Utilization Rates and Cost Factors in Timber Harvesting Based on Long-term Machine Data

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Abstract – Nacrtak

Operating forest machines is not only expensive but accurate monitoring of economic variables can be very difficult. Detailed machine data capture of economic variables within a forest enterprise can be used to support accurate decision making processes, especially costing for new investments.

The objectives of this study were to analyze economic variables of forest machinery based on long-term recorded data from one of the Austrian federal state forest machinery workshops.

The study used data from the enterprise's resource planning system over the period 2004 to 2008. In total 28 tower yarders, 19 skidders, 12 harvesters and 18 forwarders where analyzed for annual utilization, repair costs, fuel consumption and lubrication costs.

The average annual utilization of all skidders was approximately 1,150 productive machine hours excluding breaks less than 15 minutes (PMH_{15}) per year. Skidders consumed an average 7.3 L/PMH_{15} with repair costs of 11.4 €/PMH_{15}. For the fully mechanized harvesting system the harvesters achieved 2,040 PMH_{15}/year and the forwarders 2,070 PMH_{15}/year. The annual utilization of cable yarding systems is between 560 PMH_{15} and 1,500 PMH_{15}.

Keywords: forest machinery, fuel consumption, machine utilization, repair costs

1. Introduction – *Uvod*

In 2009 the Austrian annual timber harvest was 16.9 Mio m^3. Due to difficult mountainous terrain only 16% were felled and processed with harvesters. Extraction of timber from the stand to forest road side is split with 20% being carried out with cable yarding equipment, 49% with skidders, 26% with forwarders, and 5% with other means (Holzeinschlagsmeldung 2009).

Technical machine limitations, as well as social and environmental compatibility, are main decision criterions that restrict system selection. If multiple systems satisfy these criteria then the most cost-effectiveness will be used. In Austria machine cost calculation for timber harvesting is normally based on the FAO-Scheme, combined and adapted with company related data and conditions (FAO-Forestry Paper 99, 1992).

Machine rate estimation itself depends on the quality of information available for it. Jarack (1965) defined three categories of estimates depending on the sources of data. High quality estimates are calculations based on (1) long-term costs records followed by (2) knowledgeable sources. Estimates with low accuracy (3) are done with not documented or questionable sources or by use of rule-of-thumb values. Therefore high quality data should be used to assure accurate costing. Improved data recording and analyzing is an elementary component of a basic business strategy like in timber harvesting.

One of the most important factors influencing machine cost calculation is the annual use and utilization rate of forest machinery. Annual utilization rate is the ratio of productive to scheduled machine hours. Machine utilization is affected by different factors such as technical reliability of the machines, weather and road conditions, logistics, proportion of set-up time, and the workers. Such information can support strategic and operational decision making processes within a company, especially accurate costing for new investments.

The Austrian Federal Forestry company (ÖBF AG) represents 15% of forest area with a main part under mountainous conditions. It harvests approximately 1.8 Mio m^3 per year. Within its organisation it operates two technical divisions that carry out forest operations such as planning, road constructing and timber harvesting. These divisions also offer their services in private forests.

The aim of this paper is to analyse long term machine information from the ÖBF AG to improve data used for cost calculations with a focus on utilization, repair costs, fuel and lubricant consumption. Data set includes harvesters, skidders, forwarders and tower yarders. Additionally factors available for cost calculation of forest machinery are compared with the recorded data.

2. Material and Methods – *Materijal i metode*

The machine rate is usually divided into ownership costs, operating costs, and labor (FAO-Forestry Paper 99, 1992). Operating costs include maintenance and repair costs, fuel and lubricant costs, tire, track, chain, and cable replacement. Maintenance and repair may include everything from simple maintenance items to the periodic overhaul of engine, transmission, clutch, brakes, and other major equipment components (Bushman et al. 1988).

2.1 Data capturing – *Prikupljanje podataka*

The study used data from the ÖBF AG resource planning system over the period 2004 to 2008. In total 28 tower yarders, 19 skidders, 12 harvesters and 18 forwarders of different brands and payload capabilities were analyzed for annual utilization, repair costs and fuel consumption. For each machine categorized information was recorded including time elements, fuel quantities and repair and maintenance costs (Table 1).

