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ANALYSIS OF WORKING DAY SNAPSHOT OF A SMALL HARVESTER OPERATOR

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Abstract: *Snapshots of a working day, during which monitoring focuses on all the work shift and assesses absolute times and time percentages of individual actions within the work shift, are compiled for the operator of the small harvester. The highest share is taken up by operation time (unit work time) which constitutes 74.8 %. It is followed by maintenance time constituting 9.2 % and time necessary for harvester repairs which constitutes 5.9 % of the shift time. Other times, i.e. ration and shift time, represent time for the preparation and completion of work, time for work instructions, time for technical service, time for biological breaks and rest, time losses due to technical and organizational losses and other unnecessary time. The coefficient of ration and shift time for small-power harvester operation can be defined as 1.258. This coefficient increases operation time by the time necessary for the harvester operation.*

1. Introduction

Working day observation focuses on the entire work shift, from its start (operator's arrival at the workplace) till the end (performing maintenance tasks and the operator's ensuing departure). However, these limits do not necessarily have to be binding, as the operator may engage in other maintenance work required for ensuing shifts prior to or after the actual work shift. For instance, the operator may leave the workplace to go to a workshop to sharpen chains, to collect pre-ordered spare parts from the storehouse or may engage in purchasing required materials himself (new spare parts, fuel, oil, etc.). The objective of this paper is to assess the time and percentage share of individual actions which take place in the course of a work shift. Components of the shift time are listed in Table 1.

2. Materials and Methods

Experimental measurements are conducted with the help of gradual snapshots taken in the course of a work shift.
In order to obtain an outline of total time consumption in the course of a work shift, we draw on an analysis of a work day and shift time respectively. A work day snapshot and its components are measured in minutes with the help of a watch. Shift time is measured throughout the entire shift, starting with the commencement of the operator's first activity and finishing with his departure from the workplace, provided that the departure is not followed by any other activity which would be connected with procuring services necessary for the machinery operation in following shifts. The measurements obtained values of time consumption not only in the work process itself but also other non-operative times which may or may not be included in the work time, i.e. the time necessary for the preparation and concluding of work (T'_{B101}), time required for work instructions (T'_{C102}), time for technical servicing of the work place (T'_{C103}), time for technical maintenance of the machine (T'_{C104}), time for repairs (T'_{C105}), time for

biological and legally required breaks (T'_2), time losses due to technical and organizational problems (T'_E) and personal time losses (T'_D).

3. Results and discussion

3.1 Working day snapshot of Neuson small harvester operator

The largest share of the working day snapshot falls to operation time (74.8 %) which is necessary for harvesting and processing of timber into individual assortments. Its absolute value is 6.28 hours out of the average work shift of 8.40 hours (Table 1). Time necessary for machine maintenance (9.2 %) follows in descending order. This time is drawn at the beginning or finish of a work shift to prepare machinery for optimum service upon minimum operation interruption in the course of the following shift. Maintenance works which take place during a work shift predominantly encompass chain sharpening or fuel refill. Machine repair time constitutes 30 min of the entire shift, i.e. 5.9 %. The most frequent breakdowns include damage to the hydraulic control systems of the harvester head unit. Time necessary for hose replacement takes up 59.3 % of the total repair time. The second highest breakdown rate is confirmed for the cutting mechanism of the harvester head (chain rupture, lath damage, etc.) whose repairs take up 7 min of a shift time on average, which is 22.0 % of average repair time. Time required for repairs of the hydraulic system and the cutting mechanism constitute the highest ratio of harvester repairs – 81.3 %. Further time necessary for harvester technology application is time for technical servicing of the work place, which is the operator's duty. The relevant share of average shift time is 3.9 %, which includes primarily the time necessary for machinery transport or moving to another work place (81.1 %). This time does not include waiting for transport trailer or for the company responsible for transporting the machine. The abovementioned time is included in time losses due to technical and organizational problems. Time for technical servicing of the work place encompasses the time necessary for rehabilitation and other safety measures taken at the work place in the course of a work shift. Above all, this includes on-site treatment of trees which harvester operators carry out throughout their shifts and the relevant time consumption is 17.9 % of the shift unit.

