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Wheelslip in skidding with the AGT 835 T adapted farm tractor

Jurij MARENČE[1], Boštjan KOŠIR[2]

Abstract

The paper presents a wheelslip measurement method for small farm tractors (AGT 835 T) adapted for skidding, with mechanical and hydrostatic mechanical transmissions. The research focused on uphill skidding, as slip values measured in uphill skidding are higher than in downhill skidding. A comparison was made of the performance of tractors carrying equal load but equipped with mechanical and hydrostatic transmission systems. The hydrostatic drive causes higher negative load values in downhill skidding, and slightly higher slippage. As for hydrostatic tractors, wheelslip is higher in uphill skidding than in downhill skidding. The increase in the sloping of the terrain causes wheelslip to rise progressively. When a tractor travels uphill, slip is linked to a loss of energy. Wheelslip measurements are therefore important for determining the optimum conditions for individual tractor types.

Key words: skidding, farm tractor, wheelslip, measurement

Zdrs koles pri vlačenju lesa s prilagojenim kmetijskim traktorjem AGT 835 T

Izvleček

Predstavljena je metoda merjenja zdrsa na majhnih prilagojenih kmetijskih traktorjih – AGT 835 T – za spravilo lesa z mehansko in hidrostatsko-mehansko transmisijo. Poudarek je na spravilu lesa navzgor, kjer je bil ugotovljen tudi večji zdrs kot pri vožnji navzdol. Narejena je primerjava med mehansko in hidrostatsko transmisijo traktorja pri enaki obremenitvi. Hidrostatski pogon povzroča večje negativne obremenitve pri spravilu navzdol, in tudi nekaj večji zdrs. Pri spravilu navzgor je zdrs pri hidrostatski izvedbi znatno manjši. Naklon terena z večanjem progresivno vpliva na večanje zdrsa. Zdrs pri vožnji traktorjev navzgor pomeni izgubo energije, zato je meritev zdrsa pomembna za določanje optimalnih razmer posameznih tipov traktorjev.

Ključne besede: *spravilo lesa, kmetijski traktor, zdrs, meritve*

1 Introduction

1 Uvod

In skidding along trailless terrain or along a forest skid trail, powered tractor wheels may slip. Wheelslip values primarily depend on working conditions, that is on the difficulty grade of the terrain, and on the characteristics of the tractor used (HORVAT 1996, ŠUŠNJAR 2005). The factors influencing wheelslip are the longitudinal gradient of the skid trail, load size and load orientation, direction of skidding and the transmission type of the tractor (KOŠIR, MARENČE 2005). These facts are also relevant as regards use of small farm tractors, which are suitable for forest operations when fitted with proper forestry implements. Owing to poor technical characteristics of these tractors, their usage in forest operations is only possible if their limitations are carefully taken into consideration. The performance of a tractor travelling empty and the resulting wheelslip have rarely been studied to date as has tractor performance in downhill skidding. It is true that in these cases the skidding methods/equipment are subject to rules and limitations different than those applicable to uphill skidding. Slip values show a marked difference, and the principles of occurrence are not comparable with those valid for uphill skidding.

Our aim was to test the traction capacity of a small adapted farm tractor, available with a mechanical and hydrostatic mechanical transmission system, in uphill skidding. The following hypotheses were proposed: 1) the tractor is able to move uphill loads of up to 1 m^3 of wood, 2) wheelslip values will be higher in the mechanical transmission tractor, 3) slope gradient progressively affects wheelslip values and leads to a reduction in traction capacity, 4) wheelslip is expected to be highest in uphill skidding, in the steepest section of the skid trail.

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[1] dr. J. □

[2] prof. dr. B. K□

2 Work methods

2 Metode dela

In the study, wheelslip was measured in travelling of unloaded tractors with two types of transmission systems skidding a 1 m^3 load uphill and downhill and with different load orientations. Two tractors carrying equal loads were tested. Two AGT 835 T tractors (JEJČIČ 1999, 2001) were used, equal in weight and size, with the tyres of the same size, but with different transmission systems – one tractor was equipped with a mechanical and the other with a hydrostatic transmission drive (MARENČE 2005, JEJČIČ 2000a, JEJČIČ 2000b, JEJČIČ 2001, JEJČIČ *et al.* 2003). Both tractors are classified as stiff suspension tractors with equal-sized wheels, steered front wheels and a two-axle drive (JEJČIČ 2002). The technical characteristics of both tractors were described in previous research (MARENČE 2005). The tractors range among small tractors suitable for use in private forests (MARENČE 1997).

