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AN EXCAVATOR/STATIC DELIMBER COMBINATION

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Figure 1 - Komatsu PC400 Excavator and Holmes static delimber in operation

ABSTRACT

A PC400 excavator and contractor-built static delimber were evaluated, delimbing tree length radiata. The combination was part of a clearfell operation that was mechanised in all but the log-making activity. Details of the machines and the operational setup are given. Two operators were timed delimbing a total of 294 tree lengths. Estimated productivity for the two different operators was 82m³ and 120m³ per productive machine hour respectively. Variables affecting productivity are discussed including: tree size, malformation, excavator swings required, and operator variation. A costing is included.

INTRODUCTION

A recent survey of mechanised harvesting equipment (March, 1995), indicated that static delimbers are by far the most common mechanical means used for delimbing clearfell radiata pine. Of the 65 static delimbers surveyed, most work in radiata clearfell, particularly in smaller piece size operations. Approximately half are associated with cable and half with ground-based operations. Bell static delimbers make up 82% of all units surveyed. Static delimbers are popular because they are relatively inexpensive, they delimb most radiata to a reasonable standard, and they remove the need for motor-manual delimbing.

Static delimbers require a separate machine to pull tree lengths through the delimbing knives. This is most frequently achieved with one of a range of Bell Logger models, but has also been carried out effectively by grapple skidder, and more recently by hydraulic excavator-based loaders. Two previous reports describe the use of static delimbers in radiata clearfell, on cable country (Jones and Evanson, 1992), and a ground-based operation (Hill and Evanson, 1995).

This report describes the performance of a Komatsu PC400 working with the Holmes static delimber (HSD) (Figure 1), a purpose-built delimber developed by a local radiata clearfell contractor, being part of a mechanised ground-based operation.

ACKNOWLEDGEMENTS

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MACHINERY DETAILS

Komatsu PC400 :

Operating Weight - 40 tonnes
Power - 199kW
Reach - exceeds 10m
Lift (at max. reach/over front) - 6 tonnes

The HSD (Figure 2), has two wheels at the rear and a solid stabiliser at the front. A bar above the stabiliser allows the excavator to lift the front and move the delimber. The operating weight is estimated to be between four and five tonnes. The delimbing assembly is pinned centrally and can tilt on a vertical axis only. There are currently three wrap-around knife sets, one towards the front with a maximum enclosure of 70cm diameter, and two towards the rear. A single fixed knife is attached to the delimbing bed at the rear. A Lister diesel motor powers the hydraulics, usually operated at around 600psi, and the knife operation is radio controlled.

Figure 2 - Holmes static delimber

OPERATION DESCRIPTION

The PC400/HSD combination is part of a mechanised radiata pine clearfelling operation. Trees are felled and bunched by a Caterpillar 235B FB equipped with a 2800 Rotosaw. The trees are then delimbed on the cutover and left in rough bunches for extraction by a Caterpillar 518 grapple skidder. Log processing is carried out manually on the landing, by a sub-contractor.

The PC400 grapple grabs the bar above the stabiliser at the front of the HSD and usually tows it in front of the excavator when moving between felling sites or between bunches within a felling site. Less often, the HSD may be grappled in the same manner and pushed short distances between adjacent bunches.

The preferred layout for the PC400 and HSD in relation to a bunch is shown in Figure 3. Ideally, the excavator should be located near its maximum reach from the trees.

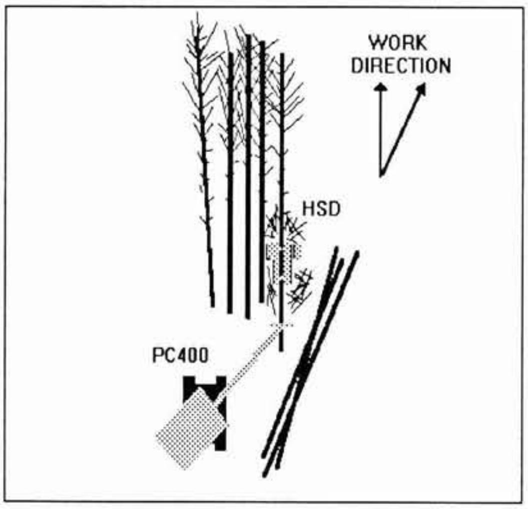

Figure 3 - Layout at delimbing site

Trees are lifted by the butt and placed on the delimbing bed of the HSD, then the wrap-around knives are closed. The excavator then slews in a clockwise direction, altering the angle of the boom to maintain a direct pull through the knives. At maximum outswing the tree is released, preferably on to other logs, to assist sliding. The excavator slews back and re-grapples the stem to swing the next section through. The final swing is often little more than opening the knives, lifting out the top and swinging it aside. A single pass through the knives usually completes delimbing, but terrain shape, log ends catching against obstacles and stem malformation, may all result in an increased number of less effective swings. Slash was periodically removed from around the delimber.

The delimbing operation progresses forwards on a swath, either directly back or on an acute angle to the right (Figure 3).

