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LEARNING CURVES OF MECHANISED HARVESTER AND FORWARDER OPERATORS

Richard Parker
Patrick Kirk
Mark Sullman


Figure 1 - Harvester and forwarder used in the mechanised thinning operation

SUMMARY

The improvements in performance of one harvesting machine operator and one forwarder operator were measured from the first day of operation.

The machines were a Waratah HTH 230 single grip harvester mounted on a modified Hitachi EX200 tracked excavator base, and a 14-tonne capacity FMG Timberjack 1210 forwarder.

MAIN FINDINGS

- The greatest increase in harvester operator productivity was in the first 30 days.
- The greatest increase in forwarder operator productivity was in the first 70 days.
- Productivity of both the harvester and forwarder operators was influenced by piece size, terrain and technique improvements.

INTRODUCTION

Mechanised harvesting methods have been used in New Zealand forests since the 1970s (Terlesk, 1976; Gordon, 1977). Much has been published on the machines used and technical aspects of mechanised harvesting, but very little on the human element of the operation - the operator.

Operating a mechanised harvesting machine is a complex task which involves continual decision making and rapid and complex hand movements on the controls. The skill of the operator has a great influence on machine productivity (Richardson and Makkonen, 1994). A review of mechanisation literature published in New Zealand (McConchie and Evanson, 1996) reported that of the 212 papers reviewed, only eight publications specifically targeted the important human factor aspects of mechanisation.

The purpose of this study was to measure the change in performance of one harvesting machine operator and one forwarder operator over time. Performance in a repetitive task, such as mechanised harvester operating or forwarder operating, improves with experience. The improvement can be described by a learning curve. Modern harvesting machines and forwarders are complex and take some time to learn to operate at a productive rate.

Knowledge of the learning curve allows the contractor and forest owner to:

- determine how long before production reaches an acceptable level
- assess trainee operators' ability against a known curve
- estimate production targets during the learning phase
- estimate expected costs in lost production, downtime and repair during the learning phase
- estimate woodflow
- determine how long production will be affected if an experienced operator has to be replaced by a novice.

ACKNOWLEDGMENTS

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OPERATION

The study took place in Kaingaroa Forest. The machines were production thinning in 13-year-old radiata pine, with an average piece size of 0.4 cubic metres (m^3). The machines were a Waratah HTH 230 single grip harvester mounted on a modified Hitachi EX200 tracked excavator base, and a 14-tonne capacity FMG Timberjack 1210 forwarder.

The harvester operator selected a tree, felled, delimbed, cut the tree to the required lengths and bunched the logs. The forwarder then loaded its bunk with processed logs and transported them to the landing where it unloaded them into stacks.

There was always a chainsaw operator following the harvester delimbing and tidying up particularly heavily branched trees. The machines and the chainsaw operator were often spread over a forest block and kept in communication by machine-mounted or helmet-mounted portable radio. Easy communication ensured good co-ordination among all members of the crew.

STUDY METHOD

The rate of work, type of work done and delays of the harvester and forwarder operators were measured by time study. The operators were observed for periods of one to two hours, initially at daily intervals, followed by weekly and then monthly intervals.

RESULTS AND DISCUSSION

Harvester

Due to financial sensitivity, the production of the harvester has been expressed as a percentage of the best production observed (Figure 2). This provides a measure of the improvement in production with time. Note the day-to-day variation in the productivity of the harvester operator.

The harvester operator could fell and process trees faster as time went on. However, it was not a smooth progression to greater production. The greatest increase in operator productivity was in the first 30 days.

Productivity was influenced by the improvement in skill of the operator, and organisational and site specific factors. For the first 70 days, the crew operated in a block with little slash, flat terrain and no real production pressure.

When the operation moved to a more difficult block, production was disrupted by tree form, slash, uneven ground and cutting saw logs (in addition to pulp). With no marked trees in some blocks, the harvester operator reported greater fatigue as he had to select trees to fell. Loss of the second operator resulted in the remaining operator working 10-hour days in the machine which he reported resulted in greater fatigue.

