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CLASSICAL AND ORDER STATISTICS OF EFFECTIVE ACTIVE TIME OF FELLING AT USE CHAINSAW

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Abstract. The time, within which accordingly to its application machine works, and an object of work and working groups are under load, is the effective active time. The purpose of the research was the classical and order statistics of effective active time of felling at use chainsaw. The average effective active time of felling of one tree was about 2 s. The cut trees were strong statistical diversified from the point of view of effective active time of felling. The positive skewness coefficient has confirmed, that statistical units with value of feature below arithmetic mean were prevailed – right-sided asymmetry.

Key words: felling, effective active time, early thinning, pine stands

INTRODUCTION

The effective active time, the subsidiary time, the technical service time, the faults deletion time, the transport drive time and the machine daily technical service time are the active time of machine. Besides, the rest time and the losses of time from independent reasons on researched machine are related to the machine active time [Glazar and Wojtkowiak 2009].

The scheme of active time classification according to BN-76/9195-01 standard are presented in Figure 1.

The working shift time (T_{04}) is defined as the productive time [Jodłowski 2000, Sowa et al. 2007]. The productive time includes the operative time (T_{02}), the technical service time (T_3) and the faults deletion time (T_4).

The operative time (T_{02}) (active operation time) is about 70% of total shift time, usually. The effective active time (T_1) and the subsidiary time (T_2) are the operative time. The effective active time is the time, within which accordingly to its application machine works, and an object of work and working groups are under load. This time includes the time of turning back or unloading the material, if these executed actions do not cause interruption in the process, in which the machine participates. The effective active time is about 50% of total shift time, usually. The subsidiary time is the time of

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<table>
<tr><td colspan="7">Time category – Kategoria czasu</td></tr>
<tr><td>T_{08}</td><td>T_{07}</td><td>T_{04}</td><td>T_{02}</td><td>T_1</td><td colspan="2">effective time
czas efektywny</td></tr>
<tr><td rowspan="11">Control shift time
Czas zmiany kontrolnej</td><td rowspan="10">total shift time
ogólny czas zmiany</td><td rowspan="9">working shift time
roboczy czas zmiany</td><td rowspan="3">operative active time
operacyjny czas pracy</td><td rowspan="3">T_2</td><td rowspan="3">subsidiary time
czas pomocniczy</td><td>T_{21}</td></tr>
<tr><td>T_{22}</td></tr>
<tr><td>T_{23}</td></tr>
<tr><td rowspan="3">T_3</td><td colspan="2" rowspan="3">technical service time
czas obsługi technicznej</td><td>T_{31}</td></tr>
<tr><td>T_{32}</td></tr>
<tr><td>T_{33}</td></tr>
<tr><td rowspan="2">T_4</td><td colspan="2" rowspan="2">faults deletion time
czas usuwania usterek</td><td>T_{41}</td></tr>
<tr><td>T_{42}</td></tr>
<tr><td>T_5</td><td colspan="3">rest time
czas odpoczynku</td></tr>
<tr><td rowspan="2">T_6</td><td colspan="2" rowspan="2">transport drive time
czas przejazdów transportowych</td><td>T_{61}</td></tr>
<tr><td>T_{62}</td></tr>
<tr><td>T_7</td><td colspan="3">daily technical service machine accompany time
czas codziennej obsługi technicznej maszyn towarzyszących</td></tr>
<tr><td rowspan="3">T_8</td><td colspan="3" rowspan="3">losses of time due to reasons independent of the researched machine
straty czasu z przyczyn niezależnych od badanej maszyny</td><td>T_{81}</td></tr>
<tr><td>T_{82}</td></tr>
<tr><td>T_{83}</td></tr>
</table>

