Long Term Repair and Maintenance Cost of some Professional Chainsaws

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Abstract – Nacrtak

A sample of 44 professional chainsaws was used to determine service life and maintenance cost for this type of equipment. Data were sourced from a large workshop, catering for regional forest crews in north western Italy. Chainsaw service life exceeded 3000 hours, and spread over a period of 6 to 9 years. Under these conditions, maintenance cost averaged 820 €, or about 120 % of the investment cost. Annual usage was highest and maintenance cost lowest for mid-size chainsaws, in the 2 to 3.5 kW power class. Models at the two extreme ends (i.e. < 2 kW and >3.5 kW) configured as specialist tools, which resulted in a lower usage and a higher maintenance cost per hour. The largest number of interventions (45% of the total) concerned the engine and the carburettor. The average chainsaw in the sample underwent 31 maintenance interventions over its service life. The cost per intervention varied between 7 and 50 €. Intervention cost was highest for engine work, and the lowest for overhaul. Overall, parts accounted for two-thirds of the cost, and labour for the remaining third. This study offers information about chainsaw service life and maintenance cost, obtained with scientific methods and hence suitable for general use.

Keywords: logging, harvesting, biomass

1. Introduction – *Uvod*

Italian forestry is characterized by steep terrain, ownership fragmentation and the application of close-to-nature management criteria, such as continuous-cover forestry (Mason et al. 1999). All these factors tend to slow down the inevitable introduction of mechanized harvesting (Febo et al. 1997), determining the current prevalence of labor-intensive operations (Magagnotti et al. 2012). Under these conditions, versatile low-investment machinery offers a suitable balance between capital and labor inputs (Picchio et al. 2009). For these reasons, chainsaws and modified farm tractors are the backbone of the Italian forest machine fleet (Spinelli et al. 2013). In fact, motor-manual felling with chainsaws is also used in the Nordic countries, where it is favored by small-scale operators, especially when dealing with biomass production (Laitila et al. 2007).

Many studies have addressed the productivity and cost of low-investment operations, based on chainsaws and farm tractors (Spinelli and Magagnotti 2012). However, most of these studies are relatively weak on costing. One of their main weaknesses is the adoption of conventional assumptions, which may not reflect current practice (Rozt 1987). The international scientific literature offers no updated information about the annual use, service life and maintenance cost of these machines. Year after year, authors use the same assumptions, originating from practical experience gained several decades ago, when both chainsaws and farm tractors were much different from the chainsaws and farm tractors we use today (Ward et al. 1985).

When chainsaws are concerned, studies offer general cost estimates, often obtained from secondary sources (Long et al. 2002, Mousavi et al. 2006). Most of these estimates date back to the early '80s (Miyata 1980). In fact, chainsaws are no longer considered in the updated versions of earlier machine rate compendia (Brinker et al. 2002). The only recent study offering good detail about chainsaw cost concerns its use in sawmilling – not in forestry practice – and therefore represents a peculiar case (Smorfitt et al. 2006).

While the international scientific community is working at improving cost methods for use at a glob-

al scale, very few people are working at developing reliable input assumptions. As a result, the lack of quality inputs may thwart all attempts to enhance the accuracy of machine cost estimates.

Therefore, the goal of this study was to provide reliable information on the service life and maintenance cost of professional chainsaws used in forest operations.

2. Materials and methods – *Materijal i metode*

The study was conducted in cooperation with a regional forest administration in north western Italy. The regional administration maintains its own logging crews, tasked with performing silvicultural operations in public forests. Regional crews are specifically trained for the task, and must attend several training courses depending on the task. Before using a chainsaw, operators must attend chainsaw use and maintenance courses. Individual chainsaw operators are responsible for the good use and maintenance of the machines they are assigned, and they are equipped accordingly. Operators conduct all minor maintenance, and especially the daily and weekly routines.

Major maintenance after severe failure or fatigue is performed by professional mechanics at a centralized workshop. All maintenance interventions conducted in this workshop are recorded in a logbook, together with information about chainsaw type, model, serial number, age and worked hours. Therefore, it is possible to reconstruct all maintenance interventions conducted over the whole service life of each chainsaw in the regional fleet, as well as the duration of their service life.