Both productive and scheduled time was recorded on a daily basis by the crew. Productive time was defined as all machine operating hours including breaks less than 15 minutes in duration (PMH_{15}). Relocation and set-up times are not included in productive machine hours. Scheduled hours include all normal working hours for worker and machine operating in one shift system, but exclude holidays and sick-days and are therefore limited to 1,650 h/year. For all calculations concerning the annual utilization only machines working a full 12 month period were taken into account.

A spreadsheet-based database was developed to combine and prepare the data. Based on these database relevant variables of different forest machineries were filtered and analyzed. For cumulative hours of machines which are older than the period for analyzing the data (i.e. pre-2004) the starting point was taken from the ÖBF AG resource planning system of the machine itself. Regarding the costs for this longer time period, the consumer price index from the Federal Institute of Statistics was taken to refer the costs back to 2004. This is comparable to the method used by Brinker et al. (2002) to compare harvest machine costs in the USA.

3. Results – *Rezultati*

3.1 Annual utilization – *Godišnja iskorištenost*

Average annual machine use for harvesters was 2,042 productive machine hours. A maximum annual use of 3,120 PMH_{15} was recorded when operating multi-shifts in wind-throw in Sweden. The majority of their operations are carried out in Austria, but during this time they also contracted abroad due to a big wind-throw event in Scandinavia. The aver-

Table 1 Overview of machines and models observed during data capturing
Tablica 1. *Pregled po vrstama strojeva i modelima praćenih tijekom prikupljanja podataka*

Attributes – *Obilježja*	Machine types – *Vrste strojeva*			
	Harvester *Harvester*	Forwarder *Forvarder*	Skidder *Skider*	Tower yarder *Stupna žičara*
Number of studied machines, *n* *Broj istraživanih strojeva, n*	12	18	19	28
Number of models, *n* *Broj modela, n*	4	6	6	7
Range of engine power, kW *Raspon snage motora*, kW	125–204	82–150	75–150	170–330
Range of cumulative operating time 2004 to 2008, PMH_{15} *Raspon kumulativnoga pogonskoga vremena 2004 –2008*, h	143–12,937	72–15,349	300–7,102	91–14,948

Table 2 Descriptive statistics concerning annual utilization of machinery, PMH_{15}/year
Tablica 2. *Deskriptivna statistika godišnje iskorištenosti strojeva, pogonskih sati godišnje*

Machine type *Vrsta stroja*	Mean *Arit. sredina*	Min.	Max.	St. Dev. *Stan. devijacija*	5 Perc. *5. percentil*	95 Perc. *95. percentil*	Scheduled Machine Hours *Godišnji fond sati*
Harvester – *Harvester*	2,042	938	3,120	408	1,509	2,737	3,300
Forwarder – *Forvarder*	2,068	787	4,254	549	1,467	2,951	3,300
Skidder – *Skider*	1,151	355	1,619	276	456	1,562	1,650
Tower Yarder – *Stupna žičara*	1,083	541	1,531	202	684	1,398	1,650

Table 3 Descriptive statistics concerning repair costs of analyzed machinery, €/PMH_{15}
Tablica 3. *Deskriptivna statistika troškova popravaka praćenih strojeva,* €/pogonskom satu

Machine type *Vrsta stroja*	Mean *Arit. sredina*	Min.	Max.	St. Dev. *Stan. devijacija*	5 Perc. *5. percentil*	95 Perc. *95. percentil*	*N*
Harvester – *Harvester*	20.2	8.1	46.0	9.7	9.4	41.3	36
Forwarder – *Forvarder*	11.2	2.4	36.3	5.9	4.2	21.1	55
Skidder – *Skider*	11.4	1.4	43.6	8.3	3.9	31.7	77
Tower Yarder – *Stupna žičara*	28.0	5.5	68.7	13.6	8.8	57.3	91

age scheduled machine hours in Austria for a harvester in single shift is 1,650 PMH_{15}. Within this machine group different harvester types show a considerably higher annual machine use than the average. The reason is that the Austrian Federal Forestry company uses a special work shift model. This system uses two workers and results in the machines being used seven days a week. Using this work shift model the scheduled machine hours are 3,300. The average machine utilization rate for all harvesters was 62% (Table 2).

