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# Improvement of bogie tracks for forestry wheeled vehicles

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**Abstract**. The article is concerned with development of a bogie track for forestry wheeled vehicles featuring extended service life, better grip and lower ground pressure as compared with the counterparts. The conditions and results of the experimental studies of wheeled forestry vehicles with and without different anti-skid tracks are described in the article.

## Introduction

Today contemporary logging methods are frequently used by the logging companies both in Russia and all over the world. The world practice demonstrates that the cut-to-length method employs machines, including a harvester and a forwarder [1, 2, 3].

Figure 1 shows an example of forestry wheeled vehicles equipped with bogie tracks.

**Figure 1.** Forestry vehicles which may be equipped with bogie tracks

These vehicles show good efficiency thanks to modern engineering equipment and automated control system. However, the vehicles suffer from one fatal flow. They are wheeled so it makes them inefficient on swampy, running soils and under subzero temperatures in such conditions as snow and glass [4, 5, 6]. Practise has shown that these vehicles are fitted with standard bogie tracks manufactured by Olofsfors, Clark and other companies.

The main feature of the bogie tracks is that the tracks distribute load over greater area and do not concentrate it on two small flat spots. Brush wood, roots, etc. often lay on the ground and help supporting a tracked machine. Tires usually press the ground and pack it.

The advantage of using properly selected bogie tracks is soil damage protection; less ground pressure and better ground clutch; less soil compacting: better propulsive thrust; reduced fuel consumption; increased cargo capacity; better stability during loading and unloading; better movement stability.

Soil is one of the main components of the forest eco-system serious damage of which can have a negative impact on vegetatio. Soil formation process takes time and soil structure may be weak.
The standard bogie tracks represent tracks inter-connected with a ring, i.e. open joint (Fig. 2).

**Figure 2.** Standard bogie tracks

An open joint is out of order very quickly while contacting with soil abrasive elements such as sand, ground, etc.

After a while a track gets extended and becomes sagged and deformed under pressure of a vehicle load and ground deformation. It occurs when the track is installed on the balance truck, the second wheel always suffers from increased travel resistance, i.e uphill movement (Fig. 3) [7, 8, 9].

**Figure 3.** Standard bogie track sagging

Taking into consideration a large number of vehicles with different load and use methods, it is very difficult to specify exact track service life. Great tension and load affecting the tracks should also be considered. The average service life of a standard track with an open joint is around 3 thousand moto hours.

The vehicle which isn't equipped with the tracks has negative effect on the soil resulting in packing down to critical values. The ground pressure is very high and is up to standard of around 75 kPa.

Considering the aforesaid, we have decided to improve joint elements of standard bogie tracks in order to Decrease ground pressure; Reduce travel resistance factor; Reduce fuel consumption; Improve track service life; Improve maintainability.

## 1. The developed enclosed metal-rubber mountings in the track.

We have reviewed the existing technical solutions in this field and come to a conclusion that the most rational option to solve the task would be to use enclosed metal-rubber mountings in the track (Fig. 4).

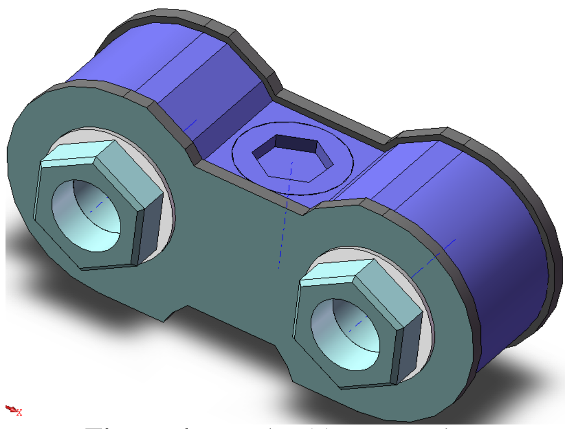

**Figure 4.** Metal-rubber mounting

This design is based on a silent block (Fig. 5). The rubber bushings and guides are cured and pressed fit into the joint housing on the press, and then the ready joints are assembled into the links on the track.