For this study, we have collected and organized all the information available in the workshop logbook. It contained data about 44 chainsaws, as shown in Table 1. All chainsaws in the study were professional models, produced by the two largest chainsaw manufacturers, and namely: Husqvarna (25 units) and Stihl (19 units). The data represented light, medium and heavy chainsaws. However, the data pool was not balanced in terms of machine size and make, which prevented proper comparisons between types and makes. The characteristics of the machines in the regional fleet reflected those of local forests and silviculture, which justified a strong bias in favor of medium-size chainsaws. Furthermore, the uneven distribution of age classes between makes depended on the variable success of the two chainsaw makes with public bids.

For the purpose of this study, maintenance interventions have been categorized into eight main classes, corresponding to the main constructive elements of a chainsaw and/or intervention type. The following categories were separated: general overhaul; engine repairs; crankcase repairs; carburettor issues; starter; electric system; chain and chain bar; safety devices.

Intervention cost was calculated by summing the costs of labor and spare parts. The former was estimated to 24 € per hour, taxes and benefits included. The latter was the actual cost indicated in the repair bills, after discounting to present value.

Statistical analysis of data was conducted with the Tukey-Duncan test at the 5% level, and with linear regression (SAS 1999).

Table 1 Chainsaw characteristics in the study
Tablica 1. *Karakteristike motornih pila uključenih u istraživanje*

Class *Razred*	Make *Proizvođač*	Model *Model*	Machines *Uređaji*	Displacement *Obujam cilindra*	Power *Snaga*	Guide bar *Vodilica*	Avg. use *Prosječna upotreba*	Interventions *Zahvati*
			n	cm^3	kW	cm	Hours – *Sati*	n
Heavy – *Teške*	Stihl	MS660	8	91.6	5.2	50	2 850	315
Medium – *Srednje*	Stihl	MS440	7	70.7	4.0	45	3 600	190
Medium – *Srednje*	Husqvarna	272XP	7	72.2	3.6	45	3 400	441
Medium – *Srednje*	Husqvarna	262XP	7	62.0	3.4	45	4 200	130
Medium – *Srednje*	Husqvarna	266XP	7	67.0	3.2	45	4 700	196
Light – *Lagane*	Stihl	MS200	4	35.2	1.8	35	1 000	103
Light – *Lagane*	Husqvarna	335XPT	4	35.2	1.6	35	400	13

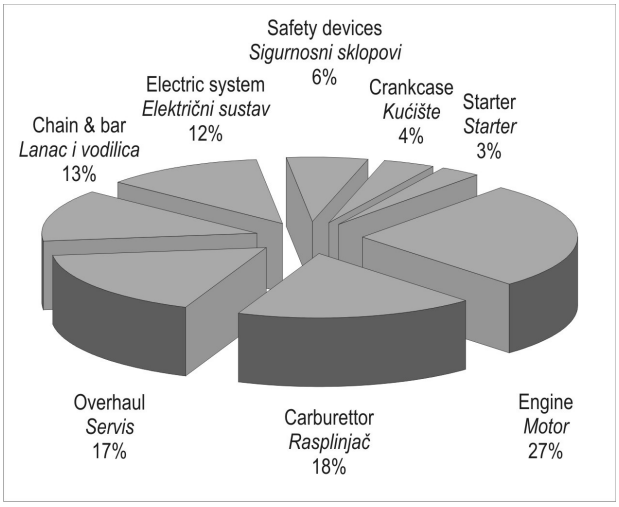


Fig. 1 Frequency of the number of interventions by intervention type
Slika 1. *Učestalost broja intervencija prema vrsti zahvata*