Upon deployment of the Neuson harvester, the remaining units of the working day snapshot constitute 2 % and less. Time necessary for biological and legally required breaks represents on average 2.1 % (i.e. 10 min of the average work shift time). Operators thus fail to take the legally required breaks in accordance with Act No. 262/2006 Coll. (Labour Code) which prescribes a 30 min break during work time. After 6 hours of work this break should take at least 30 min, if it is to be split then into a minimum of 15 min for a meal and a break. Work time must not exceed 12 hours, while break time for meals and rest is not included in work time unless it coincides with safety breaks.

Other components of shift time (Tab.1) include time losses due to technical and organizational problems which are not operator-induced (1.9%). This includes time spent waiting for servicing in times when the operator is not capable of repairing the machine himself; time spent waiting for transport trailer; time for preparing and concluding work (0.8%) which includes time necessary for continuous monitoring of the stand by the operator and time for work instructions (0.3%) administered by management or foremen, as well as other times (1.2%) which may be seen as time unnecessarily spent by the operator. This typically encompasses private phone calls or work-unrelated discussions with management and other persons at workplace.

3.2 Indicators of working day utilization

Based on the analysis of actually measured time and normal time consumption we may calculate time shift utilization and indicate possible shortcomings at the workplace. Primary indicators include the following:

- workday (shift) utilization,
- proportion of unnecessary time losses due to the worker's activities,

- proportion of unnecessary time losses due to technical and organizational problems,
- work productivity increase after eliminating unnecessary time losses due to the worker's activities,
- work productivity increase after eliminating unnecessary time losses due to technical and organizational problems.

Table 1. Working day snapshot of Neuson 8002 small harvester

Shift distribution	**Operator A**		
	Shift time		
	(min.)	**(h)**	**(%)**
Operation time (harvesting)	377	6,28	74,8
Time necessary for preparation and concluding of work	4	0,07	0,8
Time for work instructions	1	0,02	0,3
Time for technical servicing of the work place	20	0,33	3,9
Time necessary for maintenance	46	0,77	9,2
Time for repairs	30	0,50	5,9
Time for biological and legally required breaks	10	0,17	2,1
Time losses due to technical and organizational problems	9	0,16	1,9
Other time losses	6	0,10	1,2
Total time	**504**	**8,40**	**100**

3.3 Workday utilization

Mean workday utilization indicator is defined by the following relation (1):

$$\bar{K}_1 = \frac{\bar{T}_1 + T_2}{T} \cdot 100 \qquad (1)$$

where:

$\bar{K}_1$ percentage of a worker's engagement (%)

$\bar{T}_1$ mean value of measured work times (min) (h)
T_2 time for generally necessary breaks (min) (h)
T set length of a work shift (min) (h)

Owing to the fact that the time for generally necessary breaks for harvester operators is not determined by any specific law or recommendation, and with regard to the fact that the law does not determine any safety break for harvester operation, the length of minimum breaks is set only by the Labour Code. The Code defines the employer's obligation to provide employees with a work break for food and rest lasting at least 30 minutes after a maximum of 6 hours of continuous work which shall not be included into working hours. Government Order No. 178/2001 Coll. also enables further increase in breaks in cases of enforced work pace, monotonous work and work-related mental strain, where work must be interrupted by safety breaks lasting 5 to 10 minutes after every two hours of continuous work. Considering that the government order does not expressly define individual types of work and work content which it applies to, the term "monotonous" is frequently associated also with the work of operators. However, this cannot be accepted owing to the fact that the operator's work may be continuously interrupted with respect to their tiredness. It therefore follows that the activity of operators is not directly conditioned by the rhythm of the machinery.

The average duration of a Neuson operator work shift if 8.40 hours, including the break. The actual duration of the break is 10 minutes of the work shift. After deducting the break time taken by the operator (0.17 h), the length of other shift times remains 8.23 h.

Mean work time ($\bar{T}_1$) is defined by the following relation (2):

$$\bar{T}_1 = \bar{T} - \bar{T}_2 - \bar{T}_E - \bar{T}_D \tag{2}$$

where:

$\bar{T}_1$ mean value of actual measured shift times (min) (h)

$\bar{T}_2$ mean value of actual measured break times (min) (h)

$\bar{T}_E$ mean value of actual measured time losses due to technical and organizational problems (min) (h)

$\bar{T}_D$ mean value of actual measured time personal time losses (min) (h)

Shift length (T) is not explicitly determined in cases when a machine is privately owned and its operator is thus not employed by the private owner but is self-employed instead. When calculating the average utilization of a work shift we then draw on the minimum length of a work shift for a Neuson harvester operator, which is 8 hours.

