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MECHANISED PINE FELLING AND DELIMBING

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AUSTRALIAN HISTORY

Mechanical felling and delimbing in Australia started with the Windsor Harvester. In the late Sixties, Bill Kerruish of the CSIRO perceived that Australia needed a machine to improve productivity in the tedious business of first thinning pine plantations. The result was the Windsor Harvester, a machine developed in conjunction with the engineering genius of Rob Windsor. Although the Windsor Harvester was ahead of its time, it was an impressive machine. This point is underlined by the fact that Timberjack scrapped its expensive developmental programme to build a tree harvester in favour of buying the manufacturing rights for the Windsor and selling a slightly modified version of the machine under the Timberjack trade name. Having been present when the first Timberjack engineers saw the Windsor working, I can vouch for the effect on the gentlemen concerned!

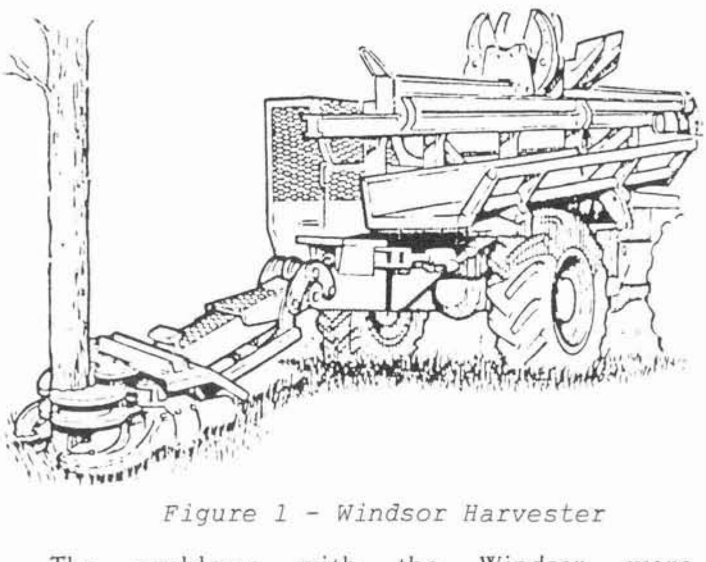

Figure 1 - Windsor Harvester

The problems with the Windsor were three-fold :

(a) It produced a long length product, at a time when Australian plants using first thinnings all had woodlines which only accepted short length billets.

(b) It did not delimb the bottom 1.2 m length of each tree.

(c) It had a limited delimbing stroke, and so sometimes wasted merchantable wood in the heads of trees.

Apart from these three shortcomings, in our contractors' hands the Windsors were highly productive, with reasonable mechanical reliability.

The next mechanical harvesting system introduced to Australia on a production basis was the Logma processor. The Logma was originally introduced in Sweden in the mid-Sixties as a tree length delimber/buncher, but on a trip to Sweden in 1976 I saw a Logma owned by a contractor which had been modified somewhat from standard. The contractor had mounted an hydraulically powered chainsaw behind the second set of delimbing knives in order to cut the delimbed stem to the various product lengths required by his customers.

This machine looked like the answer to mechanisation in Australia, though in paper costing exercises it was apparent that it would not be economic in small sized trees. The features that commended the Logma over other machines were :

(a) It could delimb from the top or bottom of the tree.

(b) It could double-shuffle a stem in order to remove any stubborn branches.

(c) It was 2.8 m wide, so could fit down our nominally 4 m wide outrows.

(d) It was mechanically simpler than the more outmoded feed-roll type processors available at that time.

(e) It was able to handle malformed trees with relative ease.

(f) It could delimb the entire length of the stem.

The CSIRO built a simple feller-buncher head which was mounted on the front of a Case tracked front end loader for an Australian trial, and APPM and ANM sponsored a Swedish operator to come to Australia for three months in order to fully assess the potential of the Logma. The machines were operated and studied in APM Forests' plantations in Victoria. Both the Logma and the feller-buncher worked well, and were declared a success in radiata pine thinning under APM Forests' conditions. APM Forests bought the Logma and a Kockums 880 feller-buncher and put the system into production on a contract basis. The system has saved us money from its introduction.