Forwarders have the largest average productive hours per year with 2,068 PMH_{15} among the investigated machines. They work the same shift model as harvesters. Variability in the hours is greater than that of harvesters, as forwarders are also used after motor-manual felling. Forwarders have the same annual scheduled machine hours as harvesters, being 3,300 hours. This results in a slightly higher machine utilization rate of 63%.

The results also show for skidder use a clear seasonal effect with higher use in winter time. Because of this effect productive machine hours ranged from 355 to 1,619, and averaged 1,151 PMH_{15} per year. The annual scheduled machine hours for a skidder are 1,650 hours. This results in a machine utilization rate of 70%.

Tower yarders show the average productive hours of 1,083 PMH_{15}/year. The difference in annual use is clearly visible. The annual scheduled machine hours for a tower yarder are 1,650 hours. This results in a machine utilization rate of 66%. A double shift system for cable yarding in steep terrain is not possible as light conditions limit the choker-setter and the faller.

3.2 Repair costs – *Troškovi popravaka*

Average repair cost for harvesters were 20.2 €/PMH_{15} based on the consumer price index benchmarked back to 2004. Forwarder and skidders had almost the same cost per hour with 11.2 € and 11.4 €, respectively. Tower yarders are the highest with 28.0 €/PMH_{15} (Table 3). No correlation was found between the amount of repair cost and annual utilization or the summarized utilization per year.

3.3 Fuel consumption and lubricants *Potrošnja goriva i maziva*

Fuel consumption of harvesters ranged from 10.2 to 24.3 L/PMH_{15} with an average of 15.6 l/PMH_{15}. The calculations yielded the average fuel consumption for forwarders of 11.1 L/PMH_{15}. Skidders show the lowest consumption rate with 7.3 L/PMH_{15}. They also have lighter engines as shown in Table 1. Tower yarders consume 16.0 L/PMH_{15}. In combination with fuel prices, the fuel cost per hour including cost for lubricants were also analyzed (Table 4).

When analyzing fuel consumption according to engine power, tower yarders show the lowest fuel consumption with 0.06 L per hour and kilowatt, followed by skidders with 0.08 L/kW, PMH_{15}. Forwarders and harvesters are close together with 0.10 and 0.09 L/kW, PMH_{15} (Table 5).

Table 4 Descriptive statistics concerning fuel consumption and lubricant costs
Tablica 4. *Deskriptivna statistika troškova goriva i maziva*

Cost factors *Troškovni faktori*	Machine type *Vrsta stroja*	Mean *Arit. sredina*	Min.	Max.	St. Dev. *Stan. devijac.*	5 Perc. *5. percentil*	95 Perc. *95. percentil*	*N*
Fuel consumption, L/PMH_{15} *Potrošnja goriva,* L/pog. satu	Harvester – *Harvester*	15.6	10.2	24.3	3.3	11.3	23.0	36
	Forwarder – *Forvarder*	11.1	1.3	20.5	3.1	7.4	17.4	55
	Skidder – *Skider*	7.3	3.6	11.3	2.1	4.0	10.8	77
	Tower Yarder – *Stupna žičara*	16.0	5.3	24.8	4.2	8.9	23.2	91
Fuel cost, €/PMH_{15} *Trošak goriva,* €/pog. satu	Harvester – *Harvester*	13.0	8.4	22.7	3.4	9.6	20.3	36
	Forwarder – *Forvarder*	9.2	1.1	19.0	3.1	5.3	13.7	55
	Skidder – *Skider*	5.5	2.8	10.2	1.7	3.0	8.4	77
	Tower Yarder – *Stupna žičara*	12.6	3.3	21.9	3.8	6.2	18.6	91
Lubricant cost, €/PMH_{15} *Trošak maziva,* €/pog. satu	Harvester – *Harvester*	1.6	0.3	3.1	0.8	0.4	3.0	34
	Forwarder – *Forvarder*	0.8	0.2	2.7	0.4	0.3	1.5	53
	Skidder – *Skider*	0.4	0.0	1.0	0.2	0.1	0.8	77
	Tower Yarder – *Stupna žičara*	1.7	0.2	4.4	1.0	0.4	3.9	91
Lubricant cost, % of fuel cost *Trošak maziva, % od troška goriva*	Harvester – *Harvester*	12.6	1.4	30.8	7.6	2.0	28.9	34
	Forwarder – *Forvarder*	7.9	2.0	18.2	3.8	3.2	15.5	53
	Skidder – *Skider*	7.2	1.0	29.7	4.3	2.6	14.5	77
	Tower Yarder – *Stupna žičara*	12.9	3.6	32.2	6.1	5.1	25.4	91

