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INTRODUCTION OF A FLAIL-CHIPPER TO NEW ZEALAND

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The Forest King 2318 working at Matahina F Forest Block

ABSTRACT

A mobile flail delimber-debarker-chipper, the Forest King 2318, started producing in-woods chips in October 1990. The Forest King processed from piles of radiata pine thinnings at the landing and loaded directly to chip cartage trucks.

The chip output was monitored for bark content, chip quality, and daily production. A six-day detailed time study of activities on the landing was carried out, as well as a longer term summary of operators' daily reports.

Bark content averaged less than 0.6%, and chip dimensions met mill requirements.

After two months of operation, daily production was regularly 9 loads or 265 green metric tonnes.

INTRODUCTION

The necessity to reduce the cost and improve the quality of pulpwood chips while making better utilisation of the wood resource has generated increased interest in chipping in the forest.

The chain flail working in conjunction with a mobile chipper has emerged in North America as a cost effective means to delimb, debark and produce quality chips for pulping. Several models are commercially available, either as delimber-debarkers working with a chipper, or as self contained delimber-debarker-chippers (Twaddle et al, 1989, and Raymond and Franklin, 1990).

Wood Processors Limited of Rotorua designed and built a New Zealand version of the flail delimber-debarker-chipper. The Forest King 2318, commissioned in late October 1990, was built over a fourteen month period. It started producing chips in Matahina F forest block supplying the Caxton Paper Limited mill at Kawerau.

This report presents the results of initial operational trials of the machine at Matahina. The chipper operated for seven weeks before modifications were carried out. Study 1 is based on operators' daily time reports and Study 2 results are based on measured time studies. Productivity data for both studies comes from weighbridge docket summaries, and bark content and chip dimension results are derived from chip samples taken at the chipper site.

ACKNOWLEDGEMENTS

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MACHINE DESCRIPTION

The Forest King has several unique features which differ from overseas models of this type of machine.

Loader

The on-loader operates independently of the Forest King flail-chipper. It is therefore free to reposition for best access to the woodpiles.

At present, loading is done with a Komatsu model 150LC knuckleboom loader equipped with an elevated cab and a by-pass rotating grapple.

Frame

The I-beam main frame is mounted on a highway trailer with tandem-axle suspension. A king pin is provided at the front end for towing by truck. Hydraulic stabilisers support the front end so the towing tractor may be detached. Folded up for transport, the unit is 14.8 metres long (excluding the towing tractor), 3.8 metres wide, and 4.2 metres high. The total weight is 28.0 tonnes, thus the unit requires a special permit for transport on public highways.

Power Units

A 448 kW (600 hp) Cummins model KTA diesel engine powers the 1.47m (58") diameter Morbark chipper by mechanical means, through a twin disk clutch and a set of vee-belts. A separate 6 cylinder Cummins model CTA 179 kW (240 hp) diesel drives the various hydraulic motors for the flail drums, the conveyors and the circuits to the stabilizer jacks. Both of these engines are located at the front end of the trailer frame above the king pin.

Figure 2 - Infeed end of the Forest King

Infeed Conveyor

The 1.0m wide infeed conveyor belt trough is 5.0 m long, supported by one powered and one idling end roller and two carrier rollers. The belt speed is set at 40 metres per minute. The chipper operator commands the start, stop and reverse of this infeed conveyor by radio remote control. A 5.0 m conveyor extension is hinged to fold up during transport. The outer support roller is powered to enable longer trees (up to 20 metres) to be processed.

Monitor Lineal Feed Velocity

The trees are taken up from the infeed conveyor and fed through the flail by powered serrated rollers. The lower roller is fixed and the upper crush roller is vertically moveable. The speed of both of the flail feed rollers and the chipper feed is monitored and displayed as a digital read-out in feet per minute lineal input velocity. The digital read-outs facilitate changing feed rates to optimise input and output quality and quantity.

As on the flail assembly, the chipper's lower feed roller is fixed and the upper is vertically moveable, providing constant down-pressure and positive feed.

Flail Chamber

The opening of the flail chamber has a protective curtain of chains as on other similar units. The gullet is further sloped or reduced inwards and downwards to a maximum 58cm (23") high and 1.27m (50") wide.

Flail Assembly

The flail drums which are 25cm in diameter (10") are horizontally mounted. The lower drum is fixed and the upper one floats up and down by balanced air cylinders. This keeps the chains at their most effective height for best quality and production. Drum rotational speed is 490 rpm, powered by direct drive radial piston hydraulic motors.