Table 2. Average utilization of Neuson harvester work day - Ø$\boldsymbol{K_1}$

operator	harvester	ØT_1		T_2		ØT		**Ø K_1**
		(min)	(h)	(min)	(h)	(min)	(h)	(%)
A	Neuson	479	8,0	30	0,5	504	8,4	**101,0**

Out of the sum of measured times (Tab.2), work day utilization is calculated at 101.0 % for a small harvester operator. Such high work day utilization is a result of unclaimed work breaks motivated by higher financial gain upon high shift productivity.

3.4 Ratio of unnecessary time consumption by the worker

Indicator of mean ratio of unnecessary time consumption by the worker is defined by the following relation (3):

$$\bar{K}_2 = \frac{\bar{T}_2 - T_2 + \bar{T}_D}{T} \cdot 100 \tag{3}$$

if $\bar{T}_2 \langle T_2$, the following relation (4) is applicable:

$$\bar{K}_2 = \frac{\bar{T}_D}{T} \cdot 100 \tag{4}$$

where:

$\bar{K}_2$ mean ratio of unnecessary time consumption by the worker (%)

With regard to the abovementioned facts specifying the time of actual measured breaks ($\bar{T}_2$) and the time of breaks required by the law (T_2), it is obvious that the minimum time planned for breaks which the operator is entitled to in accordance with Act No. 262/2006 Coll. has not been fully claimed. To calculate the ratio of unnecessary time consumption, relation (4) is applicable. The actual measured time of personal losses ($\bar{T}_D$) accounts to a maximum of 0.10 hours out of the actual work shift. The calculated mean ratio of unnecessary time consumption (K_2) is 1.2 % (Tab.3), which attests to minimum time losses caused by the worker. The measured time of personal losses cannot be understood as a time utilizable for rest which has not been fully claimed, as the operator might have engaged in activities which are out of line with activities designed for rest and eliminating tiredness.

Table 3. Average ratio of unnecessary time consumption by Neuson harvester operator – **$Ø K_2$**

operator	harvester	$ØT_2$		T_2		$ØT_D$		$ØT$		**$Ø K_2$**
		(min)	(h)	(min)	(h)	(min)	(h)	(min)	(h)	(%)
A	Neuson	10	0,2	30	0,5	6	0,1	504	8,4	**1,2**

3.5 Ratio of unnecessary time consumption due to technical and organizational problems

Indicator of mean ratio of unnecessary time consumption due to technical and organizational problems is defined by the following relation (5):

$$\bar{K}_3 = \frac{\bar{T}_E}{T} \cdot 100 \qquad (5)$$

where:

$\bar{K}_3$ ratio of unnecessary time consumption due to technical and organizational problems (%)

Upon operation of the Neuson harvester, time losses due to technical and organizational problems (T_E) are caused by the operator himself, who owns the machine. Time losses are most frequently accounted to the machine transport to a new workplace or to waiting for the transport trailer, not to breakdowns which require expert servicing. Time losses caused by the transport of a caterpillar harvester may be longer than those of wheel tractors, as the former machines cannot be driven on road. The ratio of time losses due to technical and organizational problems (K_3) in this case is 1.9 % (0.16 h) out of the total shift time (Tab.4).

Table 4. Ratio of unnecessary time consumption due to technical and organizational problems– **$Ø K_3$**

operator	harvester	$ØT_E$		$ØT$		**$Ø K_3$**
		(min)	(h)	(min)	(h)	(%)
A	Neuson	9	0,16	504	8,4	**1,9**

3.6 Growth of work productivity after eliminating unnecessary time consumption by the worker

Indicator of work productivity growth after eliminating unnecessary time consumption by the worker is defined by the following relation (6):

$$\bar{K}_4 = \frac{\bar{T}_2 - T_2 + \bar{T}_D}{T - (\bar{T}_2 - T_2 + \bar{T}_D + \bar{T}_E)} \cdot 100 \qquad (6)$$

if $\bar{T}_2 \langle T_2$, the following relation (7) is applicable:

$$\bar{K}_4 = \frac{\bar{T}_D}{T - (\bar{T}_D + \bar{T}_E)} \cdot 100 \qquad (7)$$

where:

$\bar{K}_4$ ratio of increased work productivity upon eliminating unnecessary time consumption by the worker (%)

When eliminating unnecessary time consumption by small harvester operator, we may suppose an increase in work productivity of 1.2 % (Tab.5).

