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LIMITS OF UPHILL SKIDDING WITH AGT 835 AND WOODY 110 TRACTORS

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Abstract: *The paper deals with the test results of uphill skidding wood with a WOODY 110 forestry tractor and adapted 4WD agricultural tractor AGT 835. The goal of the measurements was to compare both tractors and find the limits of uphill skidding in relation to load size, log orientation and the slope. The trial was conducted in the forest on two test skid track and with pre-designed loads of different sizes. The skid track had on the lower altitudes small inclination, which slowly increased to 42% on the track where WOODY 110 was tested and 27% where AGT was measured. The loads were skidded uphill with butt-end and in the second run with top-end forward. On many occasions tractor stopped because of the slope. The results show that butt-end forward skidding is more efficient. The difference between maximum loads at specific maximum slopes is when skidding with WOODY 110 more or less constant. Proper load formation (butt-end forward if possible) in uphill skidding is most important on steeper slopes.*

1. Introduction

The WOODY 110 tractor is hydrostatically driven and remote controlled (Marenče, 2000, Košir, 2000). Tractor is designed as classically steering frame skidder, but with hydrostatic-mechanical transmission and could be produced with various attachment and size options. Many are used in Slovenia, Austria, Germany and Switzerland.

AGT tractors (several different types) are mainly devoted to the light agricultural work and can be found on small-scale farms and on the farms with limited agricultural and forest work. Standardised adaptation of this tractor for forest use has not yet been done. For the purpose of our testing we have constructed provisional adaptation with the safety cabin and frame, front blade and attached winch. AGT 835 tractors are produced in classical (mechanic) and hydrostatic-mechanical transmission. We tested both versions.

2. Methods

The purpose of the study was to determine maximal load when skidding uphill under average conditions. As we took into comparison two very different tractors where one is conditionally for forest use because of its small dimensions and poor equipment, and other is expensive and purpose built forestry cable skidder, we can on this way determine the borders (load in relation to the slope) where other tractors for forest use can be found. The following has been a basis of our approach when testing different tractors that can be considered as suitable for forestry use in Slovenian conditions.

Technical components of tractor skidding are:

1. tractor (type and characteristics, power, weight, torque, dimensions etc.),
2. skid trail (direction of skidding, slope, distance, surface etc.) and
3. load (tree species, method of cutting, size, orientation of the load etc.).

Technological-economic components are:

1. list of operations (purpose, place and time),
2. availability (calendar time utilisation, repair rate etc.),
3. standard times and efficiency (min/m^3, m^3/h, m^3/year) and
4. costs (€/h, €/m^3 etc.).

In this study we focused on technical limits found in chosen typical situation. Both tractors can hardly be more different. WOODY 110 has built in Perkins engine1004-40T with 76,5 kW (tractor weight of 70,06 kN) of gross power at 2200 rev/min, while AGT 835 Lombardini LDW 1503 achieve only 26,4 kW at 3000 rev/min (tractor weight 20,10 kN). According to this description the dimensions are also different (WOODY 110 (length x width x height): 5400 x 1940 x 2750mm, AGT 835: 2900 x 1250 x 2100 mm with safety frame). Tyres are 7,50 x 16 on AGT 835 and 14.9/13-28 PR12 on WOODY 110. Small tractor can achieve 20 km/h, while WOODY 110 17 km/h in first gear and 30 km/h in second gear.

The shapes of both skid trails have been mainly concave. The skid trail for WOODY 110 was steeper (42%) than skid trail where AGT 835 has been tested (maximal 27 %). Each skid trail was divided in several segments (Figure 1) according to the slope and surface conditions. Segments have been classified in three joined categories as it is shown on the Figure 1.