There are six rods on the inside perimeter of each drum, on to which the 42cm, 8-link lengths of 16 mm alloy chain are anchored. There are up to 10 holes for attaching chains to each rod. Forty-eight chain lengths are currently being used on each flail drum, although it is simple to add, remove or reorganise the set-up of chains on the drum as conditions demand.

Debris Disposal

A conveyor belt system is used to remove the debris created during processing. The debris drops from the flail chamber and is conveyed on to a belt elevator to the side of the machine.

Another curtain of chains guards the exit from the flail chamber. Between this point and the chipper gullet there is a short, one metre space which allows small bits of debris to drop out. This debris would otherwise be carried into the chipper. This material is conveyed by belt to the main elevating conveyor.

The belt debris elevator frame is hinged to fold on to the top of the machine for transport. The infeed conveyor extension folds in a similar manner for highway travel, as does the chipper spout.

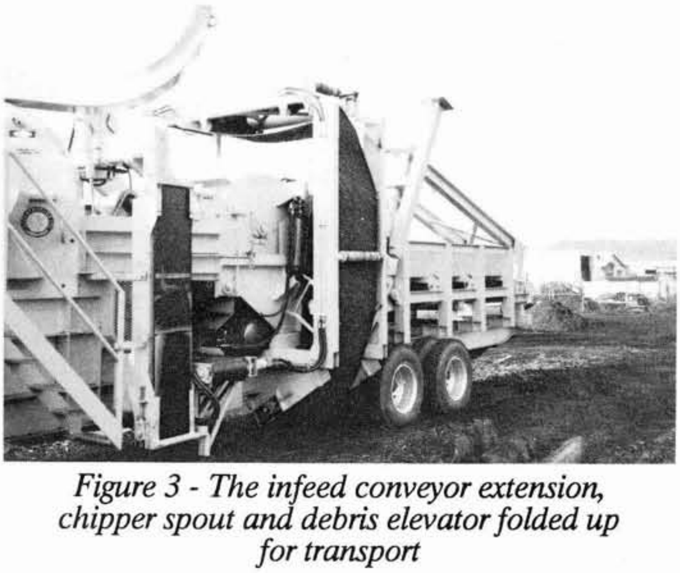

Figure 3 - The infeed conveyor extension, chipper spout and debris elevator folded up for transport

Chipper

The chipper is a Morbark Model 20 with dirt separator. Maximum capacity is 45cm log diameter. The disk is built to accommodate six knives. By inserting dummy knives into certain knife slots, the unit may be operated with six, three or two knives. Three knives are being used at present, to suit the available horsepower, tree size and lineal throughput.

Chip Loading

The chipper spout is set up for top loading, to suit the chipliner configuration popular in New Zealand, although it can be easily changed to the end loading set-up which is common in North America.

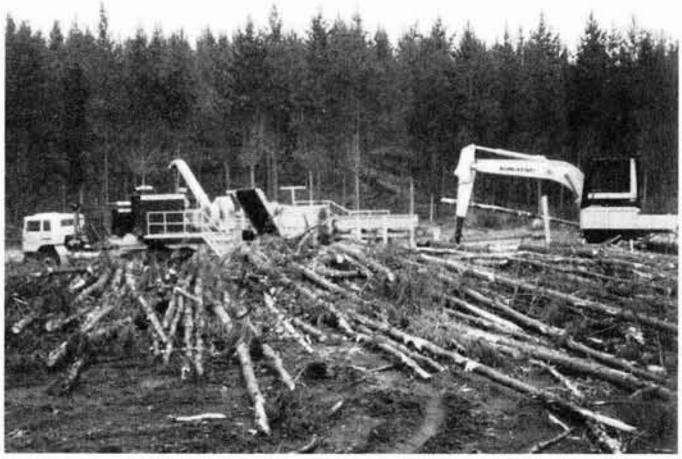

Figure 4 - Thinnings ground skidded to landings were fed directly to the Forest King by a knuckleboom loader.

SYSTEM OPERATION

The trees processed were 14 year-old radiata pine from production thinnings which had been stockpiled. The average piece size processed during both trials was 0.38 tonnes. The trees were manually felled by chainsaw and skidded to the landing by rubber-tyred cable skidder or small crawler tractor.