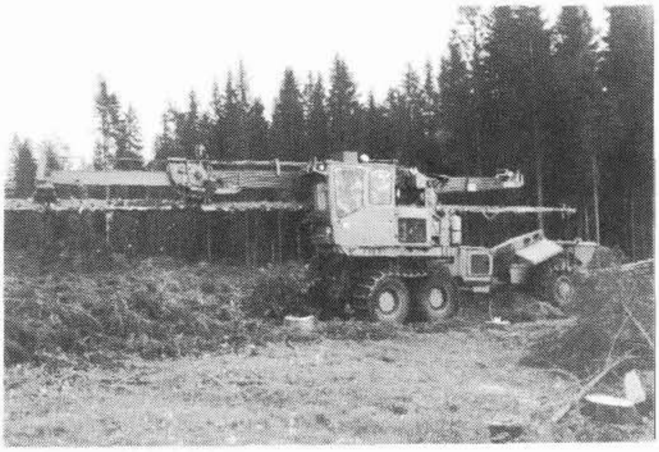

Figure 2 - Logma tree-length delimber

About the first time that APM Forests bought their first Logma, John Deere took the Australian scene by storm and sold a number of their John Deere harvesters to various companies around Australia. One of these companies was ANM, in Tasmania, who were intent on building up their experience in mechanical pine harvesting prior to starting up their new newsprint mill at Albury, New South Wales.

ANM's decision for their Albury operation (after observing their John Deeres in action for some time) was for their contractors to buy seven Kockums Logma processors and seven Kockums feller-bunchers.

In between these major events there have been many oher harvesters and processors introduced into Australia with varying degrees of success. In chronological order, these were :

(1) One Tvigg feed roll processor was bought by Pyneboard in the mid-Seventies.

(2) Various locally made feller-bunchers mounted on an assortment of carriers appeared in all the eastern States. In Queensland, due to the easy delimbing characteristics of Pinus elliottii, these were linked with gate and chain delimbers and Boschen's "Clever Hole" delimber.

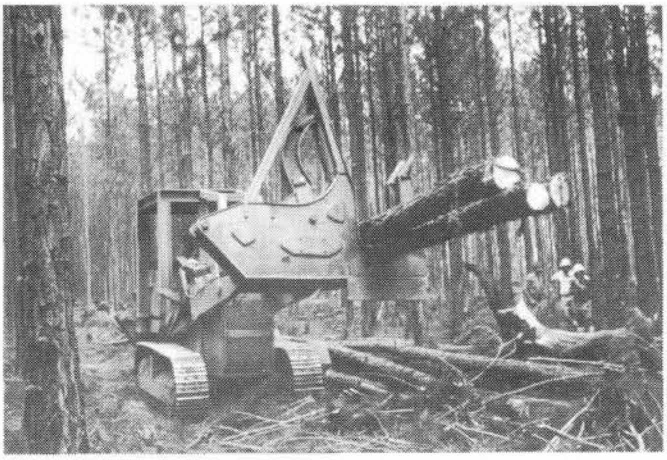

Figure 3 - Clever Hole delimber - Logs are held in front jaws during delimbing and transport

(3) We then had the era of the grapple processors, including :

  (a) The Skogsjan
  (b) The Sifer
  (c) The Steyr

(4) In response to increasing costs of Swedish equipment, APM Forests introduced two new types of slide boom processors, the Harricana and the Koehring.

(5) Two Denis slide boom processors were introduced by a contractor in the Tumut region of New South Wales.

(6) New Zealand's own Waratah harvesters were introduced to Australia, after some Australian proposed modifications were made to the initial machine.

(7) Kockums feed roll processors were bought in Western Australia and Victoria.

(8) Four Kockums GSA 62 grapple harvesters have recently been sold into Victoria.

(9) Two Osa 706/260 feed roll harvesters have been introduced into the Eastern States.

(10) A Cat 227 and two Timbco feller-bunchers have been sold into New South Wales and Victoria.

(11) Two Koehring feller-bunchers with the disc felling head, together with two Koehring processors, have been sold into South Australia recently.

(12) A Lako grapple harvester has been sold into South Australia recently.

In summary, Australian pine harvesting is highly mechanised. The trend will continue, and it is only with trees greater than 50 cm diameter at the stump that mechanical harvesting is not knocking at the door.

THE WOODLINE

Why start off a practical dissertation on mechanised pine felling and delimbing with the woodline? Because the woodline dictates, for its life of maybe 30 years, what equipment you can use in the forest, and consequently how much wood will cost delivered to the woodline.

Anyone contemplating building or modifying a woodline should keep the following points firmly in mind :

(a) Make sure the chipper will accept big logs, crooked logs and forked stems. Pine trees grow like that. It costs money to alter them.

