ASSESSMENT OF OPERATOR EFFECT ON MACHINE PERFORMANCE OF "PONSSE BUFFALO DUAL" HARWARDER

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Abstract. The analysis of the "Ponsse Buffalo Dual" harwarder operating results has timely and relevant given the ever-decreasing supply of labour which encourages the use of harvesters both among the State Forest Enterprises and contractors. The study examines the operating results (average length of work cycle, time needed for machine transformation from harvester to forwarder and vice versa) of the "Ponsse Buffalo Dual" harwarder while under the control of different operators; presents the estimates of the operating indicators of the machine (average fuel consumption for harvesting and forwarding per m^3 overbark standing, average repair and maintenance costs).

Key words: logging, harwarder, operating indicators.

Introduction

The falling supply of labour necessitates the increasing use of harvesters both among the State Forest Enterprises (SFE) and contractors. In Lithuanian State Forests in 2011, harvesters were used to fell 22.3 % of the total amount of timber felled (the corresponding statistics for the previous years are: 18.7 % in 2009, 15.7 % in 2007 and 3.8 % in 2005).

The main factors considered in the performance forecasting models of forwarding machines are the number of the assortments, timber unloading, road conditions, timber transportation distance, and the machine body dimensions. The optimum processing capacity of the harvester is reached when felling conifers the volume over bark (VOB) of which is around 1 m^3; when the VOB is less than 0.2 m^3, the processing capacity of the harvester declines significantly [1]. Vaatainen et.al. [2] estimated, that by optimisation of the log size the harvester operator can raise the productivity of the harvester – forwarder team.

Mizaras et al. [3] found that, given the lead distance of 350 m, the productivity of the "Ponsse Buffalo Dual" harwarder in forwarding is 12.4 m^3 per hour. However, the levels of productivity of the machine while under the control of different operators were not investigated. The analysis of the operating indicators of the "Ponsse BD" harwarder in different years, such as the fuel consumption and repair and maintenance costs, omitted in the aforementioned study, would also be of interest.

A number of researchers claim that multi-operational harvesters are well suited for harvesting deciduous trees measuring 30-40 cm in diameter, e.g., beeches [4]. Due to a greater bark mass and a higher number of branches, multioperational harvesters reach their capacity limits in deciduous forests faster than they do so in coniferous forests [5].

The number of problems encountered is large when felling crooked, heavy-branching and forking trees because the handling of such trees is very time-consuming [4; 6]. Schorr claims that the operational time cost of harvesters is mostly affected by heavy-branching trees and large branches. According to [6], the processing capacity of multi-operational harvesters mostly depends on the tree variety, volume, terrain, and machine operator. It has been found that the harvester operational capacity ranges from 20 to 50 % depending on the operator's skill level [7]. Beyer and Schiek [8] did not find a relationship between the operators' skill level and individual settings in the machine (speed). Pausch and Ponitz [1] have found that the processing capacity of multi-operational harvesters depends on the average distance cleared by a machine per tree, foliage density, number of assortments prepared from one tree, and the height of underwood.

The aim of the study is to investigate the operating results of the "Ponsse Buffalo Dual" harwarder while under the control of different operators, to estimate the operating indicators of the machine.

Materials and methods

The objects of the research – a mixed forest stand and the "Ponsse Buffalo Dual" ("Ponsse BD") harwarder. The research project was carried out in 2010 – 2011 in a forest area of Vaišvydava forest district belonging to Dubrava SFE (Dubrava SFE has been using the "Ponsse BD" harwarder for logging for several years). The machine is operated by four operators that possess varying levels of experience with logging equipment. The sample stand composition by tree species: spruce – 68 %, pine – 11 %, birch – 14 %, and black alder – 7 %. The area covered – 1.9 hectares; average tree height – 28 m; total timber volume to cut – 600 m^3.

