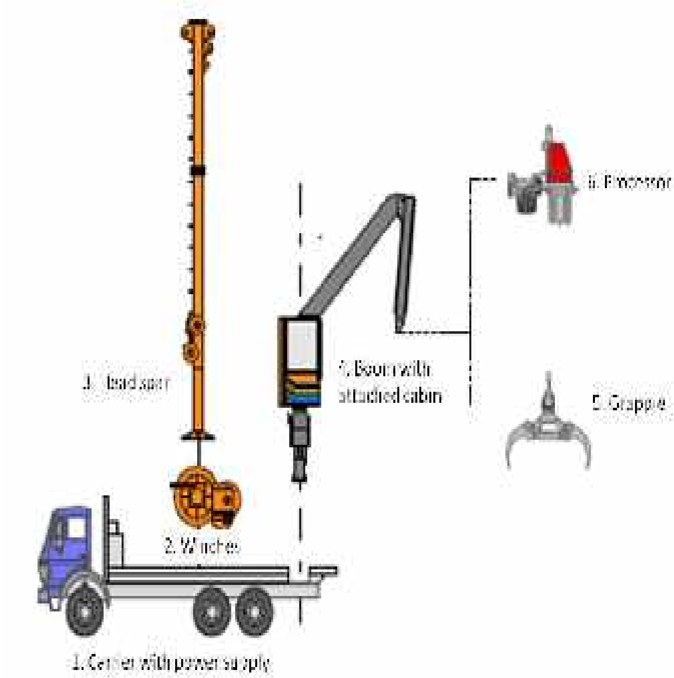

Figure 2. Truck-mounted tower yarder system components.

In 1994, Mayr Melnhof Forest Enterprise in Austria was the first company to attach the operator cabin to the boom, providing optimal sight and working conditions for the operator[5]. This improves access to skyline corridors under unfavourable yarder setup conditions (such as operating from roadside). One of the most popular mid-sized haulers is the Syncrofalke hauler (manufactured by Mayr-Melnhof Forsttechnik GmbH in Leoben, Austria) – a truck-mounted or trailer-mounted hauler with a 10–12 m tower and a knuckle boom loader for clearing the chute. The knuckle boom arm can be fitted with a processor head, allowing tree length extraction and processing to log length[6].

The present state of integration consists of the tower, the boom and the operator cab all assembled on one turntable providing a swinging range of about 240 degrees.

Some features of this system are:

- The all-terrain cable crane is mounted on a truck chassis together with the cabin and grapple loader.
- The carriage used is a remote controlled Sherpa U3 suitable for both uphill and downhill yarding.
- Maximum line tension in the skyline is 89kN (dependent upon line type).
- The carrying capacity of the cable crane is 3.0–4.0 tonnes [16]

Table 1. Rope specifications for Syncrofalke Processor-tower-yarder.

Rope Type	Length	Diameter
Skyline	900 m	22 mm
Mainrope	1,900 m	12 mm
Tailrope	1,900 m	10 mm
Guy rope	4 x 70 m	22 mm

Reference: http://www.mm-forsttechnik.at/forsttechnik/download/SF_englisch.pdf

Remote Control

By the end of the 1990s processor-tower-yarders (PTYs) equipped with radio controlled carriages and automatic carriage movement had become standard for all manufacturers (Table 2) [5].

Remote radio control results in considerable relief to the yarder operator, enabling him to carry out additional work, such as clearing the chute or stacking the extracted stems with the hydraulic loader, or even operating the processor to delimb the tree stems.

Table 2. Processor tower yarders of Central European manufacturers[5].

Manufacturer	***Yarder***	***Processor***
Herzog	Grizzly-1000	Keto 150
Koller	K-500	Konrad Woody 50
Konrad	Mounty-4000	Konrad Woody 60
Mayr-Melnhof	Syncro Falke	Silvatec 445 MD50
Tröstl	TST 700	Silvatec 555 MD60
Valentini	V 600	Wolf 50 B
Wolf	PKM 12	

Discussion

In terms of fitting an integrated knuckle-boom loader/processor to existing haulers in New Zealand, discussions with forestry equipment manufacturers and design engineers highlighted some engineering issues.

It was revealed that some companies in New Zealand had investigated adding a boom and arm to a tower yarder some years ago. This was essentially to make it operate as a swing yarder, for decking the logs to the side of the chute/machine. A number of technical issues were identified:

- A bending moment applied at the lower section of the tower.
- Boom idle position – what to do with the arm when the tower yarder was used as it was originally designed – where does the arm get 'parked'?
- When the tower was lowered for transport, the arm would be on top, and this created an over-height issue for highway moves.

These issues, however, apply only for end-mounted tower yarders. For side-mounted towers (for example the Madill 172 and the Brightwater BE 70) the storage issues are reduced as the tower lies along the machine and any arm could be no higher than the tower itself.