The skid trail selected for the test is at Jable near Trzin (MARENČE, KOŠIR 2006). It is concave in form, and has the highest longitudinal slope in its upper part. The skid trail was divided into a number of sections, differing mainly in longitudinal gradient (Figure 1).

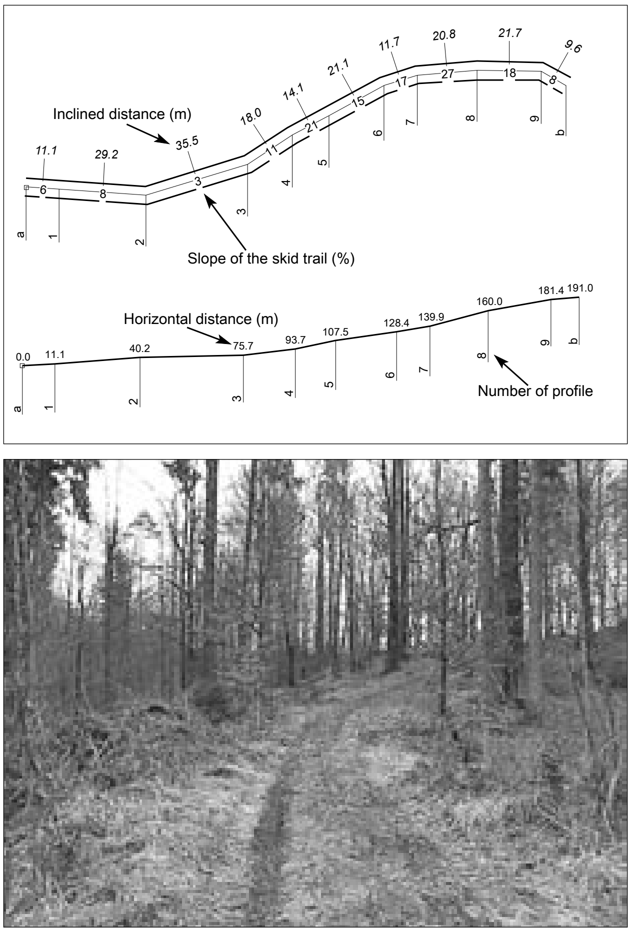

Figure 1: Test skid trail data

Slika 1: *Podatki o vlaki v poskusu*

Table 1: Skid trail profiles per section

Preglednica 1: *Profili na vlaki, združeni v odseke*

Profile	Longitudinal gradient (%)	Distance (m)
1-3	up to 10	64.7
3-7	up to 20	64.9
10-14	over 20	42.5

Several successive sections were joined into combined sections, as shown in Figure 1 and Table 1. Wheelslip was not calculated separately for the distance between profiles, but rather for sections obtained by combining individual distances between profiles with similar longitudinal gradients. In this way, the trail was divided into several longer and more homogenous units. Combination of sections was also necessary, considering that both axles of a tractor should be positioned in the same section. In view of this, the data obtained when the tractor passed over a certain profile would have to be eliminated from the research. In the case of combined sections, this was not necessary.

The load was a single fir log measuring 8 m in length. In both tractors, the load amounted to 1 m^3 and was equal in weight; after the test was finished, both logs were weighed (MARENČE 2005). Skidding was carried out with logs placed in both directions. Various load orientations were considered:

1) butt-end forward, and
2) top-end forward.

Wheelslip values derived from the research can be defined in several ways. Košir (KOŠIR 1997) defines wheelslip as:

$$\delta = \frac{(st - ss)}{st} \quad ,$$

which can be stated as (POJE 1996):

$$\delta = 1 - \frac{s_r}{s_t} \quad ,$$

where:

δ – wheelslip coefficient,
s_s, s_r – actual distance travelled,
s_t – theoretical distance travelled.

Wheelslip can be expressed as a relative number (both figures) or as percentage. In this research, wheelslip is expressed as percentage.

The theoretical distance travelled by a tractor wheel was measured with special sensors (rotary optical generators) mounted on the axle of each wheel (MARENČE 2000, 2005). When the wheel turns, it creates electrical impulses, each representing a part of the wheel circumference or a part of the distance travelled. During travel, the impulses were collected with a measuring chain on a laptop placed on the tractor. The sensor was used to measure the distance travelled by wheel, including the slip (Figure 2). Pressure in the tyres was equalized before the test started.