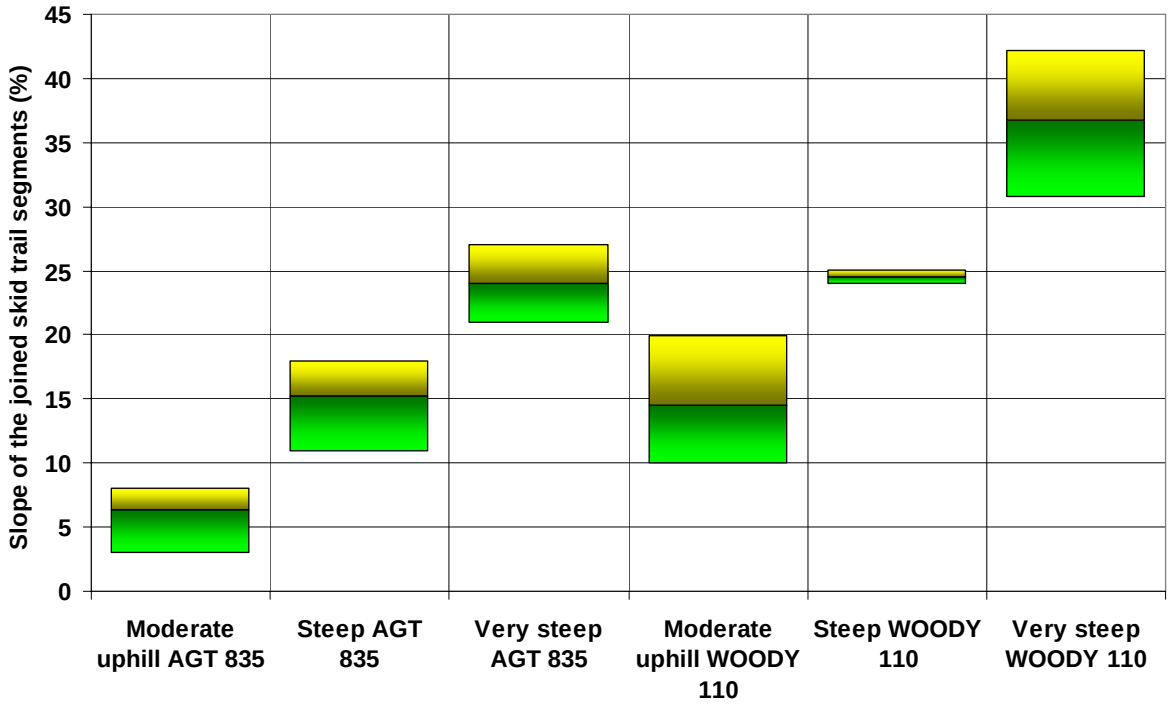

Figure 1: Categories of the slope on both skid trails (minimum – average – maximum)

Loads were composed of 4 pieces of 8 m long logs when skidding with WOODY 110 and one 8 m log when skidding with AGT 835.

Friction coefficient has been established by dragging a known load parallel to the typical surface of the skid road (average of several measurements was 0,54). The moisture of the skid trail surface over the

course of the experiment have been measured, but differences between the measurements have been small, as the weather had been changing very little (mostly sunny and windy).

3. Results

Previous studies showed (Košir, Marenče, 2007) that dependence between maximal load and slope is linear. If so, then first goal was to find two (four if we wish to evaluate load orientation) lines, which will present dependency between load and slope of small (AGT 835) and big (WOODY 110) tractors (Figure 2).

Trial showed that the combination between the load size and slope has been chosen better in the trial with WOODY 110 (tractor has been stopped in every uphill voyage because of overloading) then with AGT 835 (the stops happened only with the biggest load). Despite this it is obvious that the loads dragged by WOODY 110 have been much greater than the loads of AGT 835, but – as we see from the Figure 2 - the "meeting point" of both curves is around 40% of slope. At that slope there is no difference between tractors. This speculation can be wrong in different conditions (friction coefficient, load characteristics).

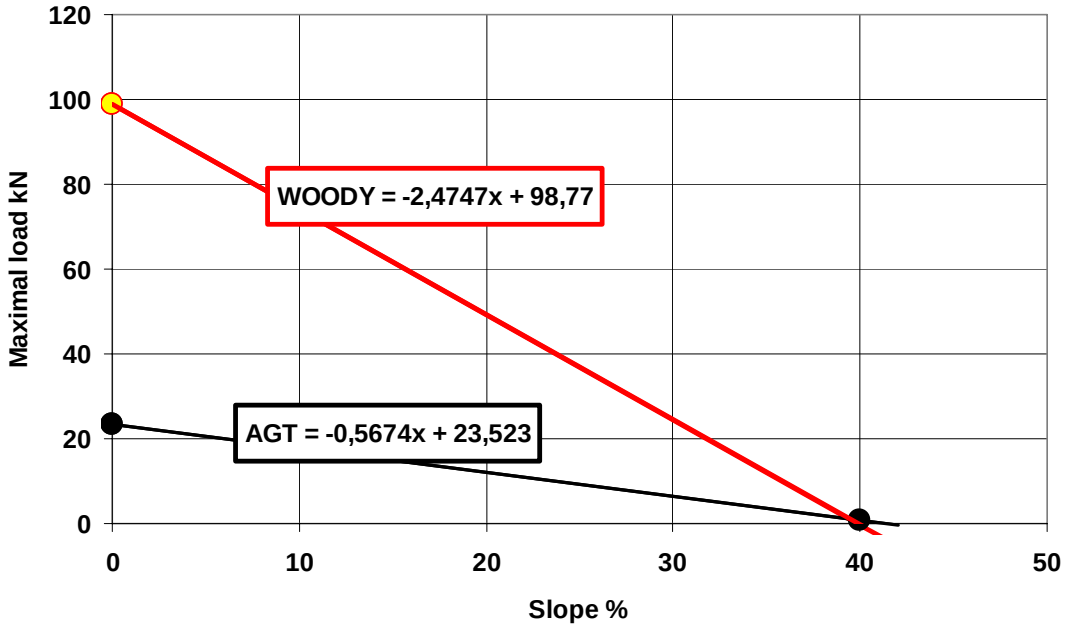

Figure 2: Maximum loads in kN when skidding uphill – triangle for assessing limits

We can see that load orientation is important factor. Practically it is impossible to expect that this knowledge can be fully exploited. All positive cases (where tractors stopped because of the slope and load) are shown in Figure 2. Loads at zero slope have not been measured, but calculated from tractor weight and friction coefficient. Absolute limit (no load at all) is for average between top-end and butt-end orientations approximately at 40%. On the Figure 2 the averages (but-end and top-end) for both tractors have been calculated. The field between the lines for AGT 835 and WOODY 110 in the Figure 2 tells us what kind of combination between tractor weight, slope and load we can expect. Tractor weight is not of course specified, but can be estimated from data of both tractors which define triangle on Figure 2. We also see, that the choice between different sizes of tractors is broader at gentle slopes than on steep slopes, where absolute differences between tractors become small.

