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CHAIN FLAIL PROCESSING: A NEW LOOK AT AN OLD IDEA

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ABSTRACT

Chain flail delimbing and debarking, coupled with in-woods chipping, is rapidly expanding in the pine plantations of the southern region of the U.S.A. The flail units now used are more advanced than those tried in New Zealand in the mid and late 1970s. This improved technology could find a place within New Zealand forestry for the production of good quality pulp chips, particularly from thinning operations. Flailing removes the need for delimbing and in-woods chipping can reduce the need for new major capital mill works. While not necessarily applicable for all locations, flail processing/in-woods chipping is a materials handling option worthy of consideration.

INTRODUCTION

The use of chain flails as part of a harvesting system is not a new concept for New Zealand. Chain flails were used as part of highly mechanised operations run by Pan-Pac in southern Kaingaroa forest for several years in the 1970s. Various other flail designs were tried by other organisations and individuals, but the practice never gained widespread use (Gordon, 1983). The flails were used predominantly to reduce the delimbing task in Southern pine species, with only limited experimentation on Radiata pine (Gordon, 1978).

At the end of the 1970s flail delimbers faded from the harvesting scene and there was a general return to traditional motor-manual operations. Emphasis on mechanising the onerous task of delimbing in thinnings is now focusing on stroke delimbers such as the Harricana and Denis.

So why relook at chain flails if they have been tried and have now disappeared? A recent trend in the South is a marked expansion in the use of chain flails for both delimbing and debarking. These units have progressed from prime mover attachments to single function units, somewhat along the lines foreseen by New Zealand logging contractor Brian Cochrane, with his innovative but uncompleted developments with flailing in Kaingaroa forest during the late 1970s.

Chain flails are relatively simple in technology. They consist of a power unit driving two drums on which are attached short lengths of chain. The feature which has led to their revival has been a design change to allow the 'floating' of multiple stems between the drums rather than using a single drum working on stems lying on the ground. This has enabled a relatively high throughput compared to single stem stroke delimbers, and has produced good quality delimbing and debarking results.

What has caused the increased use of flail processing? Flails are perceived to have a number of intrinsic advantages in the South.

1. Increased Wood Recovery

   As will be discussed below, flail processing allows the recovery of more usable fibre per hectare harvested by economically recovering smaller trees and by recovering more of the stem component.

2. Decreased Transport Costs

   For certain tree sizes, particularly in the Southern USA, it can be difficult to maintain full payloads. In-woods chipping allows the cartage of more consistently full payloads.

3. Supplement to Wood Room Capacity

   One of the big advantages of the flail processing/ in-woods chipping operation is that a product is delivered to the mill that can be entered directly into the in-feed system. Capacity can be quickly increased without major capital investment in the mill, (which must be justified with a relatively long life).

4. Improved Chip Quality

   In most mill facilities, long-length material is reduced to short-length to use drum debarking techniques. Thus short lengths are always presented to the chipper. Chips at the beginning of each new piece, and the last few chips are of lower quality because of the end effect. The chipping of long lengths reduces the number of ends and therefore reduces the proportion of lower quality chips.

CHIPPING FOLLOWING FLAILING

When stems emerge from flail processing, they are relatively "clean" and it is logical that it is best to immediately put them in a chipper. Most flail units are therefore paired with an in-woods chipper so that stems feed directly from the flail to a chipper.

In-woods chipping also had a short life in New Zealand. The only major use of this processing option was by Kaingaroa Logging Company in the early 1970s. Important reasons for the phase out of this operation was the high bark content of the resulting chips and the level of abrasive contaminants. Flail delimbing/ debarking immediately prior to chipping removes these problems.

FLAIL OPTIONS

Current flail technology in the South can best be summarised by describing some of the machines that are commercially available within the region. Table 1 shows the specifications for three selected machines: the MacMillian Forest Pro, the Manitowoc, and the Peterson Pacific. The latter machine has been on the market for several years, while the other two flail units were introduced in 1988. A fixed plant version of the Manitowoc has also been constructed for a Weyerhaeuser plant in North Carolina (Selby and Iff, 1986).