Fig. 1. Scheme of active time classification [BN-76/9195-01, Laurow 1999]: T_1 – effective time. T_2 – subsidiary time $T_2 = T_{21} + T_{22} + T_{23}$, T_{21} – turning back time, T_{22} – waste drive time in work-place, T_{23} – technological dead time. T_3 – technical service time $T_3 = T_{31} + T_{32} + T_{33}$, T_{31} – daily technical service time, T_{32} – machine preparation for work time, T_{33} – regulation conducting time. T_4 – faults deletion time $T_4 = T_{41} + T_{42}$, T_{41} – technological faults deletion time, T_{42} – technical faults deletion time. T_6 – transport drive time $T_6 = T_{61} + T_{62}$, T_{61} – drive time from berth on work-place and with return, T_{62} – drive time from work-place on work-place. T_7 – machine daily technical service time. T_8 – losses of time due to independent reasons researched machine $T_8 = T_{81} + T_{82} + T_{83}$, T_{81} – losses of time from organizational reasons, T_{82} – losses of times from meteorological reasons, T_{83} – losses of times from other reasons

Rys. 1. Schemat klasyfikacji czasu pracy [BN-76/9195-01, Laurow 1999]: T_1 – czas efektywny. T_2 – czas pomocniczy $T_2 = T_{21} + T_{22} + T_{23}$, T_{21} – czas nawrotów, T_{22} – czas przejazdów jałowych w miejscu pracy, T_{23} – czas przestojów technologicznych. T_3 – czas obsługi technicznej $T_3 = T_{31} + T_{32} + T_{33}$, T_{31} – czas codziennej obsługi technicznej, T_{32} – czas przygotowania maszyny do pracy, T_{33} – czas przeprowadzenia regulacji. T_4 – czas usuwania usterek $T_4 = T_{41} + T_{42}$, T_{41} – czas usuwania usterek technologicznych, T_{42} – czas usuwania usterek technicznych. T_6 – czas przejazdów transportowych $T_6 = T_{61} + T_{62}$, T_{61} – czas przejazdów z miejsca postoju na powierzchnię pracy i z powrotem, T_{62} – czas przejazdów z powierzchni na powierzchnię. T_7 – czas codziennej obsługi technicznej maszyn. T_8 – straty czasu z przyczyn niezależnych od badanej maszyny $T_8 = T_{81} + T_{82} + T_{83}$, T_{81} – straty czasu z przyczyn organizacyjnych, T_{82} – straty czasu z przyczyn meteorologicznych, T_{83} – straty czasu z innych przyczyn

turning back, when process is interrupted, the time of empty drive in working place, time of unloading of the gathered material and the time, in which the trailers were exchanged [Glazar and Wojtkowiak 2009].

The effective active time of felling at use the chainsaw is the time, within which accordingly to its application chainsaw works (cuts off the tree from stump, cuts off the branches, cuts off the crowns of trees, divides the trunk, etc.) and working groups are under load.

The wood cutting at use chainsaw is realised at maximum opening of carburetor throttle, usually, and the crave rotational speed of engine is achieved thanks to relevant feed force induction of chainsaw cutting groups [Więsik and Wójcik 2007].

The work of chainsaw on running light, within witch chain is immobilized and engine speed is constant, is the work without load. [Wojtkowiak et al. 2007 a, b]. During felling operation, the walking of operator from tree to tree with working engine of chainsaw is the work of chainsaw without load and according to BN-76/9195-01 standard is subsidiary time.

The effective active time of realized technology or its part (operation) is the category time, within which the machine and the operator are active involvement in this technology or operation. The detailed analysis of the effective active time can be at planning of technology realization helpful.

The purpose of the research was the classical and order statistics of effective active time of felling at use chainsaw.

MATERIAL AND METHODS

The research was carried out in a 41-year old pine stand, in which early thinning was executed. The experimental area was situated in forest division of Kliniska. The basic features of test area are presented in Table 1.

The felling operation was carried out with chainsaws: Husqvarna 350 (H350) and Husqvarna 346XP (H346XP). In total, 1258 trees (572 pcs – H350, 686 pcs – H346XP), was removed. Average volume of one removed tree was about 0.03 m^3.

The effective active time of felling, the time from touch of guide bar of chainsaw to tree to dismissing of guide bar from cut tree, was analyzed. The felling effective time measurement was led with the aid of stop watch, and the accuracy was 0.01 second.

The structure analysis of researched statistical population – cut trees, from the point of view of statistic feature – effective active time of felling, for each chainsaw model, separately, was performed on the basis of classical and order statistics.