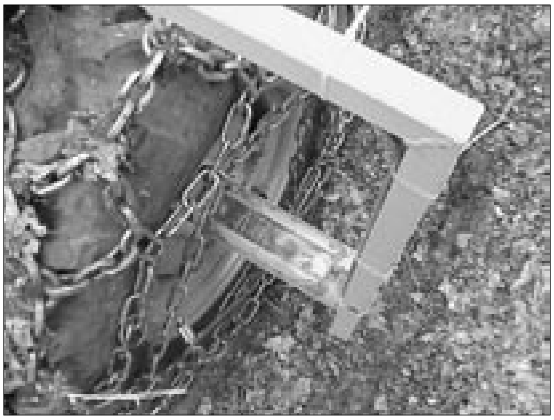

Figure 2: Sensor (rotation optical generator) mounted on wheel axle

Slika 2: *Senzor (rotacijski optični dajalnik), nameščen na osi kolesa*

The cumulative value of the measured distance shows the distance a wheel travels between two selected points. In order to calculate the wheelslip, which occurred during travel of an unloaded tractor or during skidding along a trail, the actual distance travelled was measured with a measuring tape and compared against the theoretical distance travelled by the wheel.

In more demanding working conditions, higher circumferential force on wheels is needed, and higher slip values can reasonably be expected. Ribbed tractor tyres enable higher power transfer to the ground, increasing power utilisation. Wheelslip occurs when the amount of circumferential force applied to the wheel is greater than the cohesion force in the surface (SEVER 1980). Understandably, slip also depends on the type and characteristics of the surface along which the tractor travels. Sever also links wheelslip with higher fuel consumption, shorter service life of tyres and lower efficiency, which can, in the worst case, make forest work impossible. Use of chains can affect slip values significantly. In the research, both tractors were equipped with the Tempo chains made by CMC System, d.d., Lesce (MARENČE 2002) – Figure 3.

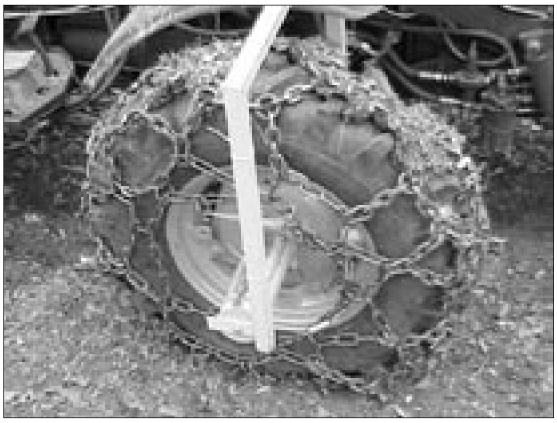

Figure 3: Chains on a powered tractor wheel

Slika 3: *Verige na pogonskem kolesu traktorja*

3 Results

3 Rezultati

Wheelslip of powered wheels has a major effect on the efficiency of the transfer of tractor's tractive force to the wheels and then to the ground. Actually, this force can be utilized for load skidding.

Wheelslip is also an indicator of ground damage caused during skidding. It can be used as a basis for determining the impact of work on the environment, and helps determine the differences that arise in skidding as a consequence of use of various working tools. This type of research is important, for it helps to acquire certain data – in this case, wheelslip data – and thus allows us to monitor closely the performance of a tractor in the wheel-surface contact. Given selected working conditions and work tools, the data and the comparison of such data can be used to assess the environmental impact of an operation performed. In these cases, wheelslip is a possible indicator of environmental impact.

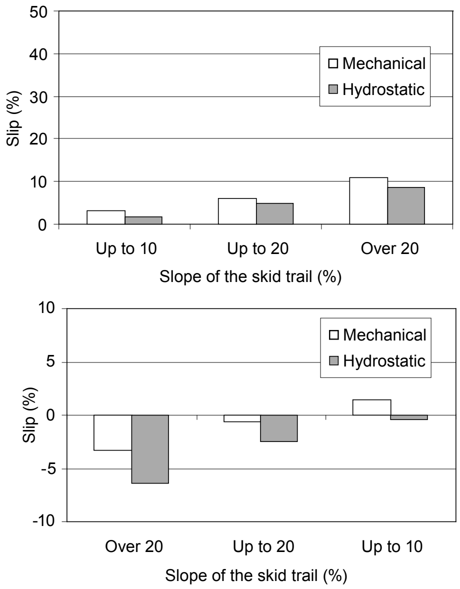

Figure 4: Wheelslip of an empty tractor travelling uphill (upper graph) and downhill (lower graph)

Slika 4: *Zdrs pri vožnji neobremenjenega traktorja po vlaki navzgor (zgornji grafikon) in navzdol (spodnji grafikon)*

On the basis of previous experience, it was expected that throughout the research wheelslip would increase as the longitudinal gradient and load size rise. Both tractors were compared when travelling empty and when skidding a 1 m^3 load. The AGT 835 T tractors are designed for agricultural use, but given proper adaptation they can be used for timber skidding. Under the selected skidding conditions, the load of 1 m^3 represents the maximum load in uphill skidding that the tractor is still able to transport on a gently sloping terrain; at the steepest section of the trail, the tractor is no longer able to move the load. The performance of a tractor travelling empty is presented in Figure 4.

