Wheel Load Changes at Boogie Axis Forest Machines in Response to Traction Forces

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Abstract:
A prerequisite for a soil protective operation of forest machines in case of harvesting and skidding is an as much as possible equal load distribution on all wheels. In difficult terrain interactions between forest machines with bogie axis and soil provokes a raising effect of appointed wheels. That raising effect leads to a load reduction at one wheel and at the same time an increasing wheel load at the associated wheel. The result of this raising effect is a partially very high wheel load, which is much higher than current static calculations suggest.

Keywords: boogie axis, wheel load, traction force, boogie axis raising effect, soil protection

1 Introduction

For the sustainable use of the renewable resource "wood" the use of modern and high specialized forest machines an thus driving on forest soils is essential (Schäffer 2002, TMLNU 2008). The resulting damage on the soil like compaction (Nemestothy 2009) and steep tracks at high soil moisture content (Kremer et al. 2007) will focus specifically on driving lanes for detailed exploitation of stands, the so-called skid trails (MLR 2003, LWF 2007, TMLNU 2008) therefore remain at least 80 % of forest floor untraveled an undisturbed (Borchert and Metan 2008). This shows that systematically and permanently applied skid trail networks are an essential requirement for an ecologically and economically sustainable use of wood (Bacher-Winterhalter and Becker 2009). It is a top priority for the enduring use of skid trails, maintaining the technical trafficability (MLR 2003, LWF 2007, TMLNU 2008).

Significant influence for a skid trail-conserving use of forest machines in timber harvesting and skidding is an equal load distribution on all wheels (Nemestothy 2009, Dreeke 2010, Erler and Borcher 2010, Schack-Kirchner 2010). In difficult terrain operations between forest machines with bogie axis and soil, it may also happen that forces drawn by travel movements can provoke a raising effect of appointed wheels. That raising effect leads to a load reduction at one wheel and at the same time an increasing wheel load at the associated wheel. Therefore significant short-terms soil pressure and wheel load peaks were observed. Studies show that the wheel load is the most effective screw for the preservation for technical trafficability (Starke et al. 2010).

The aim of the study was to characterize the driving force addicted raising effect from boogie axis and associated with the change of wheel loads during increasing traction force.

2 Material and methods

In order to describe the raising effect and associated with the change of wheel loads an exemplary 6-wheel universal skidder from a German forest machine manufacturer has been selected. On the machine with 175 HP, hydrostatic drive, articulated frame steering and 14 tons empty weight, a 2x8 tons double winch and a loading crane with 10 m reach were mounted. The test machine stood on 710/40 R 22.5 tyres at the two rear boogie axis.

To determine the wheel loads of the standing and under the influence of traction force standing machine a two-stage test set was selected.

In the first stage the static wheel loads at the boogie axis of the empty machine were determined under similar conditions. Therefore the machine was driven on four weighing platforms (Figure 1.; Producer: Haenni, with a range from 50 to 10.000 kg with 50 kg steps and a tolerance of 50 kg) which laid on flat surface and the displayed weight was noted. This procedure was repeated 10 times and the values arithmetically averaged. During the weighing process the brakes from the machine were opened and the central-torsion was unlocked to avoid tensioning.

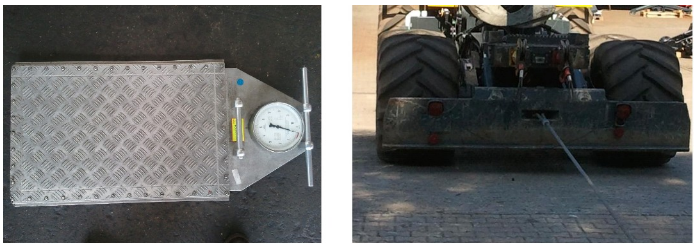

Figure 1: Weighing platform and fixed machine for traction force measurement

In the second stage the wheel loads of the empty machine and their differences together under the influence of different traction forces were tested. Therefore the machine was driven on the weighing platform similar to the first stage. After that the machine was fixed (Figure 1) with a non elastic steel cable (diameter 30 mm). On the machine side the cable was fixed in the middle of the rear blade and on the other side between the soil bolt and the cable was a traction force measuring instrument (with a range from 0 to 220 kN in 1 kN steps) fixed.

The first four wheel loads measurements were taken while the machine was standing on the weighing platforms without building up some traction forces. Than the start-up process were began and the tractions forces were increasing. Parallel to the increasing traction forces were wheel loads measurements at the four wheels (2 wheels each machine side) at the boogie axis taken. The traction force raised up to the maximum of the machines power. This procedure was 10 times repeated.