All three machines work in a similar manner. Stems are skidded to a deck in front of the flail and are fed into the flail by a hydraulic knuckleboom loader. For the MacMillian, the loader may be either a part of the flail or, with the Manitowoc, by a separate unit sitting to one side. With the Peterson the loader on the chipper is used to feed the flail.

The three flail units could best be described as semi-mobile. They are towed units designed to be left on one site for perhaps a week at a time.

MacMillian Forest Pro

Of the three units described, the Forest Pro (Figure 1) is the largest and most recently introduced. It has dual horizontal flails that are hydraulically driven with variable speeds. As with the other units, feed rate is adjustable and can be set to match the chipper. The discharge of bark and limbs is to the side using a chain conveyor. A particular feature of the Forest Pro is that it is offered with a hydraulic loader which is used to feed the flail.

Figure 1 : MacMillian Forest Pro with loader

Table 1 : Technical Comparison

Item	*MacMillian Forest Pro*	*Manitowoc*	*Peterson Pacific*
Model	*HDFPP-20*	*VFDD-1642*	*4800*
Flail design	*Dual horizontal*	*Dual vertical*	*Dual horizontal*
Flail drive	*Hydraulic*	*Hydraulic*	*Hydraulic*
Flail speed (rpm)	*525-625*	*525-625*	*525-625*
Feed opening (cm)	*52 x 122*	*122 x 41*	*58 x 122*
Feed rate (m/min)	*38*	*38*	*38*
Capacity (cm)	*50*	*40*	*58*
Power (kW)	*240*	*170*	*135*
Weight (kg)	*17,690 (20,412 w/loader)*	*15,422*	*11,340*
Price ($US in US)	*140,000 (170,000 w/loader)*	*156,600*	*125,000*
Place of manufacture	*Shreveport, Louisiana*	*Manitowoc, Wisconsin*	*Pleasant Hill, Oregon*

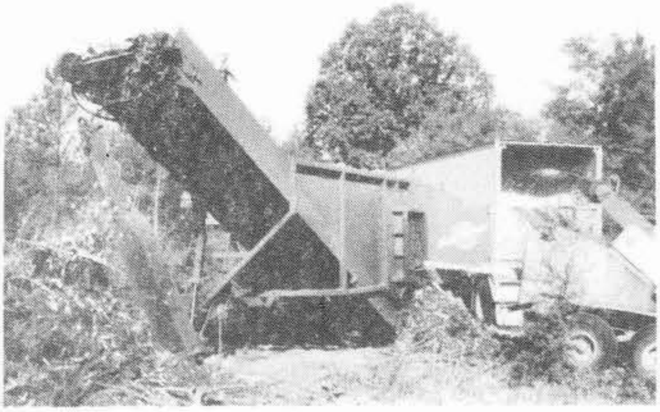

Figure 2 : Manitowoc

Figure 3 : Peterson Pacific

Manitowoc

The Manitowoc (Figure 2) originated from a Weyerhaeuser Company R & D effort. An original open-topped design allowed stems to be dropped into the flail chamber for delimbing the upper portion of the bole. After determining that the flail could satisfactorily debark stems, the design was changed to be fed from the front.

The Manitowoc is different from other flails in that it has vertical flail drums instead of horizontal drums. Flail speed and feed rate are adjustable, and residues are removed with a conveyor to the side.

Peterson Pacific

This design (Figure 3) is much smaller than the others as it has a hydraulic ram assembly to remove residue rather than a conveyor system. Flail speed can be adjusted by controlling engine speed because the flail drums are connected to the engine via a flywheel and pulley system.

RECOVERY TRIALS

Various options in whole-tree harvesting have been assessed under an ongoing co-operative research effort between Mississippi State University and the USDA Forest Service Lab at Auburn, Alabama, since 1986. Recovery efficiencies of various harvesting methods have been assessed through field trials and the use of mill recovery standards in the Southern U.S.A.

In a Flail/Chip harvesting study, the Peterson Pacific model 4800 log debarker and Morbarker 22 chipper were measured. Efficiencies would be expected to vary with other combinations of flails and chippers but the analysis is indicative of other units.

The flail study was undertaken in Slash pine (<u>Pinus elliotti</u>) plantation of age about 21 years in South Carolina.