STUDY DETAILS AND METHOD

Location	Kaingaroa Forest
Species	Radiata Pine
Age	32 years
Stocking (live)	240 sph
Malformation	7%
Av. DBH (ob)	50 cm
Av. Tree Height	41 m
Recoverable Vol/ha	587 m^3
Av. Piece Size	2.30 m^3
Terrain	Flat
Soils	Free draining pumice
Undergrowth	Light
Weather	Fine

Prior to felling, most trees involved in this study were measured for DBH, and colour coded at breast height (1.4m) into five diameter classes covering the range of diameters present. Continuous time study was carried out on the PC400/HSD combination for defined elements of the complete delimbing cycle. Diameter class, tree form and the number of excavator swings required, were recorded against the time to handle individual trees. The frequency, time and distance of HSD shifts between bunches within a felled area were recorded, but not the time taken to shift between alternative felling faces.

After delimbing, a sample of log lengths and small-end diameters was recorded, and a delimbing quality assessment was carried out.

Element Descripion

"Load" time, is the time required to pick up a tree from an unlimbed bunch, place it on the HSD and close the knives.

"Delimb" time is the time taken to pull the stem through the delimber, leaving it in a rough bunch for extraction.

"Clear" time, is the time spent removing branches that accumulate around the delimber.

"Other" work includes placing merchantable broken tops aside in heaps, delimbing some larger merchantable tops, limited shovel logging primarily to assist the following delimbing, and rearrangement of the stacks to assist extraction.

"Shift" time is the total time taken to shift and set up, from one bunch site to the next. It does not include major shifts between felling sites around the setting.

RESULTS

Two operators were observed delimbing a total of 294 trees. A diameter distribution of the delimbed trees is shown in Figure 4. A breakdown of the productive cycle time, together with an estimate of productivity is shown in Table1.

Figure 4 - Delimbed trees

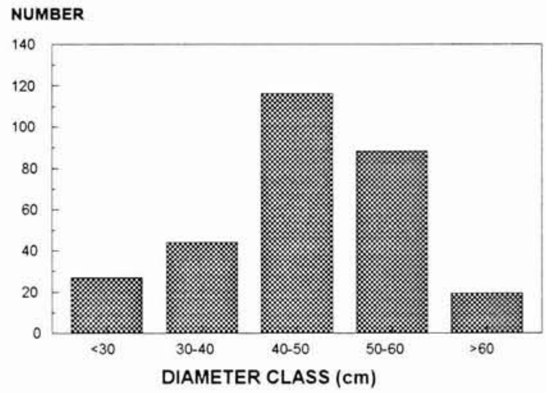

Table 1 - Productive cycle details and productivity estimate

	Operator A	Operator B	Combined Data		
Sample size	191	103		294	
Element / Operation	Av. Time/tree (mins)	Av. Time/tree (mins)	Frequency *1	Av. Time/tree (mins)	%
Load	0.28 ± 0.16 *2	0.31 ± 0.15	100%	0.29 ± 0.15	22
Delimb	0.46 ± 0.21	0.66 ± 0.29	100%	0.53 ± 0.26	40
Clear	0.04	0.09	15%	0.06	4
Other work	0.13	0.26	25%	0.17	13
Shift *3	0.24	0.36	17%	0.29	21
TOTAL	1.15	1.68		1.34	100
Trees / Shift	6.4	4.9		5.8	
Av. Shift Distance (m)	11	17		14	
Trees / PMH	52	36		45	
M^3 / PMH *4	120	82		103	

*1 Not all elements occur every time a tree is delimbed: a frequency of 50% indicates that an element occurs on average, once every two cycles. The average element time per occurrence can be determined by dividing the average time per cycle by the frequency expressed as a decimal number.

*2 Standard Deviation

*3 Allows for shifting within a single felling site, but not between alternative felling sites within a setting.

*4 Assumes an average piece size of $2.3m^3$.

"Load" times were similar for the two operators observed, and were not significantly affected by tree size.

"Delimb" time accounted for close to 40% of the productive cycle time and varied significantly between operators, mainly due to technique and terrain obstacles.

Spindly tops (due to reduced felling breakage) were often simply lifted off the HSD and swung aside, particularly if the butt of the log became stuck; this counted as an additional swing.

One operator cleared branches from around the delimber more frequently. However, overall it only accounted for around 4% of the productive time.

Differences in "shift" time between the two operators observed, are mainly due to the difference in average trees per bunch, and the distance moved between adjacent bunches. The average time per "shift", based on 51 observations, was 1.64 minutes, for an average distance of 14 metres.

The effect of tree size on "load" and "delimb" time, for the combined data, is shown graphically in Figure 5. This graph suggests a positive relationship with tree diameter, but also indicates that little of the variation that does occur is explained by tree diameter. Load and delimb time takes about 62% of the productive cycle time. It is likely that productivity in terms of m^3/productive machine hour (PMH) will be closely linked to merchantable piece size.