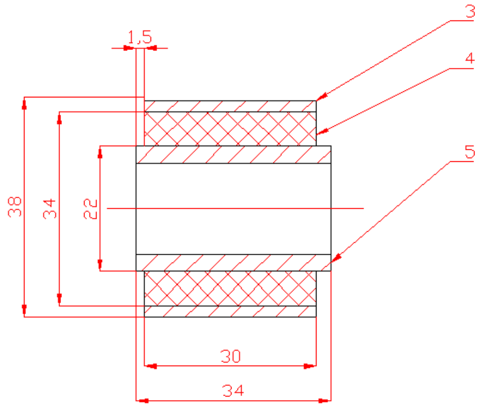


**Figure 5.** Silent block

3. Metal bushing; 4. Elastic insert (rubber, grade IRP-1357); 5. Metal bushing

Figure 6 shows a bogie track being developed

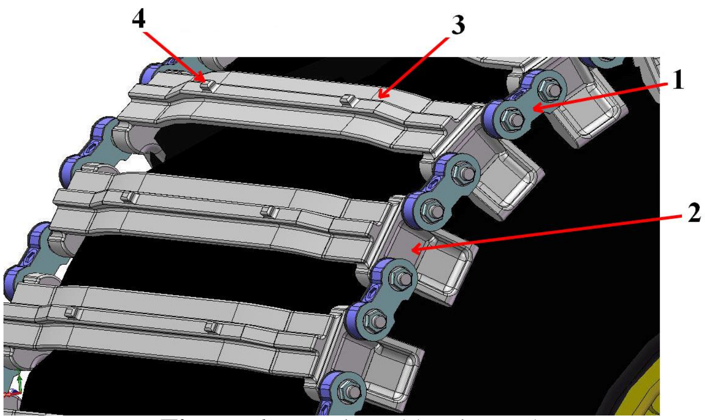


**Figure 6.** Developed bogie track

1. Metal-rubber mounting; 2. Side support; 3. Track; 4. Grouser

The strengthened use and use with varying wheel load gives extra tension to the tire bearing capacity and the pressure value, which is especially important for the forestry vehicles [10]. To improve tire strength and service life it is necessary to follow the manufacturers' recommendations since the track inner part remained unchanged, so the tire pressure recommendations (Table 1) remain the same.

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**Table 1.** Tire pressure recommendations

| Tires | | | |
|---|---|---|---|
| Tire size | Tire brand | Model of tires | Maximum pressure |
| 600/50x 22.5 | Nokian | ELS L-2(l 6) | 4.3 bar/62 psi |
| | Nokian | TRS LS-2(16) | 4.3 bar/62 psi |
| | Trelleborg | T404 | 4.0 bar/58 psi |
| | Trelleborg | T423 | 4.0 bar/58 psi |
| | Trelleborg | T428 143/150 | 4,0 bar/58 psi |
| | Trelleborg | T428 149/156 | 5.0 bar/73 psi |
| 650/45 x 22.5 | Trelleborg | T422 150 | 5,0 bar/73 psi |
| 700/45 x 22.5 | Nokian | ELS L-2(l 6) | 3.9 bar/57 psi |
| | Nokian | TRS LS-2(16) | 3.9 bar/57 psi |
| 700/40 x 22.5 | Trelleborg | M404 | 4.0 bar/58 psi |
| | Trelleborg | T423 | 4.0 bar/58 psi |
| 710/40 x 22.5 | Nokian | FK F | 3.9 bar/57 psi |
| | Trelleborg | T428 145/152 | 4,0 bar/58 psi |
| | Trelleborg | T428 151/158 | 5.0 bar/73 psi |
| 600/55 x 26.5 | Nokian | ELS L-2(l 6) | 4.6 bar/67 psi |
| | Nokian | ELS L-2(20) | 5.5 bar/80 psi |
| | Nokian | TRS LS-2(16) | 4.6 bar/67 psi |
| | Nokian | FK F (16) | 4.6 bar/67 psi |
| | Nokian | FK F (20) | 5.5 bar/80 psi |
| | Trelleborg | T421 | 5.0 bar/73 psi |
| | Trelleborg | T428 160/167 | 6.0 bar/87 psi |
| | Trelleborg | T422 154/161 | 5.0 bar/73 psi |
| | Firestone | Forestry EL | 3.9 bar/56 psi |
| 620/55 x 30.5 | Trelleborg | T428 158/165 | 5.0 bar/73 psi |
| 650/65 x 26.5 | Nokian | ELS L-2 | 5.5 bar/80 psi |
| 650/60 x 26.5 | Trelleborg | T428 161/168 | 5.0 bar/73 psi |
| 600/60 x 30.5 | Trelleborg | T421 | 5.0 bar/73 psi |
| 700/50 x 26.5 | Nokian | ELS L-2(l 6) | 4.6 bar/67 psi |
| | Nokian | ELS L-2(20) | 5.5 bar/80 psi |
| | Nokian | TRS LS-2(16) | 4.6 bar/67 psi |
| | Nokian | TRS LS-2(20) | 5.5 bar/80 psi |
| | Trelleborg | T423 | 5.0 bar/73 psi |
| | Firestone | Forestry EL | 4.6 bar/66 psi |
| 710/45 x 26.5 | Nokian | FK F (16) | 4.6 bar/67 psi |
| | Nokian | FK F (20) | 5.5 bar/80 psi |
| | Trelleborg | T428 151/158 | 4,5 bar/65 psi |
| | Trelleborg | T428 163/170 | 6.0 bar/87 psi |
| 750/50 x 26.5 | Trelleborg | T428 163/170 | 5,0 bar/73 psi |
| 750/50 x 26.5 | Trelleborg | T428 170/177 | 6.0 bar/87 psi |
| 700/50 x 30.5 | Trelleborg | T423 | 5.0 bar/73 psi |
| 750/55 x 26.5 | Nokian | ELS L-2(20) | 5.5 bar/80 psi |
| | Nokian | TRS L-2(20) | 5.5 bar/80 psi |
| | Nokian | FK F(20) | 5.5 bar/80 psi |
| 750/45 x 30.5 | Trelleborg | T428 169/176 | 6.0 bar/87 psi |
| 800/40 x 26.5 | Nokian | FK F(20) | 5.0 bar/73 psi |
| | Trelleborg | T423 | 5.0 bar/73 psi |

