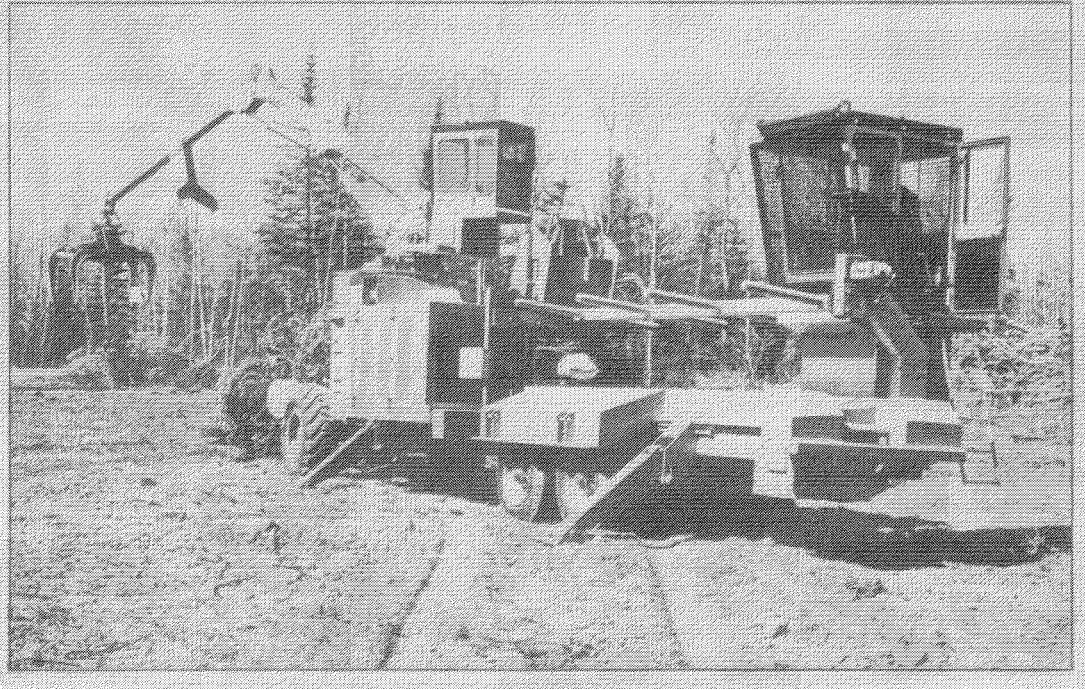
FERIC FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA
INSTITUT CANADIEN DE RECHERCHES EN GÉNIE FORESTIER

Technical Report No. TR-52

April 1982

Evaluation of the Hahn Pulp/Logger II Limber - Slasher

M.P. Folkema and R. Levesque



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PREFACE

This report on the Hahn Pulp/Logger II is one of a series of FERIC reports aimed at evaluating new logging machines. It is based on a series of detailed time studies carried out on several operations during 1981.

Some of the limitations of short-term studies are that they cannot fully explore the long-term production potential of machines which must often work under a broad range of conditions. Also, the observation period is too short to evaluate maintenance problems and the machine's mechanical availability. To provide the reader with some insights on mechanical problems, the major reasons for downtime during 1981 as reported by the user company, are also discussed in the report.

A conversion table for Metric and Imperial units is provided at the end of this report.

Grateful appreciation is extended to the company personnel of Riverlake Timber Ltd., Ignace, Ontario, to Pearson Lumber Ltd., of Atikokan, Ontario, and to Hahn Machinery Inc. of Two Harbors, Minnesota. A special word of thanks is extended to Chuck Spittlehouse of Riverlake Contractors Ltd., to Dan Murphy formerly of Hahn Machinery Inc. and to Doug MacGregor of FERIC for their contributions to this project.

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SUMMARY

The Hahn Pulp/Logger II is a self-propelled roadside processor that normally requires two operators. It delimbs and slashes full trees into pulpwood and sawlog lengths. FERIC's evaluation was based on a series of time studies on two Pulp/Logger II units operating in north-western Ontario during 1981.

One Pulp/Logger II operating near Atikokan, Ontario was a demonstrator unit operated by two persons employed by the manufacturer. The machine produced both pulpwood and sawlogs during a one-week demonstration period. The other unit located near Ignace, Ontario, was contractor-owned. It produced only 2.5-m pulpwood on a one-shift-per-day basis. The operators of the Ignace unit were more experienced and skilled than the two Hahn employees that operated the unit at Atikokan. The productivity results are summarized in Table S-1.

Table S-1. Productivity Summary

	Sawlogs & Pulpwood			Pulpwood Only		
	I[1]	II[2]	III[3]	I[1]	II[1]	III[1]
Volume per tree, m^3	.27	.30	.31	.15	.12	.18
Trees per processing cycle	2.1	1.1	1.5	2.0	2.2	2.5
Processing cycles per PMH	40	45	43	62	62	55
Trees processed per PMH	85	49	63	125	138	137
Productivity, m^3 per PMH	23.0	14.9	19.5	19.0	16.1	24.6

[1] Hahn is "on the road" - in front of the full tree pile.
[2] Hahn is "across the road" - straddling the road.
[3] Hot logging - Hahn is located on a landing.

The following general remarks on productivity can be made about the Hahn Pulp/Logger II:

i) Multiple-stem delimbing and slashing tend to reduce the adverse effect of small tree size on productivity. To optimize production the loader operator must load multiple stems whenever possible.

ii) The skill of the operators and their ability to co-ordinate their activities are the key factors to high productivity.

iii) The production of sawlogs & pulpwood vs. pulpwood only, for any given tree size, does not appear to affect productivity provided that there is adequate piling room available (i.e. no additional debris clearing is necessary to allow piling of sawlogs).

iv) Productivity on the Hahn is relatively insensitve to most of the normal variation in tree size and branchiness in the boreal forest. However, severe delimbing conditions may, at times, require a second or third pass of the delimbing carriage, thus reducing the productivity in some situations.

Delimbing quality was excellent on all the studies conducted by FERIC. Due to the direct drive and "axe-effect" of the hydraulically-driven delimbing carriage, all limbs, even those up to 13 cm in diameter could be removed.

The accumulation of logging slash on the road represents a major limitation to the use of the Pulp/Logger II if the road has to be kept open for other traffic. This debris must normally be pushed away with a skidder or crawler tractor before road vehicles can pass by. The debris build-up varies with the branchiness of the trees, the height of the full tree pile, the road width, etc.

The mobility of the Pulp/Logger II, when equipped with the hydrostatic rear tandem axle drive presented no problems during FERIC's studies. However, severe muddy conditions or sloping roads (hills) were non-existant in the study areas.

Some mechanical problems, as reported by the owner of the Ignace machine, occurred during the first year of use. The most significant problems included hydraulic leakage at the swivel couplings between the loader and the main frame (resulting from hose twisting), leakage of hydraulic fluid into the engine gearbox (resulting from seal failure) and cracks in the boom base of the loader unit. These problems are currently being studied by the manufacturer and may be reduced or eliminated in future units built.