(b) Make sure your debarker and conveyors will accept the above logs, and if the capital cost is not too much higher, that it will accept logs with a fair number of limbs still on them, and still do a good job of debarking.

(c) Make sure that the line will accept wood in a restricted random length range, and avoid a slashing deck if possible. However, leave space for a slashing deck to be installed later, if technology changes. Slashing decks tend to need well delimbed straight stems in order to operate smoothly, a point which should never be forgotten.

(d) Make sure the bark outfeed conveyor can handle branches and bits of broken logs, as well as bark.

(e) Build the whole thing up in the air so that it's easy to clean the inevitable debris out from under it, using machines.

Having said all this, it is likely that most people contemplating mechanisation in pine harvesting are saddled with an existing woodline which will impose a number of limitations on their harvesting equipment. How many limitations depend to a large extent on the degree of liaison between the woodyard crew and the bush crew. The closer their links and understanding of each other's problems, the less trouble will occur at this vital interface.

MECHANISED FELLING

The simplest way to fall a tree mechanically is with shears. This method is not widely used overseas because of the end checking which occurs in the butts of trees, particularly when they are frozen. However, APM Forests' experience is that, provided the shears are properly aligned and they are kept sharp, the maximum checking in radiata pine seems to be about 5 cm long, which leads to less wood loss than occurs when a proper scarf is used in falling the tree by hand.

Figure 4 - Mechanical tree shears

The advantages of falling trees with shears are :

(a) Shears are a relatively low maintenance piece of equipment.

(b) They leave a low stump, provided your woodline can tolerate the resultant buttressing on the log. This means that about 2% more wood is being produced per hectare than is the case with standard chainsaw felling. Butt wood is also the most valuable wood for kraft pulping, and your re-establishment costs tend to be lowered with the stump.

(c) They are quick and safe.

The disadvantages are :

(a) There is some splitting in the butt of the tree. This is particularly bad in the case of shears using a single blade cutting against an anvil, such as the Fleco. Scissor shears minimise the splitting.

(b) Shears require a heavy head to support the forces involved in their operation.

The other way of mechanically falling trees is by means of a saw, either a circular saw or a chainsaw. These are so different that they should be treated separately.

Felling heads which use chainsaws are relatively light in weight, and generally are designed to just cut through the tree and tip it over in a desired direction.

Such heads have the following advantages :

(a) They can be mounted on the end of long booms, due to their light weight and the fact that they are not picking the whole tree up when it is cut off.

(b) They produce no checking in the log, although some of them have a tendency towards a "barber chair" slab being left on the stump.

(c) There is no scarf, so no waste at all at the butt of the tree.

(d) Without a massive increase in size of the head, trees of 50-60 cm diameter at the butt can be felled.

(e) Low power requirements.

(f) They handle wind thrown trees with ease.

Their disadvantages include :

(a) They are easily damaged, particularly by learner operators, and are a high maintenance item.

(b) They leave higher stumps than do shears.

Figure 5 - Koehring circular saw felling head

The only high speed circular saw felling head in use in Australia is the Koehring. This is a remarkable unit in terms of felling speed in a clear falling operation, but its cutting speed is of no real advantage in thinnings. My experience of this machine is not good enough to comment on its mechanical realibility, but it does make a woolly mess of the butt end of the tree. I am assured that this has no affect on the quality of the sawn product from the butt log, but I cannot verify this comment from my experience.

MECHANISED DELIMBING

In this section, I will only talk about processors, i.e. machines which remove the branches from felled trees and cut them to desired lengths. Our experience in Australia has been with two main types :

(a) The slide boom types, pioneered by the Logma

(b) The feed roll type, pioneered by the Tvigg in Australia.

Figure 6 - Koehring slide boom delimber

The slide boom type has the following advantages :

(a) The slide boom can be mounted on an excavator type carrier. These carriers are cheap, reliable, mechanically simple and, since the advent of variable displacement hydraulic pumps, can do remarkable things with very low engine power. Excavators are also cheap to operate, but they need quite a bit of guarding to make them suitable for bush operations.

(b) Slide booms can process crooked and forked stems fairly easily, and can delimb the whole length of the tree.

(c) They have good delimbing forces.

(d) Slide booms are comparatively simple and rugged.

Their main disadvantage is their throughput. Given trees of good form, they are generally slower than feed roll processors.

There are two classes of feed roll processors :

(a) The grapple type feed roll processor, which hangs on a boom mounted on the carrier (e.g. Skogsjan, Sifer, Steyr).