Distribution was characterized by location, spread and shape.

The following descriptive parameters were used to statistical analysis:

- arithmetic mean (AM), median (Me), mode (M), quartile (Q_1, Q_3),
- variance (V), standard deviation (σ_x), coefficient of variation (CV),
- skewness coefficient (SC).

The hypothesis testing about lack of difference between average values of effective active time of felling for used chainsaw models was performed on the basis t-test application.

Table 1. Basic features of the research area
Tabela 1. Podstawowe cechy taksacyjne powierzchni wybranej do badań

Regional State Forest Directorates RDLP	Szczecin
Forest Division Nadleśnictwo	Kliniska
Forest District Leśnictwo	Załom
Compartment Oddział	450c/449c
Size of area, ha Wielkość powierzchni, ha	1.00
Natural station Siedlisko	Bśw
Participation of species Udział gatunków	So
Age Wiek	41
Stand quality class Bonitacja	II
Average d.b.h., cm Przeciętna pierśnica, cm	10
Average height, m Przeciętna wysokość, m	12
Afforestation Zadrzewienie	0.9
Stand quality Jakość	22

RESULTS OF INVESTIGATIONS

The basic quantities characterising researched statistical population – cut trees, from the point of view of statistic feature – effective active time of felling, with taking into consideration used models of chain-saw are presented in Table 2.

The effective active time of felling of one tree was the statistic feature. The average effective active time of felling of one tree was 2.402 s at use H350 chainsaw and 2.316 s at use H346XP chainsaw. In both variants, the time of felling of one tree was 2 s most often. Half the population had values of time of felling less than 2 s.

The effective active time of felling was deflected from average effective active time about near ±1.27 s in variant with H350 chainsaw and ±1.21 s in variant with H346XP chainsaw. It was 52.7% of average effective active time of felling for H350 variant and 52.2% for H346XP variant. It gives bases to ascertain, that the cut trees were strong statistical diversified from the point of view of effective active time of felling in both.

Table 2. Basic quantities characterising the researched statistical population – cut trees, from the point of view of statistic feature – effective active time of felling, taking into consideration used models of chain-saw

Tabela 2. Podstawowe wielkości charakteryzujące badaną zbiorowość statystyczną – ścinane drzewa, ze względu na wybraną cechę – efektywny czas ścinki z uwzględnieniem stosowanych modeli pilarek

Model of chain-saw Model pilarki	H350	H346XP
Number of removed trees, pcs Liczba ściętych drzew, szt.	572	686
Total effective active time of felling for all trees, s Suma efektywnego czasu ścinki wszystkich drzew, s	1 374	1 588.75
Minimal effective active time of felling, s Minimalny efektywny czas ścinki, s	0,69	0.59
Average effective active time of felling, s Średni efektywny czas ścinki, s	2.402	2.316
Maximal effective active time of felling, s Maksymalny efektywny czas ścinki, s	11.57	15.88
Mode, s Dominanta, s	2.32	1.91
Median, s Mediana, s	2.17	2.06
Quartile Q_1, s Kwartyl Q_1, s	1.68	1.67
Quartile Q_3, s Kwartyl Q_3, s	2.73	2.54
Variance, s^2 Wariancja, s^2	1.62	1.47
Standard deviation, s Odchylenie standardowe, s	1.271	1.212
Coefficient of variation, % Współczynnik zmienności, %	52.73	52.22
Skewnees coefficient Współczynnik asymetrii	0.07	0.34

The positive skewness coefficient has confirmed, that statistical units with value of feature (effective active time of felling) below arithmetic mean were prevailed.

The values of skewnees coefficient qualify the distribution of effective active time as:

- weak right-sided asymmetry in variant H350,
- moderate right-sided asymmetry in variant H346XP.

The particular distributions of effective active time of felling are presented in Figures 2 and 3.

According to the statistical analysis of quartiles, 25% of the data was less than 1.68 s and 75% of the data was less than 2.73 s in variant with H350 chainsaw (1.67 s and 2.54 s in variant H346XP, respectively).