A production and cost analyses of the Hahn Pulp/Logger II indicates that where suitable operating conditions exist, pulpwood and/or sawlogs can be produced at a cost similar to logging systems using sliding-boom delimbers with small, mobile, 2-product slashers. However, the capital investiment required for the Hahn is considerably lower.

INTRODUCTION

The Hahn Pulp/Logger II is a roadside processor that delimbs and slashes full trees into pulp and sawlog lengths, using two retractable butt plates. The machine was developed over a three year period by Hahn Machinery Inc. of Two Harbors, Minnesota, U.S.A.

The Pulp/Logger II is self-propelled, has three axles, and is equipped with a 119 kW diesel engine. The machine is 13.7 m in length and weighs approximately 24,000 kg. It requires two operators: one to operate the knuckle-boom loader, located at the front of the machine, and the other to operate the processing unit. The machine can be operated by a single operator since duplicate loader controls are provided in the processor operator's cab.

The loader unit is mounted on a turntable with continuous rotation. The knuckle-boom has a 7.3-m reach and 1 m^3 by-pass grapple. The delimbing carriage is hydrostatically-driven, has a 5.5-m delimbing stroke and travels at a maximum speed of 149 metres per minute. Sawlogs and pulpwood are fed into baskets located on each side of the machine by a hydraulically-driven, two-way sorter bar. Additional specifications are provided in Appendix A.

The two machines studied by FERIC had the following features, which were not available on earlier Pulp/ Logger units:

1) The delimbing knives opened wider to aid in loading of full tree butts and closed to 7 cm for improved delimbing quality.

2) A pyramid-shaped appendage was attached to the frame to aid in loading full trees into the delimbing knives.

3) The loader boom was extended from 6.7 to 7.3 m, to aid in discarding slash.

4) The shape of the "guillotine" holding mechanism was changed to redistribute holding pressure and reduce log end splitting.

5) Retractable 2.5 and 5.0-m butt plates were provided. This replaced an (unsatisfactory) photo-cell measuring system used on earlier Pulp/Logger units.

6) A retractable arm to help remove slash and debris from the infeed end of the machine was added.

7) The processor operator's cab was turned 90^{o} to face the infeed end of the machine.

8) The short wood basket was enlarged and closed on the ends to prevent logs from slipping out when working on slopes.

Hahn Machinery Inc. provides a hydrostatic drive system to both rear axles as optional equipment on the Hahn Pulp/Logger II. The above drive system was used on the Pulp/Logger II located at Pearson Lumber. The Pulp/Logger II owned by Riverlake Timber Ltd. had hydraulic drive only to the single front axle. NOTE: The type of drive and suspension system used did not have any effect on production during the studies conducted by FERIC, because of the limited test conditions.

Another feature only on the Pearson unit was a "live" heel on the loader which helped to extract large trees from the full tree pile more quickly.

In November 1981, the price of a Hahn Pulp/Logger II with the optional rear tandem axle drive was C$246,000 f.o.b. Thunder Bay, Ontario.

Figure 1. The Hahn Pulp/Logger II.

OPERATING SEQUENCE

The Hahn Pulp/Logger II is positioned close to the butts of the full tree pile. The loader then grasps a full tree and places the butt end onto the delimber carriage. The limbing knives close and the tree is advanced under the guillotine holding mechanism. The mechanism comes down on the butt and the first 5.0-m section of the tree is delimbed. The delimbed section is advanced to the butt plate and is cut off; two cuts are required if this section is divided into pulpwood. The rotator is activated and the bolt is kicked into the sawlog or pulpwood basket. Limbing and bucking is repeated until the tree is fully processed.

Multiple Trees - are sometimes butted against the lowered guillotine holding mechanism for better butt indexing.

Clearing slash - is done by returning the carriage to the front of the machine. The slash is held in place by lowering the retractable holding arm. The carriage is then quickly advanced and returned, dumping the debris onto the ground.

Piling processed products and clearing debris from around the machine is done with the loader grapple.

STUDY PROCEDURE

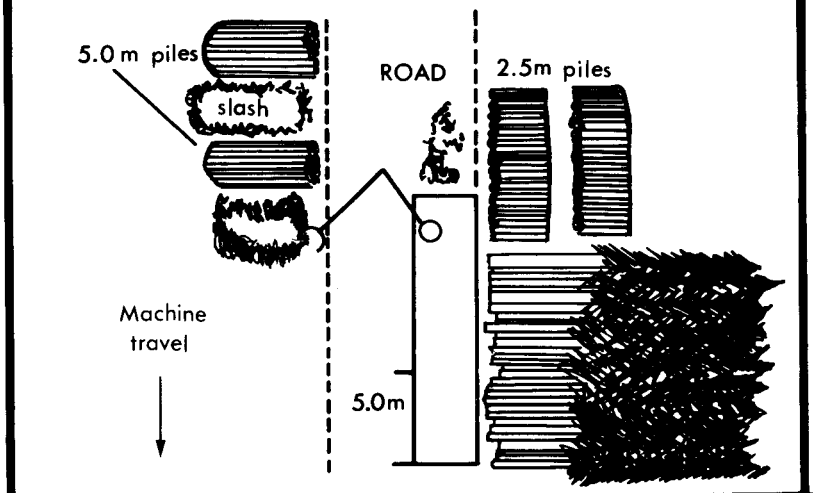
Two machines were studied by FERIC using electronic watchboards with time elements recorded to the closest centiminute (1/100 min.). This report presents the results of the processing cycle. The loader cycle was also studied but the results were not included because the loader and processor cycle are interdependent and because FERIC's studies indicated that with experienced operators (in most eastern Canadian conditions) the loader causes much more delay to the processor than vice versa.

Each study was based on continious timing and included operational delays, mechanical breakdowns and personal delays of less than 10 min. duration. Delays were treated in different ways depending on their duration:

0-5 cmin are included in the time elements shown in Table 2.
5 cmin - 10 min. are recorded as "delays"; also shown in Table 2.
10 min. are not considered as part of productive time (PMH) and are therefore excluded.

$$\text{Branchiness class, \%} = \frac{\text{Merchantable length with live branches}}{\text{Total merchantable length}}$$

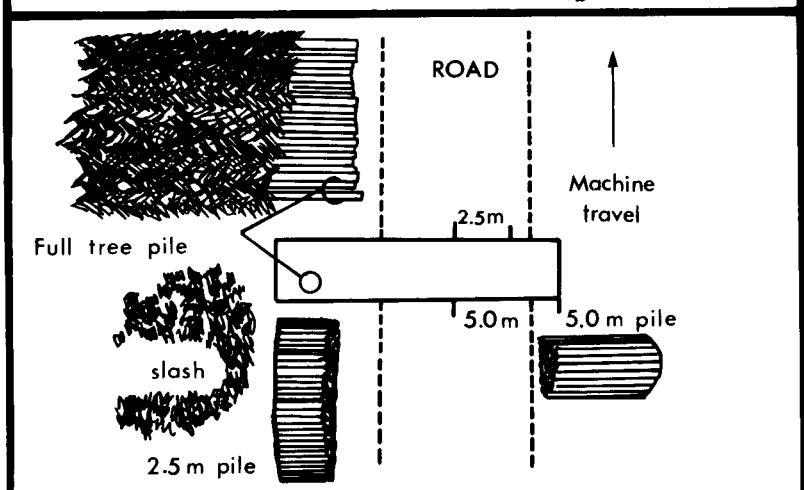
Class 1: 0 - 33%
Class 2: 34 - 66%
Class 3: 67 - 100%



ON THE ROAD (Studies 1, 4, 5, 6)

The Hahn is stationed on the road in front of a full tree pile. If both sawlogs and pulpwood are being produced, full trees can be piled on only one side of the road since more space is required to pile two types of processed products. When producing pulpwood only it may be possible to have full tree piles on both sides of the road provided that the pile height is limited. In each case the build-up of debris contributes greatly to the lack of space.