The "Ponsse BD" harwarder was used to fell spruce trees. Four drivers took turns in operating the machine. Operator I – born in 1964 – with 15 years of experience in forestry, had previously worked with a wheeled tractor + forestry trailer for 9 years, and had 3 years of experience working with a harwarder. Operator II– born in 1958 – with 21 years of experience in forestry, had previously worked with a forestry tractor – MTZ skider for four years, and later with a tractor + trailer, and had 3 years of experience working with a harwarder. Operator III – born in 1968 – with 9 years of experience in forestry, had worked with a Valtra 8350 tractor + trailer, and had 3 years of experience working with a harwarder. Operator IV – born in 1971 – with 12 years of experience in forestry, had first worked as a workshop mechanic, and later worked in forestry with a wheeled tractor + forestry trailer, and also had 3 years of experience working with a harwarder.

A time study method was used to investigate the work cycle of the harwarder (harvester/forwarder). A stopwatch with a 1-second measurement accuracy was used to measure the amount of time that each operator needed to position the harvester head, to process the tree, to transform the machine from a harvester to a forwarder and vice versa, as well as the length of time needed to load and unload the machine.

The work cycle of the harvester was divided into the following stages: positioning, tree processing and other. The cycle length was measured for each tree being felled. The cycle consists of the amount of time needed to fell and to process a tree. The work cycles follow numerical order.

The length time of the changeover from a harvester into a forwarder is defined as the period of time required for the removal of the harvester head, fitting of the forwarder equipment and reprogramming of the machine computer. The length of time required for the reverse process, i.e., the changeover from a forwarder to a harvester, was also measured.

The work cycle of the forwarder was typically divided into the following stages: 1 – driving without load, 2 – loading of timber, 3 – driving with load, 4 – unloading of timber, 5 – other. The cycle consists of the amount of time needed for driving without load from the timber landing place to the cutting area, collecting of logs, driving with timber and, finally, unloading timber onto the pile.

In order to analyse the operating indicators, the data – provided by Dubrava SFE – from the first three years (2008, 2009 and 2010) of machine use were employed. The following data were collected monthly: the amount of the timber harvested and forwarded by the "Ponsse BD" under the control of different operators, average fuel consumption for harvesting and forwarding per m^3 VOB, average repair and maintenance costs.

Results and Discussion

The research displays that the best results operating the "Ponsse BD" harvester were achieved by Operator I, born in 1964, possessing 15 years of experience in forestry. On average, he took 10.8 ± 3 s (Table 1) to position the harvester head. Operators IV and III took a little longer.

Paradoxically, Operator II, being the most experienced in forestry out of all four operators, took the longest amount of time to position the harvester head – a high of 15.6 ± 5 s on average, or 44 % more. Tree processing operations were most successfully carried out by Operator III (76.8 ± 8 s on average) and Operator I (77 ± 10 s on average, or 0.3 % longer.); while Operators IV and II needed a little more time.

The data recorded observing Operator I transform the "Ponsse BD" forwarder into a harvester show (Fig. 1) that the most time-consuming stage of the process – 547 seconds or 42 % of the total duration of the transformation – was taken up by reprogramming of the computer. The setting of the harvester head took 334 seconds or 25 % of the total duration. The dismantling of the forwarder head took 265 seconds (20 %), taking down the forwarder pillars took 133 seconds (10 %), and, finally, uploading the harvester head onto the transportation platform took only 45 seconds.

Table 1

The results achieved by the different operators working with the "Ponnse Buffalo Dual" harvester version

Operator	Average time needed to position the harvester head ($R_{0.05}$ = 4.8 s)		Average time needed for tree processing ($R_{0.05}$ = 14.6 s)	
	seconds	percent	seconds	percent
Operator I	10.8 ± 3	100	77 ± 10	100.3
Operator II	15.6 ± 5	144	91.6 ± 18	119
Operator III	11.4 ± 3.5	105.5	76.8 ± 11	100
Operator IV	11 ± 4	102	84.4 ± 6	110

