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THE LIEBHERR 731C CRAWLER TRACTOR IN LOGGING

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Figure 1 - The Liebherr 731C crawler tractor with trailing arch

ABSTRACT

A study of a Liebherr 731C crawler tractor extracting 31 year old radiata pine uphill in a clearfell operation was carried out.

A comparison was made of the machine pulling directly off the winch versus a trailing arch. The machine had little trouble working on slopes up to 30 degrees. No formal tracking pattern was employed, the operator preferring to negotiate stumps rather than remove them.

After standardising some variables, including haul distance and drag volume, a 13% increase in productivity was recorded when using the trailing arch. Using a trailing arch significantly increased the potential daily productivity of the Liebherr tractor. The increase was mainly due to the tractor being able to walk with the drag on steeper slopes, thus making travel loading times much faster.

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INTRODUCTION

Tractors and skidders have been used to log relatively steep ground in New Zealand for many years. The general approach is to skid logs downhill, either over the cutover or on formed tracks, to landings at the foot of the slope or in the valley. In many forests in New Zealand, roading near valley bottoms is undesirable due to wet, steep or unstable soils or stream protection requirements. In many of the clay forests, existing access roads are on the dry stable ridge tops. However, the productivity of skidders and conventional drive tractors reduces significantly when pulling uphill. Field (1986) discussed the versatility and advantages of using a hydrostatic drive Liebherr 721 crawler tractor for uphill extraction on 20 degree to 26 degree slopes in Whitford Forest, near Auckland.

More recently, a Liebherr 731C crawler tractor has been used in clearfell radiata pine at Timberlands Berwick Forest. This area had been planned for hauler extraction due to the constraints of the clay soils, climate and ridgetop roading pattern. The availability of the Liebherr tractor and its recognised potential on such sites, coupled with no suitable hauler in the area, resulted in the decision to tractor log as much of the area as possible. The tractor operation had been economically viable while still maintaining required minimal soil disturbance.

This Report discusses the operating characteristics of the hydrostatic drive machine and compares productivity pulling directly off the winch against using a trailing arch, uphill.

THE MACHINE

Powered by a 110 kW Mercedes V6 engine, the tractor is fully hydrostatic. This allows it to maintain maximum torque at very low speeds. Power is continually supplied to both tracks which is advantageous during climbing and tracking. The even distribution of power allows winching, blade operation and steering to be carried out at the same time. Forward, reverse and steering is all controlled from one joystick. The engine is protected from overload by a limit switch which automatically adjusts the hydraulic pumps and motors to regulate speed and power according to changing work requirements.

A 27 tonne line pull hydrostatic logging winch was fitted to the tractor. Attached to this was a 22 mm mainrope and four 19 mm strops. The winch had no free spool mechanism fitted and therefore had to be powered out.

Liebherr 731C Specifications

Engine	- 110 kW (150 hp)
Operating weight	- 17.5 tonnes
Travel speed	- 0-6.2 km/hr
Side track rollers	- 6

Hydrostatic Drives

Hydrostatic drives transfer engine power to traction power by using hydraulic oil under pressure. An engine mounted hydraulic pump supplies oil to an hydraulic motor on the track. Usually two separate circuits are used for tractors, one for each track.

This type of drive allows the engine speed to be independent of ground speed because the hydrostatic system has a continuously variable speed ratio. Variable displacement pumps and motors are used to achieve this.

The two extremes of hydrostatic operation are :

1. High traction loads at low speed by pumping less oil at higher pressure.
2. Low traction loads at high speed by pumping more oil at lower pressure.

Compared with a mechanical drive, hydrostatics offer the following advantages.

- constant engine speed at the optimum setting
- comparable or better efficiency. (Pump or motor losses compared with the losses in the large number of gear meshes in a mechanical drive).
- no friction parts (i.e. steering brake linings).
- speed and direction control by one lever.
- each track is supplied with the power it needs to move. Whereas in a mechanical system the inner track in a turn is slowed by absorbing power in the steering brake.

STUDY AREA

The study of the Liebherr tractor pulling directly off the winch was undertaken in November, 1987. In March 1988 the Liebherr was studied using a trailing arch. Weather during both studies was fine and well suited for tractor extraction on the clay soil. The stand of 31 year old radiata pine stood at 250 stems per hectare with little undergrowth. Slopes that the tractor worked on were up to 30 degrees. The same area was used for both studies.

STUDY METHOD

Continuous time study using a Husky Hunter Data Logger was used for both of the studies. Eighty-six cycles were collected when the tractor was pulling directly off the winch and 41 using the arch (the gang finished the block and no other areas were suitable). Data collected during both studies also included gross productivity, haul distances, slope, pieces per drag and volume measurements.