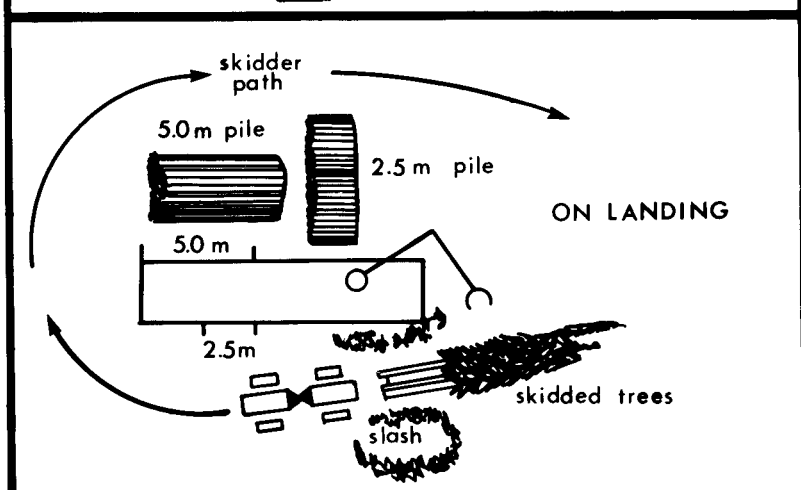
This is the normal method of operating the Hahn, and is used wherever operating conditions permit.



ACROSS THE ROAD (Study 2)

This method can be used where debris build-up is excessive or where there is insufficient space to pile both pulpwood and sawlogs. Terrain adjacent to the road must be level and firm.

The main disadvantage of this method is that moving time between set-ups is greatly increased and that the machine completely blocks the road.



HOT LOGGING (Study 3)

The Hahn is situated on a large landing and skidders deposit loads of full trees from the stump area and from cold decks. The advantages and disadvantages of this method are discussed on page 11.

Figure 2. Operating methods studied by FERIC.

STUDY SITES

Pearson Lumber Ltd., Atikokan, Ont.

A Hahn Pulp/Logger II, producing both sawlogs and pulpwood, was studied by FERIC at Pearson Lumber Ltd., a small privately-owned sawmill whose logging operations were located 70 km northwest of Atikokan, Ontario.

The Pulp/Logger II was demonstrated on this company's logging area for a one week period in early October 1981, on a one-shift-per-day basis. The two-man crew consisted of two Hahn employees. The one who operated the processor unit was considered to be "excellent"; the operator of the loader unit was considered to be "fair", similar to a new operator of average capability with 2 to 3 weeks experience.

Riverlake Timber Ltd., Ignace, Ont.

The second Hahn Pulp/Logger II studied by FERIC was owned and operated by Riverlake Timber Ltd. of Ignace, Ontario. This logging contractor produced 200,000 m^3 of 2.5-m pulpwood annually for Great Lakes Forest Products Ltd. of Thunder Bay, Ontario. The logging area consisted mainly of sandy outwash plains and gently rolling terrain.

The Hahn, purchased in February 1981, was operated on a one 9-hour-shift-per-day basis five days per week. FERIC made three time studies of this machine, each study in conditions of differing average tree size and/or operator skill.

The operators, who were employees of Riverlake Timber Ltd., worked on an hourly basis without a provision for bonus. For each study the processor operator was the same. He started on the Hahn machine in February 1981 and was considered to be an "excellent" operator. Two loader operators were observed by FERIC. The one observed in Study IV had about 3 months experience, but was considered an average or "good" operator. For Studies V and VI another person operated the loader. This person, although he had only 2 months of experience, was considered by FERIC to be an "excellent" operator.

RESULTS

The results of FERIC's time studies are summarized in Table 1.

TABLE 1. Detailed Time Study Results

Company and location	Pearson Lumber, Atikokan, Ont.			Riverlake Timber, Ignace, Ont.		
Products produced	Sawlogs and pulpwood			Pulpwood only		
Operating method	Study I on the road	Study II across the road	Study III hot logging	Study IV on the road	Study V on the road	Study VI on the road
DESCRIPTIVE INFORMATION						
Date of study	Sept. 1981	Oct. 1981	Oct. 1981	May 1981	Oct. 1981	Oct. 1981
Operator class - loader	fair	fair	fair	good	excellent	excellent
- processor	excellent	excellent	excellent	excellent	excellent	excellent
Branchiness class* - 1	50	80	80	70	80	80
- 2	50	20	20	30	20	20
- 3	--	--	--	--	--	--
Species - black spruce	40%	--	--	--	40%	30%
- jack pine	60%	100%	100%	100%	60%	70%
TIME DISTRIBUTION						
Study duration, hours *	2.08 (100%)	2.28 (100%)	2.60 (100%)	1.61 (100%)	1.17 (100%)	5.47 (100%)
Processing	63%	62%	70%	76%	90%	85%
Move machine	4	5	--	2	--	2
Delays: Wait loader						
- clearing debris	8	12	2	5	21	1
- other	16	15	15	17	8	11
: visitors or personnel	5 33	1 33	-- 30	-- 22	-- 10	-- 13
: wait for skidder	--	--	12	--	--	--
: miscellaneous	4	5	1	--	2	1
TOTAL	100%	100%	100%	100%	100%	100%
PRODUCTIVITY						
Percentage of cuts @ 2.5 m	14%	36%	35%	100%	100%	100%
@ 5.0 m	86%	64%	65%	--	--	--
Volume per tree, m^3 (ft^3)	0.27 (9.6)	0.30 (10.7)	0.31 (11.0)	0.15 (5.3)	0.12 (4.1)	0.18 (6.4)
Trees per processing cycle	2.10	1.10	1.46	2.01	2.22	2.53
Volume per processing cycle, m^3 (ft^3)	0.57 (20.1)	0.33 (11.7)	0.45 (16.0)	0.30 (10.6)	0.26 (9.2)	0.46 (16.1)
Processing cycles per PMH	40	45	43	62	62	55
Trees processed per PMH	85	49	63	125	138	137
Volume per PMH, m^3 (ct)	23.0 (8.1)	14.9 (5.3)	19.5 (6.9)	19.0 (6.7)	16.1 (5.7)	24.6 (8.7)

* for definitions see page 3.