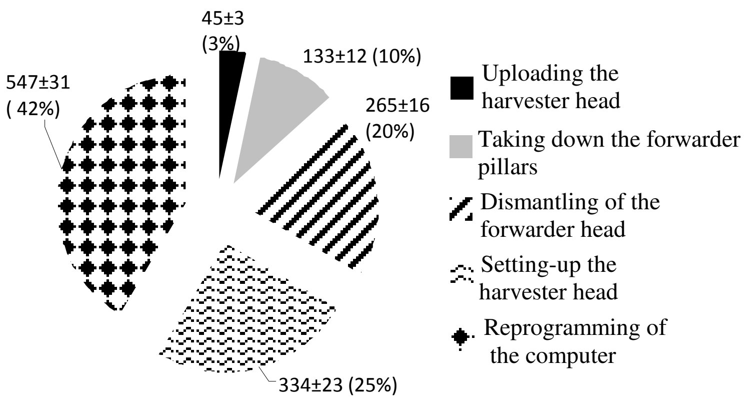


Fig. 1. **Stages of the forwarder into harvester transformation (s)**

The data recorded observing Operator IV transform the "Ponsse BD" harvester into a forwarder show (Fig. 2) that the most time-consuming stage of the process – 231 seconds or 35 % of the total duration of the transformation – was taken up by dismantling of the harvester head. The setting of the forwarder head took 186 s (31 %), setting-up the forwarder pillars took 132 s (22 %), and, finally, computer reprogramming took only 72 seconds or 12 % of the total duration.

No significant differences in the working pace of different "Ponsse BD" operators were observed. Operator I spent 532 ± 28 s on average on timber collection (Table 2), while Operator I spent an average of 574 ± 33 s, or as much as 8 % longer. For forwarding of the timber over a 100 m distance Operator I spent 37 ± 6 s on average, while Operator IV spent 38 ± 3 s, or 3 % longer. Operator IV spent an average of 166 ± 20 s unloading the timber, while Operator I spent 174 ± 21 s or 5 % more.

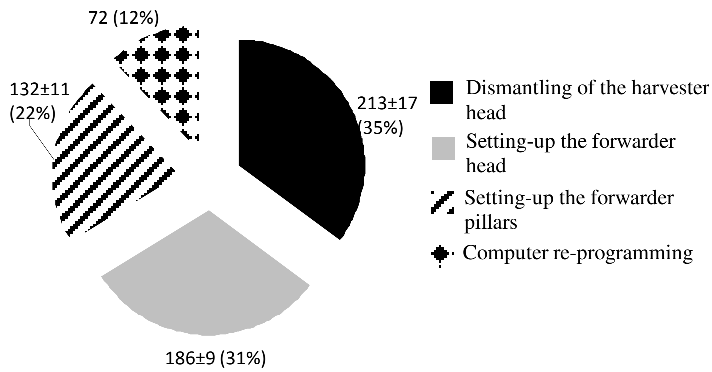


Fig. 2. **Stages of the harvester into forwarder transformation (s)**

Table 2

The time required for principal operations by "Ponsse Buffalo Dual" forwarder operators

Operator	Average time needed for timber collection		Average time needed to forward timber over 100 m distance		Average time needed for unloading timber	
	s	%	s	%	s	%
Operator I	574 ± 33	108	37 ± 6	100	174 ± 21	105
Operator IV	532 ± 28	100	38 ± 3	103	166 ± 20	100