The product flow for this machine pairing is illustrated in Figure 4. It shows that through losses from felling, dragging to the roadside, delimbing, debarking and chipping, only 69.3% of the whole standing tree is converted into chips loaded into the chip van in

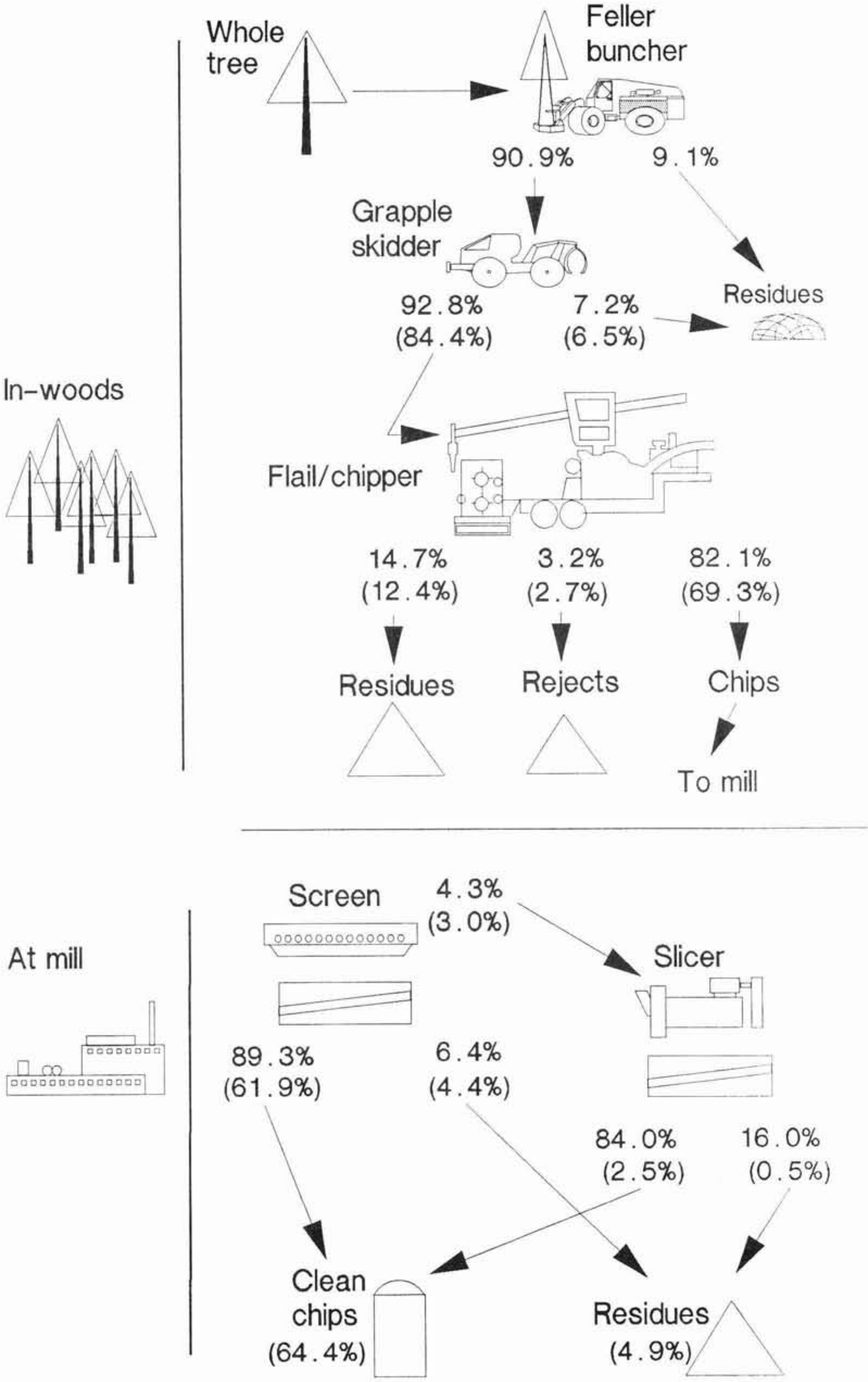

Figure 4 : Product Flow in Slash Pine

the forest. Of the original whole tree that makes it to the flail, about 15%, or about 30 to 35 tonnes per hectare in the Slash pine, is left as residue.