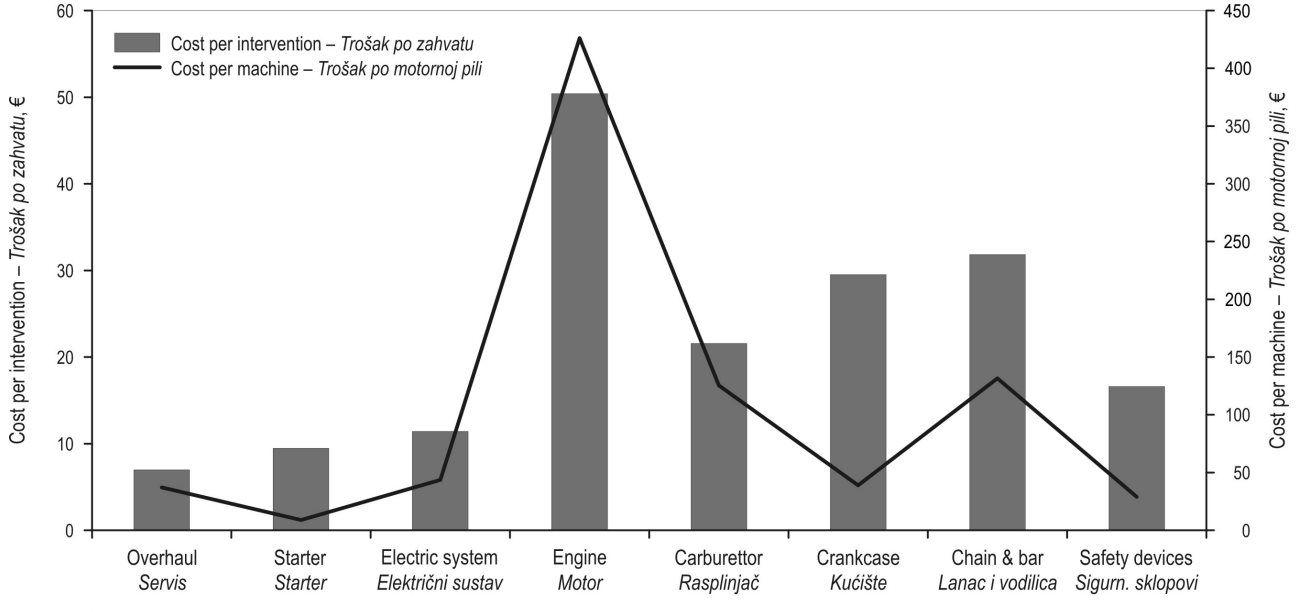
Overall, this study contains information about 1 388 maintenance interventions, corresponding to a total expenditure of 36 970 €.

3. Results – *Rezultati*

The service life of the chainsaws in the data pool ranged between 400 and over 4000 hours, with a weighed average of 3 175 hours. Service life was significantly higher for medium-size chainsaws, than for the other types. Light chainsaws were characterized by a very low utilization, and especially the lightest type (Husqvarna 335 XPT). That depended on the almost exclusive use for park maintenance, and on the relatively young age of the machines in the study, which had been bought two years earlier and were still in service. Average machine age was 8 years, with wide variations. Resulting average utilization was 400 hours per year.

The largest number of interventions (45% of the total) was made on the engine and the carburettor, and generally consisted of carburettor diaphragm replacements and piston-cylinder kit substitutions. In contrast, very few interventions concerned the starter (Fig. 1). The average chainsaw in our data pool underwent 31 maintenance interventions over an average service life of 3 175 hours.

The cost per intervention varied between 7 and 50 € (Fig. 2). It was highest for engine work, and lowest for overhaul. As an average, the total cost per chainsaw was 840 €, over the whole service life considered in this study. The largest share of this cost was related to engine, carburettor and chain/bar issues. Overall, parts accounted for two-thirds of the cost, and labor for the remaining third. Assuming that the average investment cost of the chainsaws in the study pool was 700 €,



■	6.97	9.46	11.40	50.40	21.56	29.50	31.81	16.59
—	37.06	8.81	43.54	426.08	125.47	38.88	131.59	29.03

Fig. 2 Average cost per intervention and machine, by intervention type
Slika 2. *Prosječan trošak po intervenciji i uređaju prema vrsti zahvata*

then cumulative repair and maintenance amounted to 120% of investment cost.

Conducted at the 5% level, the Tukey-Duncan test allowed grouping machines in three categories, as a function of the number of interventions per machine (Fig. 3). Machines with a power exceeding 3.5 kW were characterized by a significantly higher number of interventions per machine. The number of interventions was lowest for chainsaws with a power below 2 kW. Machines with a power between 2 and 3.5 kW were in between, requiring more maintenance than smaller machines, but less maintenance than larger ones. Overall, average maintenance time over the whole machine life was 18 hours for machines with power above 3.5 kW, 8 hours for machines with power between 2 and 3.5 kW, and 6 hours for machines with power below 2 kW. Statistical analysis also showed that the total number of interventions was independent from machine life: chainsaws in the intermediate power class (i.e. 2 kW > power > 3.5 kW) had a longer service life than heavier chainsaws, but underwent fewer interventions.