We have made torsion and cranking resistance designs for the silent block to reduce ground pressure. This allowed strength of the metal-rubber mounting would strive to turn the track towards the ground contacting area [11]. This also solves the task of reducing travel resistance as the ground contacting area enlarges; the metal-rubber mounting strength constantly levels the ground contacting area and the second wheel of the balance truck moves with least travel resistance that should significantly reduce fuel usage. The bogie tracks with metal-rubber mountings were tested on timber harvesting machine Ponsse Beaver in Murashinsky logging company in Kirov region.

## 2. Test conditions

The tests were performed in winter under the conditions when the tire clutch on the snow surface is minimum and it must be increased to improve running performance of the wheeled vehicles. All winter tests were performed under air temperature from -2 to +5°C in three backgrounds: virgin snow 16 – 25 cm deep and density of 0.2 – 0.26 g/cm$^3$, snow road with depth of snow layer pressing depth of 9 – 15 cm with density of 0.45 – 0.51 g/cm$^3$ and snow-iced compacted road with upper layer density of 0.64 – 0.66 g/cm$^3$. During testing the snow surface temperature was from -2.5 to +0°C. The selected routes used for runs were horizontal without visible inclines and rises. Due to dry winter we could not find sections with deeper snow for tests. During the tests the air and snow were measured with thermometer. The snow density was detected by taking samples by a gage glass on measuring sections of the route. This snow was melted and then a measuring tube was used to determine the volume of the water and hence the weight of the scow sample.

In spring the tests were performed on dry (W = 15-17%) and wet (W = 28-33%) loamy roads.

The moisture and density of soil were determined with the Kovalev meter.

During the test pulling characteristics of the vehicle with two types of bogie tracks (standard and with metal-rubber mountings) as well as without tracks were measured. The characteristics were measured during steady movement on the sections 50 meter long. Ehe tested vehicle carried additional load of 2000 kg.

The pulling loads were created by tractor K-703. The loads were measured with pulling stain-gage link inserted into the towing cable. Wheel spinning of the tested vehicle was determined by the results of measurement of wheels' turns and track-measuring wheel turns with a sensing probe. The measured values were recorded with a decoder. The recording equipment was located in the cab of tractor K-703.

The tested vehicle had tracks on the tandem dolly only.

## 3. Test results

Table 2 gives values of clutch coefficients of the vehicle with standard tracks, developed tracks and without tracks.

**Table 2.**

| Background | Grip coefficient | | |
|---|---|---|---|
| | Developed tracks | Olofsfors ECO-TRACK | Without tracks |
| Virgin snow | 0.59 | 0.39 | 0.34 |
| Snow road | 0.53 | 0.49 | 0.30 |
| Snow-iced road | 0.57 | 0.50 | 0.29 |
| Wet loamy road | 0.62 | 0.55 | 0.53 |
| Dry loamy road | 0.73 | 0.68 | 0.72 |

The given figures show that the vehicle equipped with developed tracks features better pull during spinning by 40 - 50 %. The developed bogie tracks are more efficient than the standard ones by 14 - 18 %.

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## 4. Conclusion

Using bogie tracks in the structure as joint elements of the metal-rubber mountings makes it possible to reduce ground pressure, travel resistance factor, fuel consumption, improve track service life and their maintainability.

Working on a very soft soil it is necessary to use metal-rubber mounting along with tracks of a special form which protects soil and its subsurface against damage.

The given data shows that the vehicle equipped with developed tracks features better pull during spinning by 40 - 50 %. The developed tracks are more efficient than the standard ones by 14 - 18 %.

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