It is generally accepted that in forest production a tractor travelling empty does not constitute many problems. The working conditions specified in the research set no specific limitations regarding the travelling of both empty tractors. The highest longitudinal gradient of the skid trail was 27%, which is close to the gradient value (30%) that certain specialists describe as the maximum slope gradient for a typical tractor terrain. Wheelslip in relation to slope gradient can be compared with the results obtained in other similar or significantly more powerful tractors normally used in forest operations (KOŠIR 2000). These comparisons were not the subject of this research.

In empty travelling uphill, slip is up to 10%. It is highest in the upper and steepest part of the trail. Given their technical characteristics, both tractors had very little problems overcoming the selected longitudinal slope. Nevertheless, several differences in their performance were noted. As a rule, the hydrostatic transmission of traction force to the surface causes lower wheelslip. Up to 2% difference was measured in tractors travelling empty.

In empty downhill travelling, the results are slightly more difficult to explain. In this case, wheelslip is the result of the tractive force applied to the wheels and the added gravity that changes with regard to the size of the longitudinal gradient. In literature, the problem of wheelslip is mostly considered in uphill skidding. This is quite logical and expected because wheelslip values are highest in uphill skidding and as such set numerous limitations for various work tools in forestry operations.

Wheelslip is lower in travelling downhill than in travelling uphill. When a tractor travels empty, negative wheelslip may occur. The tractor weight pushes the tractor down the skid trail and the tractor reacts with a negative momentum. In travelling downhill, the force of gravity predominates – the highest negative wheelslip (-6%) was measured in the upper, steepest part of the trail. Owing to sliding caused by gravity, the distance travelled by a tractor wheel was shorter than the distance actually travelled by the tractor along the trail. The absolute distance decreases at lower longitudinal gradients and reaches 0% in the lower, more gently sloping part of the skid trail (Figure 4). The impact of transferring force from the wheels to the ground and the impact of gravity are evened out in this part of the trail.

In timber skidding, the selected 1 m^3 load represents the threshold value for both tractors. In the steepest part of the trail where the gradient is 27%, both tractors stopped. Slip values presented in the continuation of this paper are mean values applicable to the entire combined section of the trail and are defined through longitudinal gradient. The values for the last, steepest part of the trail indicate the average value of wheelslip from the beginning of a section up to the moment of stopping.

In comparison with travelling empty, slip is significantly higher in uphill skidding of a load. Slip increases as the longitudinal gradient of trail rises and in the steepest part of the trail its value is four times higher than the value measured in a tractor travelling empty (Figure 5). For the load of 1 m^3, this part of the trail represents the most demanding working conditions, as it is also associated with the highest slip values, reaching 42% for the mechanical transmission tractor. In uphill skidding, wheelslip also depends on load orientation and on the type of tractors transmission. If the load is transported top-end forward, wheelslip is higher, which also means that the tractor uses more energy and, most likely, more time. These general findings have been stated in previous research (MARENČE 2005, MARENČE, KOŠIR 2006).