Overall, chainsaw maintenance incurred a cost between 0.13 and 0.50 € per hour (Table 2). Again, statistical analysis showed that machines could be divided into three groups. Chainsaws in the intermediate power class (i.e. > 2 and < 3.5 kW) incurred a significantly lower maintenance cost than all the other chainsaws. Chainsaws with a power below 2 kW or above 3.5 kW incurred a maintenance cost of 0.36 € per hour, i.e. more than twice as large as incurred in the intermediate power class (i.e. 14 € hour^{-1}). In this respect, there were no significant differences between chainsaws in the two extreme power classes.

Table 2 Maintenance cost

Tablica 2. *Troškovi održavanja*

Power – *Snaga*	Cost – *Troškovi*
kW	€ hour^{-1}
5.2	0.38
4.0	0.26
3.6	0.45
3.4	0.13
3.2	0.14
1.8	0.50
1.6	0.21

4. Discussion – *Rasprava*

Service life is much longer than indicated in previous studies, which quote between 1000 (Miyata 1980) and 2000 hours (Piegai et al. 2010; Spinelli and Mag-

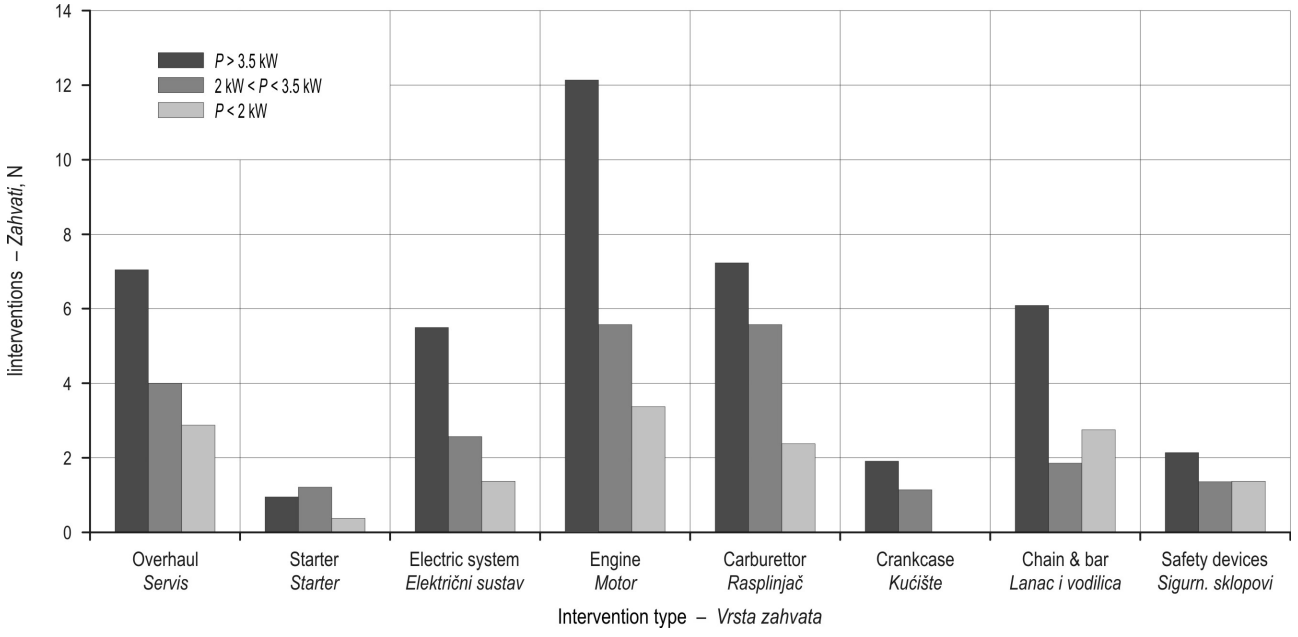


Fig. 3 Number of interventions by intervention type and chainsaw power class (P)

Slika 3. *Broj intervencija prema vrsti zahvata i razredu snage motorne pile (P)*

agnotti 2011). Annual use is much below the 1 000 hours quoted by Miyata (1980), but in line with the 500 hours reported by Piegai et al. (2010) and Spinelli and Magagnotti (2011). The very long service life is probably related to the peculiar strategies of public agencies, which are often equipped with their own repair workshops and tend to internalize repair costs. In that case, maintaining the workshop is a fixed cost, and reducing the cost of repairs by a more frequent machine turnover may not lead to any savings in terms of overall management cost. Extended service life is consonant with an accumulation of repair and maintenance cost, eventually exceeding the investment cost. Even if extending service life for such a long time may prove economically viable, one should check the effect of machine aging on ergonomic performance, especially for what concerns vibration and noise (Martinić et al. 2011). Further studies should clarify if proper maintenance can prevent the decay of ergonomic performance, despite use and age.

