IMPROVEMENT OF THE SOFT GROUND CAPACITY OF REGULAR FORWARDERS

1. Background

In the middle of the 1980’s the Development Section of Metsähallitus (the Finnish Forest and Park Service) carried out a large number of studies on timber harvesting on soft ground. The background to the studies was a rapidly increasing need for thinnings on the large drained peatland areas in Ostrobothnia and Lapland. The objective of the studies was to identify the best methods and equipment for harvesting operations in those conditions. The questions to be studied were:

- Can regular forest machines be used by improvements in design and equipment?
- Do rubber tracked crawlers or other special machines offer a solution to the problems?
- How should the operations be planned and enforced?

A full summary of the studies is available in Finnish (Högnäs 1997). This paper only focuses on the trials to improve the soft ground capacity of regular forwarders by using different auxiliary equipment.

2. Studies and results

Comparison of different wheel track types

In the autumn 1984 the Development Section carried out a comparison of wheel tracks for forwarders on unfrozen ground (Kumpuniemi 1985). Five common wheel track models were selected and one alternative was not to use wheel tracks at all. The test was carried out in different terrain conditions on specially designed test tracks. The driving pattern of the forwarder was designed to imitate normal extraction. The ground damages were quantified by measurement of the depth and cross section of the ruts and the proportion of damaged ground surface. Differences in bark and wood damages on roots were studied by measurement of damages on passed beds of fresh pine poles.

Generally speaking the differences between the alternatives were small. In peatland conditions the differences could be explained by differences in the ground contact area. However, the impact of the size of the space between the track plates was not significant. With regard to ground surface and bark and wood damages on roots there were slight differences between the alternatives. The results are compressed in the selection scheme presented in figure 1.
Are the wheel tracks used to prevent the machine from getting stuck? yes → “L” track
no → Hi-Grip track

Is there a risk for rutting? no → No wheel tracks (bare tires)

Is there a frequent need to access the forest road? yes → Moccasin track
no → Moccasin track

Is the stand sensitive to root damages? yes → Superbearing track
no →

Figure 1. Selection of wheel track for unfrozen ground (Kumpuniemi 1985)

Test of a polyurethane based wheel track

The Gislaved Moccasin polyurethane based wheel track was also tested on a Ponsse S 15 forwarder operating on normal sites (Högnäs 1986a).

The polyurethane based track was better than traditional steel wheel tracks mainly just with regard to root damages on bearing ground. However, in those conditions it often is possible to operate without wheel tracks. The main weaknesses of the track were the questionable durability, slipperiness and a little increase in ground contact area due to the soft track plates.

Tests with rubber based wheel tracks

Traditional wheel tracks mounted on boggie wheel tires have many weaknesses: they damage the ground, increase the moving resistance and add vehicle weight. These are all good reasons to search for a better design.

The Swedish forest machine developer Mr. Lars Bruun had developed an interesting continuous rubber wheel track. The track was thin and straight and mounted on a lorry twin boggie. An inside steering ridge between the twin tires prevented the track from slipping off. The solution was studied in Filipstad in Sweden in the autumn 1985 (Högnäs 1985a).

Due to the structure of the wheel track the ground damages were smaller than for traditional steel tracks of same width. The problem was the strength of the rubber-based track. The track was also too narrow for operations on soft ground, but could be widened.

Also Valmet company developed a similar wheel track solution that was studied in the autumn 1986. In this solution the rubber wheel track run via a driving roll and the boggie twins did not have any own transmission. The wheels were attached to the boggie by a pendulum mechanism, which kept the track tight in all conditions. The study results were quite similar to those for the Bruun model.
Analysis of the dynamics of traditional wheel tracks

To find better solutions the problems with traditional wheel tracks were analysed in depth (Högnäs 1986b, Högnäs & Rieppo 1986).