DISCUSSION

Productivity

Sawlogs & Pulpwood vs. Pulpwood Only:

Table 1 indicates that both sawlogs & pulpwood were produced at Pearson Lumber, while pulpwood only was produced on the operation at Riverlake Timber.

The number of processing cycles per PMH for the first three studies (sawlogs & pulpwood) was considerably lower than for the last three studies (pulpwood only). The primary reasons for this difference were:

1. The larger, longer trees of Studies I, II, and III required more time to process as compared to the smaller, shorter trees of Studies IV, V and VI.

2. When both sawlogs and pulpwood were produced, more space had to be cleared of debris in order to pile these products separately.

3. The loader operator for Studies I, II and III was classified as only "fair". Longer "Wait loader" times for the processor were attributed to the loader operator's inexperience.

Study I vs. Study II Results: The large difference in production between Study I (23.0 m^3 per PMH) and Study II (14.9 m^3 per PMH) was mainly due to the difference in the number of trees per processing cycle (2.1 and 1.1 respectively). There was no apparent reason for the lower trees per processing cycle in Study II; the difference was attributed by FERIC to operator preferences and motivation.

Trees per Processing Cycle: In addition to operator ability and motivation, the following factors can influence the number of trees per processing cycle:

1. tree size - larger trees are more likely to be processed singly.

2. uniformity of tree size - if small and large trees are mixed together, some pre-sorting is required by the loader operator to avoid cutting undersize trees into sawlogs.

3. branchiness - fewer branches make the loading and processing of multiples of trees easier.

4. branch diameter - the larger the branches the more difficult it is to process multiples of trees.

5. tree form - crooked and forked trees usually have to be processed one at a time.

For the three pulpwood-only studies the number of processing cycles per PMH was similar for each study; also the number of trees processed per cycle averaged more than 2. Thus, in spite of much smaller tree size the productivity was comparable to that obtained for processing larger trees (e.g. Study I, and II and III). In other words, the multi-stem processing capability of the Hahn permitted a reasonable level of production even in small trees. This appeared to be the normal operating level for two fully trained operators under these conditions. At Riverlake Timber both the loader and processor operator reached this level of proficiency after $1\frac{1}{2}$ or 2 months.

General: The following general remarks on productivity can be made:

1. Multi-stem delimbing and slashing tend to reduce the adverse effect of small trees on productivity.

2. The skill of the operators and their ability to co-ordinate their activities are key factors contributing to high productivity.

3. The production of sawlogs & pulpwood vs. pulpwood only, for any given tree size, does not appear to affect productivity provided that there is adequate piling room available (i.e. no additional debris clearing is necessary to allow piling of sawlogs).

4. Productivity on the Hahn is relatively insensitive to most of the normal variation in tree size and limbiness found in the boreal forest.

Delimbing Quality

Due to the direct drive and "axe-effect" of the hydraulically-driven delimbing carriage all limbs, even those up to 13 cm in diameter can be removed. A second or third stroke is often required in multi-stem delimbing of small trees and for heavily-branched stems; that reduces productivity. The delimber knives close down to 5 cm and can open to accommodate trees of 65 cm. Delimbing quality is usually excellent both in trees with heavy branches and in multi-stem limbing.

Loading Speed vs. Processing Speed

For operating conditions where merchantable tree lengths range from 10 to 15 metres (provided the Hahn loader and processor operators are fully trained) the processor operator will normally be delayed 10 to 15% or more of the time. This is due to an imbalance in the workload between the two operators. The loader operator must clear debris and pile processed products in addition to placing full trees onto the delimber infeed. NOTE - FERIC time studies of the loader cycle also indicate that the loader operator sometimes waits for the processor to clear the delimbing carriage. However, this type of delay is usually only a fraction of the waiting time experienced by the processor and is minimal for an experienced loader operator, since he soon learns to sychronize loader activities with that of the processor.

The amount of time spent by the processor in "Wait for Loader" will be higher than the level mentioned above (10-15% of PMH) if:

1. the loader operator is less skilled than the processor operator.

2. the trees are short - since less processing time is required for short trees.

3. sawlogs & pulpwood are produced - as compared to pulpwood only. This is because additional time is required to move the second product and to clear the debris to make space for it.

Debris Accumulation

The accumulation of slash on the road and along the sides of the road represent a major limitation to the use of the Hahn Pulp/Logger II. The Hahn produces a mat of debris (mostly foliage) along the road as it retreats. This debris must be cleared with a skidder or crawler tractor before any road vehicles can pass by. These piles of debris at roadside may be undesirable for aesthetic or fire hazard reasons.

The accumulation of debris around the machine normally presents an operational problem only when producing both sawlogs & pulpwood. This assumes that full trees are piled on only one side of the road.

B. Andersson [1] reported that during an October 1980 trial comprising 175 PMH, that slash accumulation was not a serious problem due to the limited height (1.7 m) of the full- tree piles and the low proportion of sawlogs (less than 10%). Slash accumulation did present a problem if:

1. the trees were very branchy.
2. a high percent (e.g. 30-40%) of sawlogs were produced.
3. sawlogs and pulpwood were piled on opposite sides of the road.

To reduce slash build-up around the machine pre-topping the full trees in the felling area was tried. Although the slash was reduced, processing was complicated since the Hahn used the tree tops as a "handle" to move the last tree section. Without this handle, stem utilization decreased and the number of short pieces increased.

Effect of Full-Tree Piling Method

The method of full-tree piling can affect the Hahn's productivity. If the trees are tangled extra time is required for loading. In all of FERIC's studies the full trees were drop-piled by skidders minimizing the tangling problem. However, the experience obtained from an earlier study [1] of the Hahn Pulp/Logger II is useful and is repeated below:

Cold (Rolled) Roadside Decks - Each skidder load was piled and rolled with a skidder blade. The rolling caused tangling of branches among the tops and excessive tree breakage occurred when the full trees were being loaded. NOTE - The amount of tree breakage and the increase in loading time with this piling method varies with the branchiness of the trees.

Cold (Drop-Piled) Roadside Decks - The loaded skidders drove onto the rear of and over the pile to make it higher. This resulted in a minimum of tangling.

Hot (Skidding) - Trees were skidded to the infeed end of the Hahn. This method caused the least tangling. It also resulted in a much smaller swing arc for the loader.

Koehring Feller-Forwarder (KFF) Piles - There were very few tangling problems since the trees were well aligned in the KFF basket during harvesting. However, due to the KFF pile height additional space was required for piling debris and processed products. Therefore KFF piles should be spaced some distance apart. Harvesting in two phases also may be required to provide adequate room at roadside.

Another company, Boise Cascade Ltd., Newcastle, N.B. during a trial on their operations in early 1981 noted [2] that they had considerable problems with loading full trees from KFF piles due to tangled trees. Some of the problem was attributed to the hardwoods (mostly white birch) that composed about 3% of the KFF piles. Snow and ice also posed problems for the loader operator reducing productivity. Tops of trees can freeze onto wet ground, placing extra strain on the loader.