Loads of both tractors have been also compared (Figure 3), despite the differences between tractors can hardly be bigger. Bigger difference between maximal loads is when skidding with butt-end forward (WOODY 110 is relatively more efficient). On gentle and moderate terrain the differences between tractors and load orientation are not changing very much. Slope inclinations over 20% cause however faster increasing of differences in tractor efficiency.

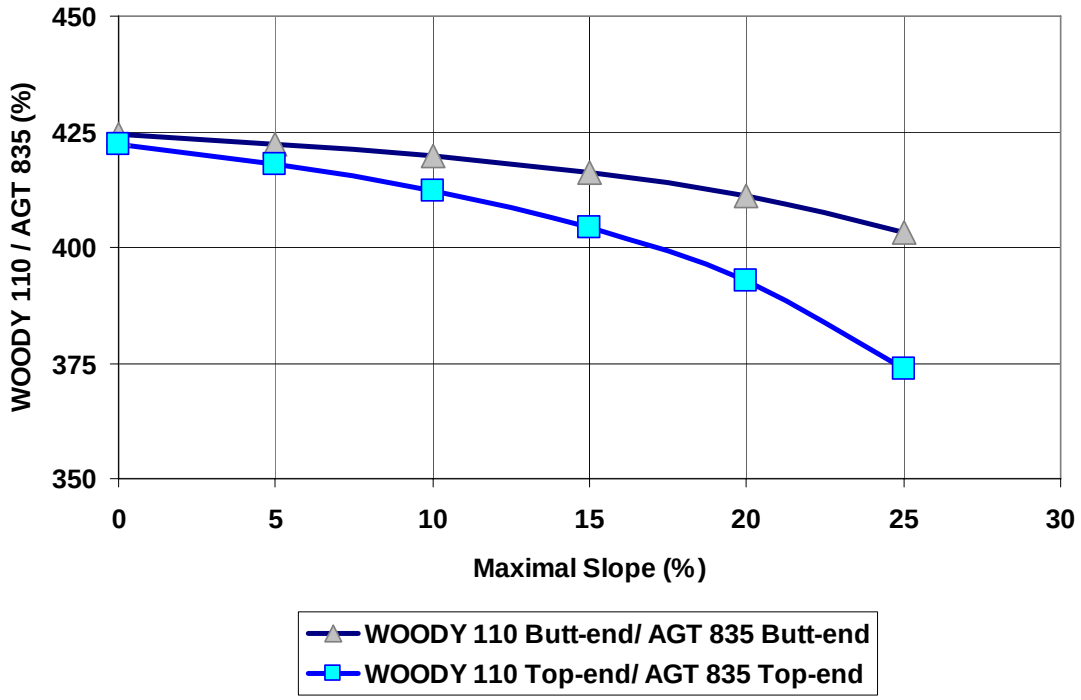

Figure 3: Relative differences between tractor loads at different maximal slopes

4. Discussion and conclusions

This paper deals with comparison of maximal loads of two very different tractors for timber skidding. This should be kept in mind when comparing results. Smaller tractor is built for light farm work and is not intended to go to forest without proper adaptation. We have equipped it therefore with basic forestry adaptation (cabin, front and rear blade, winch, tyre chains). Bigger cable skidder is made for forest work, despite it belongs to the group of light skidders. This choice has not been coincidental as we wished to draw on this way borders of tractor use in Slovenian conditions. We can expect that maximal loads of other tractors can be found somewhere between the borders of investigated two tractors. Many different parameters have been measured, but this article deals only with capability of tractors to drag different loads uphill on different slopes (Marenče 2005, Košir, Marenče 2005, Šušnjar, 2005, Tomašić, 2007). The results showed interesting relations between tractors, loads and slope. Butt-end load orientation is always better and more efficient. In our case the average difference with WOODY 110 was 7,18 kN (718 kg), and 1,59 kN (159 kg) when skidding uphill with AGT 835. Difference between mechanical and hydrostatic-mechanical transmission of AGT 835 has not been discussed, but it was estimated, that the difference is small. Absolute differences between tractor loads at gentler slopes are greater, but relative differences increase with steeper slopes. Load orientation becomes more important with steeper slopes also. Comparison between tractors also has been made and showed that greatest difference is at even terrain. On steep terrain the difference between the maximal loads decreases.

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