Table 5 Descriptive statistics concerning fuel consumption per hour dependent on the engine power, L/kW, PMH_{15}
Tablica 5. *Deskriptivna statistika potrošnje goriva po pogonskom satu ovisno o snazi motora*

Machine type *Vrsta stroja*	Mean *Arit. sredina*	Min.	Max.	St. Dev. *Stan. devijacija*	5 Perc. *5. percentil*	95 Perc. *95. percentil*	*N*
Harvester – *Harvester*	0.095	0.077	0.119	0.012	0.077	0.118	36
Forwarder – *Forvarder*	0.098	0.011	0.146	0.020	0.077	0.129	55
Skidder – *Skider*	0.075	0.031	0.117	0.020	0.041	0.108	77
Tower Yarder – *Stupna žičara*	0.060	0.023	0.108	0.017	0.034	0.089	91

Table 6 Analysis of variances concerning the variables
Tablica 6. *Analiza varijance odabranih obilježja*

	Sum of Square *Zbroj kvadrata*	df *Stup. slobode*	Mean of Square *Varijanca*	*F*	Sig. *Značajnost*
Adjusted Model – *Prilagođeni model*	4,046.514	4	1,011.628	108.289	<0.001
Constant – *Konstanta*	358.487	1	358.487	38.374	<0.001
Engine power – *Snaga motora*	448.686	1	448.686	48.029	<0.001
Machine type – *Vrsta stroja*	871.332	3	290.444	31.090	<0.001
Std. Error – *Stand. pogreška*	2,372.846	254	9.342		
Sum – *Zbroj*	45,725.424	259			
Adjusted Sum of Variation *Prilagođena suma varijabilnosti*	6,419.360	258			
Sum – *Zbroj*	6,134.037	255			

Further analysis estimated the rate of fuel consumption per hour depending on the engine power and type of forest machine. The significant covariates are the machine type (MT) and power of engines used by different machines. In the next step a model based on the data was developed (Table 6 and Table 7). The model (1) shows an adequate R-Square with 63%.

Table 7 Descriptive statistics concerning engine power of analyzed machine types
Tablica 7. *Deskriptivna statistika snage motora analiziranih vrsta strojeva*

Machine type *Vrsta stroja*	Engine power – *Snaga motora*, kW				
	Mean *Arit. sredina*	Minimum *Najmanja vrijednost*	Maximum *Najveća vrijednost*	5 Perc. *5. percentil*	95 Perc. *95. percentil*
Harvester – *Harvester*	162	125	204	125	204
Forwarder – *Forvarder*	118	82	150	82	150
Skidder – *Skider*	99	75	150	75	150
Tower Yarder – *Stupna žičara*	271	170	330	170	330
All Machines – *Svi strojevi*	176	75	330	75	330

With the previous analysis the following model was developed:

$$f_c = 5.055 + power^{0.04+CMT} \qquad (1)$$

Where:

f_c fuel consumption, L/PMH$_{15}$
P engine power, kW
CMT coefficient machine type:
Tower yarder – $CMT = 0$
Harvester – $CMT = 3.924$
Forwarder – $CMT = 1.488$
Skidder – $CMT = –1.744$

Based on the developed model, fuel consumption can be estimated for different forest machine types. Fig. 1 shows observed data and estimates. Estimating fuel consumption per hour was just done based on the machine data available.

4. Discussion – *Rasprava*

Information regarding machine utilization and repair costs gives forest engineers a useful tool for cost-evaluation in logging operations. This study used long term machine data captured by the ÖBF AG for 4 different machine categories, and each category included multiple machines for a total of 77 machines. The data used were from the period 2004 – 2008.