It is also worth noticing that the utilization of medium-size chainsaws is significantly higher than the use of the extreme models. That is compatible with the higher versatility of machines in the central class, which are used more frequently. Both light and heavy chainsaws configure as specialist tools, used for special jobs only.

Frequent use may partly explain the lower maintenance cost of chainsaws in the intermediate power class: both the operators and the mechanics were very familiar with these machines, which facilitated preventive maintenance, diagnostics and repairs. Furthermore, spares were more readily available, due to the larger number of machines in use. Differences in maintenance cost between power classes may also be explained by their different use, and the resulting different solicitations. Heavy chainsaws were used mostly for felling large trees, whereas small chainsaws were used in arboriculture, especially for pruning and delimbing. Medium-size chainsaws were the most versatile, used for a variety of jobs, and especially felling and processing. For this same reason, machines in the different power classes would have different construction characteristics, with light chainsaws being generally less sturdy than heavy or medium-size models, in view of their less intense use. This may have an effect on machine reliability and duration. Part of the variability may also be explained by individual model design: some models may have a better design than others, leading to differences in maintenance frequency and cost.

As to hourly cost, the only available comparison is the figure reported by Smorfitt et al. (2006), which amounts to 0.27 € $hour^{-1}$, after discounting to 2013 values and converting Australian dollars to European currency. That fits well into our 0.13 – 0.50 € $hour^{-1}$ bracket, and offers a close match to the 0.36 € $hour^{-1}$ specifically found for heavy chainsaw models, such as those used in the Australian study. Despite their specific regional source, the hourly costs obtained from this study may be suitable for general use, or at least for representing a wider reality than actually probed.

By itemizing maintenance frequency and cost, our study may point chainsaw manufacturers towards specific problem areas, where technological development is especially urgent. At present, engine and carburettor maintenance are still the most frequent and expensive. In their quest for lighter and more powerful engines, chainsaw manufacturers should not forget reliability, which is still a main issue. In contrast, the maintenance of compulsory safety devices (throttle safety catch, chain brake, etc.) incurs very little cost, denying earlier complaints that the (then) new devices would represent an additional complication, and the possible cause of further malfunctions.

Unfortunately, this study could not establish a clear relationship between chainsaw age and maintenance cost. Hourly maintenance cost is supposed to increase with machine use, as a result of fatigue and general decay. Estimating this relationship in numerical terms would have helped decisions about the eventual decommissioning of older machines, for substitution with new models. However, the workshop bills contained no indication of the hours worked at the time of repair, and their dates were often unreliable. Consequently, it was impossible to associate maintenance costs with the hours worked by each machine, as needed for developing a predictive model. Future studies should address this subject, which is extremely important for operation managers.

Finally, readers must recall that our study concerns major maintenance performed at a workshop, and not daily maintenance conducted in the field. However, field maintenance is generally minor, and consists of sharpening, cleaning and small repairs. We can safely assume that the largest component of field maintenance cost is labor, which is accounted for by including maintenance with delay time, as normally done in field studies (Magagnotti and Spinelli 2012).

5. Conclusions – *Zaključci*

This study offers information about chainsaw service life and maintenance cost, obtained by scientific methods and suitable for general use. Contrary to previous assumptions, the service life of professional

chainsaws can exceed 3 000 hours and span over up to 8 years. During this period, a chainsaw will undergo about 30 maintenance interventions, for a cost that is 1.2 times its purchase price. Engine and carburettor maintenance accounts for the largest number of interventions and the highest share of total maintenance cost. Versatile chainsaws in the intermediate (> 2 kW and < 3.5 kW) power class are characterized by the highest annual use and the lowest maintenance cost.