The side-mounted towers also lend themselves more to the fitting of a completely independent boom with processor or de-limber attachment. It would most likely have to be mounted at the cab end so the operator could view what he/she was doing. Issues might be the overall width of the yarder, additional stabilising legs, strengthening the chassis for the overturning moment from the arm with a log on the end of it, overall weight of the machine with a three or four tonne processing head, plus boom weight. It is likely it would be feasible to fit a boom onto a new yarder, but not feasible on existing yarders without incurring excessive costs.

Economically it was estimated that the cost of retrofitting any attachment to existing haulers would likely be more than the value of the machine it was fitted to considering the condition and age of most of these machines in New Zealand.

In order for any productivity advantage to be achieved in a tree length cable logging operation, the yarder operator will have to perform operations such as clearing the chute, delimbing/processing and preliminary sorting (Figure 4)[5].

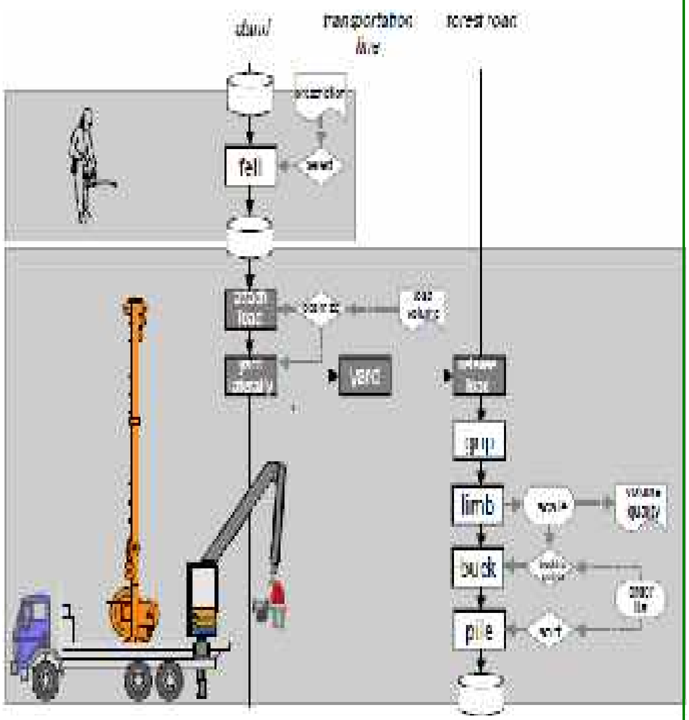

Figure 4. Integrated cable yarder system: Processing at the landing with an integrated boom-mounted processor[5].

In that case, most of the "productive" elements of the yarder cycle – such as outhaul, position carriage, hook on, break out and inhaul – would have to be automated. Automated or semi-automated control systems for carriage/rigging outhaul and inhaul (as well as unhook) have been developed. In this scenario, control over the carriage/rigging movement would be transferred to the breaker-out once reaching the cutover, allowing better control, improved safety and decreased cycle time.

From recent hauler productivity data[8, 9, 10] it is clear that these cycle elements take up to 80% of haul cycle and if these could be automated as is the case with the Central European mobile yarders, the yarder operator would be efficiently utilised performing delimbing/processing/sorting operations on the skid site. That could increase system productivity and reduce costs by reducing the number of machines (excavator loader for chute clearing or a dedicated processor-loader) and labour required.

In order for such a system to work in a commercial plantation radiata pine harvesting operation, however, most of the "traditional" yarder cycle elements would have to be automated – such as automatic carriage/rigging out-haul and in-haul as well as unhook.

Radio controlled chokers provide an immediate solution for the unhook cycle element. Radio controlled carriages and automatic carriage movement would need to be developed in conjunction with integrating the loading arm/processor head to the yarder body. Also, additional training would be required if such a system is developed, and some practices may need to change in terms of implementing new and "less common" cable rigging systems.

Conclusions

Processor tower yarders (PTY) equipped with radio controlled carriages and automatic carriage movement are widely used in Europe and parts of South America.

In terms of fitting an integrated knuckle-boom loader/processor on the existing haulers in New Zealand, some engineering issues have been highlighted by equipment design engineers which could be overcome at a cost.

However, the requirements for retrofitting such as weight issues mean that such a system is more likely to be feasible as part of the design of a new machine than fitted to an existing one.

Radio controlled chokers, carriages and automatic carriage movement should be considered in conjunction with integrating a loading arm/processor head to the yarder body.

Additional training would be required if such a system is developed, and some practices may need to change.

Future harvesting research should focus on further integration of intelligent behaviour of yarders and carriages through mechatronics, automation, and teleoperation. Such changes would necessitate thorough investigation of harvest systems design and application of ergonomics.

Acknowledgements

The contributions of Wayne Gray from Brightwater Engineering Ltd and Tony Taylor from EMS Ltd are highly appreciated.

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