On relatively flat terrain where landing size was not restrictive, the chipper was moved among several skidding crews. These crews prepared stockpiles for the chipper, and then re-used the same landings.

A knuckleboom loader fed trees butt end first on to a live belt in-feed conveyor. Pulpwood chips were blown into a parked chip trailer and debris from the chipper's dirt separator was blown out to the side. Flail debris was conveyed on to the ground.

The introduction of a flail-chipper and chip liners into the system did not require major changes in harvesting.

RESULTS

Productivity

Productivity was expressed in green metric tonnes (GMT) (Table 1).

Study 1 - November, 1990

The learning curve and some "teething" problems during the initial start-up period was obvious. Production went from 4 loads per day at the start to an average of 7.3 loads per day in early December. At this production rate, chipper utilisation (actual chipping time) was under 55 %, with the remaining time used waiting for trucks, positioning trucks, moving on landing, and moving to new landings.

It took 36 minutes and approximately 75 trees to produce 29 green metric tonnes of chips. Moves between landings and lunch breaks generally took place while waiting for trucks. Most mechanical maintenance was carried out outside the working shift. In-shift mechanical breakdown was minimal, being mostly confined to the on-loader grapple.

Study	Loads /day	GMT per Load	GMT per PMH	GMT per SMH	Time/ Load (min)	Machine Utilisation (%)	Machine Availability (%)
1. November, 1990	7.3	29.5	31.7	26.8	36.1	54.6	90.0
2. February, 1991	9.0	29.4	36.7	30.0	29.4	49.9	91.3

Table 1 - Chipper Productivity, Utilisation and Availability

Scheduling of the chipliners had to be flexible to react to daily changes in production, or operating problems, although 9 loads per shift were often achieved.

In-field modifications were carried out to the debris disposal system, significantly reducing lost time from logs jamming up.

Some modifications were done to the Forest King over the Christmas shut-down. A hydraulic oil cooler was added, and part of the debris disposal system was re-designed. The outer idler roller on the infeed end was powered to improve log feed.

Study 2 - February, 1991

Production improved to the point that it now took only 29 minutes to chip a 29 tonne load, and daily production regularly averaged 9.0 loads.

Chipper utilisation decreased from 54.6% to 49.9%. The 6.7 minutes per load improvement in "load chips" was partly due to reduced delays after modifications, and partly from improvements in operating techniques.

Solutions to logistical problems such as the chipper waiting for trucks, trucks waiting for loads, moving to new landings and optimum piling of trees on the landings had to be found.

Chip Quality

Bark Content

In October/November chip samples were collected from 51 loads and analysed for bark content.

A chip sample (approximately 2.5 kg) was collected from the loaded chipliner prior to it leaving the chipper site using a standard procedure. For each sample, the total bark was weighed to 0.1 gram accuracy. The total green weight of bark was expressed as a percentage of total green weight of chips plus bark:

$$\textbf{Bark Content} = \frac{\textbf{(Bark Weight x 100)}}{\textbf{Total Sample Weight}}$$

= Mean 0.58 %

At 99% Confidence level, the mean is

0.58 ± 0.12.

Chip Size Classification

Chip dimensions were analysed using procedures and techniques accepted to classify, weigh, and check chips for bark content. Analysis was carried out using a Williams classifier.

The acceptable size parameters vary from mill to mill. Since the chips on this project were destined for the Caxton Paper Limited mill, the chip analysis was based as closely as possible on their specifications (Figure 5).