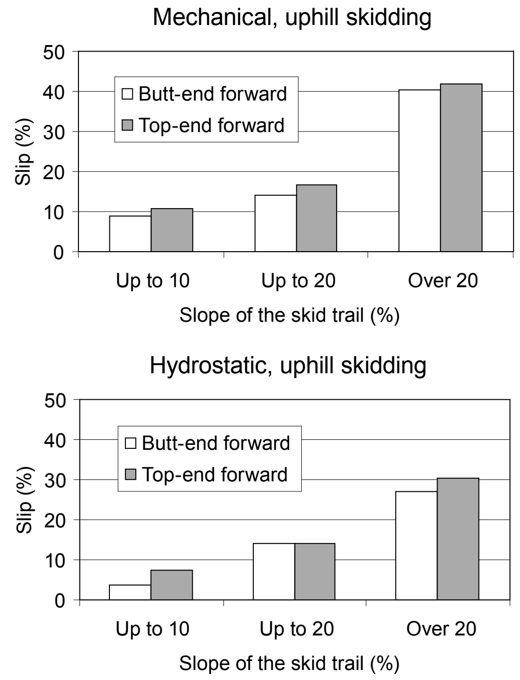

Figure 5: Uphill skidding of a 1 m^3 load

Slika 5: *Vlačenje bremena 1 m^3 po vlaki navzgor*

When logs are transported butt-end forward, wheelslip is normally lower. Such load orientation with logs lifted from the ground in their front part puts additional pressure on the rear end of the tractor (more than when the load is transported top-end forward). Wheel/surface contact is better, which reduces wheelslip. This principle is confirmed along the entire skid trail and throughout the test.

The hydrostatic power transmission tractor has lower wheelslip in uphill skidding (Figure 5). Differences are highest in the critical, steepest part of the skid trail. The difference is approximately 13%, which is quite significant considering the relation between wheelslip and the distance travelled.

As expected, wheelslip is lower in downhill skidding of a 1 m^3 load. Similarly to downhill travelling of an unloaded tractor, negative wheelslip also occurs in downhill skidding. Measurements showed that negative slip only occurs in the upper, steepest part of the skid trail (Figure 6). The influence of various factors is highly complex in this part of the trail. The result depends on the following factors:

- transfer of power to the ground affects wheelslip values,
- higher longitudinal gradient in this part of the skid trail has a stronger effect on the force of gravity, which acts both on the tractor and on the load,
- load skidded along the ground is a braking factor.

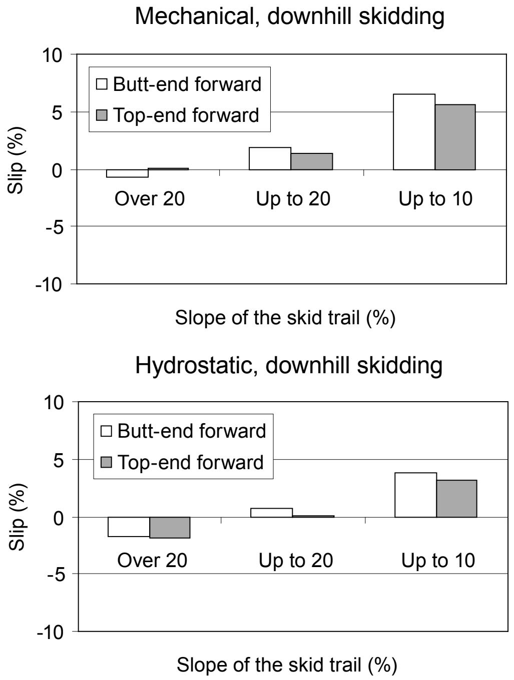

Figure 6: Downhill skidding of a 1 m^3 load

Slika 6: *Vlačenje bremena 1 m^3 po vlaki navzdol*

The result of all these factors is negative wheelslip, which only occurs in this part of the skid trail. In a mechanical transmission, tractor wheelslip is negative but no closer to 0 than in the hydrostatic version that shows significantly higher slip values (about -2%) in both load orientations (Figure 6). As the load is gradually skidded downhill, the slope gradient of the trail decreases, and the required tractive force increases. Wheelslip gradually increases and passes into the »positive« area. In the central part of the trail with gradients up to 20%, negative slip is not longer present. In this trail section, slip values are up to 2%. In the lower, more gently sloping part of the trail with gradients up to 10%, slip is up to 7%. These results clearly indicate the difference between both types of power transmission systems:

- at gradients of up to 20%, the hydrostatic transmission records higher negative slip than the mechanical transmission,
- at gradients below 20%, the hydrostatic transmission records lower slip values than the mechanical transmission.

Higher negative slip values are not associated with higher energy consumption, as the braking is automatically performed by the hydrostatic transmission system.

Also in downhill skidding, positive wheelslip is higher in the mechanical transmission tractor. Additionally, slip values are higher when the load is transported butt-end forward.

4 Conclusions and discussion

4 Zaključki in razprava

The purpose of the research was to devise a method and derive the technical parameters of machines suitable for use in forestry operations. The data such as slip values can be used to determine the suitability of a machine. Various machines and diverse skidding conditions can thus be compared. In conclusion, wheelslip can be used as a decisive parameter to assess the suitability and usability of tools and implements as well as the appropriateness of working conditions.