At the mill further losses through screening and reslicing of over-sized chips resulting reduce final utilisation to 64.4% of the whole tree.

How does this 64.4% recovery compare with conventional operations in Slash pine stands? The dominant pulpwood harvesting method in the South is tree-length harvesting, where trees are delimbed and topped in the woods and transported in full tree length. At the mill, the stems go over a slash deck and are then drum debarked before chipping.

Similar trial work in these conventional systems have shown that 75.9% (c.f. 69.3%) of the whole tree biomass (bole and bark) is delivered to the mill and ultimately 61.5% is recovered as clean chips for pulping (Stokes and Watson, 1988). The use of the flail and in-woods chipper can therefore recover an additional 3% of usable raw material per hectare in Slash pine.

Loblolly pine (Pinus taeda) is probably closer in its characteristics to Radiata pine when harvested. The branches on Loblolly are more persistent than Slash therefore less biomass is lost through felling and extraction. Using a similar analysis to the above, an estimated 74% of the whole tree is converted to clean chips with flail processing and in-woods chipping (Figure 5).

BARK CONTAMINATION

Paper product manufacturers are commonly concerned about the proportion of bark contaminants in their raw material. The chain flail process generally does not remove the same proportion of bark from the bole as do the fixed plant installations.

Initial indications are that bark residues constitute about 1-3% of the unscreened weight (Stokes and Watson, In prep.). This may limit the total volume of flail processed wood which can be blended into conventionally debarked wood in some processes.

BRANCH REMOVAL WITH RADIATA PINE

The pine stands in the South have a finer branching habit than Radiata pine so how would the flail units cope with the more persistent, larger branches of Radiata pine?

It is expected that not all branches on Radiata would be removed by the flailing action, however experience with heavily branched hardwoods indicates that those branches remaining attached would be debarked and could enter the chipper. It is possible that the design of the infeed system might have to be adjusted to handle Radiata pine by using some form of feed roll crushing to reduce the larger crowns.

INCREASED CAPITAL COSTS

The use of the flail processing/in-woods chipping systems will undoubtedly cause an increase in the amount of capital required to put an operating system in the forest. Table 1 indicates that the price of a flail unit is $US130,000 to $US160,000, while a matching in-woods chipper would cost $US230,000 to $US275,000.

In the South this level of investment requires a throughput of about 250 tonnes per day. Estimated payment rates are $US16-18/tonne delivered at the mill.

One option found in various forms in the U.S. South is the transportation of whole trees to a central site for delimbing/debarking and chipping. The cost of increased capital at the processing site is shared over a greater volume.

