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EVALUATION OF A DENIS DP550 LOG PROCESSOR

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Abstract

During the winter of 1989-90, the Forest Engineering Research Institute of Canada (FERIC) monitored the performance of a Denis DP550 log processor working in a conventional landing operation. The study took place near Fraser Lake, British Columbia, and was conducted in cooperation with West Fraser Mills Ltd. Production, availability, utilization and costs were determined. The Denis DP550 is the most recent boom-attached processor to be introduced to Canada's rugged forest conditions.

Introduction

Équipement Denis Inc. of Montreal (now Denharco Inc.), in cooperation with Waratah Forestry Equipment of New Zealand, introduced the Denis DP550 log processor (Figure 1) to the Interior of British Columbia during the summer of 1989 (Araki 1990). The DP550 is designed after the Waratah feller-processor, but has been modified to suit the rugged Canadian forest conditions. The machine was set up to operate only as a processor, capable of processing stems with a maximum diameter of 50 cm. It can be mounted on any medium-sized (90-100 kW) excavator carrier and is suitable for most forest stands in the Interior of British Columbia.

During the winter of 1989-90, the Forest Engineering Research Institute of Canada (FERIC) assessed the performance of a Denis DP550 processor operating in the Fraser Lake area for West Fraser Mills Ltd. FERIC also studied a second Denis DP550 at Vanderhoof to determine productivity when length measuring was required. Both DP550's were mounted on John Deere 690D excavators and were used to process stems in a conventional landing operation (Figure 2). The base cost of each machine was $352 500, with the head representing about 35% of this amount.

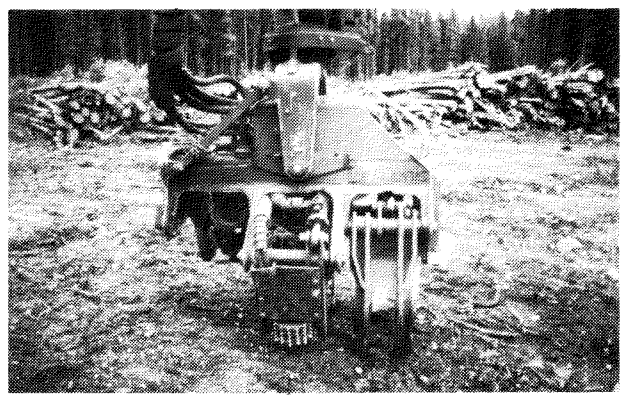

Figure 1. DP550 processing head.

Figure 2. DP550 mounted on a JD 690D excavator carrier, working on a conventional landing.

Keywords: Harvesting, Processing, Delimbing, Evaluation, Productivity, Costs, Denis DP550 processor.

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Study Method

Two types of studies are reported here. In the shift-level study, information was collected with a DSR Servis recorder, and in the detailed-timing study information was collected with a hand-held data logger during short observation periods. The shift-level study recorded the mechanical availability and utilization of the processor, the number of trees processed, and the reasons for delays longer than 10 minutes. FERIC also classified mechanical delays of the processor and carrier by cause and duration. The volume of logs produced during the study period was determined from the weigh-scale records at the sawmill. Because the DP550 can be attached to any carrier, cost comparisons were separated so other carrier costs can be substituted.

The data logger enabled a FERIC researcher to gather parameters such as butt-diameter class and species, and events such as long-butting[1] and resetting, during the processing of individual stems. Appendix I presents a complete description of the recorded elements, parameters, and events. Detailed-timing data were collected periodically throughout the shift-level period to gain a representative sampling of data.

Butt classes were divided into 10-cm increments (Table 1).

FERIC determined the average volume per stem in the individual diameter classes by measuring a sampling of stems in each class, down to a 10-cm top. Volumes derived by FERIC were used to compare the relative productivity of the processor during the detailed-timing segment and are not representative of the average volume for the whole block.

Table 1. Butt-Diameter Classes

Butt-diameter class at mid point (cm)	Butt-diameter range (cm)
10	<14.9
20	15.0 - 24.9
30	25.0 - 34.9
40	35.0 - 44.9
50	45.0 - 54.9
60	≥55.0

[1] Long-butting is a term that refers to cutting off the butt end of the stem to eliminate defect (e.g. rot, flare, pistol grip, undercut notches, stump pull, etc.) before processing commences.