Technique improvements such as delimbing as the tree falls and slewing while delimbing, resulted in the rapid increase in production by day 156. However, injury to the operator's finger which controls the head tilt button, then resulted in a decrease in production.

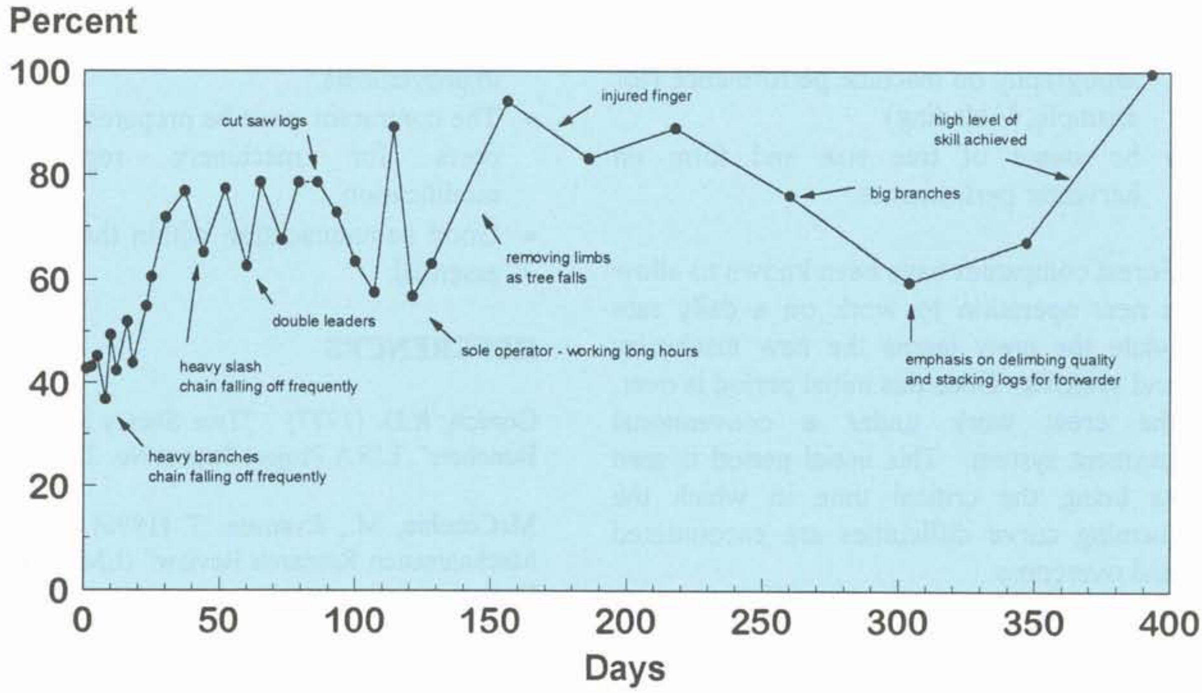

Figure 2 - Harvester productivity learning curve (as a % of the most productive day)

The limiting step in gaining a productive rate of operation was in the processing phase. In this study, an improvement of 30% faster processing was achieved within the first month of operation with a motivated trainee operator. Moving between trees, clearing slash to see the base of the tree, setting the head at the base of the tree and felling the tree are skills which are quickly learned. However, processing is the most difficult phase of the operation and needs practice. A trainee operator would gain considerable advantage operating the machine at a stockpile processing stems in order to have as much processing practice as possible.

Forwarder

The main improvement in loading productivity for the forwarder occurred within the first 70 days of operation (Figure 3). The operation then moved to a new block where the work environment was considerably less favourable than the previous block in terms of terrain, piece size and undergrowth hindrance. Consequently, the forwarder operator underwent a further short learning curve.

After the initial increase, loading productivity improved until a sawlog specification was introduced into the operation at day 90. This necessitated the sorting and grouping of logs according to whether they were saw or pulp logs, prior to their loading on to the forwarder. Consequently, a third short learning curve occurred until day 112, where loading productivity stabilised for the next 28 days until the end of the recording period.