Hot Logging

The Hahn Pulp/Logger II can be situated on a landing or an open area and have freshly-felled trees and/or trees from roadside cold decks skidded to it.

The main advantages of this system are:

1. the loader on the Hahn swings through only a small arc permitting increased loader productivity.

2. the trees are usually not tangled and are easy to load.

3. debris is normally cleared using the blade of a passing skidder. This is much more efficient than using the Hahn's loader grapple.

The main disadvantages of this system are:

1. the additional cost of an extra skidder if it is used to deliver trees from roadside decks.

2. system interdependence - if one machine breaks down it affects the other(s).

Mobility, Flotation & Speed

Mobility: An earlier report [1] on the Hahn Pulp/Logger II has indicated that the limited mobility of the unit (on poor road conditions or going up slippery hills) has been a major disadvantage of the machine. This earlier unit had hydraulic single axle front wheel drive. This axle also steered the machine. Because most of the weight was on the rear tandem axles only limited traction could be obtained. As a result the Hahn often became stuck when road conditions were poor. Usually a utility skidder was parked nearby to pull the machine free, as required.

However, since the cost of a skidder must be added to the processing cost this is not a good solution to the problem. The Hahn at Riverlake Timber was equipped with single-axle front-wheel drive. Due to good road conditions no mobility problems were observed during FERIC's studies. A grapple skidder was usually operating nearby and could assist if the Hahn became stuck.

The Hahn Pulp/Logger II at Pearson Lumber Ltd. had a hydrostatic rear tandem-axle drive, an optional feature. Although muddy road conditions were experienced during FERIC's studies the Pearson Lumber unit had no mobility problems. The unit was not observed on slopes, but it is expected that the performance would be much superior to that of the single axle front-wheel drive. A disadvantage of the rear tandem-axle drive is that to tow the Hahn, using a fifth wheel, the rear axle had to be removed or the hydrostatic drive had to be disconnected. NOTE - An optional drive system (provided at a higher price) is a hydrostatic drive to all 6 wheels. This type of unit was being tested at the time of writing at La Tuque, Québec. The objective was to angle the front of the machine off the road to reduce problems of debris accumulation. It is expected that the limited ground clearance of the axles (approx. 30 cm) may present a problem if the machine is used partly off the road.

Flotation - The weight of the Pulp/Logger II is approximately 24,000 kg. With its standard tires, the ground bearing pressure is approximately 95 kPa.

Speed - Although not measured by FERIC, the on-road maximum speed of the Hahn with rear tandem axle drive was reported to be about 5 to 6 kilometres per hour.

Log Length Accuracy

The two machines tested by FERIC were both equipped with two retractable butt plates, one for 2.5 m, the other for 5.0 m logs. The retractable butt plates provided a good, accurate measuring system, especially for processing single trees. For multiple-stem processing some short bolts were produced for reasons stated below:

1. When several trees are loaded onto the delimbing carriage with the tree butts unevenly aligned, the processor operator can do little to align them; butting the trees against the lowered "guillotine" holding mechanism has limited results. Thus, the first cut may produce one or more short bolts.

2. For successive cuts the guillotine holding mechanism (see Fig. 3) sometimes did not grip all the trees firmly in the delimber grapple. As the delimber carriage moved out to delimb, a small tree not firmly held by the guillotine

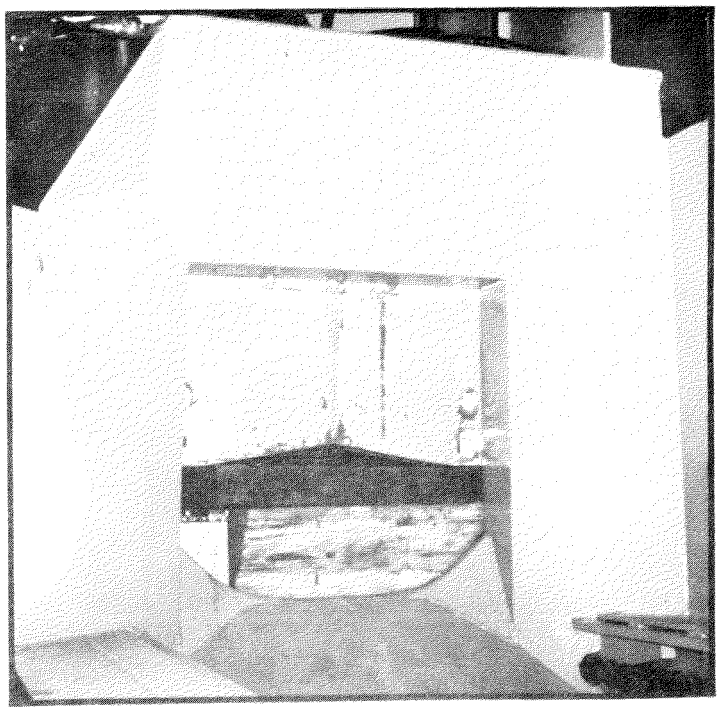


Fig. 3. Guillotine holding mechanism.

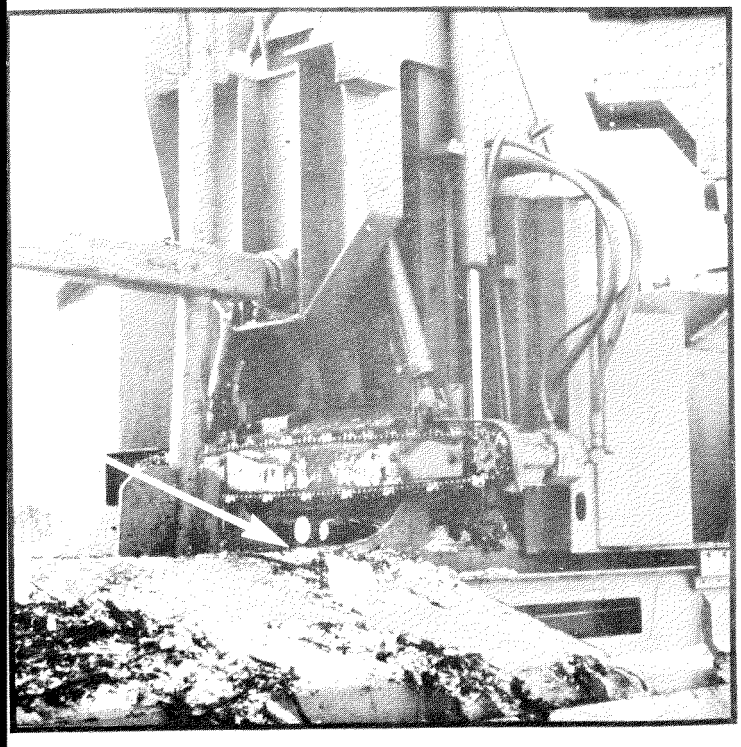


Fig. 4. Poorly formed trees require the use of the wedge, located directly below the chainsaw, to prevent chainsaw binding (see arrow).