Site and System Descriptions

The DP550 processor, owned by Sandback Logging Ltd., worked under contract for West Fraser Mills Ltd. at Fraser Lake, British Columbia. The study block, located southwest of Fraser Lake, was a stand of mature lodgepole pine, white spruce, and sub-alpine fir. Average stand volume was 250 m^3/ha and average tree size was 0.48 m^3. The equipment force on the harvesting operation included a Case 1187 feller-buncher with a Harricana felling head, two skidders (grapple and line), the DP550 processor, and a Caterpillar 966 loader. Stems were processed by the DP550 on the landing, with the sub-alpine fir being separated from the pine and spruce. All stems were loaded onto off-highway trucks and hauled, tree-length, to the mill.

The second DP550, owned by Pitka Logging Ltd., operated near Vanderhoof, British Columbia for Westar Timber Ltd. The lodgepole pine/white spruce stand was very uniform in height and size. Average stand volume was 350 m^3/ha with an average stem size of 0.4 m^3. The harvesting operation included a Koehring feller-buncher, two John Deere 743 grapple skidders, a Steyr KP40 processor, the DP550 processor, and Caterpillar 966 loader. As part of the processing procedure, the operator separated sub-alpine fir as well as large and small stems. Stems were processed for highway hauling, i.e. maximum log length was 19.7 m.

Operating Procedure

The DP550 processor head is positioned over the butt of a stem in the deck of unprocessed stems, and a set of long grapple arms closes around the butt. A set of roller arms clamp the butt against a hydraulically driven spiked chain that, together with the powered spiked rollers, drives the stem through a set of delimbing knives on the grapple arms at speeds up to 3.5 m/s. While processing is taking place, the boom swings the processor over a delimbing area between the decks of full-tree and tree-length stems. The butt of the stem slides out onto the deck of manufactured logs and when the desired log length is reached, the operator aligns the top of the log and bucks it off with the hydraulically powered chain saw. If the stem can be bucked into two or more logs, the processor continues processing until the minimum top diameter is reached.

Processing very large stems was accomplished by grasping the stem at the butt and pulling it partially out of the full-tree deck and dropping it onto the tree-length deck. The DP550 is positioned at the butt to set the length-measuring device. The head moves

down the length of the log until the roller arms can firmly grasp the stem, and then normal processing continues. The DP550 has enough power to pull and delimb the large stems once the rollers are engaged. The spiked rollers did not spin or slip once they were fully engaged. On a number of occasions the operator was able to process several small stems at the same time.

Results and Discussion

Shift-Level Study

Shift-level studies were done only at the Fraser Lake operation. During the 62-day monitoring period, the delimber worked ten hours per day, six days per week. FERIC recorded production over 54 shifts; two days were lost due to a major breakdown and waiting for parts, and six days were weekend days or time off. The DP550 had a machine availability of 82.1% and a utilization level of 79.1% (Table 2). Although the Servis recorder was not able to differentiate the moving times, the operator noted these each day so the processing time could be determined.

Comparison of the relative daily production of the processors showed that the timing for both moving and organizational procedures played important roles in determining the productivity. The Fraser Lake operation produced approximately nine off-highway loads per day, or 520 m^3 per day. Because the landings were small, the processor moved at least twice each day with move time accounting for 0.78 h/day. On the other hand, the Vanderhoof operation produced 15 highway loads or 650 m^3/day, because the delimber rarely moved more than once a day. Landings were slightly larger, but were organized to accommodate two decks of full-tree stems placed one behind the other. At least 450 m^3 of stems were decked at each landing for the processor.

Appendix II summarizes the mechanical delays; two production days were lost when the electrical system failed. The machine availability would have been higher if some parts, such as hydraulic hoses, had been available on the site. A total of 54 361 stems were processed, resulting in 24 494 m^3 of logs.

Detailed-Timing Study

Thirty-two hours of detailed-timing data were collected during the shift-level study; 4525 stems, or 1891 m^3, were processed during this timing period. Both the Fraser Lake and Vanderhoof data are summarized in Table 3. The average production was 142 stems/h or 59.35 m^3/h. The difference in production of the DP550's in the two operations can be attributed to a number of factors: better quality of timber, more efficient use of landings, better organization, and a more experienced processor operator at the Vanderhoof site. The Vanderhoof detailed-timing study involved two visits to the operation. Timing was done for approximately 4 h each visit.