The learning curve for the unloading productivity, while not being as dramatic as that for loading, did follow the same trend with the most improvement occurring during the first 50 days (Figure 3). After this point, unloading productivity stabilised at approximately twice that measured on the first day. On moving to a new block at day 70, a short steep learning curve occurred before unloading productivity stabilised once more until the introduction of the sawlog specification at day 90. At this point, the unloading productivity decreased substantially due to the increased handling and sorting now required.

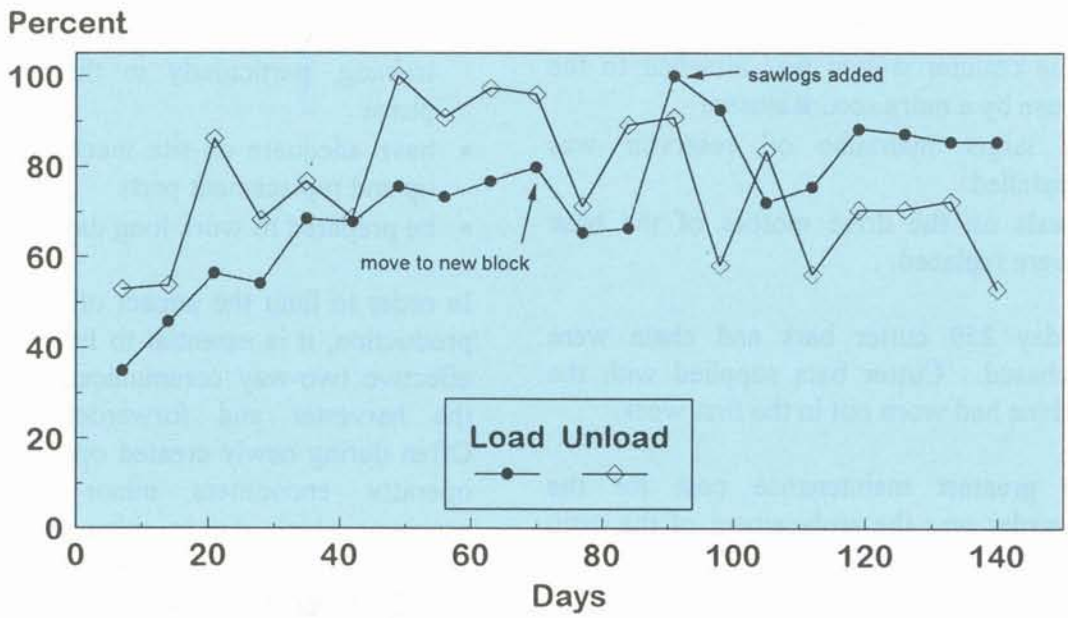

Figure 3- Learning curve of time taken to load and unload forwarder (as a % of the most productive day)