Fig. 5. Automatic pressure relief in the butt plate also prevents chainsaw binding (see arrow).

holding mechanism can slip out. This can result in a short piece being cut off after the trees are advanced. These short pieces usually fall to the ground and are lost (see also Guillotine Holding Mechanism).

Guillotine Holding Mechanism

The problem of improper grip on small tree(s) when delimbing multiples of trees occurred in spite of a Hahn design improvement to "round" the gripping surface of the mechanism.

Another problem observed with this holding mechanism was that the processor operators often applied excessive pressure to avoid having tree(s) slip out of the holding mechanism. This tended to crush the wood fibre.

A design change to further improve the holding mechanism is recommended by FERIC. An inverted clamp could be installed so that multiple stems can be gripped firmly on all sides. This change, if successful, should permit delimbing of larger bunches of small trees, reduce processing time, and should prevent fibre loss from short lengths which fall onto the ground.

Chainsaw Operation

The chainsaw device, which uses 1.2-m L & M bar with sprockets on each end and a 1.9-cm pitch chain, has been used on other Hahn machines for up to eight years. It worked well during FERIC's studies. The supervisor of the Riverlake unit noted that it required a (sharpened) chain every second day or twice per week, unless (as occurred infrequently) the chainsaw struck an obstacle.

The saw bar is prevented from being pinched by two features:

a) an operator-controlled wedge, located below the chainsaw, can lift the log from below, opening the kerf; and b) the butt plate retracts 3 cm each time the guillotine is activated, relieving the forward-applied pressure of trees against the butt plate.

Extended Loader Boom & Live Heel

Both machines studied by FERIC had a loader reach of 7.3 m, compared to 6.7 m on earlier units. This proved especially useful for depositing debris behind the processed product piles. Another useful feature not available on earlier units was the "live" heel on the loader. The "live" heel (see Fig. 6) had two advantages:

1. it prevented tree butts from striking the outer boom crowd cylinder.

2. it permitted the tangled tops of large trees to be lifted out of the full tree pile more quickly. Previously the entire boom was used requiring more time.

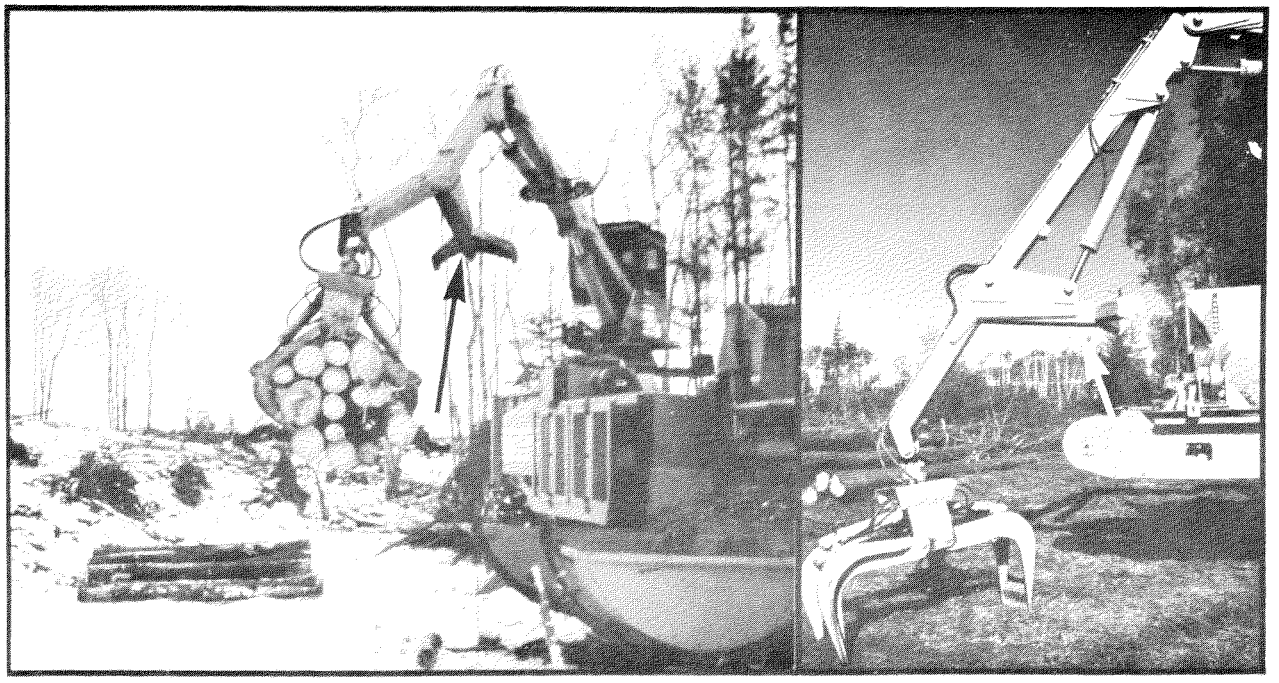


Fig. 6. Left: fixed heel on loader (see arrow).
Right: live heel on loader (see arrow).

Pulpwood Basket Design

Several different designs of pulpwood baskets have been used on the Hahn Pulp/Logger II:

1. two curved open-ended forks - the problem with this design is that bolts slip out when operating on slopes.

2. a small, one-piece basket used on the Pearson Lumber unit - it was too small, and frequently overflowed.

3. a large, heavy-one-piece basket; by lifting the stabilizer legs the basket is raised at the same time.

4. a two piece basket with ample room for debris to fall through - (used at Riverlake Timber Ltd. - see Fig. 7).

Based on FERIC's limited studies the pulpwood basket at Riverlake (4) appeared to be the best solution. To raise the basket the loader grapple lifts each side of the basket onto the frame; the machine can then be moved.