Table 2. Shift-Level Study: Summary - Fraser Lake

Elements	Results
Productive machine hours (PMH) (h)	393.8
Mechanical delay hours (MDH)	
Wait (h)	23.8
Repairs (h)	55.8
Service (h)	9.6
Subtotal (h)	89.2
Nonmechanical delay hours (NDH)	
Operational (h)	9.6
Organizational (h)	5.0
Subtotal (h)	14.6
Total: All delays (h)	103.8
Total machine hours (TMH) (h)	497.6
Utilization (PMH/TMH) (%)	79.1
Mechanical availability (TMH-MDH)/TMH (%)	82.1
Total stems processed [a] (no.)	54 361
Volume produced (m^3) [b]	24 494
Average volume (m^3/stem)	0.45
Shifts with production (no.)	52
Productivity	
Stems/PMH (no.)	138.0
Stems/TMH (no.)	109.2
m^3/PMH	62.2
m^3/TMH	49.2
m^3/8-h shift	393.6

[a] Total stems may be incorrect as operator may have incorrectly counted the total stems/day.
[b] Volume from sawmill weigh scale.

Distribution of productive time elements is presented in Table 4. The majority of the move time in the Fraser Lake study is really travel time that occurred between landings rather than being the time required to position the excavator along a log deck. FERIC was unable to verify that any significant increase in processing time occurred when measuring was required. Total delimbing and bucking times at both operations were not significantly different even though individual timing elements may have been different.

Table 5 shows the distribution of average processing times by butt sizes and species for both study sites. Although processing time per stem increased with diameter, productivity also increased dramatically with butt diameter.

The combined average time to process a stem was 0.39 min. Table 6 shows the individual elements used to determine this average processing time.

Table 3. Detailed-Timing Study: Summary

Elements	Fraser Lake		Vanderhoof		Total	
	min	%	min	%	min	%
Productive Time						
Processing	1400.78	92.5	397.30	96.4	1798.08	93.3
Handling nonmerchantable (Abort)	12.15	0.8	3.91	1.0	16.06	0.9
Moving	20.75	1.3	6.82	1.6	27.57	1.4
Total delays <10 min	81.91	5.4	4.02	1.0	85.93	4.4
Total study time	1515.59	100.0	412.05	100.0	1927.64	100.0
Total stems processed (no.)	3320		1205		4525	
Average volume/stem (m^3)	0.40		0.47		0.42	
Total volume processed (m^3)	1324		566		1891	
Average stems/h (no.)	132		177		142	
Average volume/h (m^3)	52.9		83.3		59.4	

Table 4. Breakdown of Productive-Timing Elements

	Observed time						
	Fraser Lake		Vanderhoof		Total	Occurrences	Average time/ occurrence
Activity [a]	min	%	min	%	(min)	(no.)	(min)
Pick	489.96	35.0	151.37	38.2	641.33	4 430	0.14
Process	723.14	51.7	205.32	51.9	928.46	4 430	0.21
Process 2	54.76	3.9	28.19	7.0	82.95	348	0.23
Move	108.73	7.8	5.81	1.3	114.54	105	1.09
Clean	13.35	0.9	2.50	0.6	15.85	65	0.24
Deck	10.84	0.7	4.11	1.0	14.95	43	0.34
Subtotal	1 400.78	100.0	397.30	100.0	1 798.08		
Delay	81.91	-	4.02	-	85.93	24	3.58
Sumtime	20.75	-	6.82	-	27.57	69	0.40
Abort	12.15	-	3.91	-	16.06	35	0.46
Total	1515.59		412.05		1927.64		

[a] See Appendix I for definitions.

Delay times less than 10 min recorded during the detailed timing are summarized in Table 7.

Other Observations

The spiked rollers did leave some indentations in the bark and outer wood. The indentations did not appear to be a problem to the destination sawmill. Spike marks in soft sapling wood would be deeper and could become a concern.

The electrical hookup to the processor needs to be simplified or modularized so that the operator can easily repair it. Although the electrical system of the DP550 was not complicated by any measuring attachments, the contractor still had difficulty locating an electrical failure.