The effect of the number of swings per tree on the "delimb" time is shown in Figure 6 and indicates a strong positive relationship. Tree size had little effect on the number of swings required.

Malformed stems (sample size = 21) took on average 33% longer to load and delimb, than normal formed stems, primarily due to the increased number of swings required to

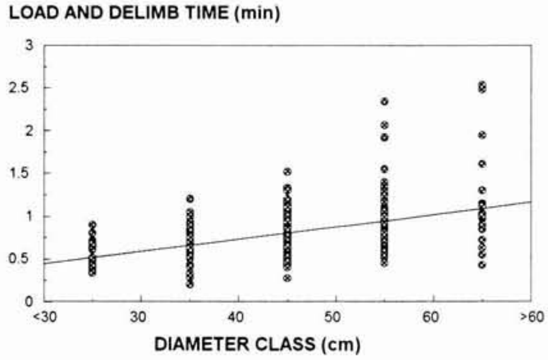

Figure 5 - Load and delimb time versus diameter class

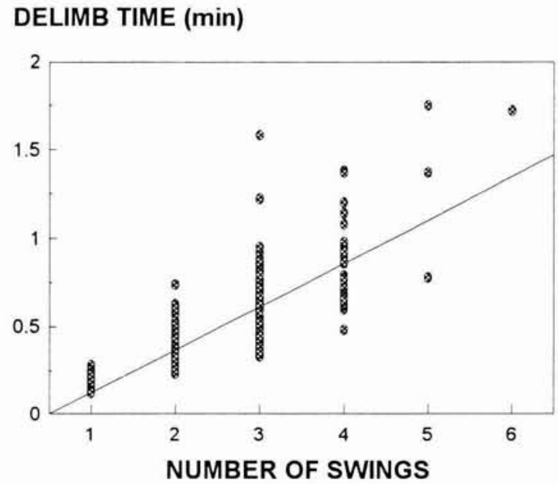

Figure 6 - Delimb time versus number of swings

pull them through the delimber (3.2 versus 2.5). Also, delimbing was often incomplete and the overall quality was lower than that observed on normal formed stems.

A sample of 60 delimbed tree lengths, covering the range of diameters present, was measured for length and small end diameter (SED). Average length was 28 metres (range 17m to 41m), and average SED was 18cm.

A subjective assessment of delimbing quality showed a reasonable but variable standard. Malformation, including swept and twisted stems, seemed to cause poor delimbing quality or stem sections left unlimbed. Occasionally, tops were lifted aside unlimbed, particularly when the butt became stuck well out from the excavator. Few instances of branch tear or draw were noted, and there was little evidence of grapple damage or knife slicing along the stem. Considerable amounts of bark were removed during delimbing and when running the logs across each other.

COSTING

A costing for the PC400/HSD combination, with an operator (fully utilised for delimbing only), was carried out using the LIRO costing format (Riddle, 1994). Capital costs used for estimating daily costs were $500,000 for the PC400, with 50% residual value after 8000 hours, and $80,000 for the HSD with 25% residual value after 5,000 hours. Assuming 235 work days per year, a daily cost of $1265 was derived as follows:

PC400	$735
HSD	$175
Operator	$165
Supplies and Overheads	$15
Transport	$60
Profit - 10%	$115
TOTAL	$1265 / workday

Assuming daily production of 650 tonnes, the cost of delimbing by this method is $1.95/tonne.

DISCUSSION

- Due to the short duration of this study, non-productive delay time has been excluded. However during the study, both machines were mechanically reliable and utilisation was high.
- The most proficient operator mentioned that it took him around six months to develop his technique, and that as his skills developed, damage to the HSD reduced.
- The strong positive relationship between delimbing time and the number of swings required, suggests that operating with a smaller excavator in this large tree size, is likely to be significantly less productive, due to reduced reach, and reduced lift at maximum reach. This had been confirmed by the contractor's previous experience in this tree size with a PC300.
- The tidy bunches prepared by the feller-buncher enhanced the delimbing operation. Delimbing productivity following manual felling would be significantly lower.
- Stands with a high incidence of malformation will not suit this delimbing operation. Productivity and/ or delimbing quality would suffer.
- A modification replacing the existing wheels with small skidder wheels, should improve the ability to move the HSD across the cutover.
- An environmental benefit of this delimbing option is that all branch material is left distributed across the cutover.
- The excavator gives the operation a degree of flexibility, with its ability to shovel log, bunch for grapple skidder extraction, and even load and sort if required. Any time spent on these other activities during a normal shift will reduce daily production, however a double shift is an option. The delimbing operation has worked successfully at night.

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Hill, S., Evanson, T. (1995) : "The Trinder Static Delimber in a Ground-Based Clearfell Operation", LIRO Report Vol. 20 No. 10.

Riddle, A. (1994) : "Business Management for Logging", LIRO Handbook.

The costs stated in this report have been derived using the procedure shown in the LIRO "Business Management for Logging" Handbook. They are only indicative estimates and do not necessarily represent the actual costs for this operation.