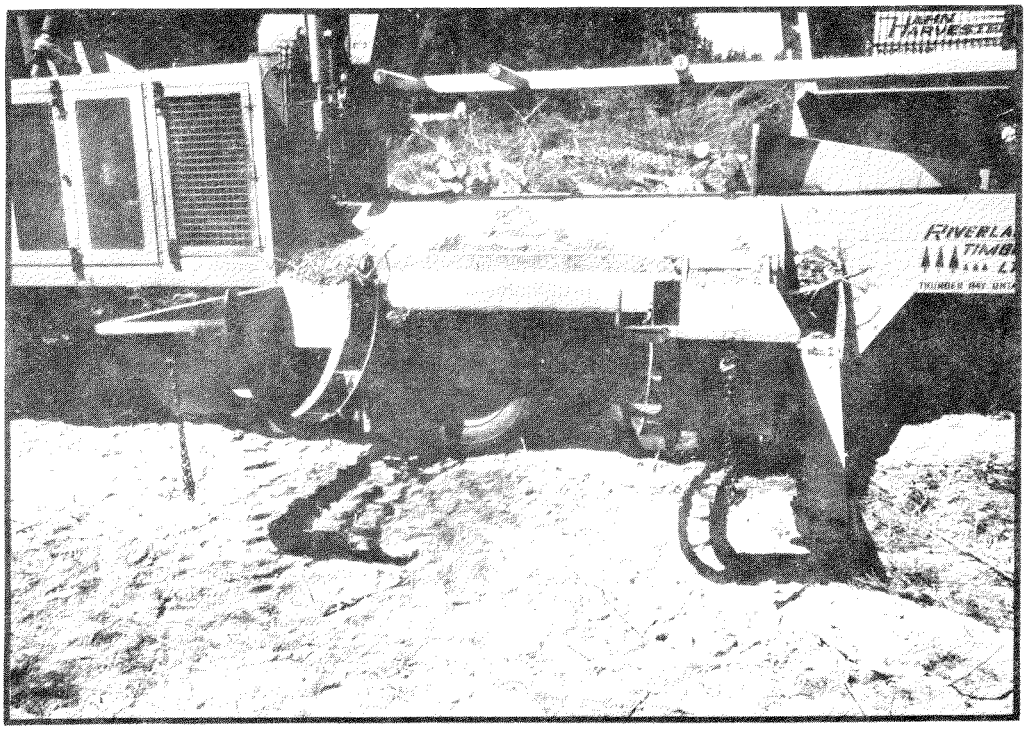


Fig. 7. Pulpwood basket design at Riverlake Timber Ltd. The closed-end design prevents pulpwood from sliding out when working on slopes.

MECHANICAL RELIABILITY

The following remarks are based on general impressions obtained by FERIC staff during the study:

The Hahn Pulp/Logger II appears to be well designed, due perhaps to Hahn's earlier experience with the Processor and Treelength Delimber models. Rigid hydraulic tubing is used wherever possible and is mainly located under the main frame where it is well protected. Removable and/or hinged panels provide easy access to electrical, hydraulic and engine components. The Hahn Treelength Delimber, which has many similar components, has a good availability record [2]. It is expected that the Hahn Pulp/Logger II, is also capable of achieving a high level of mechanical availability.

The Hahn Pulp/Logger II should not, however, be considered a "simple" machine. Although it uses well-proven hydraulic and electrical components some mechanics in field garages may not be familiar with them. For example, there are many limit switches on the machine; also, it has electro-hydraulic Monsun-Tison control valves. With a capable, skilled mechanic and well-trained operators the machine should be capable of achieving a high level of mechanical availability. Hahn Machinery Inc. provides a 1-week training program for both mechanics and operators for new machine buyers. This should prove very useful.

Some specific mechanical problems reported by Riverlake Contractors Ltd., (based on the first 8 months of use) are discussed below:

1. Swivel Couplings between the Loader and the Main Frame - Fluid leaks (both oil and coolant) have occurred. New, sturdier swivel couplings have been installed by the manufacturer. However, due to the constant twisting of the hoses that occurs when the loader turns, this will likely continue to be a high maintenance area.

2. Hydraulic Pumps - Failure of the shaft seals occurred on both the hydrostatic pump and the gear pump. The leaking hydraulic oil mixed with gearbox lubricant in the gearbox located between the pumps and the engine. This could result in premature internal gearbox wear.

3. Loader Base - Considerable downtime resulted from structural cracks that occurred in the loader base above the turntable. This was attributed to improper welding at the factory. NOTE - problems with the turntable base also occurred on a Pulp/ Logger II observed by FERIC at La Tuque, Québec in Dec. 1981 (see Fig. 8).

This may have resulted from incorrect torque on the turntable holding screws. Turntable problems may have been aggravated by using the loader to lift the entire front end of the Hahn .5 m (by pushing onto the ground with the grapple) to allow the fifth wheel of a truck to be inserted or removed. This practice should be avoided; it requires further study by the manufacturer. One solution would be to place the stabilizers on blocks.

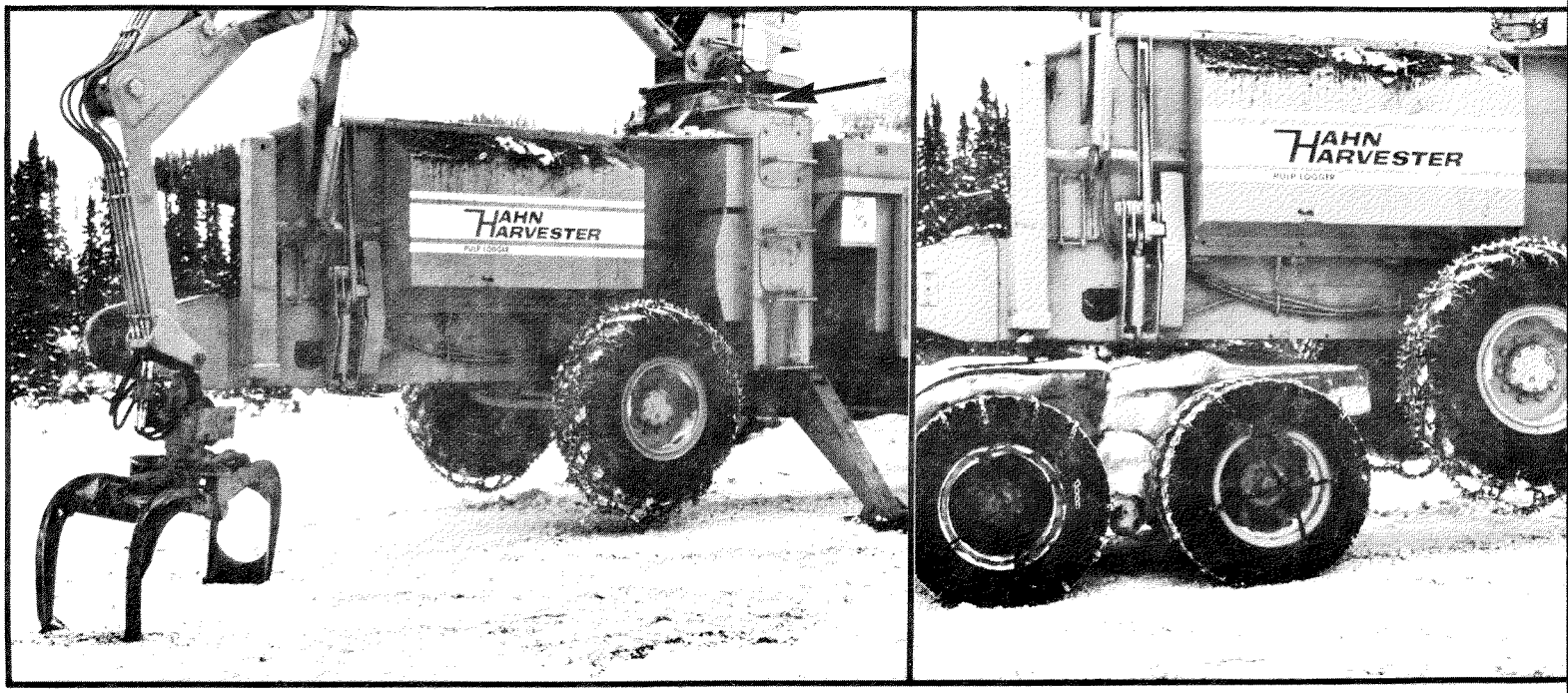


Fig. 8. Structural cracks in the base of the loader (see arrow) may be partially caused by using the loader to lift the front end of the machine, to allow a 5th wheel to be inserted.