Scaling of a sample of 84 individual trees gave a mean extracted volume of 1.64 m^3 per piece and a relationship between piece volume and large end diameter (r^2 = 0.72). The volume of individual drags was estimated by applying this relation-ship to the measured large end diameter (under bark).

LOGGING METHOD

Felling

The fallers felled the trees across the slope for butt first extraction. A high standard of trimming was completed in the bush. This reduced the time spent secondary trimming at the landing and also helped reduce slash build up.

Extraction

While pulling directly off the winch the operator normally walked the machine down the hill to the drag and bladed the logs together prior to hooking on. This reduced the amount of mainrope to be pulled out.

As there was no free spool mechanism on the winch, the faller had to be available to pull out the mainrope and

Table 1 - Productivity of the Two Systems

	WITHOUT ARCH		WITH ARCH	
Element	No. of Observations	Mean time per Cycle (min)	No. of Observations	Mean time per Cycle (min)
* Travel Empty	86	1.77	41	1.77
* Blade Bush	40	0.47	21	0.47
Position	55	0.22	39	0.58
* Hook On	86	3.09	41	3.09
Break Out	86	1.74	41	1.47
Winch In Bush	86	2.20	33	2.35
Travel Loaded	86	2.45	41	1.67
Unhook	86	0.59	41	0.38
* Blade Skid	40	0.24	12	0.24
* Fleet	71	0.35	3	0.35
Total Cycle Time (mins)		13.12		12.37
Drag Volume (m^3)		5.74		6.10
Logs per Cycle		3.50		3.72
* Average Skidding Distance (m)		110		110
Productivity (m^3/PMH)		26.3		29.6
Production (m^3/6.5 PMH day)		171		192

* Elements standardised for comparison

strops as the machine operator powered out the rope from the winch. After breakout, the drag was winched up the hill until the slope reached between 10 degrees and 12 degrees. From this point, the tractor was normally able to walk with the drag.

The basic logging procedure with the arch did not differ greatly from that used when pulling directly off the winch. Positioning the tractor and the arch took longer but this increase was offset by the fact that the tractor was able to walk with drags on slopes from approximately 16 degrees.

RESULTS AND DISCUSSION

Due to the small difference in the average haul distance during the two trials (average 109 metres when pulling off the winch and 103 metres when using the trailing arch) a standardised average of 110 metres was used for both.

To provide an equitable comparison between the two systems, other elements were also standardised. The elements which were left with the actual recorded times were position, breakout, winch in bush, travel loaded and unhook. The reason for this was these were the areas where the arch had a real effect on productivity. The other elements were not affected by either of the two operating systems. The only hindrance to cycle times caused by the arch was positioning the arch for hook on and winching. As can be seen from Table 1, the arch did have advantages in certain phases of the extraction cycle. Breakout, for instance, was slightly quicker at 1.47 minutes per cycle as against 1.74 minutes per cycle when pulling off the winch. This 18% difference was mainly due to the arch providing elevation to the drag during breakout. Later in the extraction cycle, the use of the arch restricted the tractor's winching ability.

The height of the arch and the maximum length of the rope to be wound in (30 metres) resulted in the forces from winching the drag being transferred to the front of the tractor lifting the back off the ground, thereby reducing the tractor's holding ability. When using a trailing arch, the influence of lift is usually effectively restricted to a distance from the arch four times the height of the roller (Liley, 1983). In this case, the arch was three metres high and the advantage of the lift obtained was lost when winching more than twelve metres behind the arch. The arch gave the tractor the ability to walk with the drag on steeper slopes and cover the distance to the landing faster. Furthermore, the use of the arch resulted in the butts being more spread out when the drag was dropped on the skid, resulting in a 36% decrease in unhook time.

CONCLUSIONS

The addition of the arch had the effect of increasing productivity 13% (192 m^3 vs 171 m^3 per 6.5 machine hour day). This was achieved through better weight distribution and increased drag volume by approximately 6%. The use of the arch enabled the machine to walk with a heavier drag on slopes of up to 16 degrees. This resulted in a significant increase in potential daily productivity.

The Liebherr tractor proved its ability to climb and manoeuvre on the steep slopes (up to 30 degrees). While ground conditions at the time of the study were good for tractor logging, any deterioration of the clay soil due to rain would adversely influence the performance of the machine.

The hydrostatic drive machine should continue to demonstrate its advantage over a mechanically or conventionally driven machine in adverse conditions by its ability to retain drive power to both tracks.

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