LOGGING INDUSTRY RESEARCH ASSOCIATION
NEW ZEALAND
ISSN 0111-6711
REPORT
Vol. 11 No. 5 1986


# EVALUATION OF LOGQUIP SMART ARCH

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## INTRODUCTION

The Logquip Smart Arch (Ref. 1) was designed to improve the productivity of 50 to 60 kW tractors in logging. It was developed by contractor, R. Linton, who had the prototype built eighteen months ago and has used it ever since. The basic principle of the Smart Arch is that it transfers the weight of the load from the back of the tractor to the castor wheel through the fairlead of the Arch. This is done without sacrificing the manoeuvrability or flexibility of the tractor because the Arch is connectd by two pins to the rear of the machine, and can be lifted clear of the ground when not loaded.

The Logquip Smart Arch showed considerable potential even in its original prototype form. LIRA evaluated the unit and this Report describes the controlled tests and production trials done.

*Figure 1 - Smart Arch butt pulling on to the skid at Omataroa Forest*

*ACKNOWLEDGEMENTS*

*LIRA acknowledges the support and assistance of designer/contractor, R. Linton, for his co-operation during the trials; manufacturer, N. Pritchard, for advice on technical details; and Caxton Paper Mill's Omataroa Forest staff for providing a suitable test site and a loader for weighing logs.*

## CONTROLLED TESTS

The controlled testing was carried out to accurately measure the difference in performance of the Cat D3B tractor when used in the following configurations :

(1) With a towed arch
(2) Pulling directly off the winch
(3) With the Logquip Smart Arch
(4) Through an integral arch

These tests consisted of timing the machine pulling the optimum drag size (i.e. what it could walk comfortably with on flat ground) over the circuit ten times; five in a butt pull situation and five with head pull. The test circuit consisted of an unprepared track through a thinned stand of 14 year old radiata pine. It incorporated a 10 m section of uphill slope (+ 10%), a 10 m section of downhill slope (- 10%), and 10 m on flat. To avoid excessive track disturbance affecting following configurations, two uphill and two downhill tracks were selected. Table 1 summarises the results of these trials.

From the Table, it can be seen that when butt pulling the towed arch was capable of pulling a bigger drag than all the other configurations. The Smart Arch could handle a similar drag size to the towed arch when head pulling, but at slightly faster travel speeds, i.e. .06 km/h downhill, and .13 km/h uphill. Note that when compared with the Smart Arch, drag size was lower when pulling directly off the winch, and lowest with the integral arch. Larger drag sizes were tried in both these latter configurations, but the machine was unable to climb the 10° adverse grade without winching. It is interesting to note that generally uphill travel speeds with head pull were actually faster than with butt pull. It is presumed that this is a function of the weight distribution of the drag over the short 10 m incline.

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Ref 1 : Pritchard, N.; Linton, R. The Logquip Smart Arch for Small Crawler Tractors - LIRA Technical Release Vol 8 No 3 1986.

*Table 1 - Drag Weights and Travel Speeds Recorded in Controlled Testing*

| Tractor Configuration | Type of Pull | No. of Logs | Drag Weight | 10° Favourable | Travel Speeds Flat Ground | 10° Adverse |
|---|---|---|---|---|---|---|
| | | | t | km/h | km/h | km/h |
| Towed Arch | Butt | 6 | 3.19 | 2.13 | 2.10 | 1.29 |
| | Head | 5 | 2.48 | 2.13 | 2.00 | 1.30 |
| Winch Only | Butt | 4 | 2.23 | 2.10 | 1.91 | 1.16 |
| | Head | 4 | 2.23 | 2.05 | 1.90 | 1.26 |
| Smart Arch | Butt | 5 | 2.48 | 2.33 | 1.95 | 1.41 |
| | Head | 5 | 2.48 | 2.19 | 1.99 | 1.43 |
| Integral Arch | Butt | 4 | 1.70 | 2.46 | 2.03 | 1.35 |
| | Head | 4 | 1.70 | 2.38 | 2.03 | 1.54 |

*Figure 2 - The breakout phase of a cycle extracting over Route 2 with the Smart Arch*

## PRODUCTION STUDIES

In production studies, the performance of the D3B Cat and Smart Arch was compared with the same machine fitted with an integral arch (considered the most common configuration used on 50 kW tractors).