6. References – *Literatura*

Brinker, R., Kinard, J., Rummer, B., Lanford, B., 2002: Machine rates for selected forest harvesting machines. Circular 296 (Revised). Alabama Agricultural Experiment Station, Auburn University, AL. 32p.

Febo., P, Pipitone., F, Peri., G., 1997: The preservation of Sicilian forests with poorly mechanized logging processes. J Agr Eng Res 67: 229–233.

Laitila, J., Asikainen, A., Nuutinen, Y., 2007: Forwarding of whole trees after manual and mechanized felling bunching in pre-commercial thinnings. Int J For Eng 18: 29–39.

Long, C., Wang, J., McNeel, J., Baumgras, J. (2002): Production and cost analysis of a feller-buncher in central Appalachian hardwood forest. Proceedings of the 25th COFE meeting, Auburn, Alabama. 5p.

Magagnotti, N., Spinelli, R., Güldner, O., Erler, J., 2012: Site impact after motor-manual and mechanised thinning in Mediterranean pine plantations. Biosys. Eng. 113: 140–147.

Magagnotti, N., Spinelli, R. (Ed.) 2012: COST Action FP0902 – Good practice guideline for biomass production studies. CNR IVALSA. Florence, Italy. ISBN 978-88-901660-4-4. Available on line at: www.forestenergy.org. 41 p.

Martinić, I., Landekić, M., Šporčić, M., Lovrić, M., 2011: Forestry at the EU's doorstep – how much are we ready in the area of occupational safety in forestry? Croat J For Eng 32: 431–441.

Mason, B., Kerr, G., Simpson, J., 1999: What is continuous cover forestry? Forestry Commission Information Note 29. Forestry Commission, Edinburgh. 8p.

Miyata, E. 1980: Determining fixed and operating cost of logging equipment. General Technical Report NC-55. Forest Service North Central Forest Experiment Station, St. Paul, MN. 14p.

Mousavi, R., Nikouy, M., Uusitalo, J., 2011: Time consumption, productivity, and cost analysis of the motor manual tree felling and processing in the Hyrcanian Forest in Iran. J Forestry Res 22: 665–669.

Picchio, R., Maesano, M., Savelli, S., Marchi, E., 2009: Productivity and energy balance in conversion of a Quercus cerris L. coppice stand into high forest in central Italy. Croat J For Eng 30: 15–26.

Piegai, F., Fratini, R., Pettenella, D., 2010: Costi macchina. Confronto tra diversi metodi di calcolo. Supplemento scientifico degli approfondimenti di Sherwood – Foreste ed Alberi Oggi, Compagnia delle Foreste, Arezzo, Italy. 30p.

Rozt, C., 1987: A standard model for repair costs of agricultural machinery. Appl Eng Agr 3: 3–9.

SAS Institute Inc, 1999: StatView Reference. SAS Publishing, Cary, NC. ISBN-1-58025-162-5. p. 84–93.

Smorfitt, D., Harrison, S., Herbohn, J., 2006: Short-run and long-run costs for milling rainforest cabinet wood timbers. Australian For 69: 223–232.

Spinelli, R., Magagnotti, N., 2011: The effects of introducing modern technology on the financial, labour and energy performance of forest operations in the Italian Alps. For Pol Econ 13: 520–524.

Spinelli, R., Magagnotti, N., 2012: Wood extraction with farm tractor and sulky: estimating productivity, cost and energy consumption. Small Scale For 11: 73–85.

Spinelli, R., Magagnotti, N., Facchinetti, D., 2013: A survey of logging companies in the Italian Alps. Int J For Eng. In press.

Ward, S., McNulty, P., Cunney, M., 1985: Repair costs of 2 and 4 WD tractors. Trans ASAE 28: 1074–1076.

Sažetak

Dugoročni troškovi popravaka i održavanja profesionalnih motornih pila

Šumarstvo u Italiji obilježavaju strmi tereni, usitnjeno vlasništvo i primjena kriterija u gospodarenju bliskih prirodi. Svi ti čimbenici pomalo usporavaju neizbježno uvođenje mehaniziranoga pridobivanja drva i pridonose trenutačnomu prevladavanju radno intenzivnih operacija. U takvim uvjetima raznovrsna relativno jeftina mehanizacija pruža odgovarajuću ravnotežu između kapitalnih ulaganja i radnih resursa. Zbog toga motorne pile i adaptirani poljoprivredni traktori čine okosnicu talijanske šumske mehanizacije. Motorno-ručno obaranje s motornim pilama primjenjuje se također i u nordijskim zemljama, gdje je popularno kod malih izvoditelja šumskih radova, osobito u slučajevima vezanim uz proizvodnju biomase.