(b) The larger type which are mounted on the back of a forwarder or modified feller-buncher (e.g. Kockums, Osa)

The grapple type has problems delimbing trees with big limbs. They are fairly flimsy in construction and are a high maintenance item. Their length measuring ability is variable, ranging from very good to mediocre. They are comparatively cheap, however, and can be mounted on a cheap carrier with low operating costs, apart from maintenance of the head.

Figure 7 - Steyr KP40 delimbing head

The larger type processor on the back of a forwarder, such as the Kockums, is now using Super Single, radial ply truck tyres in place of the spiked feed rolls used by similar machines in the past. When fitted with wheel chains, these tyres seem able to exert a greater pull on the stems than the spiked feed rolls were capable of. The result is that the delimbing effort of these machines now seems as good as that of the slide boom processors. Their ability to handle crooked trees is also much improved. Their main drawback lies in their complexity, but their ability to automatically merchandise a tree into a number of products may make them attractive to some users.

All feed roll processors suffer from one common fault. They are unable to delimb the bottom metre of the tree, which is the distance between the feed rolls and the delimbing knives.

HARVESTERS

A harvester is defined as a machine that cuts down the tree and processes it into the final product. The Scandinavian approach to harvesters has been to add a falling function to their processors, which satisfies two classes of customer and basically one type of machine. Harvesters operating in Australia include :

(a) John Deere
(b) Osa
(c) Lako grapple harvester
(d) Kockums GSA grapple harvester
(e) Waratah

There are quite a few secondhand John Deere's available in Australia. The Osa is a well engineered, highly productive machine but is complex and very expensive. The Lako and Kockums GSA both have a large number of vulnerable hydraulic hoses around their head. The Osa, Lako and Kockums GSA all use chainsaw felling systems which are very vulnerable to operator abuse, particularly during the learning phase.

Figure 8 - Osa boom mounted processing head

The Waratah is a simple rugged piece of equipment, with one less function than all other harvesters. It uses gravity instead of feed rolls to propel the tree through the delimbing knives. The only recurring problem with this machine centres around repeated valve bank failures, a problem which should be solved in the not too distant future. Unfortunately, it has the major drawback of not having a length measuring system for the wood it produces.

All these harvesters share the common problem that feed roll processors suffer from - the inability to delimb the bottom metre or so of each tree. The Waratah, however, gets lower than most, and the Kockums GSA, with delimbing knives both sides of the feed rolls is on a par with the Waratah.

THE CHOICE

These is an incredible range of equipment to choose from. Perhaps we should discuss some of the factors which should influence such a choice.

(a) Mechanical Reliability

Every function on every machine has a reliability rating. The more functions you add, the more chance that at any one time the machine will be broken down. Let us say the prime mover has a reliability of 90%, that is you can expect it to have some mechanical failure for 10% of the time during which it should have been working. Now put a processor on that prime mover. The processor has a reliability of 90% too, but in combination with the prime mover, the overall reliability drops to 90% of 90%, or 81%. Now convert that processor into a harvester by adding a felling attachment with a 90% reliability. The overall reliability now becomes 90% of 81%, or 73%. These percentages are fairly realistic, so forwarders, processors and feller-bunchers can be expected to have about 80% utilisation, and harvesters can be expected to have about 70% utilisation. Utilisation in this context is defined as :

$$\frac{\text{The number of machine hours worked}}{\text{The number of hours a man is available to work it}} \times \frac{100}{1}$$

It measures not only the mechanical reliability of the machine, but also the efficiency of the system within which it works.

There is one exception to this general rule and that is the Waratah harvester, which uses gravity as its "processor" function. Gravity has a reliability rating of 100% here on earth, so the Waratah has a utilisation of about 80% in common with feller-bunchers.

The advantage of a "feller-buncher followed by a processor" system is that you can have, say, 4 days stockpile of wood on the ground between the two machines, and between the processor and the extraction machine, which gives you plenty of time to repair breakdowns. In this way, the flow of wood never stops, so the whole system produces continuously at 80% efficiency. However, you need more capital, more men and a higher quota to justify this system than you need if you selected a harvester.

(b) **Simplicity**

In the early stages of learning about mechanical harvesting, there is a lot to be said for sticking to the simplest machinery available. Having said this, though, our experience has been that once contractors get used to the more complex machines, breakdowns take no longer to fix than they do on the simpler machines. For example, Logmas have an electrical micro switch in their joystick control. The first time this failed it took one and a half days and a specialist auto electrician to trace the problem and fix it. Nowadays, spare micro switches are a standard item in the Logma operator's "buggery" box and the diagnosis of the failure and replacement of one of these switches takes about 20 minutes, and is done by the operator.