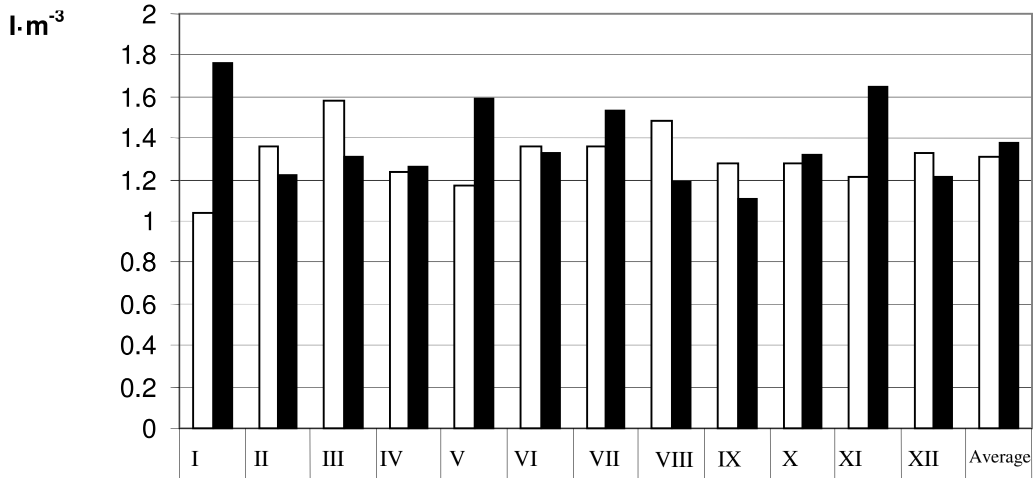
The data, provided by Dubrava STE, on the first few years of work with harwarder "Ponsse BD" show an improvement in the results achieved due to the increasing amount of the operators' experience working with the machine. In 2010, Operator I harvested 25.5 %, Operator II – 31.5 %, Operator III – 56.9 %, and Operator IV – 31.7 % more timber (Table 3) compared to 2009.

The best results in harvesting timber in 2009 were achieved by Operator I who harvested 6001 m^3, while Operator II harvested 2 % less, Operator IV– 25.4 % less, and Operator III– as much as 30.6 % less. In 2010, the best results were achieved by Operator II who harvested 7732 m^3, Operator I – 2.6 % less, Operator III – 15.5 % less, and Operator IV – 23.8 % less. The best results in extraction of timber were achieved by Operator I who, in 2009, extracted 7460 m^3, while Operator II extracted 2.3 %, Operator IV – 11.3 %, and Operator III – 18.8 % less. In 2010, Operator IV demonstrated the best results among the operators by extracting 8050 m^3 of timber, while Operator III extracted 7 %, Operator II – 1.3 %, and Operator I – 12.7 % less.

Table 3

Harwarder "Ponsse Buffalo Dual" operators' results in 2009-2010

Operator	Harvested m^3			Extracted m^3		
	2009	2010	Percentage change	2009	2010	Percentage change
Operator I	6001	7532	+25.5	7460	7030	-5.8
Operator II	5881	7732	+31.5	7291	7225	-0.9
Operator III	4166	6535	+56.9	6054	7483	+23.6
Operator IV	4477	5895	+31.7	6614	8050	+21.7

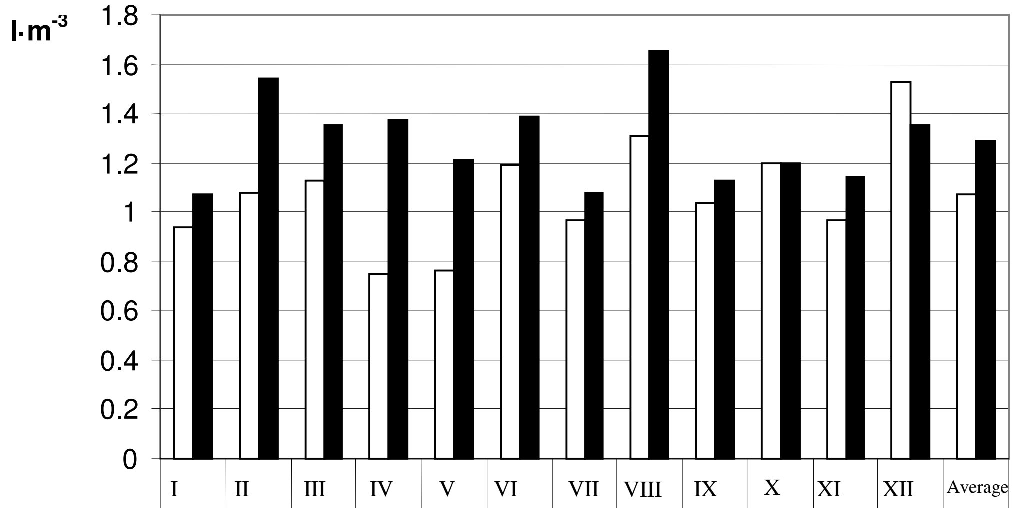


	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
□ 2009	1.04	1.36	1.58	1.24	1.17	1.36	1.36	1.48	1.28	1.28	1.21	1.33	1.31
■ 2010	1.76	1.22	1.31	1.26	1.59	1.33	1.53	1.19	1.11	1.32	1.65	1.21	1.37