The average annual use is reported for all machines. The data show that the average utilization rates ranged from a low of 62% for the harvesters up to a high of 70% for skidders. The new working shift model, used by the Austrian Federal Forestry Company for their harvesters and forwarders, shows a clear increase in the annual machine use in comparison to the skidder and tower yarder. According to

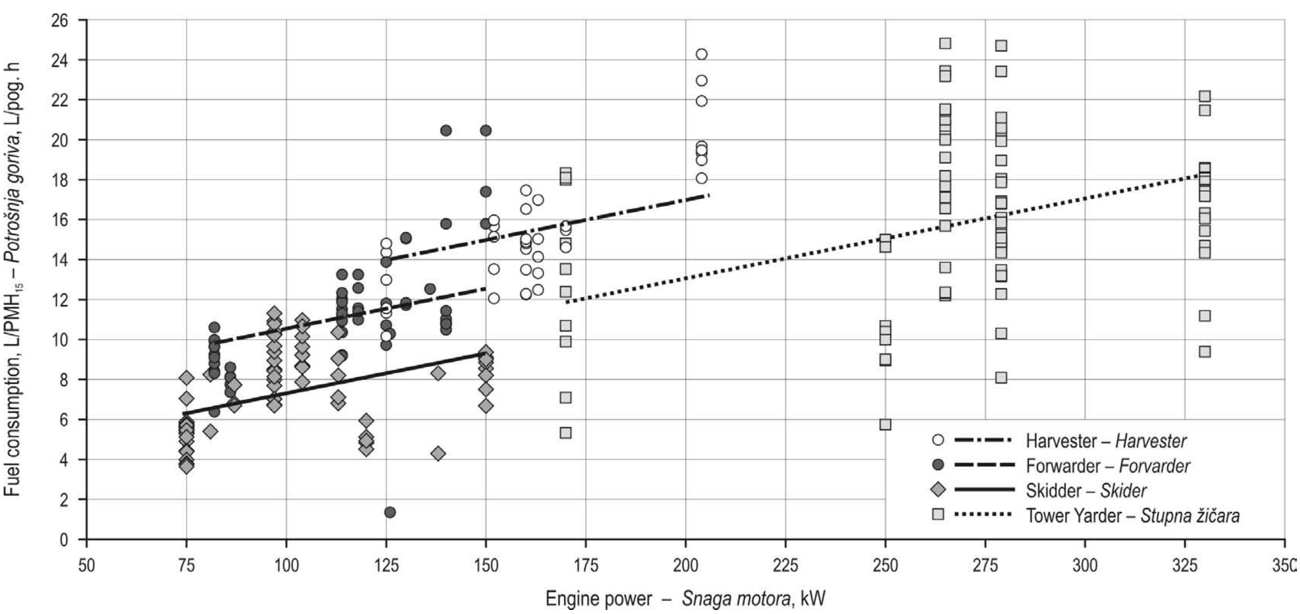

Fig. 1 Observed fuel consumption and the model based estimates of different forest machinery
Slika 1. *Snimljena potrošnja goriva i procjene zasnovane na modelu različitih šumskih strojeva*

Spinelli et al. (2011), the average annual utilization of harvesters and forwarders with 1,439 and 1,617 hours per year reaches 70% and 78%, respectively, of the value in this study. Spinelli and Visser (2008), based on a large number of separate time studies, determined an average delay for harvesters of 28.9%. Therefore, the utilization rates from that study are almost the same. Repair costs showed a high variability between machine types and with the cumulative operating time.

In Finland the repair and maintenance costs for harvester and forwarder averaged 9.66 €/h and 5.06 €/h, respectively. The fuel consumption for harvesters and forwarders were about 12.79 L/h and 10.76 L/h. Repair and service costs (classified as variable costs) of a logging contractor with a harvester-forwarder in Finland was studied by Väätäinen et al. (2006) and covered 6.2% of total costs. Maintenance costs defined as fixed costs accounted for 5.3% of total costs.

Pausch (2002) reported fuel consumption of 14.1 L/h for a medium sized harvester compared to 15.4 L/h for the model developed in this study. Löffler (1991) estimates the average fuel consumption for a forwarder with a medium sized engine of approximately 9.7 L/h compared to 10.9 L/h in this study.