Mnoga su istraživanja razmatrala proizvodnost i troškove nisko investicijskih operacija na temelju motornih pila i poljoprivrednih traktora. Ipak, većina je tih istraživanja relativno nepouzdana što se tiče troškova. Jedna od njihovih glavnih slabosti je prihvaćanje konvencionalnih pretpostavki koje možda ne odražavaju sadašnju praksu. Međunarodna znanstvena literatura ne nudi nove podatke o godišnjoj uporabi, uporabnom vijeku i troškovima održavanja ovih strojeva. Iz godine u godinu autori se koriste istim pretpostavkama poteklim iz praktičnoga iskustva stečenoga prije nekoliko desetljeća, kada su se i motorne pile i poljoprivredni traktori znatno razlikovali od motornih pila i traktora koji se danas upotrebljavaju.

Kada se promatraju motorne pile, istraživanja daju opće procjene troškova, često dobivene iz sekundarnih izvora. Većina tih procjena potječe iz ranih 80-ih. Ustvari, motorne pile više nisu uključene u ažuriranim verzijama ranijih pregleda zastupljenosti strojeva. Jedina novija studija s detaljnim troškovima motornih pila odnosi se na primjenu u pilanama, ali ne i u šumarstvu.

Dok međunarodna znanstvena zajednica radi na poboljšanim troškovnim metodama za primjenu na globalnoj razini, vrlo je malo ljudi angažirano na razvoju pouzdanih ulaznih pretpostavki. Kao rezultat, nedostatak kvalitetnih ulaza može omesti sva nastojanja da se unaprijedi točnost procjena o troškovima strojeva. Zbog toga je cilj ovoga istraživanja bio pružiti vjerodostojnu informaciju o uporabnom vijeku i troškovima održavanja profesionalnih motornih pila u šumskim radovima.

Istraživanje prikazano u radu provedeno je u suradnji s regionalnom šumskom upravom u sjeverozapadnoj Italiji. Regionalna šumska uprava servisira vlastite sjekačke ekipe, zadužene za obavljanje poslova u javnim šumama. Regionalne su ekipe posebno uvježbane za radne zadaće i moraju pohađati nekoliko tečaja osposobljavanja ovisno o vrsti zadaće. Prije korištenja motorne pile rukovatelji moraju polaziti tečaj o uporabi i održavanju motorne pile. Sami su sjekači individualno odgovorni za pravilno korištenje i održavanje pila za koje su se zadužili, i za to su odgovarajuće opremljeni. Sjekači provode sve manje održavanje i osobito uobičajene dnevne i tjedne postupke.

Velike popravke i održavanje zbog ozbiljnih kvarova ili dotrajalosti obavljaju profesionalni mehaničari u središnjoj radionici. Svi se popravci i održavanje u toj radionici bilježe i evidentiraju u dnevniku, zajedno s podacima o tipu motorne pile, modelu, serijskom broju, starosti i radnim satima. Stoga je moguće rekonstruirati sve zahvate na održavanju svake motorne pile u regiji te trajanje njihova uporabnoga vijeka.

Za ovo su istraživanje prikupljene i organizirane sve informacije dostupne u dnevniku radionice. To je obuhvatilo podatke o 44 motorne pile. Sve su motorne pile u istraživanju bile profesionalni modeli, koje su proizvela dva najveća proizvođača motornih pila: Husquarna (25 jedinica) i Stihl (19 jedinica). U podacima su zastupljene i lake, srednje i teške motorne pile. Ipak, podaci u bazi nisu ujednačeni s obzirom na veličinu i proizvođače strojeva, što je onemogućilo odgovarajuće usporedbe između tipova pila i proizvođača. Karakteristike motornih pila u regionalnoj upravi odražavaju značajke lokalnih šuma i njihova uzgajanja, što objašnjava veliku zastupljenost srednje velikih pila. Nadalje, neravnomjerna razdioba starosnih razreda između modela ovisna je o različitom uspjehu dvaju proizvođača motornih pila na javnim natječajima.

Za potrebe istraživanja postupci su održavanja kategorizirani u osam glavnih razreda ovisno o glavnim konstruktivnim elementima pile i/ili vrsti intervencije. Razdvojene su ove kategorije: opći pregled, popravci motora, popravci kućišta radilice, pitanja rasplinjača, starter, električni sustav, lanac i vodilica, sigurnosni uređaji. Troškovi održavanja i popravaka izračunati su zbrajanjem cijene rada i rezervnih dijelova. Prethodno je procijenjeno na 24 € po satu, uključujući porez i doprinose. Potonje predstavljaju stvarne cijene navedene u računima popravaka nakon diskontiranja na sadašnju vrijednost. Istraživanje je obuhvatilo podatke za 1388 zahvata na održavanju, što odgovara ukupnim troškovima od 36 970 €.

Rezultati pokazuju da uporabni vijek motornih pila premašuje 3 000 sati i da traje od 6 do 9 godina. U takvim su uvjetima troškovi održavanja prosječno iznosili 820 € ili oko 120 % troška investicije. Godišnja je uporaba bila najviša, a troškovi održavanja najmanji za srednje velike motorne pile u razredu od 2 do 3,5 kW snage. Modeli na dva ekstremna kraja (tj. < 2 kW i > 3,5 kW) kao specijalistički alati rezultirali su manjom uporabom i višim troškovima održavanja po satu. Najveći dio popravaka (45 % od ukupnoga broja) odnosi se na motor i rasplinjač. Prosječna motorna pila u uzorku prošla je 31 zahvat održavanja tijekom svoga uporabnoga vijeka. Trošak po zahvatu iznosio je između 7 i 50 €. Trošak je popravaka bio najveći za rad na motoru, a najniži za opći pregled. Rezervni su dijelovi iznosili dvije trećine ukupnoga troška, a rad preostalu trećinu.

Razvrstavanjem učestalosti i troškova održavanja provedeno istraživanje može uputiti proizvođače motornih pila prema specifičnim problemskim područjima, gdje je tehnološki razvoj osobito nužan. Trenutačno su popravci motora i rasplinjača još uvijek najčešći i najskuplji. U njihovoj potrazi za lakšim i snažnijim motorima proizvođači ne bi trebali zaboraviti pouzdanost koja je i dalje glavno pitanje. S druge strane održavanje obaveznih sigurnosnih uređaja (kočnica lanca i sl.) izaziva vrlo malo troška, što pobija prijašnje prigovore da novi uređaji mogu biti dodatna komplikacija i mogući izvor daljnjih kvarova.

Nažalost, provedeno istraživanje nije moglo utvrditi jasnu vezu između starosti motornih pila i troškova održavanja. Pretpostavlja se da trošak održavanja po satu raste s uporabom pile kao rezultat dotrajalosti i općega trošenja. Procjena toga odnosa u brojčanim iznosima pomogla bi u donošenju odluka o eventualnom otpisivanju starijih strojeva radi zamjene novim modelima. Međutim, računi radionice nisu sadržavali bilješke o učinjenim radnim satima u trenutku popravka, i njihovi su datumi često bili nepouzdani. To je onemogućilo povezivanje troška održavanja s radnim satima svake motorne pile, kao što je potrebno za razvoj prediktivnoga modela. Buduća bi istraživanja trebala razmotriti to pitanje koje je iznimno važno za operativno rukovođenje.

Također na umu treba imati da je istraživanje obuhvatilo samo velike popravke obavljene u mehaničkoj radionici, bez dnevnoga održavanja koje se obavlja na terenu. Međutim, terensko je održavanje općenito manje i sastoji se od oštrenja, čišćenja i sitnih popravaka. Sa sigurnošću se može pretpostaviti da najveći dio u trošku terenskoga održavanja čini ljudski rad, koji je unaprijed uračunat uključivanjem održavanja motorne pile u dodatno vrijeme sječe i izrade, kako je to uobičajeno kod terenskih istraživanja. Provedeno istraživanje ipak pruža podatke o uporabnom vijeku i troškovima održavanja motornih pila, koje su dobivene znanstvenim metodama i stoga su pogodne za opću primjenu.

Ključne riječi: sječa, pridobivanje drva, biomasa, motorne pile, uporabni vijek, troškovi održavanja

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