Table 5. Ratio of increased work productivity upon eliminating unnecessary time consumption by the worker – ***Ø K₄***

operator	harvester	$ØT_2$		T_2		$ØT_D$		$ØT_E$		$ØT$		**$Ø K_4$**
		(min)	(h)	(min)	(h)	(min)	(h)	(min)	(h)	(min)	(h)	(%)
A	Neuson	10	0,2	30	0,5	6	0,1	9	0,2	504	8,4	**1,2**

3.6 Growth of work productivity upon eliminating unnecessary time consumption due to technical and organizational problems

Indicator of growth productivity after eliminating unnecessary time consumption due to technical and organizational problems is defined by the following relation (8):

$$\bar{K}_5 = \frac{\bar{T}_E}{T - (\bar{T}_2 - T_2 + \bar{T}_D + \bar{T}_E)} \cdot 100 \qquad (8)$$

if $\bar{T}_2 \langle T_2$, the following relation (9) is applicable:

$$\bar{K}_5 = \frac{\bar{T}_E}{T - (\bar{T}_D + \bar{T}_E)} \cdot 100 \qquad (9)$$

where:

$\bar{K}_5$ ratio of work productivity increase after eliminating unnecessary time consumption due to technical and organizational problems (%)

After eliminating unnecessary time consumption due to technical and organizational problems, we may suppose an increase in work productivity (K_5) by 1.8% (Tab.6).

Table 6. Ratio of work productivity increase after eliminating unnecessary time consumption due to technical and organizational problems – *Ø* $\boldsymbol{K_5}$

operator	harvester	$ØT_2$		T_2		$ØT_D$		$ØT_E$		$ØT$		**Ø** $\boldsymbol{K_5}$
		(min)	(h)	(min)	(h)	(min)	(h)	(min)	(h)	(min)	(h)	(%)
A	Neuson	10	0,2	30	0,5	6	0,1	9	0,2	504	8,4	**1,8**

Total increase in work productivity may be calculated from the following relation (10):

$$\bar{K}_p = \bar{K}_4 + \bar{K}_5 = \frac{\bar{T}_z}{T - \bar{T}_z} \tag{10}$$

where:

$\bar{K}_p$ ratio of possible work productivity increase (%)

$\bar{T}_z$ average lost time per shift (min) (h)

$$\bar{T}_z = \bar{T}_D + \bar{T}_E$$

The abovementioned indicators and results suggest a possible increase in Neuson 8002 work productivity of 3.0 %, which in relation to stem volume in spruce harvesting may increase its hourly performance by 0.08 m^3/h upon volume of 0.05 m^3/stem to 0.28 m^3/h upon stem volume of 0.35 m^3/stem. Nevertheless, it must be stressed that the high utilization of work day is conditioned by the fact that legally required work breaks were not taken. Time losses due to technical and organizational problems (T_E) and personal time losses (T_D) may then be viewed as times acceptable for rest, provided that no other activities are performed at the same time.

4. Conclusion

With the exception of work (operation) time, *total shift time* encompasses other norm times and time losses which are affected by organizational management, technical condition of machines and the operators themselves. Small-harvester operation time constituted 74.8 % of the total shift time, or 77.3 % after deducting time losses. Operation time ratio of 71 % of the total shift time is confirmed for example by Glöde (1999). These results correspond to or approximate the proposed coefficients for operation time – 0.75 – which are included in performance standards. For other necessary activities, defined as rate or shift time, 15 minutes are calculated to the full hour (Glöde-Sikström, 2001).

References

Glöde, D. and Sikström, U. (2001). Two felling methods in final cutting of shelterwood, single-grip harwester produktivity and damage to the regeneration. Silva Fennica, vol. 35, no. 1, 71 – 83.

Glöde, D. (1999). Single- and double-trip harvesters – productivity measurments in final cutting of shelterwood. Journal of Forest Engineering, vol. 10, no. 2, 63 - 74.

Klouda, M., Syrovátka, K. and Bluďovský, Z. (1988). Normování práce v lesním hospodářství. Ministerstvo lesního a vodního hospodářství a dřevozpracujícího průmyslu. Praha: SZN v Praze. 208.