The model for estimating fuel consumption could be improved with further investigation using more detailed data capture. It must also be mentioned that for life cycle analysis, fuel consumption of machinery has to be calculated differently. Self-driven tower yarders already included the fuel necessary for relocating the machinery. Skidders, harvesters and forwarders just show the figures concerning the logging processes without any relocating processes.

Currently data is being recorded manually by the ÖBF AG and their crews. In future data availability and calculation of results could be automated with defined interfaces between costing and enterprise resource planning system. Cost calculation could, therefore, be based on online data from the ERP for new machinery or for harvesting costs. Further work could also include more detailed data capture for investigating parameters influencing the repair costs of forest machines. The results of this paper can also be applied as basic information in life cycle assessment.

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Sažetak

Iskorištenost i troškovni faktori strojeva pridobivanja drva temeljem dugoročnoga praćenja

Među najvažnije čimbenike koji utječu na izračun troškova strojnoga rada jest godišnja uporaba i stopa iskorištenosti šumskih strojeva. Godišnja je stopa iskorištenosti stroja omjer proizvodnoga (pogonskoga) i ukupnoga radnoga vremena. Iskorištenost je stroja pod utjecajem različitih čimbenika, kao što su: tehnička ispravnost strojeva, vremenski uvjeti, stanje cesta, logistika, priprema rada (npr. montaža i demontaža žičnih linija), radnici. Takve informacije mogu pomoći u postupku donošenja strateških i operativnih odluka u tvrtki, a osobito u točnom utvrđivanju troškova prilikom novih investicija.

Austrijske savezne šume (ÖBF AG) gospodare s 15 % površine austrijskih šuma, čiji je glavni dio u planinskim područjima te siječe oko 1,8 mil. m³ godišnje. Poduzeće je organizirano u dva odjela koji provode šumske zahvate: planiranje radova, izgradnju cesta i pridobivanje drva. Ti odjeli izvode radove i u privatnim šumama.

Cilj je ovoga rada analizirati dugoročne podatke o strojevima dobivene od ÖBF-a radi unapređenja korištenja podataka za izračun troškova s naglaskom na godišnju iskorištenost strojeva, troškove popravaka te potrošnju goriva i maziva. Podaci obuhvaćaju harvestere, skidere, forvardere i stupne žičare. Dodatni podaci o šumskim strojevima dostupni za izračun troškova uspoređeni su s ranijim objavama.

Za istraživanje su korišteni podaci ÖBF-ova sustava planiranja resursa za razdoblje od 2004. do 2008. godine. Ukupno je 28 stupnih žičara, 19 skidera, 12 harvestera i 18 forvardera različitih proizvođača i nosivosti tereta analizirano s obzirom na godišnju iskorištenost, troškove popravaka i potrošnju goriva. Za svaki su stroj snimljeni kategorizirani podaci, koji su obuhvaćali: utroške vremena, količinu goriva te troškove održavanja i popravaka.

Proizvodno i ukupno radno vrijeme na dnevnoj osnovi snimali su radnici. Proizvodno (pogonsko) vrijeme određeno je kao svi radni sati stroja, uključivši i prekide rada kraće od 15 minuta (pogonski sati rada). Premještanje strojeva i vrijeme pripreme rada (kod žičara montaža i demontaža) nisu uključeni u proizvodno vrijeme. Ukupno radno vrijeme uključuje sve normalne sate rada za radnika i stroj u jednoj smjeni, ali isključuje praznike i bolovanja te je stoga ograničeno na 1650 sati godišnje. Za sve izračune povezane s godišnjom iskorištenošću uzeti su u obzir samo strojevi koji su radili svih 12 mjeseci u godini.

Baze podataka koje služe za pripremu i obradu podataka razvijene su u tabličnom kalkulatoru. Temeljem tih baza podataka odabrane su i analizirane odgovarajuće varijable različitih šumskih strojeva. Za cjelokupne (kumulativne) sate rada strojeva koji su stariji od razdoblja za koje su analizirani podaci (tj. prije 2004), početna je točka preuzeta iz ÖBF-ova sustava planiranja resursa za pojedini stroj. Za isto razdoblje podaci su o troškovima definirani pomoću indeksa potrošačkih cijena dobivenih od Saveznoga zavoda za statistiku.