Delimbing quality on small-diameter stems in the winter was very good because the branches were brittle. In the spring and summer limbs may be more flexible, and therefore extra delimbing time may be incurred.

Machine-Cost Analysis

The cost of processing with the DP550 in this study varied from \$1.92/m^3 at the Vanderhoof location to \$2.11/m^3 at Fraser Lake (Appendix III). The Vanderhoof cost is based on an estimated production of 54 m^3/h, while the Fraser Lake production cost is based on the shift-level study production of 49.2 m^3/h. FERIC's cost analysis does not include taxes, profit and risk, or supervisory costs.

Table 5. Production, by Species and Butt-Diameter Class

Location and species	Butt-diameter class at mid point (cm)	Gross merchantable volume (m^3/stem)	Total stems (no.)	Total time (min)	Volume processed (m^3)	Average processing time (min/stem)	Projected productivity: Stems (no./h)	Projected productivity: Volume (m^3/h)
FRASER LAKE								
Pine	10	0.083	107	33.25	8.9	0.31	193.1	16.0
	20	0.285	781	286.93	222.6	0.37	162.1	46.2
	30	0.804	171	83.32	137.5	0.49	122.3	98.3
	40	1.220	28	16.08	34.2	0.57	104.5	127.5
	50	2.381	1	1.07	2.4	1.07	56.1	133.5
Spruce	10	0.077	195	62.32	15.0	0.32	187.7	14.5
	20	0.188	545	197.83	102.5	0.37	161.6	30.4
	30	0.657	270	126.62	177.4	0.48	124.7	82.0
	40	1.162	126	76.70	146.4	0.62	96.5	112.1
	50	2.111	34	32.20	71.8	0.95	63.4	133.7
	60	4.107	14	17.96	57.5	1.28	46.8	192.1
Sub-alpine fir	10	0.091	130	36.43	11.8	0.28	214.1	19.5
	20	0.231	622	214.88	143.7	0.35	170.9	39.5
	30	0.583	189	85.34	110.2	0.46	131.6	76.7
	40	1.408	36	18.94	50.7	0.53	114.0	160.6
	50	2.015	4	4.23	8.0	1.14	52.6	106.1
	60	3.950	2	2.12	7.9	1.06	56.6	223.6
All	10	0.083	432	132.00	35.7	0.31	196.4	16.2
	20	0.241	1 948	699.64	468.8	0.36	164.6	39.6
	30	0.675	630	295.28	425.1	0.48	126.0	85.0
	40	1.217	190	111.72	231.3	0.60	100.5	122.4
	50	2.108	39	37.50	82.2	0.97	61.9	130.4
	60	4.087	16	20.08	65.4	1.26	47.8	195.4
VANDERHOOF								
Pine	10	0.080	66	19.39	5.3	0.29	239.1	19.1
	20	0.372	676	206.47	251.1	0.31	196.4	73.1
	30	0.833	238	105.14	198.3	0.44	136.6	113.8
	40	1.305	32	17.64	41.8	0.55	109.0	142.3
	50	1.981	4	1.94	7.9	0.48	125.7	248.9
Spruce	10	0.075	67	16.59	5.0	0.24	245.6	18.4
	20	0.200	79	23.29	15.6	0.29	207.2	41.4
	30	0.635	11	4.19	7.0	0.37	160.2	101.7
	40	1.115	4	2.65	4.4	0.66	90.9	101.4

Table 6. Average Time to Process a Stem

Activity	Time (min)
Pick	0.15
Process	0.22
Process 2 [a]	0.02 (.24)
Total	0.39

[a] This element did not occur on every stem, but the value shown is the average prorated time. The bracketed number is the average actual time for processing second log.

Table 7. Delay Time: Summary

Activity	Total time (min)	Occurrences: no.	Occurrences: %
Saw chain	29.0	14	33.8
Personal[a]	20.4	7	23.7
Discussion	17.5	4	20.4
Service[b]	10.9	2	12.7
Unknown	7.2	10	8.3
Traffic[c]	0.9	1	1.1
Total	85.9		100.0

[a] Personal time sometimes included the operator's lunch hour because he ate while the machine moved to a new landing.
[b] Servicing was not always done between shifts.
[c] Processor had to move off road to let other vehicles pass.