Fig. 5. **Harwarder "Ponsse BD" fuel consumption per m³ of harvested timber, 2009-2010**

The data, provided by Dubrava Enterprise, show that in 2009, harvesting one m^3 of timber required 1.31 ± 0.14 litres of diesel (Fig. 5), while in 2010, the diesel consumption stood at 1.37 ± 0.2 l, or 4.6 % more compared to 2009. On the other hand, in 2009, the extracting of 1 m^3 of timber required 1.07 ± 0.22 l of diesel (Fig. 6), while in 2010, the diesel consumption rose to 1.29 ± 0.18 l, or 20.6 % more compared to 2009.

The harwarder fuel expenditure did not change much over the 2008-2010 period (Fig. 7). In 2008, 142250 LTL were spent on fuel; in 2009, the fuel expenditure stood at 139920 LTL (only 1.6 % less than in 2008); and in 2010, 149430 LTL were spent on fuel, which is only 6.8 % higher than the fuel expenditure in 2009.



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
□ 2009.	0.94	1.08	1.13	0.75	0.76	1.19	0.97	1.31	1.04	1.2	0.97	1.53	1.07
■ 2010	1.07	1.54	1.35	1.37	1.21	1.39	1.08	1.65	1.13	1.2	1.14	1.35	1.29

Fig. 6. **Harwarder "Ponsse BD" fuel consumption per m³ of extracted timber, 2009-2010**

However, the oil expenditure did vary significantly over the period. In 2008, 4915 LTL were spent on purchasing oil, while in 2009, the numbers dropped to 1940 LTL, which amounted to a 60.5 % change from the previous year. In 2010, the oil expenditure was 4560 LTL – a 34.4 % increase compared to 2008.

Similar trends were seen in the repair costs data. In 2008, the total repair costs of the harwarder "Ponsse BD" came up to 77920 LTL, while, in 2009, the repair costs fell to 54230 LTL – 30.4 % less than in the previous year. In 2010, the repair costs rose to 150610 LTL which is nearly double the amount spent on repairs in 2009 (an increase of 93.3 %).

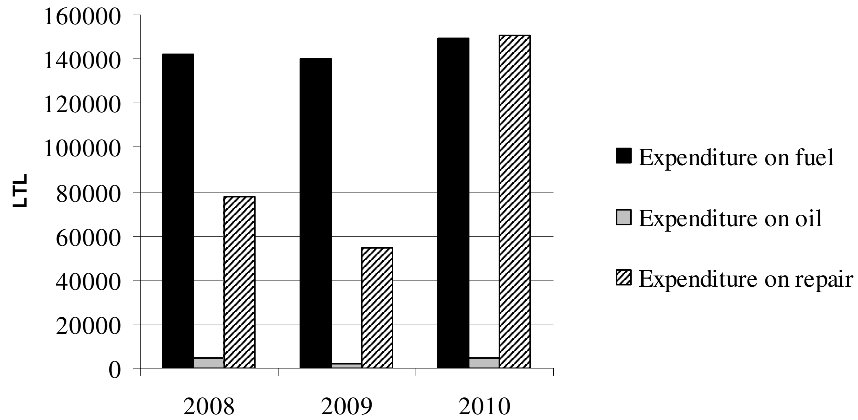


Fig. 7. **Harwarder "Ponsse BD" operating costs, 2008-2010**

The analysis of the composition of the harwarder "Ponsse BD" repair costs revealed that the majority of the repair costs were due to servicing. In 2008, the machine servicing expenditure was 619890 LTL (79.6 % of all repair costs), while, in 2009, the servicing expenditure fell to 38890 LTL – 37.3 % less than the year before – and made up 71.7 % of all repair costs. In 2010, the servicing expenditure stood at a high 141490 LTL – a 360 % increase from the previous year – and made up 93.9 % of all repair costs. The tire expenditure made up 12.9, 16.7, and 4.9 % of all annual repair costs in 2008, 2009, and 2010, respectively. Similarly, the amount of money spent on spare part purchases made up 7.5, 11.6, and 1.2 % of all annual repair expenses in 2008, 2009, and 2010, respectively.