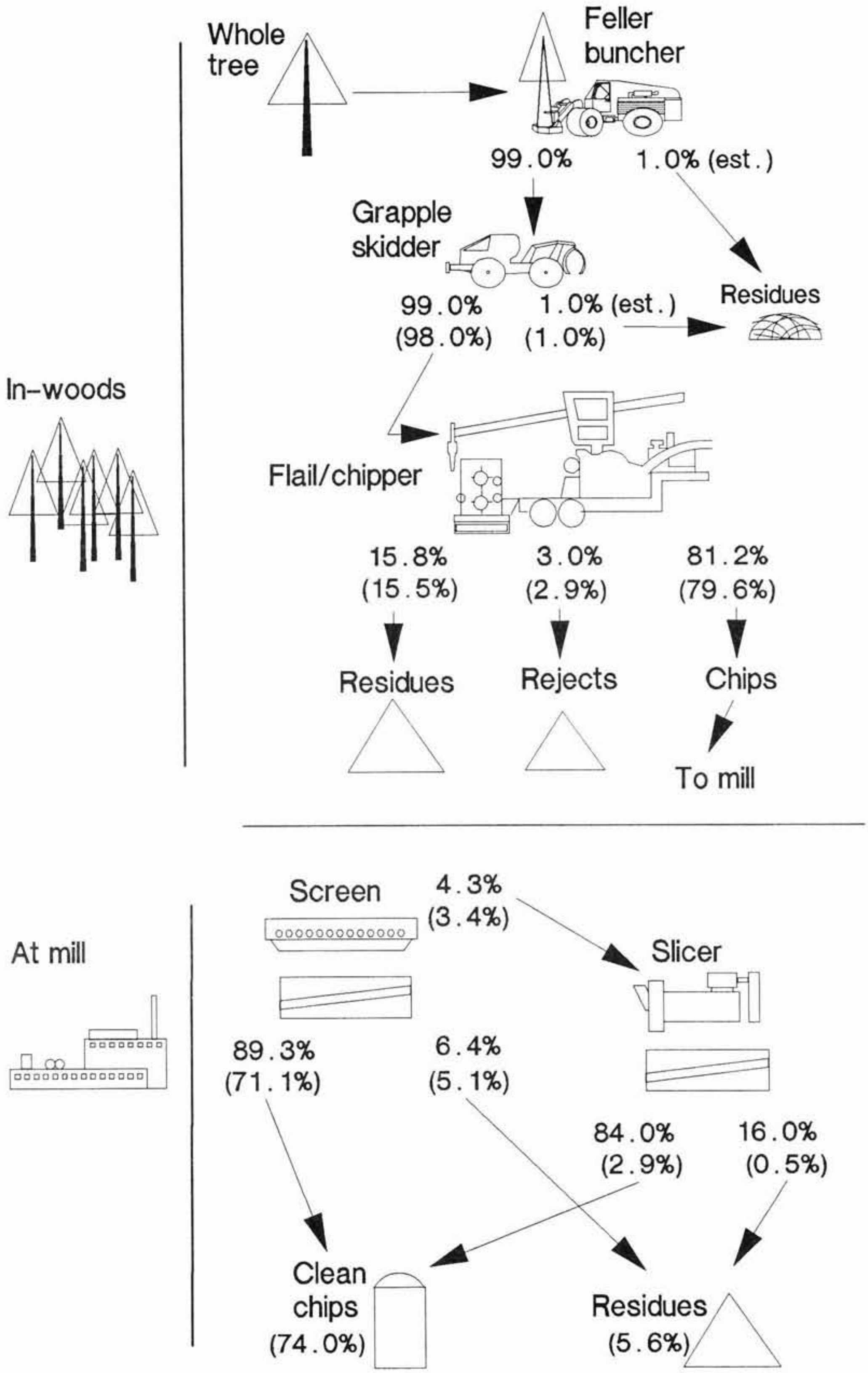

Figure 5 : Product Flow in Loblolly Pine

Also there is the additional benefit that harvesting productivity is improved by the removal of one phase of the operation from the logging site. Where significant thinning activity is being undertaken in an area, it may be feasible in New Zealand for two or more harvesting crews to feed one delimbing-chipping unit.

SUMMARY

The pine plantations of the South are a vast resource totalling almost 9 million hectares in the 12 Southern states from Texas to Virginia. These predominantly Loblolly pine stands are not too dissimilar in appearance to the young Radiata pine stands of New Zealand. This large concentration of resource allows the development of specialised harvesting technology, of which flail processing will be but one example.

From the experience of its use in the South, the flail/chipper option could potentially be used in New Zealand in the following conditions:

A. *Where medium scale thinning operation or early clearfelling is being undertaken with pulp chips the main product.*

B. *On terrain where mechanical felling can be employed, as the system requires a reasonably high throughput to remain economically efficient.*

C. *Where mill capacity must be supplemented over the short term, or where it is not economic to construct fixed plant facilities.*

D. *Where chip destination will be uncertain. Flail/chipping allows the product to go directly to a consumer (mill/yard/port), without going through a central site.*

Some or all of these conditions match the logging environment in many current or future forests in New Zealand. Flail processing combined with in-woods chipping may provide the most economical processing solution in these sites.

REFERENCES

Gordon, R. 1978 : "Delimbing Studies". LIRA Project Report No. 4.

Gordon, R. 1983 : "Early Attempts at Mechanised Felling/Delimbing in New Zealand" in Research and Development in Tree Harvesting and Transportation. LIRA Proceedings, Rotorua, New Zealand.

Selby, J.S. and Iff, R.H., 1986 : "Multi-stem Delimbing-Debarking with a Double Chain Flail". LIRA Technical Release Vol. 8 No. 10.

Stokes, B.J. and Watson, W.F., 1988 : "Flail Processing: an Emerging Technology for the South". ASAE Proceedings, Paper No. 88-7527.

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