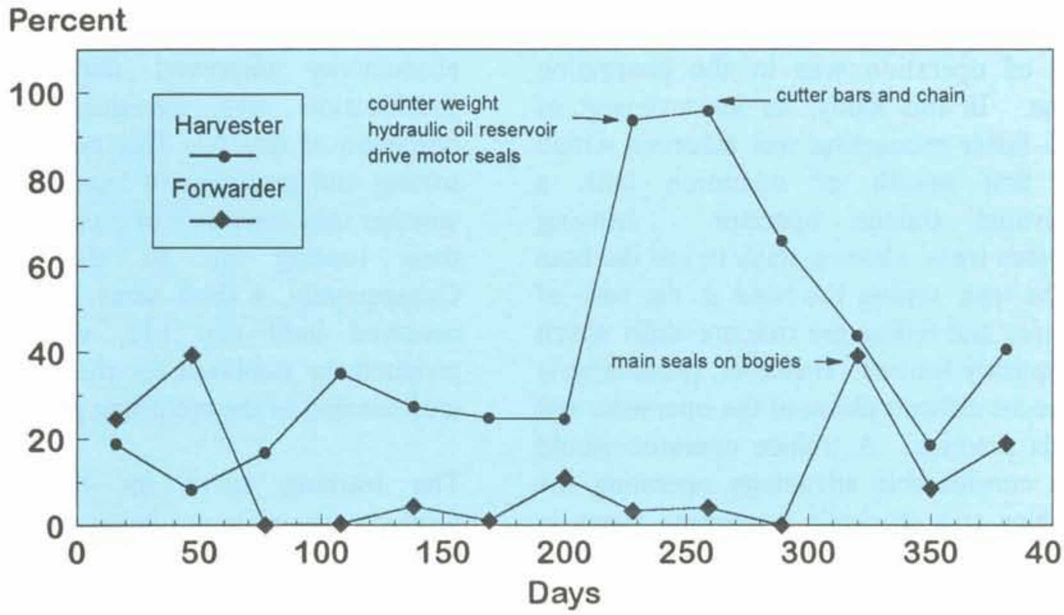

Figure 4 - Fluctuation in operating costs of harvester and forwarder (as a % of the most expensive month)

Operating Costs

The contractor must be prepared for large fluctuations in costs when machinery needs repair or modification. A significant cash surplus must be accumulated and kept in reserve for the inevitable breakdowns.

Operating costs for the harvester included: replacement cutter bars and chain, repair, maintenance and modifications. At day 228 there was a large expenditure on modifications to the harvester:

- the counter weight was attached to the base by a more secure system
- a larger hydraulic oil reservoir was installed
- seals on the drive motors of the base were replaced.

At day 259 cutter bars and chain were purchased. Cutter bars supplied with the machine had worn out in the first week.

The greatest maintenance cost for the forwarder was the replacement of the main seals of the rear bogie at day 320.

RECOMMENDATIONS

To be successful, a mechanised harvesting contractor must:

- be able to operate the harvester/forwarder himself to "cover" for injury, illness or operator learning
- be financially prepared for occasional high operating costs
- be prepared to incorporate a chainsaw operator working in conjunction with the harvester, especially when first starting
- be prepared to invest time and money in training, particularly in the processing phase
- have adequate on-site mechanical back-up and replacement parts
- be prepared to work long days.

In order to limit the impact of problems on production, it is essential to have clear and effective two-way communication between the harvester and forwarder operators. Often during newly created operations, one operator encounters minor operational problems which, due to either poor lines of communication, or misunderstanding, quickly develop into serious time wasting problems.

One method adopted during the early stages of operation, was to take time at the end of each day to go over the system being used. This involved walking an area of the stand which the harvester had thinned, but the forwarder had not yet extracted. Issues discussed by the machine operators during these inspections included: presentation of logs by the harvester to the forwarder (small tight bundles versus large scattered stacks), tracking paths chosen by the harvester (possible manoeuvring problems), log marking systems (saw log versus pulp logs) and so on. These discussions highlighted problems which could then be solved immediately.

In order to ensure optimum performance of a mechanised harvesting system, the forest company or planner must:

- keep the frequency of block changes to a minimum
- allow a "learning period" on hourly rates for a newly mechanised contractor
- use a small number of log specifications
- reduce the frequency of log specification changes
- be aware of the effects of block topography on machine performance (for example, V blading)
- be aware of tree size and form on harvester performance.

Forest companies have been known to allow a new operation to work on a daily rate while the crew learns the new machinery and systems. Once this initial period is over, the crew work under a conventional payment system. This initial period is seen as being the critical time in which the learning curve difficulties are encountered and overcome.

Possibly a more effective alternative may be to allocate a set amount of time that the crew have available on the daily rate (say one month). In this way, the crew may find that their first block is an easy one and they are quickly able to get the operation running smoothly within one week, having encountered few operational problems. They then go off the daily rate system and operate under normal conditions. The crew still have the remaining three weeks of daily rate time in reserve which they can draw on at a later time when they encounter new operating problems such as difficult terrain or multiple log specifications.

CONCLUSIONS

- The greatest increase in harvester operator productivity was in the first 30 days.
- The limiting step in gaining a productive rate of harvester operation was in the processing phase.
- The greatest increase in forwarder operator productivity was in the first 70 days.
- The forwarder operator underwent a short learning curve when conditions changed (for example, moving to a new block, introducing a saw log specification).
- Productivity of both the harvester and forwarder operators was influenced by piece size, terrain and technique improvements.
- The contractor must be prepared for high costs for machinery repair or modification.
- Good communication within the crew is essential.

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