Conclusions

FERIC studied the performance of two Denis DP550 log processors working in the harvesting conditions of the British Columbia Interior in the winter of 1989-90. The processors, mounted on John Deere 690D excavators, were the first two sold in the province and were performing reliably after only six months of operation.

The DP550 observed in this study had a machine availability of 82.1%, but this would have been higher if spare parts had been readily available on site. The utilization level of 79.1% is reasonable because the nonmechanical delays represented only 3% of the total study time.

Based on the shift-level data collected by FERIC, the DP550 processed an average of 49.2 m^3/h at a calculated cost of \$2.11/m^3.

References

Araki, Dennis. 1990. Initial evaluation of the Denis DP550 Processor. FERIC, Vancouver. Field Note Processing-18. 2 pp.

Disclaimer

Appendix I

Definitions

Timing Elements

pick - Time required from discharge of top of previous stem to secure butt of next stem.

process - Time required from the point when the stem begins moving in the delimber until first log is manufactured.

process 2 - Time required from the end of bucking the first log to the end of cutting the second log.

move - Time taken by the excavator to move into position to process more stems.

clean - Time taken to clean around working area.

deck - Time taken to rearrange logs on the log deck.

delay - Time where the delimber was not actively processing stems.

sumtime - Total processing time when timing of individual elements were missed.

Timing Events

abort - Stem that is discarded or not processed after it is picked up.

Appendix II

Shift-Level Delays: Summary

Description	Occurrences (no.)	Time (h)
Nonmechanical delays		
Personal (lunch, coffee)	21	7.1
Organizational	8	4.6
Other equipment delay	1	1.0
Unknown operational	8	1.9
Total nonmechanical delays	38	14.6
Mechanical delays		
Wait for parts	3	23.8
Repair to carrier	4	13.6
Repair to attachment		
Hydraulics	6	14.1
Electrical	13	21.6
Structural	10	6.5
Service and warm-up	30	9.6
Total mechanical delays	66	89.2

Appendix III

Machine Costs: DP550 Processor and John Deere 690 Excavator Carrier

Ownership costs	
Processor	
Total price, including measuring device (P) ($)	128 000
Scheduled time (h/y)	3 000
Expected life (H) (h)	9 000
Insurance (Ins) %	3
Interest (Int) %	14
Salvage value (S) = (P • .25) ($)	32 000
Average investment (AVI) = (P + S)/2 ($)	80 000
Loss in resale (P - S)/H ($/h)	10.66
Insurance cost (Ins • AVI)/h ($/h)	0.80
Interest cost (I • AVI)/h ($/h)	3.73
Total ($/L)	15.19
Carrier	
Total price, including guarding and conversion (P) ($)	224 500
Scheduled time (h/y)	3 000
Expected life (H) (h)	12 000
Insurance (Ins) (%)	3
Interest (Int) (%)	14
Salvage value (S) = (P • .25) ($)	56 125
Average investment (AVI) = (P + S)/2 ($)	140 312
Loss in resale (P - S)/H ($/h)	14.03
Insurance cost (AVI • Ins)/h ($/h)	1.40
Interest cost (AVI • Int)/h ($/h)	6.54
Total ($/h)	21.97
Total ownership cost (OC) ($/h)	37.16
Operating costs	
Annual repairs @ 20% of P (combined value) (R) ($)	70 500
Fuel (F) L/h	20
Fuel cost (C) ($/L)	0.42
Lube & oil (@ % of F • C) (%)	15
Wages (W) ($/h)	18.00
Benefits (% of W)	0.35
Repairs (R/h) ($/h)	23.50
Fuel & lube ($/h)	9.67
Wages & benefits (W • 135%) ($/h)	24.31
Overtime (2 h/8 h @ 1.5 • W •) 1.35) ($/h)	9.11
Total operating cost (OP) ($/h)	66.59
Total ownership & operating cost [a] ($/h)	103.75
Production (m^3/h)	49.2
Cost ($/$m^3$)	2.11

[a] These figures are based on FERIC's standard accounting formula for determining ownership, repair, and operating costs, and do not account for remote accommodation and machine support expenses. Actual hourly rates may vary.