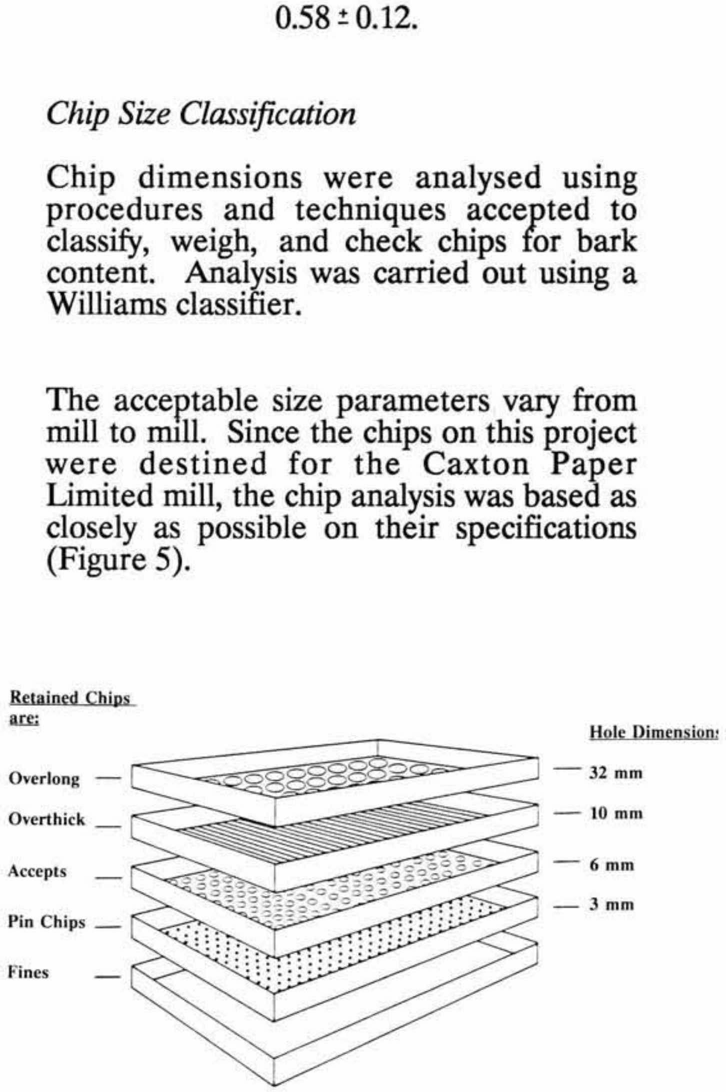

Figure 5 - Williams Classifier

The results of six batches of chips sampled from 18 loads of radiata thinnings are illustrated in Figure 6.

Chips from young radiata during summer conditions tend to include "cards". This increases the oversize percentage somewhat. This same phenomenon was noted in radiata chips from other millyard chippers and suggests that carding is more of a

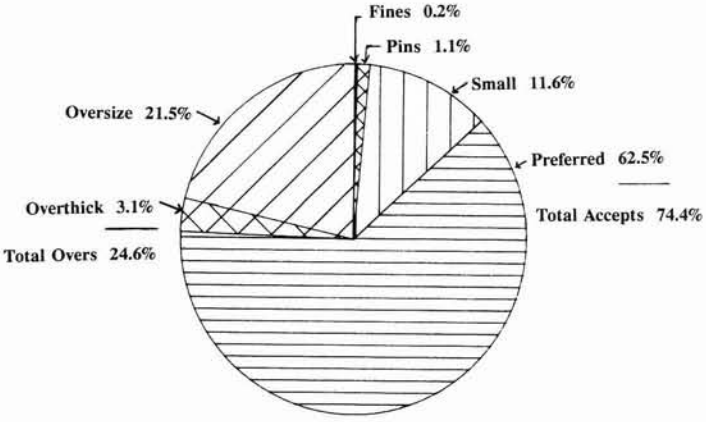

Figure 6 - Chip Classification Results

species problem than a chipper problem. Regarding the oversize proportion, the quality of chips from the Forest King (particularly brightness and cleanliness) makes them Caxton Paper Limited's preferred furnish.

COST OF PRODUCTION

Since the Forest King is a prototype with only five months of production experience, it is difficult to predict the operating life of the various components. Hence no costings have been undertaken.

The purchase price quoted by the manufacturer for the Forest King is NZ$695,000. Other equipment which may be required for the operation includes a knuckleboom loader, towing truck, fuel truck and a utility service truck.

The operation can run with two people, provided that at least one is capable of mechanical operating repairs.

CONCLUSION

Chip samples, taken from 51 loads, averaged 0.58 % bark content. At the 99% confidence level, the mean bark content is less than 0.7%.

Samples of unscreened chips from the Forest King put through the classifier show that size and shape is acceptable in young radiata pine. The percentage of pins and fines is very low. However, the percentage of overs exceeds that of mill specifications, in summer conditions. Information on chips produced at other millyards and other millyards' permanent chipping installations shows that the same problem exists.

These early studies confirm that a potential production rate of one green metric tonne per minute can be achieved with the Forest King. However, logistical problems such as keeping a supply of wood to the chipper and an available chipliner in place, significantly reduce this productive potential.

The subject of a later progress report will show that **daily** production increases significantly on a semi-permanent landing, as the chipper utilisation improves through reduced truck and raw material scheduling problems, and through the elimination of frequent shifts between landings.

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