It was established that the hydrostatic version of the AGT 835 T tractor is more favourable due to lower slip values. Similarly, lower slip values are measured in uphill skidding if timber is transported butt-end forward. Thanks to lower slip values, the machine can work efficiently under more demanding working conditions, and the tractor can overcome higher longitudinal gradients or transport larger loads over the skid trail of the same sloping.

Another important measurement was wheelslip in tractors travelling empty and in skidding downhill. Wheelslip also occurs in these conditions, and negative slip occurs in downhill travelling of an empty tractor. In the future it would be useful to determine the effect of negative slip on the forest floor – does the negative slip carry a different impact than equal slip values in uphill travelling? It would also be useful to compare the performance of the same tractors without the use of chains under the same working conditions or on significantly more humid surface.

In extreme floor conditions, wheelslip can cause damage to the forest floor, which is why tests should be considered that could draw a connection between impact to the ground, the transmission system and wheelslip values. In fact, this is a problem that has not been solved to date and is indeed much more complex than the test itself suggests. The use of different types of machines on trailless terrain is governed by the same principles and therefore the experience derived from this experiment is also relevant for the considerations on the use of semi-trailers and harvesters.

5 Povzetek

Zdrs pogonskih koles traktorja, do katerega prihaja pri vlačenju lesa, smo analizirali na primeru manjšega kmetijskega traktorja AGT 835 T slovenske proizvodnje. Traktor v osnovi ni namenjen delu v gozdu – zaradi njegovih

slabših tehničnih lastnosti in iz njih izhajajočih omejitev pa ga lahko ob primerni gozdarski opremi uporabljamo tudi pri delu v gozdu. Na zdrs koles pri tem bistveno vplivajo velikost bremena, vzdolžni naklon vlake, orientacija bremena, smer vlačenja in vrsta traktorske transmisije. V tovrstnih raziskavah ugotavljamo, da se zelo redko preučuje zdrs pri vožnji traktorja brez bremena ali vlačenju po vlaki navzdol. Zato smo obravnavi največjega zdrsa pri vlačenju po vlaki navzgor dodali še analizo dogajanja pri vožnji in vlačenju v nasprotni smeri.

Oba traktorja (z mehansko in hidrostatsko transmisijo) smo primerjali med vožnjo brez bremena in pri vlačenju 1 m^3. Vlaka, na kateri je potekal poskus, je bila konkavne oblike, z naraščajočim vzdolžnim naklonom, z največjim naklonom 27 % v njenem zgornjem delu. Izbrano breme predstavlja zgornjo mejo, ki je traktorja samo v največji strmini ne zmoreta več. V tem primeru sta se oba traktorja zaustavila zaradi prezahtevnih delovnih razmer.

Pri analizi zdrsa traktorja brez bremena smo ugotovili največje vrednosti pri vožnji navzgor. V najbolj strmem delu vlake so znašale okrog 10 % . Oba traktorja sta vlako zmogla brez večjih težav. Ugotovili smo, da hidrostatski prenos povzroča manjši zdrs – razlike so do 2 % . Nasprotno so bile vrednosti zdrsa pri obeh traktorjih pri vožnji navzdol manjše. V tem primeru so bile vrednosti zdrsa rezultat vlečne sile na kolesih in vpliva težnosti samega traktorja. Zato je interpretacija rezultatov pri vlačenju navzdol precej bolj zahtevna. Pri prazni vožnji navzdol namreč prihaja do negativnega zdrsa – to pomeni, da prevladuje sama teža traktorja in ga potiska po vlaki navzdol. Največji zdrs (-6 %) smo izmerili v zgornjem, najbolj strmem delu vlake. Pri vožnji navzdol se vzdolžni naklon vlake postopoma zmanjšuje, enako se zmanjšuje tudi absolutna vrednost zdrsa. V spodnjem, položnejšem delu doseže nivo zdrsa okrog 0 % . To pomeni, da sila težnosti v tem delu vlake ne prevladuje več.

Pri vlačenju bremen se vrednosti zdrsa bistveno povečajo. V primeru vlačenja 1 m^3 po vlaki navzgor smo največje vrednosti zdrsa pričakovano dosegli v najbolj strmem delu vlake – pri traktorju mehanske izvedbe je znašal 42 % . Primerjava s traktorjem brez bremena nam v največji strmini (nad 20 %) kaže na štirikratno povečanje zdrsa. Pri tem tudi orientacija bremena pomembno prispeva k velikosti zdrsa. Pri vlačenju bremena z debelejšim delom obrnjenim v smer vožnje dosegamo praviloma manjše vrednosti zdrsa. V tem primeru je zadnji del traktorja dodatno obremenjen z bremenom, oprijem koles s podlago je večji, skupni odpori so manjši, zato je tudi zdrs manjši. Razlike so do 4 % . Tudi drugačna transmisija traktorja povzroča različno velik zdrs. Ugotovili smo, da traktor s hidrostatskim prenosom sil s koles na tla povzroča pri vlačenju navzgor manjši zdrs. V najbolj strmem delu vlake so razlike okrog 13 % .