As far as simplicity is concerned, it is hard to find a simpler prime mover than an excavator. It is no coincidence that they are finding so much favour in timber harvesting in Australia and that manufacturers are adapting so many attachments to mount on excavators. They have got some limitations, however, including :

(1) Comparatively slow travel speed.

(2) Poor guarding underneath for bush operation

(3) Inability to travel on public roads

(4) A rigid track system. This causes problems in broken country and where stumps have to be walked over.

(c) **Local Content**

If you are thinking of buying into mechanised harvesting equipment, go over the machine(s) available and see how much of their componentry is available off the shelf, or can be serviced locally with experienced service personnel, without having to resort to the agent from whom you bought the machine. You may be surprised. Such things as :

- Diesel engines
- Hydraulic motors and pumps
- Bearings
- Transmissions
- Hydraulic cylinders
- Shear blades
- Electrical componentry
- Axles and differentials

can often be either sourced locally or a local equivalent can be substituted for a broken down part. Give preference to buying machines which fall into this category.

(d) **Matching**

I mean a number of things under this heading. Firstly, can you develop a system which is based on machines with identical componentry? Examples are the Kockums feller-buncher, Logma and forwarder; and excavator mounted feller-buncher with a grapple processor mounted on the same model excavator. The reduction in parts inventory, operator and mechanic familiarity with all machines, and the ability of all machines to operate up to the same terrain limits, recommend taking this path if possible.

Matching also means matching the productive capacity of your machines within the system. For example, three Waratah's and one large forwarder can produce 45,000 m3 per year in first thinnings, with an average merchantable tree size removed of 0.14 m3. If the average tree size removed were 0.32 m3, two Waratah's would produce about 47,000 m3 per year, and the forwarder would be struggling to keep up with them. So, if you bought three Waratah's for the latter situation, you would not have a matched system. However, it may be possible to double shift the forwarder and produce 70,5000 m3 per year with three Waratah's and one large forwarder in the first thinning with a 0.32 m3 tree size removed. But will the mill be open to accept the wood if you decide to double shift?

Another example of more complex matching would be a harvesting system designed for an average tree size to be removed of 0.8 to 1.0 m3 Such a system, capable of harvesting about 120,000 m3 per year, could consist of one feller-buncher working on a single shift, two slide boom processors working on a double shift and two forwarders working on a single shift. Whether the wood comes from thinning or clearfelling has little effect on productivity. Tree size is the main factor affecting productivity of mechanical harvesting systems once a threshold of about 80 m3/ha yield has been reached.

Figure 9 - The different production levels of harvesting machines need to be matched within a system. (Kockums forwarder extracting wood processed by Koehring - APM Forests)

(e) **Roadside Processing**

This has a lot to recommend it from the point of view of harvesting efficiency. However, the forest owner must first ask himself whether the effect on the soil can be tolerated. In Victoria, APM Forests grows its plantations on shallow infertile soils, in the main. On these soils, the policy is to process the trees as close to the stumps as possible so that the nutrients and organic matter can be returned to the site as evenly as possible. However, given New Zealand's deep, fertile soils, it may be that roadside processing can be tolerated. This means that the processing unit can be mounted on a cheap, less robust carrier, and the falling and extraction can be combined in the one machine, such as the Timberjack 520 clambunk, fitted with a Hultdins chainsaw felling head. The productivity per day of the processor is likely to be greater than that of one which has to travel cross country because of the constant processing time and the lack of breakdowns with the carrier, roadside processing also lends itself well to steep country operations, where the minimum work is carried out on the slope and the maximum on the road.

The main drawback with roadside processing is that the payload of the machine extracting the wood to roadside is reduced due to the drag effect of the branches on the trees it is skidding. However, this machine is usually not the limiting machine in the system, so if its productivity is down it probably won't alter the overall output of the system.

SHOULD NEW ZEALAND MECHANISE ITS PINE HARVESTING?

I think this is inevitable, and the only questions which really need to be asked are "when" and "with what"? The first of these questions is an economic one, and any country which has been able to economically justify the radical silviculture practiced in New Zealand should be capable of turning Australian productivity figures into New Zealand dollars and reaching a decision. As to the second question, the possible machinery has, in the main, been filtered through Australia's experience in mechanising radiata harvesting, and you need look no further to make a choice.

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