Conclusions

1. The research shows that the best results operating the "Ponsse Buffalo Dual" as a harvester were achieved by Operator I, born in 1964, possessing 15 years of experience in forestry:
   - he spent 10.8 ± 3 s on average to position a harvester head, and an average of 77 ± 10 s on timber processing
2. 2. The transformation of the machine from a forwarder to a harvester takes twice as long as the reverse process:
   - transforming the machine from a forwarder into a harvester takes approximately 21 min., while the reverse procedure takes only ≈10 min.;
   - computer reprogramming was the most time consuming part of the forwarder-to-harvester transformation process – it took 547 s, or 42 % of the time needed for the transformation;
   - dismounting of the harvester head took 213 s, or 35 % of the time needed for the harvester-to-forwarder transformation.
3. There was a marked improvement in the results achieved due to the increasing amount of the operators' experience working with the machine. In 2010, Operator I harvested 25.5 %, Operator II– 31.5 %, Operator III – 56.9 %, and Operator IV – 31.7 % more timber compared to 2009.
4. The majority of the harwarder "Ponsse Buffalo Dual" maintenance costs are imposed by the servicing costs.

References

1. Pausch R., Ponitz K. Harvesterleistung und Hiebsbedingungen. [Productivity and working conditions of harvesters]. Forst und Technik 4, 2002, pp. 10-14.
2. Väätäinen K., Ala-Fossi A., Nuutinen Y., Röser D. The Effect of Single Grip Harvester's Log Bunching on Forwarder Efficiency. Baltic Forestry, 12 (1), 2006, pp. 64-69.
3. Mizaras S., Sadauskienė L, Mizaraitė D. Medienos ruošos technologijų lyginamoji ekonominė analizė. (The comparative economical analysis of different logging systems) Žemės ūkio mokslai, 16(1-2), 2009, pp. 61-68. (In Lithuanian with English summary)
4. Schorr M. Der Einfluss von Starkästen und Zwieseln auf die Leistung von Harvestern bei der Laubschwachholzernte. (The influence of small deciduous trees brancheness on harvester's productivity). Forst und Holz 16, 2000, pp. 520-522. (In German)
5. Forbrig A. Konzeption und Anwendung eines Informationssystems über Forstmaschinen auf der Grundlage von Maschinenbuchführung, Leistungsnachweisen und technischen Daten. (The concept and use of information systems of forestry machinery). KWF-Bericht Nr. 29, 2001, 213 S. (In German)
6. Forbrig A., Bohlander F., Hauck B. Beurteilung der Verfahren. (The evaluation of technologies) in: KWF (Hrsg.) (2000): Forstwirtschaft im Einklang von Mensch, Natur, Technik. Tagungsführer zur 13. KWF-Tagung 200, 2000, pp. 156-161. (In German)
7. Glöde D. Single and Double Grip Harvesters – Productive Measurements in Final Cutting of Shelterwood. Journal of Forest Engineering 10(2), 1999, pp. 63-74.
8. Beyer R. Schieck R. Erarbeitung eines Produktivitätsmodells für Caterpillar-Radharvester. (Development of work productivity model of wheeled Caterpillar harvester). Diplomarbeit an der Fakultät Forst-, Geo- und Hydrowissenschaften der Technischen Universität Dresden, 2001, 102 S. (In German)
9. Glöde D., Sikström U. Two Felling Methods in Final Cutting of shelterwood, Single-Grip Harvester Productivity and Damage to the Regeneration. Silva Fennica 35(1), 2001, pp. 71-83.