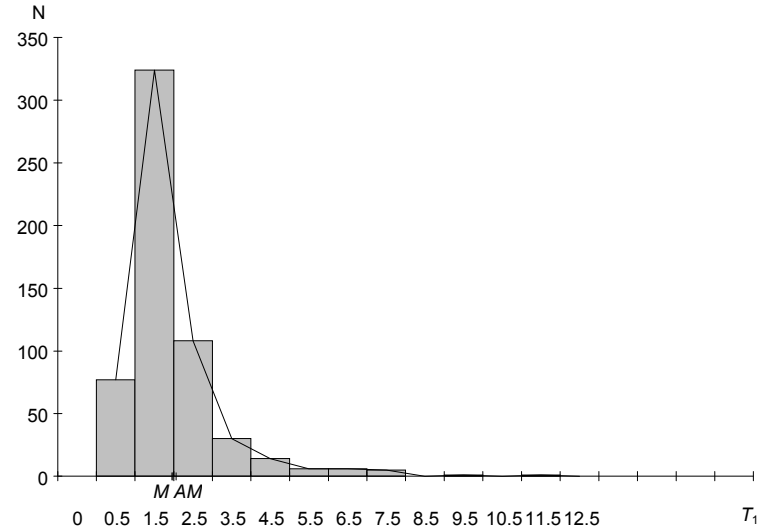

Fig. 2. Distribution of effective active time of trees felling while using H350 chain-saw: T_1 – effective felling time, N – number of trees, M – mode, AM – arithmetic mean

Rys. 2. Rozkład efektywnego czasu ścinki drzew z użyciem pilarki H350: T_1 – efektywny czas ścinki, N – liczba drzew, M – dominanta, AM – średnia arytmetyczna

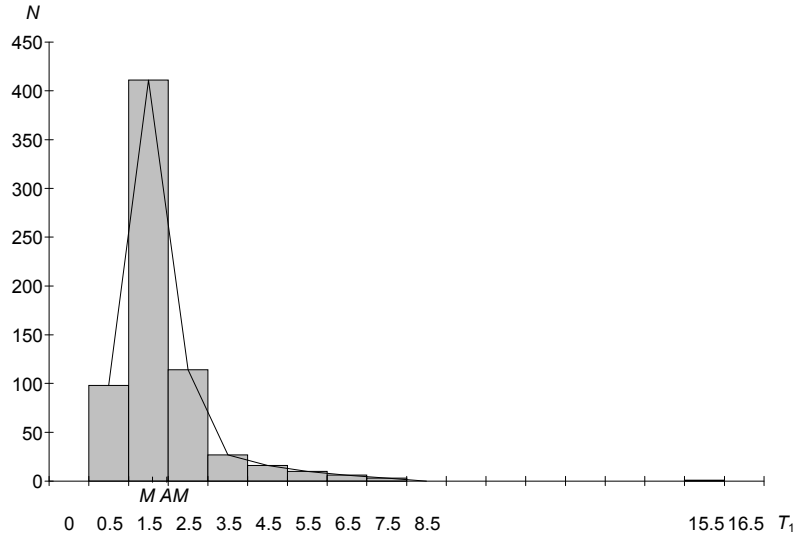

Fig. 3. Distribution of effective active time of trees felling while using H346XP chain-saw: T_1 – effective felling time, N – number of trees, M – mode, AM – arithmetic mean

Rys. 3. Rozkład efektywnego czasu ścinki drzew z użyciem pilarki H346XP: T_1 – efektywny czas ścinki, N – liczba drzew, M – dominanta, AM – średnia arytmetyczna

Between average values of effective active time of felling H350 and H346XP chainsaw no statistical substantial differences were found (t = 1.27, degrees of freedom = 1256, p = 0.206).

DISCUSSION

The slash wood in the form of pole lumber and medium-size wood in the form of stake wood, length 2.40 m most often, and perches wood (S3) are mainly in first thinnings of pine stands harvested. A chainsaw is the basic device used in first thinnings, in activities such as tree felling, limbing and conversion.