The weaknesses of traditional on boggie mounted wheel tracks can largely be identified as a consequence of the poor dynamics of the design. The wheel track plates follow the rounded section of the tire and they are linked to each other on a lower level than the tire, which leads to different rolling radiiuses and peripherical speeds for tire and track. The consequence of this is a planing track on hard ground and digging wheels on soft ground. If the wheel track has ribs or grousers for a better grip, the phenomenon leads to an efficient “cultivation” of the ground. Other consequences are an increased moving resistance leading to higher fuel consumption and wearing of the engine and transmission.

Use of tracks mounted on a single wheel

Traditional wheel tracks cannot be used on front wheels of 6-wheeled machines. However, there is sometimes a need for use of tracks on single wheels. The front ground pressure is quite high on a 6-wheeled forwarder, and even worse, the pressure is virtually the same for an empty vehicle as for a loaded. The options are the use of traditional wheel tracks mounted via small auxiliary wheels or to have a pure single wheel track. Both options were tested.

The auxiliary wheel track solution is an old solution and it worked very well. The problem was mainly the additional weight. The problem with a single wheel track was the small increase in ground contact area in relation to the increase in weight.

Exploring the use of wide, dual and twin tires

Any practical tire tests were not carried out. Wide single tires as well as dual and twin tire designs have been widely tested in North America and the experiences were surveyed based on existing literature (Byl & Högnäs 1985).

Based on the literature the experiences from the use of wide tires on soft ground were good. The North American studies reported improved soft ground capacity, increased productivity, less ground damage and reduced fuel consumption as a consequence of introduction of wide tires. However, an evaluation indicated that the solution is not so promising on forwarders in thinning conditions in Finland as on skidders in clearfellings in North America.

Test of the impact of the tire inflation pressure

Originally any studies on the impact of the tire inflation pressure were not planned. The assumption was that the tires must have the recommended pressure and will be damaged, if a lower pressure was used. However, in connection to a forwarder test (Högnäs 1985b) one manufacturer cheated by dropping the inflation pressure in the front tires before accessing the test track. Consequently, the impacts of a moderately dropped air pressure in conventional low forwarder tires had to be studied (Högnäs 1985c).

The inflation pressure in the front tires did not have very significant impact on rutting in the studied conditions. Even for lowest test pressure - 80 kPa – the conventional low space tire was still surprisingly stiff. A lower air pressure and use of another tire design may indicate a clearer impact, however.

Design of auxiliary equipment
An “equipment package” for 6-wheeled forwarders was designed based on earlier study results (Vilkko 1986). The package included 900-mm wheel tracks with a rolling radius close to that of tire on the rear boggies and 240 mm wide spreader-wheels attached to the regular wheels in the front. The package was designed in cooperation with a local engineering workshop with large experience from design of different wheel track models. The equipment package was compared with use of a conventional equipment package (“L” tracks rear and chains in front) and with use of no extra equipment at all. The unit was also followed up in normal thinning operations.

There was a significant improvement in soft ground capacity for the forwarder when using the designed “equipment package”: less rutting, more loads on the same strip road and a lower moving resistance. The wheel track was excellent and has been a model for later developments in this area. The stem and root damages in thinning were not bad although the machine was recognised to be too wide.

3. Conclusions

The conclusions from the studies carried out in 1980ies can be summarised as follows:

- Traditional steel wheel tracks mainly designed for good grip in snow improve the soft ground capacity of regular forwarders, but at the expense of a high level of ground damage
- The differences between traditional steel wheel track models are relatively small with regard to rutting as well as other ground damages
- Rubber or polyurethane based wheel tracks are not strong enough to be used on regular forwarders and their impact on the soft ground capacity is often small
- The problem with traditional steel wheel tracks is their poor dynamics, not the material
- Wider tires can be used, but overwide designs used on skidders in North America are not applicable on forwarders in Finnish conditions
- The traditional wheel track design can be significantly improved with regard to ground damage and moving resistance

References:


