Efficiency and Ergonomic Benefits of Using Radio Controlled Chokers in Cable Yarding

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Abstract – Nacrtak

Chokers are wire rope slings used to secure the felled trees to the rigging during cable yarder extracting. Standard chokers are set manually by the choker-setters along the corridor, and then unhooked manually by the yarder operator at the landing. Radio-controlled chokers are also set manually but have the advantage that they can be released remotely at the landing. In addition to possible safety improvement at the landing, the advantage is that it reduces the unhook phase of the operation and thereby potentially improve productivity. However, the additional weight of the radio controlled chokers may also increase the work load of the choker-setters on the slope. A standard manual choker bell weighs 0.34 kg, whereas the radio-controlled choker bell weighs 1.6 kg. To assess the possible efficiency and ergonomic benefits of radio-controlled chokers a study was carried out on a Wanderfalke yarder. The study site was in the eastern Austrian Alps, working in Norway Spruce with a piece size ranging from 0.4 to 0.86 m^3, on slopes between 50 and 60%, and in corridors of 90 to 200 m long. It included both a time and motion study in a full factorial layout as well as measuring the choker-setter workload through continuous monitoring of the heart-rate. Results showed that there was a 9% productivity gain using the radio-controlled chokers at the average piece size. However the workload of the choker-setter also increased; the percent heart rate reserve, a measurement of worker strain, increased from 40 to 44%. So although this study showed that productivity improvements are possible with radio-controlled chokers, it was at the expense of increased worked load of the choker-setter.

Keywords: radio controlled choker, cable yarding, choker-setter, ergonomic benefits

1. Introduction – *Uvod*

Efficient harvesting in steep terrain is normally linked to cable-based harvesting systems. Technical developments and system optimization during the last decades have targeted more efficient, socially acceptable and ecologically sustainable ways to use cable yarding systems. Radio-controlled applications allow for automation of processes and enables both the yarder operator as well as the choker-setter to control the yarder (Heinimann et al. 2006).

Chokers are wire rope slings used to secure the felled trees to the rigging during cable yarder extracting. Unhooking chokers at the landing is time consuming, accounting for 10 to 20% of the productive cycle time, depending on the system (Baker et al. 2001). For operations where the yarder operator leaves his cab to unhook, the time taken to get in and out of the cab can be saved. For yarder systems where the logs are landed either next to or in front of the yarder the job of the »poleman« (person who unhooks at the landing) can be saved, which also reduces the yarders operational delay time (Huyler and LeDoux 1997; Biller and Fisher 1984). Therefore automation of choker releasing is a significant opportunity for further improvement of both productivity as well as safety.

During the 1970's the first trials of mechanical self-releasing chokers were done in Austria and Norway (Samset 1985). Use was limited due to their unreliability. It was not until the first radio-controlled chokers were developed that the potential for efficiency improvements was recognized. In addition to continued reliability problems caused by the hard working environment of cable yarding, the other main factor was a choker weight of more than 4 kg (Hemphill 1985; MacDonald 1990). Technical developments and new materials over the last two decades have allowed the operating mechanism to

become more robust and the weight of a choker to be significantly reduced – as low as 1.6 kg for smaller diameter chokers.

The classic goal of modern ergonomics is to optimize both the systems efficiency and the working conditions. The heavier weight of the radio-controlled chokers could lead to an increase of the choker-setters physical strain. It is therefore important that an increase in productivity is not at the expense of an increase of physical strain on the choker-setter.

Acquisition and maintenance costs of radio-controlled chokers are high. A manual choker typically cost 11 , but a set of four radio-controlled chokers costs 9000 (product information Giritzer). If a productivity increase is found then the question of payback time of the investment should also be considered. Currently, there is no literature available on productivity, physical strain of choker setter, work safety, and cost effectiveness. This study examines efficiency and ergonomic impacts of radio-controlled chokers and evaluates their cost-effectiveness.

2. Methodology – *Metode istraživanja*

2.1 Study layout – *Područje istraživanja*

There are many time and motion studies on cable yarding operations, whereby yarding productivity is commonly used as the dependant variable. Most studies show that the three main parameters that influence productivity are mean volume per piece, yarding distance, as well as lateral yarding distance.

In this study the following productivity hypothesis is used:

Yarding productivity = f (tree volume, yarding distance, lateral yarding, CHOKER TYPE)

A factorial layout is utilized to investigate the productivity hypothesis. Six extraction corridors with and without the use of radio-controlled chokers are alternated within one operation area.

2.2 Study sites – *Mjesto istraživanja*

The study area is located in the eastern part of the Austrian Alps. The location is characterized by patches of wind thrown trees, whereby the root balls were cut off using a chainsaw. The forest consists almost exclusively of Norway Spruce, with an average extracted tree volume during the study ranging from 0.42 to 0.86 m^3 (Table 1). The age varies between 55 and 85 years. As per the study design, six cable corridors were used, with the length of the corridors ranging from 89 to 201 m. Slope gradient ranged from 50 to 60%. Due to the harvest focusing on the extraction of the small areas of wind-thrown trees, timber volume extracted in each corridor varied from 50 to 220 m^3.

3. Harvesting system – *Sustav pridobivanja drva*

The trailer mounted »Wanderfalke« yarder (company Mayr-Melnhof) extracted the whole trees to the forest road. The Sherpa U 1.5 carriage, with a maximum payload of 1.5 t, was used. Further processing of trees was done using a harvester head Kesla 20RH that is mounted on wheeled excavator base. A radio-controlled system is used so that both the operator of the processor as well as the choker-setter can control the tower yarder: there is no separate yarder operator. The processor operator also unhooks when using manual chokers.

In addition to the standard manual chokers, »Ludwig« radio-controlled chokers (Company Giritzer, Fig. 1) were used. The weight of each choker is 1.6 kg, and can be used on with a maximum choker cable diameter of 13 mm. When in use they are re-

Table 1. Stand description
Tablica 1. *Opis sastojine*

	Standard choker *Standardna spojna kopča*			Radio-controlled choker *Radijski upravljana spojna kopča*		
Age, year – *Dob,* god.	85	53	55	55	65	65
Average tree volume, m^3 Prosječni *obujam stabala,* m^3	0.86	0.59	0.60	0.42	0.66	0.60
Corridor length – *Duljina trase žičare,* m	137	102	140	148	201	89
Slope – *Nagib,* %	52	58	50	60	55	50
Total volume extracted, m^3 *Obujam iznesenoga drva,* m^3	50.2	220.0	76.3	56.7	103.0	76.3
Harvested volume per meter of corridor, m^3/m *Drvni obujam po metru trase žičare,* m^3/m	0.37	2.16	0.55	0.38	0.51	0.86

Fig. 1 Radio controlled choker system »Ludwig«
Slika 1. *Radijski upravljana spojna kopča »Ludwig«*

leased by the processor operator through a small control panel. The control panel allows for all the chokers to be released at once, or can be released individually. Each choker is colour-coded for this purpose. To avoid damaging the radio-controlled chokers, the wire rope lengths are not equal.

4. Data collection – *Prikupljanje podataka*

4.1 Time study – *Studij rada i vremena*

A time and motion data for the yarder system and choker-setter were recorded using the »Latschbacher« portable-time study computers. Work was divided into elemental work tasks for the yarder system (Table 2) and the choker-setter (Table 3).

For each of the six study replicates, the following response variables, factors and covariates have to be gathered or calculated at the yarding-cycle level (Table 4).

4.2 Heart rate – *Bilo*

A Polar RS 800 G3 portable heart rate monitor is used on the choker-setter during the entire working day, including rest and lunch breaks. It consists of a pericardial heartbeat capturing-transmitting unit on a strap with electrode areas and a receiver-storage unit similar to a digital wristwatch. The heart rate reserve (%HRR) was determined by applying the following formula:

$$\%HRR = (HRw - HRr) \cdot 100 / (HRmax - HRr)$$

Where:

HRw	Working heart rate: Average number of heart beats per minute, bpm
HRmax	Maximum heart rate calculated as: 220 – worker age
HRr	Resting heart rate

At the start of the workday the choker-setter sits for a period of 10 minutes. The resting heart rate is then assumed to be the lower of two values; either (a) the average value for this 10 min sitting period, or (b) the minimum heart rate for the whole working day.

Table 2 Work task definitions for yarder system
Tablica 2. *Radni zadaci definirani za žičare*

Work task – *Radni zadatak*	Description – *Opis zadatka*
Carriage out – *Vožnja neopterećenih kolica*	Carriage movement from the landing out to the choker-setter *Kretanje kolica od stovarišta do kopčaša*
Hook-up – *Podizanje tereta*	Rope is fed out from the carriage until load touches the carriage *Spuštanje užeta, izvlačenje užeta te kopčanje i podizanje tereta*
Carriage in – *Vožnja opterećenih kolica*	Carriage movement from the choker-setter back to landing *Kretanje kolica od kopčaša do stovarišta*
Landing – *Spuštanje tereta*	Lowering load and feeding in and out of the mainline *Otpuštanje kolica i spuštanje tereta*
Release choker – *Odvezivanje tovara*	Operator unhooks load, includes getting in and out of the cab *Radnik odvezuje teret, što uključuje i izlazak/ulazak u kabinu vozila*
Manipulation – *Premještanje tovara*	Moving or processing trees by loader arm – *Premještanje ili obrada stabala krakom dizalice*
Waiting – *Zastoji*	Operational delay time – *Operativno vrijeme kašnjenja*
Delays < 15 min – *Zastoji < 15 min*	Delays shorter than 15 minutes – *Zastoji kraći od 15 min*
Delays > 15 minutes – *Zastoji > 15 min*	Delays longer than 15 minutes – *Zastoji duži od 15 min*
Miscellaneous – *Neodređeno*	Non assignable times – *Neodređeni prekidi rada*

Table 3 Work task definitions for the choker-setter
Tablica 3. *Radni zadaci kopčaša*

Work task – *Radni zadatak*	Description – *Opis zadatka*
Pull rope out – *Izvlačenje užeta*	Rope is fed out from the carriage until first tree is reached *Spuštanje te izvlačenje užeta od kolica do najbližega oborenoga stabla*
Hook-up – *Podizanje tovara*	Load is hooked up – *Kopčanje tereta*
Lateral in – *Postrano privlačenje*	Load pulled back to carriage, until carriage is unclamped from skyline *Postrano privlačenje do trase žičare, dok su kolica nezakočena*
Load preparation – *Priprema tovara*	Preparing work for the next yarding cycle – *Priprema za sljedeći radni ciklus žičare*
Chainsaw work – *Rad motornom pilom*	Operating chainsaw – *Rukovanje motornom pilom*
Waiting – *Zastoji*	Operational delay time (choker setter is waiting for carriage) *Zastoji u radu (čekanje kolica)*
Delays < 15 min – *Zastoji < 15 min*	Delays shorter than 15 minutes – *Zastoji kraći od 15 min*
Delays > 15 minutes – *Zastoji > 15 min*	Delays longer than 15 minutes – *Zastoji duži od 15 min*
Miscellaneous – *Neodređeno*	Non assignable times – *Neodređeni prekidi*

5. Statistical analysis – *Statistička analiza*

Variance analysis was used to quantify the influence of nominal or ordinal-scaled variables. The statistical analysis is carried out using SPSS 15.0 for Windows, with the statistical fundamentals as described in Stampfer (2002). The following analysis strategy was chosen:

Estimation of significant effects of covariables and factors and analyzing of their statistical significance (variance analysis)

Evaluation of non-linearity of covariables

Analysis of interactions between factors and covariables

Parameter estimation of significant factors and covariables

Regressions analysis

Check model assumptions (residual analysis)

Adjustment of model.

The co-variable tree volume is a major component of all production functions, but the relationship between productivity and tree volume is rarely linear. A power factor is used to transform tree volume, whereby Häberle (1984) recommends the estimation

Table 4 Variable Definition for Data Sampling
Tablica 4. *Prikupljanje podataka*

Dependant variables *Zavisne varijable*	Cycle *Turnus rada*	Total time for one yarding cycle – *Vrijeme 1 turnusa rada žičare*	min
	Load volume *Obujam tovara*	Total load volume for each yarding cycle – *Ukupni obujam tovara po turnusu rada žičare*	m^3
	Productivity *Proizvodnost*	(Load volume/cycle)*60 – *(Obujam tovara/radni turnus)*60*	m^3 per PSH_0
Factor *Faktor*	Choker *Spojna kopča*	(0) standard choker, (1) radio-controlled choker *(0) standardna spojna kopča; (1)radijski upravljana spojna kopča*	2 levels
Covariates *Nezavisna varijabla*	Tree volume *Obujam stabala*	Mean tree volume per load – *Srednji obujam stabla u tovaru*	m^3
	Pieces *Broj komada*	Number of pieces per load (trees, tops, butts) *Broj komada u tovaru (stabla, vrhovi stabala, trupaca)*	n
	Lateral yarding *Postrano privlačenje*	Lateral distance from skyline and felled trees *Udaljenost od nosivoga užeta do srušenih stabala*	m
	Distance *Udaljenost*	Distance between tower yarder and stopping position of carriage *Udaljenost između pogonskoga uređaja i mjesta odvezivanja tovara*	m

Table 5 Comparison of standard and radio-controlled choker
Tablica 5. *Usporedba standardne i radijski upravljane spojne kopče*

	Standard choker – *Standardna spojna kopča*			Radio-controlled choker – *Radijski upravljana spojna kopča*		
	Mean *Arit. sredina*	$Quantile_5$ *5. percentil*	$Quantile_{95}$ *95. percentil*	Mean *Arit. sredina*	$Quantile_5$ *5. percentil*	$Quantile_{95}$ *95. percentil*
Cycle – *Radni turnus,* min	4.70	2.69	8.13	4.42	2.46	7.88
Load volume – *Obujam tovara,* m^3	0.90	0.27	1.70	0.81	0.27	1.51
Producitivity, m^3/PSH_0 *Produktivnost,* m^3/PSH_0	12.5	3.1	26.6	12.1	3.7	25.9
Extraction Distance, m *Udaljenost privlačenja,* m	69.2	25	113	59.6	22	122
Pieces/turn *Broj komada tovara po turnusu,* n	1.28	1	2	1.26	1	2
Tree volume – *Obujam stabala,* m^3	0.77	0.20	1.53	0.71	0.19	1.47
Velocity carriage out, m/sec *Brzina kretanja neopterećenih kolica,* m/s	2.28	0.56	3.94	1.64	0.46	3.13
Velocity carriage in, m/sec *Brzina kretanja opterećenih kolica,* m/s	2.22	1.03	3.15	2.08	0.86	3.52

of this power value using an iterative procedure to optimize the coefficient of determination and the distribution of the residues.

6. Results – *Rezultati*

Table 5 shows a summary of the results, including the mean and the 5th and 95th quantiles, split out for the standard and radio-controlled choker. Note that carriage velocity is simply the time for the carriage work element divided by the distance.

Overall, the radio-controlled chokers reduced the average cycle from 4.70 to 4.42 minutes. Much of that time saving can be contributed to the landing phase, which reduced from 0.33 to 0.12 minutes. There was no difference in the hook-up phase, and only a slight, but not significant difference in the carriage in. Interestingly, there was a time increase in the carriage out phase, where the average carriage speed decreased from 2.3 to 1.6 m/sec. This was attributed to the varied choker lengths used with radio controlled chokers, and that at greater speed they would hit, and sometimes tangle in the trees lining the extraction corridor (Leitner 2009).

Overall, the statistical analysis of in total 936 cycles resulted in the following efficiency model:

$$\text{Efficiency } (\text{min}/\text{m}^3) = \\ = 0.96 + 3.49*\text{tree volume} - 0.53*\text{Choker} \quad (R^2=0.77)$$

This equation suggests that 77% of the efficiency (min/m^3) variance can be explained through the variables tree volume and Choker. We would also expect extraction distance to figure into this resulting equation. This study mainly worked with short extraction distances (average 65.5 m), and therefore this variable had no significant influence on the cycle time. Similarly, the extraction corridors typically used in Austria for whole-tree extraction are only

Table 6 Efficency modell
Tablica 6. *Model učinkovitosti*

Variable – *Varijabla*	Coefficient *Koeficijent*	Std. Error *Standardna pogreška*	*t*-Value *t-vrijednost*	Significance, p=0,05 *Signifikantnost, p=0,05*
Constant – *Konstanta*	0,960	0,178	5,394	0,000
Tree Volume – *Obujam* stabla	3,495	0,070	49,873	0,000
Choker – *Spojna kopča*	–0,528	0,203	–2,609	0,009

R-Squared = 0,774, corrected R-squared = 0,773

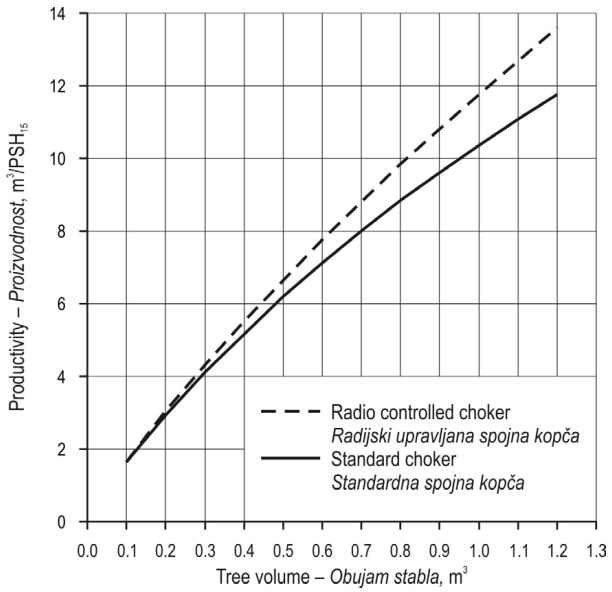

Fig. 2 Productivity of the cable yarder system depending on tree volume and choker system

Slika 2. *Produktivnost rada žičare ovisno o obujmu stabala i vrsti spojne kopče*

20 meters apart (Stampfer 2002), so there is little lateral extraction and this was also not significant in the final analyses.

Fig. 2 shows the productivity for cable yarding extraction dependent on tree volume and choker system. At an average tree volume of 0.6 m³ the productivity increased from 7.10 to 7.72 m³/PSH_{15} when using the radio-controlled choker system. This corresponds to an increased productivity of 9%.

For this scenario it is possible to provide an indicative estimation of the pay-back time of the capital cost of the radio-controlled chokers. The difference in productivity is 0.62 m³/PSH_{15} with an average tree volume of 0.6 m³. For this particular operation the felling and extraction rate was 32 /m³. This suggests that using the radio-controlled chokers would increase revenue by 0.62*32=19.84 per hour. If we simply divide the investment cost of 9000 by 19.84 per hour, then the payback period would be approximately 450 hours (not including depreciation or repair and maintenance costs). By a harvest rate of 25 /m³ the payback period would be 580 hours.

In total 95 hours of heart-rate data was collected from the choker-setter using both manual and radio-controlled chokers. A sustainable work load for a day is defined as the heart rate reserve being not greater than 40% for an 8 hour working day. When using the manual chokers the work load was 40% HRR, and this increased significantly to 44% HRR when using radio-controlled chokers (3). For com-

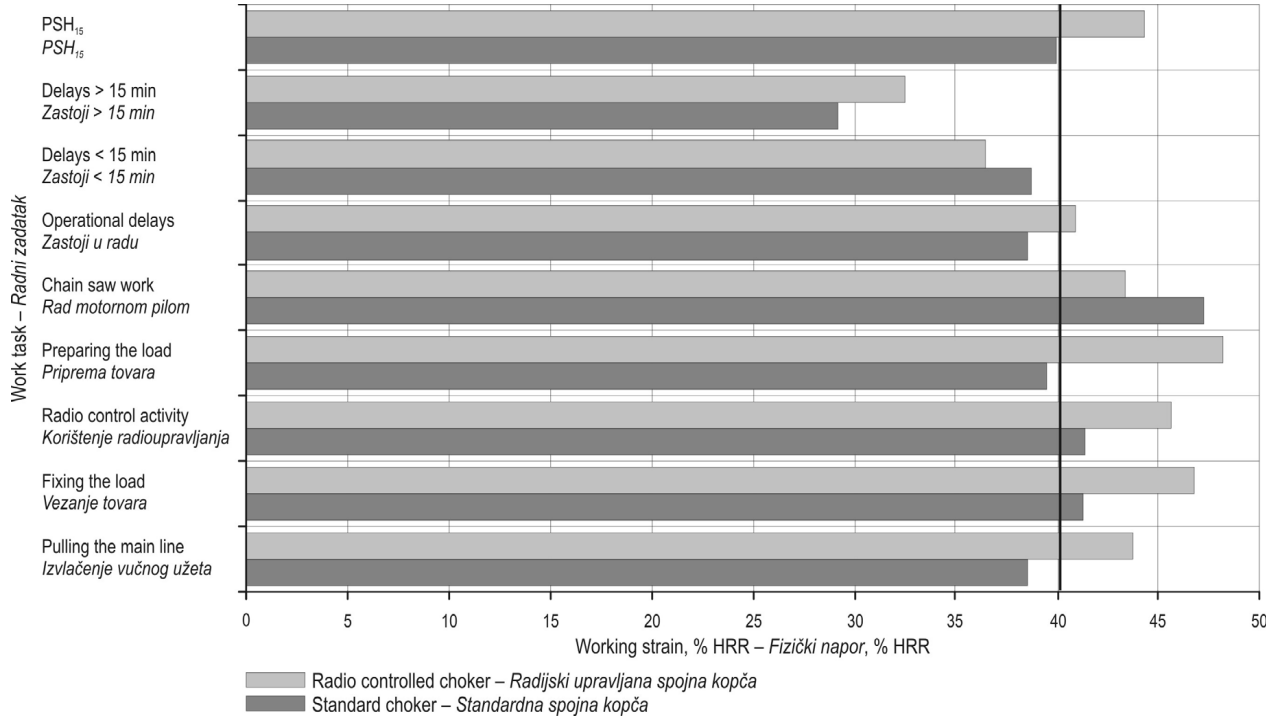

Fig. 3 Working strain for the choker-setter depending on choker system

Slika 3. *Fizički napor kopčaša ovisno o vrsti spojne kopče*

parison, these values are considerably higher than those measured by Kirk and Sullman (2001). In their study of choker-setter in New Zealand the heart rate reserve ranged from 31.9 to 38.5 % HRR.

Fig. 3 shows that the tasks of preparing the load, the radio-controlled activity, fixing the load as well as pulling the mainline the heart rate reserve was considerably higher for the radio-controlled chokers. While some of this additional strain may be attributed to the extra weight of the radio-controlled chokers, this result may also be compounded by the quicker cycle time. Only in the »other« activities of chainsaw work and short delays was the heart-rate higher for the manual chokers.

7. Discussion – *Rasprava*

While this study showed that the radio-controlled chokers can increase productivity, it also highlighted that it may have come at a cost of a higher workload for the choker-setter. It was noted that during the study the choker-setter rarely took a rest-break, and this may be attributed to the exceptionally short extraction distances, as dictated by the study area. This is also evident in the overall productivity model which showed no correlation with extraction distance. Some additional data was captured on a Syncrofalke yarder working in longer extraction corridors. In analysing the data the extraction distance was significant in the productivity model, but with the longer extraction cycles there was no productivity increase associated with the radio-controlled chokers. The heart rate reserve for the choker-setters exceeded the endurance limit in both instances, but was not statistically different.

The yarder operator in this study was particularly pleased with this new technology and noted not only the simplification of his routine but also the additional safety around the landing. However the choker-setter noted the added difficulty associate with the varied choker lengths. The lengths were varied to avoid the chokers impacting on each other. This however caused quite wild swinging motions in the carriage out phase, resulting in the operator having to reduce carriage out velocity. He also noted additional maintenance of the chokers associated with the difficulty of wind-throw, as well as the reduced choking effect on smaller tree diameters. He suggested that an additional safety hook may prevent the cap from releasing early. Overall there were only small problems associated with either the radio-control of the yarder and of the chokers.

8. Conclusion – *Zaključci*

Radio-controlled chokers were studied during cable yarder extraction of wind-thrown trees in the Austrian Alps. The primary benefit associated with these chokers is in the reduced time associated with the landing of the trees (un-hooking), and the corresponding improvement in safety by eliminating this potentially hazardous task. This proved to be correct with the time study showing an overall improvement in productivity. The study also indicated that despite the relatively high investment cost associated with purchasing a set of radio-controlled chokers, that with a productivity improvement of 0.62 m^3/PSH_{15} in the pay-back time is just 480 hours. However this calculation does not include repair and maintenance costs.

To be truly considered a system improvement then the work load on the choker-setter should not increase, or at least not exceed the sustainable work rate for the day. The study however showed that the radio-controlled chokers did significantly increase the heart rate, and it did exceed the sustainable work load.