Different chainsaws and different techniques of cuts use in dependence on thickness of tree in place of cut. Chainsaws with cutting chain or circular saw without accessories can use to cut down trees < 20 cm in diameter. In this case 28 cm (11") bar is recommended and the felling is made with one horizontal felling cutting mainly [Pilarki... 2002].

The felling operation was carried out on the research surface with chainsaws with cutting chains and the felling was made with one horizontal felling cutting, usually. From a 41-year old pine stand with 1 ha dimension of area, 1258 trees were removed and average volume of one removed tree was about 0.03 m^3. That corresponds to intensity of cutting on Jodłowski's [2000] investigative surfaces in pine stands – number of removed trees – 1120 pcs/ha, average volume of one removed tree was about 0.03 m^3, age – 29-35 years old.

The effective active time of felling, within which working groups of chainsaw were under load, was analysed. The time of the operator walking from tree to tree with working engine of chainsaw, the time of the putting of position of operator before start of felling, the necessary time of falling of a hooked tree to the ground, etc., were not analysed.

The time of felling, from touch of guide bar of chainsaw to tree to dismissing of guide bar from cut tree, by Wójcik [2007] was analysed. According to Wójcik [2007], the effective active time of felling of one tree, about 5.9-61.0 cm diameter at breast height, was from 5 s to 246 s. The time of felling depends also on technical parameters of harvested trees. The diameter at place of felling cut has the strongest influence on felling time [Wójcik 2007].

Within the executed research from the point of view of a small size tree (0.03 m^3) the average effective active time of felling of one tree was about 2 s.

Increase of diameter of felling trees in the place of cutting is connected with techniques of felling consisting in execution of one felling cutting with one or two under horizontal cut [Pilarki... 2002], that lengthen time of felling.

The effective active time of felling by Więsik [2001] was analysed, too. In a 60-year old pine stand, within executed thinning, the effective active time of felling of trees of about 15.8 cm average diameter at breast height and 0.18 m^3 average volume, was over 30 s.

In total, effective active time of felling of all cut trees on the experimental area, was 0.82 h (10% of operative time).

The joint time, within which the operator works with the chainsaw in shift time, has a great importance the point of view of ergonomics [Stempski 2007].

CONCLUSIONS

1. Within the executed research the average effective active time of felling of one tree was about 2 s.

2. Value of effective active time of felling was deflected from average effective active time about near ±1.27 s in variant with H350 chainsaw and ±1.21 s in variant with H346XP chainsaw.

3. Cut trees were strong statistical diversified from the point of view of effective active time of felling, both in variant with H350 chainsaw and in variant with H346XP chainsaw.

4. Positive skewness coefficient has confirmed, that statistical units with value of feature below arithmetic mean prevailed – weak right-sided asymmetry in variant H350, moderate right-sided asymmetry in variant H346XP.

5. Between average values of effective active time of felling H350 and H346XP chainsaw no statistical substantial differences were found.

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ANALIZA EFEKTYWNEGO CZASU ŚCINKI DRZEW Z UŻYCIEM PILARKI SPALINOWEJ NA PODSTAWIE WYBRANYCH KLASYCZNYCH I POZYCYJNYCH PARAMETRÓW OPISOWYCH

Streszczenie. Czas efektywny to czas, w którym urządzenie obrabia bądź przetwarza zgodnie z przeznaczeniem przedmiot pracy, a jego zespoły robocze są obciążone. Celem badań była analiza efektywnego czasu ścinki drzew z użyciem pilarki spalinowej, na podstawie wybranych klasycznych i pozycyjnych parametrów opisowych. Średni efektywny czas ścinki jednego drzewa w analizowanym drzewostanie, w ramach wykonywanego zabiegu trzebieży wczesnej, wynosił około 2 s. Ze względu na efektywny czas ścinki, ścinane drzewa były bardzo zróżnicowane. Dodatni współczynnik asymetrii potwierdził, że przeważały jednostki o wartościach cechy (efektywnego czasu ścinki) mniejszych niż średnia arytmetyczna – rozkład o asymetrii prawostronnej.

Słowa kluczowe: ścinka drzew, czas efektywny, trzebież wczesna, drzewostany sosnowe

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