Pri vlačenju bremen navzdol so vrednosti zdrsa manjše in tudi tukaj prihaja do negativnega zdrsa. Pojav obstaja le v zgornjem, najbolj strmem delu vlake. Vpliv dejavnikov, ki vplivajo na zdrs, je v tem primeru zelo kompleksen – na končno vrednost vplivajo prenos sile s koles na tla, vpliv sile težnosti, ob vsem tem pa zaradi trenja še zaviramo z bremenom, ki ga vlačimo navzdol. Pri hidrostatski izvedbi znaša zdrs okoli -2 % , pri mehanski je bližje vrednosti nič. V manjših vzdolžnih naklonih se potrebna vlečna sila postopoma veča, zato se negativen zdrs ne pojavlja več. Pri vzdolžnem naklonu do 20 % znaša do 2 % , pri še manjših naklonih (do 10 %) pa do 7 % . Z meritvami smo ugotovili, da ima hidrostatska transmisija pri naklonih nad 20 % večji negativni zdrs kot mehanska transmisija, pri vseh naklonih pod 20 % pa manjši zdrs od nje. Pri orientaciji bremena pa v primeru vlačenja z debelejšim delom v smeri vožnje prav tako ugotavljamo večji zdrs.

5 Summary

Wheelslip of powered tractor wheels, which occurs during skidding, was analysed on the case of a small farmland tractor AGT 835 T made by a Slovene manufacturer. The tractor is not primarily designed for forest work due to its poor technical characteristics and the resulting limitations. However, it can be used in forestry operations if fitted with appropriate forestry implements. Wheelslip is largely influenced by the longitudinal gradient of the skid trail, load size and load orientation, direction of skidding and the transmission type of the tractor. The research has shown that wheelslip values are rarely determined for tractors travelling empty and for downhill skidding. In the present research, however, downhill travelling and skidding were analysed in addition to the highest slip in uphill skidding .

Both tractors (with mechanical and hydrostatic transmission systems) were compared when travelling empty and when skidding a load of 1 m^3. The test skid trail was concave in shape, with an increasing longitudinal gradient reaching 27% in the upper part of the trail. The selected 1 m^3 load represents the threshold value that the tractors can move along the trail except for the steepest section of the trail. In the test, both tractors stopped at this point due to the demanding working conditions.

In analysing the performance of empty tractors, wheelslip was highest in travelling uphill. In the steepest reaches of the trail, skid values climbed to 10%. Both tractors had practically no problems overcoming the trail. It was found that the hydrostatic transmission causes lower wheelslip, with the differences reaching up to 2%. Conversely, in travelling downhill wheelslip values were lower in both tractors. In this case, wheelslip is a result of the traction force applied to the wheels and the gravity of the tractor. Therefore, interpretation of results for downhill skidding is more demanding. When an unloaded tractor travels downhill, negative wheelslip occurs, which means that the tractor weight pushes the tractor down the skid trail. In the steepest reaches of the trail, skid values measured were -6%. In travelling downhill, the longitudinal gradient of the trail reduces gradually, as does absolute wheelslip. In the lower, more gently sloping part of the trail wheelslip is about 0%, indicating that in this trail section the force of gravity is no longer prevalent.

Wheelslip rises significantly when a tractor transports a load. In skidding 1 m^3 load up the trail, wheelslip was highest in the steepest section of the trail, where it reached 42% in the mechanical tractor. In comparison with an unloaded tractor, wheelslip was four times higher in the steepest section of the trail (over 20%). Load orientation strongly affects wheelslip values. When logs are transported butt-end forward, wheelslip is normally lower. In this case, the rear end of the tractor is additionally burdened with the load, the adhesion mass is larger, resistances are lower and consequently slip values drop. The differences can reach up to 4%. Differences in slip values can also result from the transmission system of a tractor. It was established that the tractor with the hydrostatic power transmission causes lower wheelslip in uphill skidding. In the steepest section of the skid trail, these differences amount to 13%.