EXPECTED OPERATING COSTS

The expected operating costs for the Hahn Pulp/Logger II are shown in Table 7, below. The operating costs are based on realistic assumptions for a typical softwood logging operation in eastern Canada, using a properly trained 2-man crew on the Hahn. For cost calculation purposes a productivity (long term) of 105 trees per PMH, with an average tree size of .17 m^3 (approx. 6.0 ft^3) is assumed (this is slightly lower than the short term productivity observed by FERIC - see Table 4). The operating costs also assume a machine utilization of 75%, repair costs at 120% of depreciation, operators wages at $14.00 per scheduled hour (including fringe benefits), an operating period of 220 days per year, two-shift-per-day operation, 8 hours per shift, a machine life of 6 years and an 17% interest rate.

Also shown in Table 7 are expected productivity and operating costs for a two machine system for delimbing and slashing, using a sliding-boom delimber (e.g. Denis, Roger, Harricana) plus a mobile slasher capable of producing both 2.5 and 5.0 m-lengths from a single tree (e.g. Tanguay CC-100) at roadside. Expected operating costs are based on the same criteria as for the Hahn Pulp/Logger II, except that machine utilization is assumed to be 80% (due to greater machine simplicity). Table 7 indicates that for trees averaging .17 m^3 that the use of the Hahn Pulp/Logger II provides similar operating costs as compared to the two machine system. However, the capital investment required for the Hahn is considerably lower.

TABLE 7. Cost Comparison*

	Hahn Pulp/Logger II	Sliding-Boom Delimber	Mobile Slasher (e.g. Tanguay CC-100)
Machine list price	$246,000	$220,000	$125,000
Operating cost/PMH	$91.00	$63.00	$45.50
Productivity, m^3 (ct) per PMH	17.8 (6.3)	22.1 (7.8)	19.5 (6.9)
Cost per m^3 (ct)	$5.10 ($14.44)	$2.84 ($8.04)	$2.33 ($6.60)

* Direct logging costs only - includes all fixed, operating, maintenance and repair costs, but with no allowance for engineering, roads, supervision, overhead or profit.

GENERAL COMMENTS

The results of this study indicate that the Hahn Pulp/Logger II can be used profitably for delimbing and slashing full trees into pulpwood and/or sawlog lengths under certain operating conditions. The use of the Hahn should be considered where most, or all, of the following factors are applicable:

1. Local markets for both 5.0 m sawlogs and 2.5 m pulpwood exist.
2. The hauling of log lengths and/or pulpwood, as opposed to tree-lengths, is the normal method.
3. Pulp mill(s) and sawmill(s) are located in different places; this favours product separation at roadside.
4. Sawlogs (per m^3) have a higher value than pulpwood; there is therefore an incentive to produce higher value products. The greater the value difference between the two products the greater the incentive for maximizing sawlog production.
5. The higher the percentage of sawlog material in the trees to be processed, the more profitable the use of the Hahn will be.
6. The existence of government policy that prevents the use of sawlog material for pulpwood.
7. Relatively large volumes of softwoods can be delimbed and slashed in the same location or area. This means less time will be spent in moving the Hahn.
8. Full tree piles are usually on only one side of the road.
9. Debris that will accumulate on the road can be periodically cleared to allow other traffic circulation.
10. Logging access roads are of good quality; this would allow the Hahn to be moved without undue difficulty.

Human factors are just as important. FERIC's study of the Pulp/Logger II indicates that production per PMH is very dependent on the capability, experience and motivation of each of the two operators. In fact, the productivity of the Hahn is only as good as the rate of work of the slowest operator. Since it normally requires several months for each operator on the Hahn to become fully proficient, there should be planned continuity in regards to the operators. Crew compatability is also a factor, since the two operators must work together.

The work of the operators is repetitive and requires full concentration. Although both operator cabs are comfortable and are equipped with joystick controls, it may be useful for the operators to switch jobs every few hours. The change in position should allow the operators to relax cramped muscles and to stay mentally alert.

The capability and experience of the mechanic servicing the Hahn will also be a factor in the successful application of this machine. The Pulp/Logger II is a relatively complex logging machine (e.g. joystick controls, electrically-operated valves, etc.). The average field mechanic will probably be unfamiliar with many of the electrical and hydraulic components. The one week, on-site training course provided by the manufacturer should help to reduce this potential problem.

To summarize: The Hahn Pulp/Logger II is a viable machine for delimbing and slashing at roadside that can provide, where conditions are suitable, pulpwood and/or sawlogs at a cost similar to that of logging systems using sliding-boom delimbers plus mobile, two-product slashers. However, the capital investment required for the Hahn is considerably lower.

REFERENCES

1. Andersson, B. 1981. The Hahn Pulp/Logger II as a Component in a Full-Tree Harvesting System. Can. Pulp & Paper Assoc. March 1981.

2. Powell, L.H. 1981. Interior Limbing, Bucking and Processing Study: Evaluation of Hahn Treelength Delimber. For. Eng. Res. Inst. Can. (FERIC), Tech. Note TN-51.

APPENDIX A

TECHNICAL SPECIFICATIONS

HAHN PULP/LOGGER II

General

weight - 23,800 kg
height - 3.8 m
width - 3.0 m
length - 13.7 m

Engine

Cat, Cummins or GM
(approx. 120 kW)

Tires

Front axle - 17.5 x 25
rear axles - 15 x 22.5

Drive System

Hydrostatic drive on
both rear axles

Loader

Hahn model 793 w/dual motor swing; 7.3 m-boom; 1 m^3 by-pass grapple w/continious rotation. Duplicate loader controls allow machine to be run with one or two operators.

Delimb

149 m/min maximum carriage speed
5.5 m delimbing stroke, hydrostatic carriage drive.

Hydraulic Chainsaw

1.22 m bar; 1.9 cm pitch chain

APPENDIX B

CONVERSION TABLE

1 cm	1 centimetre	:	0.39 inch
1 m	1 metre	:	3.28 feet
1 km	1 kilometre	:	0.62 mile
1 m^3	1 cubic metre	:	0.353 cunit
1 L	1 litre	:	0.22 Imperial gallon
		:	0.26 American gallon
1 L/s	1 litre per second	:	13.20 Imperial gallons per minute
		:	15.85 American gallons per minute
1 kg	1 kilogram	:	2.20 pounds
1 kW	1 kilowatt	:	1.34 horse-power
		:	3,425 BTU
1 kPa	1 kilopascal	:	0.145 pounds per square inch
1 lx	1 lux	:	0.093 foot-candle
		:	0.093 lumen per square foot
^oC	degree Celsius	:	$\frac{5}{9}$ (^oF-32)