Prosječna godišnja uporaba harvestera iznosi 2042 pogonska sata rada. Najveća godišnja uporaba od 3120 pogonskih sati rada zabilježena je u višesmjenskom radu pri saniranju vjetroizvala u Švedskoj. Većinu vremena strojevi su radili u Austriji, ali tijekom promatranoga razdoblja ugovoreni su i radovi u inozemstvu zbog velike količine vjetroizvala u Skandinaviji. Prosječan fond radnih sati harvestera u Austriji za jednu smjenu iznosi 1650 pogonskih sati rada godišnje. Unutar te grupe strojeva različiti tipovi harvestera pokazuju značajno višu godišnju uporabu stroja od prosjeka. Razlog je u tome što Austrijsko savezno šumarsko poduzeće koristi poseban model smjenskoga rada. Taj sustav koristi dva radnika, a rezultat je da strojevi rade sedam dana u tjednu. Primjenom toga modela smjenskoga rada godišnji fond radnih sati iznosi 3300 sati. Prosječna je stopa iskorištenosti harvestera 62 %.

Među analiziranim strojevima forvarderi imaju najvišu prosječnu ostvarenost od 2068 pogonskih sati rada, pri čemu rade u istom smjenskom modelu kao i harvesteri. Kod forvardera varijabilnost s obzirom na broj ostvarenih pogonskih sati godišnje veća je nego kod harvestera jer se forvarderi koriste i nakon ručno-strojne sječe i izradbe drva. Forvarderi imaju isti fond radnih sati kao i harvesteri (3300 pogonskih sati rada), što dovodi do malo veće iskorištenosti vozila (63 %).

Rezultati, također, pokazuju jasan sezonski utjecaj pri uporabi skidera s većom iskorištenošću u zimskom razdoblju. Zbog toga utjecaja pogonski sati rada kreću se u rasponu od 355 do 1619, a u prosjeku iznose 1151 pogonski sat godišnje. Fond radnih sati skidera iznosi 1650 sati godišnje, što rezultira iskorištenošću od 70 %.

Stupne žičare ostvaruju prosječno 1083 pogonska sata godišnje. Razlika u godišnjoj uporabi žičare jasno je vidljiva. Godišnji fond radnih sati za stupne žičare iznosi 1650 sati, što rezultira stopom iskorištenosti od 66 %.

Sustav dvostrukih smjena za iznošenje drva žičarom na nagnutom terenu nije moguć zbog ograničenja trajanja dnevnoga svjetla za kopčaša i sjekača.

Prosječni troškovi popravaka za harvester bili su 20,2 € po pogonskom satu rada temeljeno na indeksu potrošačkih cijena iz 2004. godine. Forvarderi i skideri imali su gotovo isti trošak po satu, odnosno 11,2 € i 11,4 €. Stupne su žičare imale najviši trošak od 28,0 € po pogonskom satu rada (tablica 3). Nije utvrđena korelacija između iznosa troškova popravaka i godišnje iskorištenosti strojeva.

Prosječna potrošnja goriva harvestera iznosi 15,6 L, a forvardera 11,1 L po pogonskom satu rada. Skideri pokazuju najnižu prosječnu potrošnju goriva od 7,3 L (u odnosu na druge strojeve imaju i najlakše motore, tablica 7), a stupne žičare najvišu od 16,0 L po pogonskom satu rada. U kombinaciji s cijenom goriva analizirani su i troškovi goriva po satu, uključujući i troškove maziva.

Trenutačno radnici ÖBF-a snimaju podatke ručno. Dostupnost podataka i izračun rezultata u budućnosti mogu biti automatizirani, s definiranim sučeljima između sustava planiranja resursa i troškova unutar poduzeća. Izračun troškova može biti temeljen na online podacima ERP-a za nove strojeve ili za troškove pridobivanja drva. Daljnji rad može također uključiti prikupljanje preciznijh podataka za utvrđivanje parametara koji utječu na troškove popravaka šumskih strojeva. Rezultati ovoga rada mogu se također primijeniti kao temeljna informacija u postupku utvrđivanja analize životnoga ciklusa šumskih strojeva.

Ključne riječi: šumski strojevi, potrošnja goriva, iskorištenost stroja, troškovi popravaka

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