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Sažetak

Učinkovitost i ergonomske prednosti korištenja radijski upravljanih spojnih kopči pri iznošenju drva žičarama

Učinkovito je pridobivanje drva na strmim terenima najčešće povezano s korištenjem užetnih sustava. Tehnički razvoj i poboljšanje sustava rada tijekom posljednjih desetljeća omogućili su učinkovitiji, društveno prihvatljiviji i ekološki održiv način korištenja šumskih žičara. Radijski upravljani uređaji omogućuju automatizaciju radnih postupaka pri pridobivanju drva šumskim žičarama i za radnika na stovarištu, ali i za radnika kopčaša u sječini.

Spojna kopča na užetu žičare svojevrsna je žičana omča koja služi za kopčanje i osiguranje tereta prilikom privlačenja drva šumskom žičarom. Radnik u sječini prilikom kopčanja tereta ručno postavlja standardne spojne koče, a radnik na stovarištu ručno ih otklanja s tereta. Tijekom sedamdesetih godina prošloga stoljeća provedena su prva ispitivanja samootpuštajućih mehaničkih spojnih kopči u Austriji i Norveškoj, ali je njihova primjena bila ograničena zbog nepouzdanosti. Izumom prve radijski upravljane spojne kopče uočena je mogućnost poboljšanja učinkovitosti rada, međutim trebalo je i smanjiti tjelesno opterećenje na radnike jer su uz već teške terenske uvjete rada i spojne kopče težile preko 4 kg. Tehnički razvoj i korištenje novih materijala u zadnja dva desetljeća omogućili su stvaranje čvrstih te lakših spojnih kopči i tako je opterećenje na radnika smanjeno.

Radijski upravljane spojne kopče također se postavljaju ručno na teret (kopčanje tereta), ali prednost njihova korištenja jest da se mogu upravljati na daljinu odnosno teret se na stovarištu daljinski odvezuje bez prisutnosti radnika. Uz moguću povećanu sigurnost rada na stovarištu, prednost radijski upravljanih spojnih kopči jest skraćivanje vremena odvezivanja tereta. Međutim, dodatna masa radijski upravljanih spojnih kopči može povećati opterećenje na kopčaša na terenu strmoga nagiba. Standardna spojna kopča teži oko 0,34 kg, dok je masa radijski upravljane spojne kopče oko 1,6 kg. Cilj je ergonomije poboljšati učinkovitost sustava rada i radne uvjete, stoga je važno da povećanje produktivnosti sustava šumskih žičara nije na štetu povećanja fizičkoga napora kopčaša.

Za ocjenu učinkovitosti i ergomskih poboljšanja pri korištenju radijski upravljanih spojnih kopči provedeno je istraživanje u sastojini obične smreke u istočnim Alpama u Austriji uz korištenje šumske žičare Wanderfalke. Prosječan obujam komada drva bio je 0,4 – 0,86 m^3, nagib je terena bio 50 – 60 %, a duljina trase žičare iznosila je 90 – 200 m. Napravljena je studija rada i vremena uz mjerenje otkucaja srca kopčaša kao pokazatelja radnoga opterećenja. Rezultati su pokazali da je korištenjem radijski upravljanih spojnih kopči povećana produktivnost sustava rada za 9 % pri teretu prosječnoga obujma. Iako su ulaganja pri kupnji radijski upravljanih spojnih kopči relativno visoka, povećanje produktivnosti od 0,62 m^3/PSH_{15} omogućuje povrat uloženih sredstava već nakon 480 radnih sati. Ovaj izračun troškova ne uključuje troškove popravka i održavanja.

Međutim, korištenjem radijski upravljanih spojnih kopči povećao se tjelesni napor kopčaša jer se frekvencija srca pod opterećenjem povećala oko 40 – 44 %. Uočeno je da tijekom istraživanja kopčaš rijetko uzima stanku od rada, no to se može pripisati i iznimno kratkim udaljenostima privlačenja drva. Iako je ova studija pokazala da se korištenjem radijski upravljanih spojnih kopči pri privlačenju drva šumskim žičarama povećava produktivnost rada, ta su povećanja bila na štetu radnika kopčaša čiji je tjelesni napor pri tome porastao.

Ključne riječi: radijski upravljana spojna kopča, šumske žičare, kopčaš, ergonomska poboljšanja

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