The operation was a first thinning of 14 year old radiata pine in a setting with a mixture of uphill and downhill extraction to a skid site located at the road edge. The two main extraction routes used during the study are shown in Figure 3.

A total of 47 Smart Arch cycles and 53 integral arch cycles were recorded over the four day study but not all were considered in the analysis. (The discarded cycles were over short distances with a wide variation in piece sizes and could not be used in the comparison.)

Each drag was individually scaled for volume at the landing. In the analysis of the results, the common elements, not influenced by machine configuration, (i.e. breakout, delimb, unstrop, etc.) were calculated as a time per piece. Travel times are calculated on a distance of 150 m, and then travel speeds (indicated in brackets) are derived from actual time over distance.

Drag volumes are derived from averaging the piece size extracted over the particular route, and multiplying by the number of pieces pulled. Bush travel loaded speeds include the time taken to drop and winch. Daily production estimates are determined by dividing cycle times into 415 minutes and multiplying the average drag size by the number of cycles per day (assuming 6.9 productive machine hours per day). Because of the varying nature of the two extraction routes, the machine cycles over them have been analysed separately.

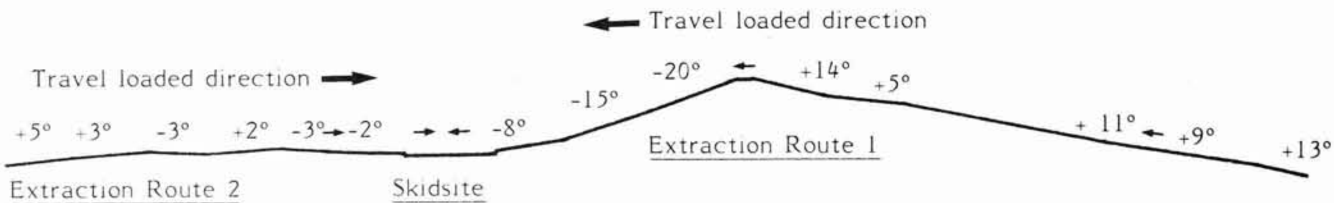


*Figure 3 - Profile of Extraction Routes 1 and 2*

## Route 1

Route 1 was a 240 m long, formed track traversing a ridge into a second catchment area. It included over 160 m of loaded uphill travel, ranging in slope from +5° to +14°. Table 2 summarises element times for extraction over Route 1.

*Table 2 - Element Times for Extraction Route 1*

| Element | Smart Arch | Integral Arch |
|---|---|---|
| No. of cycles | 11 | 19 |
| | Element Times (min) | |
| Travel empty[1] - skid | .35 | .24 |
| - bush | 2.28 (3.94 km/h) | 2.15 (4.18 km/h) |
| Position | .39 | .57 |
| Dismount (and release lifting strop[2]) | .16 | .11 |
| Breakout | 5.21 (4.33 pieces) | 4.69 (3.90 pieces) |
| Travel loaded[1] - bush - walking | 2.20 } (2.82 km/h) | 1.27 } (2.22 km/h) |
| - winching | .99 } | 2.79 } |
| - skid | .46 | .46 |
| Delimb | 1.48 (4.33 pieces) | 1.34 (3.90 pieces) |
| Unstrop | .43 " | .39 " |
| Winch in (and raise arch[2]) | .21 | .12 |
| Butt, fleet and blade skids | 1.06 " | .95 " |
| Delays | .92 | .88 |
| Total cycle times | 16.14 | 15.96 |
| Average drag volume[3] | 1.69 $m^3$ | 1.52 $m^3$ |
| Predicted production (daily) | 43.5 $m^3$ | 39.5 $m^3$ |

Notes : [1] Calculated for a 150 m standard haul
[2] This element only occurs with the Smart Arch
[3] Based on average piece size of 0.39 $m^3$

*(Note : All times are expressed in decimal minutes)*

It can be seen from Table 2 that travel empty speeds with the Smart Arch were slower than with the integral arch. This is due to the fact that the machine had to turn and reverse up the +20° slope from the landing to the top of the hill, then turn again to continue down the other side. With the integral arch, it was able to climb the slope forwards for 40% of the time. The release lifting strop element in the Smart Arch study added only .04 minutes to the overall cycle time.