3 Results

The results of the first stage shows (Figure 2) a very well balanced wheel load from 2.000 kg each wheel at the two boogie axis under static conditions.

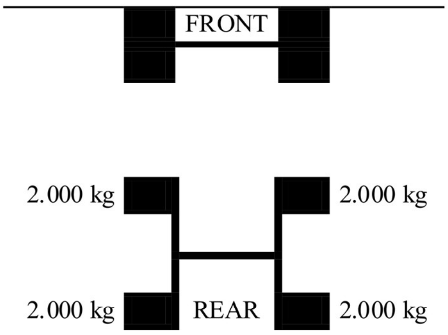

Figure 2: Averaged wheel loads at the rear boogie axis in kg

The results of the second stage were drawn in Figure 3 and 4. They show each two curves representing the change in wheel loads during the traction force influence. In each slice there is the wheel loads change from the front (Fr) and rear (Re) wheel form the several side (right = Ri / left = Le) drawn.

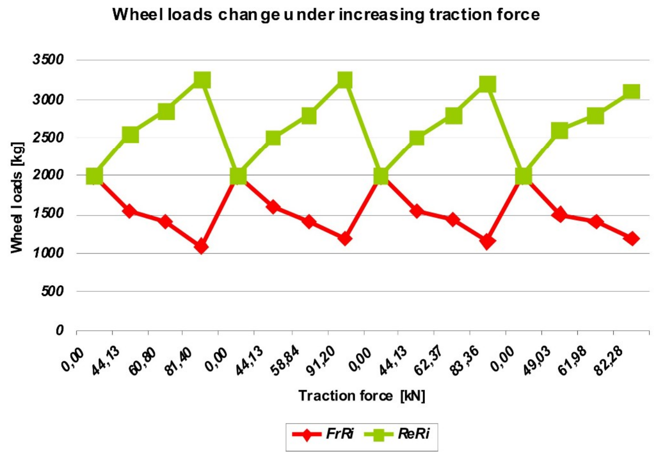

Figure 3: Increasing and decreasing wheel loads from the right boogie axis (front wheel right (FrRi) and rear wheel right (ReRi)) during increasing traction forces

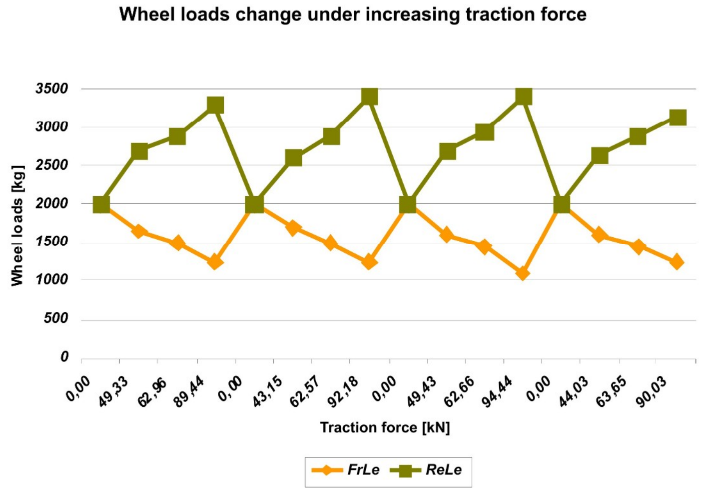

Figure 4: Increasing and decreasing wheel loads from the right boogie axis (front wheel left (FrLe) and rear wheel left (ReLe)) during increasing traction forces

The results shown in Figure 3 and 4 were eight picked examples of the measurements. Both slices show with an increasing traction force the wheel loads in driving direction are decreasing while the wheel loads towards the driving direction are increasing. At the maximum traction force at 94,44 kN (Figure 4) the different wheel loads between the front- and rear wheel are 2.300 kg. In that case the front wheel has 1.100 kg wheel loads, the rear wheel 3.400 kg (170 % compared with the ground level of 2.000 kg each wheel).

4 Discussion and outlook

The results show that under traction forces a considerably raising effect in driving direction on a boogie axis is measured. The results also show that with increasing traction forces a much higher raising effect is visible. The tests were done without any load. So under praxis conditions with payload and a stop and go ride on the skid trail the raising effect and out of it resulting wheel loads differences might be higher. The results show that this high wheel loads is much higher than current static calculations suggest.

Further experiments are planed to get wheel loads online during drive interactions. These results give technical indications to construct a mechanism to prevent the boogie axis raising effect and related wheel loads differences.

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