In downhill skidding, slip values are lower. Negative wheelslip may occur, although only in the upper, steepest reaches of the trail. The influence of factors affecting wheelslip is highly complex. The ultimate value is determined by power transmission, gravity, and the friction-related braking of a loaded tractor. In the hydrostatic tractor version, wheelslip is about –2%, whereas in mechanical tractor it is closer to 0. At lower gradient, the required tractive force gradually increases, eliminating the phenomenon of negative wheelslip. At a gradient of up to 20%, wheelslip is up to 2%, at lower gradients (up to 10%) it is up to 7%. The measurements have shown that at gradients of over 20% the hydrostatic transmission system is linked to higher negative wheelslip values than mechanical transmission, and in slope gradients lower than 20% wheelslip is lower in hydrostatic transmission than in mechanical tractors. Additionally, slip values are higher when the load is transported butt-end forward.

6 References

6 Viri

HORVAT, D., 1996. Proračun nekih veličina vučnih značajki četiriju vozila za privlačenje drva u proredama brdsko-planinskih sastojina = Calculations of some tractive parameters for four vehicles used for wood transportation in mountain thinning. V: Zaštita šuma i pridobivanje drva, Hrvatsko šumarsko društvo, Vol. 2, Zagreb, 243–252.

JEJČIČ, V., 1999. AGT 835 T. Tehnika in narava, 3, 3: 8–9.

JEJČIČ, V., 2000a. Hidrostatična transmisija. Tehnika in narava, 4, 3: 18–19.

JEJČIČ, V.,. 2000b. Hidromehanska traktorska transmisija. Tehnika in narava, 4, 4: 19–22.

JEJČIČ, V., 2001. Hidrostatični traktor AGT 835T. Tehnika in. narava, 5, 3: 4–6.

JEJČIČ, V., 2002. Dve gozdarski izvedbi AGT 835 T. Tehnika in narava, 6, 4: 5–7.

JEJČIČ, V. / POJE, J./ MARENČE, J. / KOŠIR, B., 2003. Razvoj mjerne opreme za šumarski traktor AGT 835 s mehaničkom i hidromehaničkom transmisijom V: Proceedings, 31. International Symposium on Agricultural Engineering, Opatija, Croatia, Zavod za mehanizaciju poljoprivrede, 65–74.

KOŠIR, B., 1997. Pridobivanje lesa. Ljubljana, BF – Oddelek za gozdarstvo in obnovljive gozdne vire: 330 str.

KOŠIR, B., 2000. Lastnosti prenosa sil na podlago pri traktorju Woody 110. Gozdarski vestnik, 58, 3: 139–145.

KOŠIR, B. / MARENČE, J., 2005. Determining Technical Parameters in Tractor Skidding – Basis for the Choice of Tractor, Proceedings: FORMEC 2005, Ljubljana, 43–55.

MARENČE, J., 1997. Izbor in gospodarnost prilagojenih tehnologij pridobivanja gozdnih lesnih sortimentov v zasebnih gozdovih : magistrsko delo, Ljubljana, samozaložba: 141 str.

MARENČE, J., 2000. Ugotavljanje tehničnih parametrov traktorja Woody 110 (metodologija in merilni instrumenti). Nova znanja v gozdarstvu - prispevek visokega šolstva : zbornik referatov študijskih dni, Kranjska Gora, Ljubljana: Biotehniška fakulteta, Oddelek za gozdarstvo in obnovljive gozdne vire, 209–228.

MARENČE, J., 2002. AGT835T z verigami v gozdarski rabi. Teh. narava, letn. 6, št. 4, str. 11.

MARENČE, J., 2005. Spreminjanje tehničnih parametrov traktorja pri vlačenju lesa – kriterij pri izbiri delovnega sredstva: doktorsko delo, Ljubljana, samozaložba: 271 str.

MARENČE, J., KOŠIR, B., 2006. Vpliv tehničnih parametrov gozdarskega traktorja ob njegovi izbiri. Gozd. vestn., letn. 64, št. 4, 213–226.

POJE, T., 1996. Potrošnja energije radom traktora s priključcima za različite načine obrade tla: magistrsko delo. Zagreb, samozaložba: 64 str.

SEVER, S., 1980. Istraživanja nekih eksploatacijskih parametara traktora kod privlačenja drva: doktorska disertacija (Sveučilište u Zagrebu, Šumarski fakultet). Zagreb, samozaložba: 301 str.

ŠUŠNJAR, M., 2005. Istraživanje međusobne ovisnosti značajki tla traktorske vlake i vučne značajke skidera. Doktorska disertacija = Interaction between soil characteristics of skid road and tractive characteristics of skidder: dissertation thesis. Zagreb, pp. 271.