While actual recorded breakout times were significantly longer during the Smart Arch study, it was purely a function of the type of bush being worked at the time, and not related to the machine configuration. Standardising these elements, using average time per piece from both configurations multiplied by the actual number of pieces, makes the data more comparable. Bush travel loaded speeds were faster with the Smart Arch (by .60 km/hr). Winch in (raise arch) was longer with the Smart Arch because it entailed linking a chain strop into the grab hook on the canopy before winching in. Delay times are the average time lost per cycle for each configuration.

As the Table shows, predicted daily production with the Smart Arch would be 4.0 $m^3$ (10%) greater than the integral arch when extracting over this route.

## Route 2

The second extraction route was a partially formed track which skirted the base of a hill, and access to the felled wood was achieved by reversing up from the track.

Table 3 shows the cycle times for extraction over Route 2.

*Table 3 - Element Times for Extraction Route 2*

| Element | Smart Arch | Integral Arch |
|---|---|---|
| No. of cycles | 17 | 15 |
| | Element Times (min) | |
| Travel empty[1] - skid | .30 | .30 |
| - bush | 1.92 (4.69 km/h) | 2.20 (4.09 km/h) |
| Position | .51 | .48 |
| Dismount (and release lifting strop[2]) | .19 | .11 |
| Breakout | 3.81 (4.94 pieces) | 3.22 (4.18 pieces) |
| Travel loaded[1] - bush - walking | 2.15 } (3.73 km/h) | 2.47 } (3.45 km/h) |
| - winching | .26 } | .14 } |
| - skid | .42 | .39 |
| Delimb | 1.75 (4.94 pieces) | 1.48 (4.18 pieces) |
| Unstrop | .63 " | .54 " |
| Winch in (and raise arch ) | .23 | .13 |
| Butt, fleet and blade skids | 1.21 " | 1.02 " |
| Delays | .92 | .88 |
| Total cycle times | 14.30 | 13.36 |
| Average drag volume[3] | 1.58 $m^3$ | 1.34 $m^3$ |
| Predicted production (daily) | 45.9 $m^3$ | 41.6 $m^3$ |

Notes : [1] Calculated for a standard 150 m haul
[2] This element only occurs with the Smart Arch
[3] Based on average piece size of .32 $m^3$

*(Note : All times are expressed in decimal minutes)*

From Table 3, travel empty speeds with the integral arch were slower than with the Smart Arch over Route 2. Again, the release strop and raise Smart Arch elements were longer (by .08 and .10 minutes respectively) but there was very little difference in the position element. Bush travel loaded speeds over Route 2 were .28 km faster with the Smart Arch compared to the integral arch.

Predicted daily production with the Smart Arch is 4.3 $m^3$ (10%) higher.

## CONCLUSIONS

In both situations, the Smart Arch had the potential to out-produce the integral arch configuration by an average of 10%. During the study the operator tried to load the integral arch configuration up with larger drags on several occasions, but with the extra weight, the machine reared up on its back sprockets and excessive winching resulted.

In the controlled tests, it was proven that the D3B with a Smart Arch could not pull as much as a towed arch, but it could out perform pulling directly off the winch or using an integral arch. While travel speeds were comparable, the Smart Arch was actually quicker than the towed arch and the winch only configuration, but slower than the integral arch. Note though that drag size of the integral arch was 31% less than that of the Smart Arch.

Long term benefits of the Smart Arch were not quantified during the brief study period. These benefits could include reduced track wear, fewer drive component failures and lower fuel consumption. Contractor, R. Linton, has been recording operating hours with his machine and already track life using the Smart Arch has exceeded the life of the original tracks when the integral arch was fitted.

This study has shown that the Logquip Smart Arch will allow small crawler tractors to increase their payloads in thinnings without sacrificing machine manoeuvrability or versatility.

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RP 10726/11/86