# IMPROVEMENT OF BOGIE TRACKS FOR WHEELED VEHICLES

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The article describes the development of a bogie track for multi-purpose wheeled vehicles. The aim of the study was to create a track that would have an extended service life, better grip, and lower ground pressure than that of its counterparts [11].

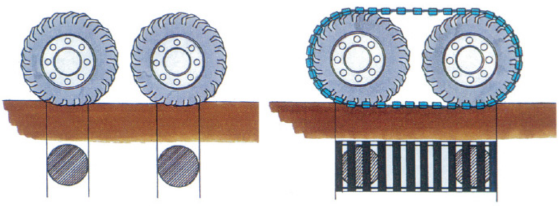
Figure 1 shows an example of multi-purpose wheeled vehicles equipped with bogie tracks.

(a) (b) (c)

**Figure 1**. Vehicles, which may be equipped with bogie tracks.
a – transport, b – military, c – timber harvesting

These vehicles are quite efficient thanks to modern engineering and automated control systems [1]. However, the vehicles suffer from one fatal flaw. As they are wheeled, their use on swampy ground, loose soils, or in sub-zero temperatures, and in ice and snow conditions is inefficient [5, 8]. Experience has shown that when the vehicles are fitted with standard bogie tracks manufactured by Olofsfors, Clark and other companies [13], there is a significant improvement.

The main advantage of the bogie tracks is that the tracks distribute the load over a greater area, and does not concentrate it on to two small flat patches (Fig. 2). Often, the ground is covered with brush, roots, and other forest debris, which help to distribute the weight of a tracked machine, whereas a vehicle with tires rather presses the ground and packs it.



(a) (b)

**Figure 2**. A diagram of the ground pressure: (a) without tracks; (b) with tracks

The advantages of using properly selected bogie tracks include: less damage and better protection for the soil; less ground pressure and better grip; less packing of the soil; better propulsive thrust; reduced fuel consumption; increased cargo capacity; better stability during loading and unloading; better movement stability.

Soil is one of the crucial components of the forest eco-system [2, 12]. Forest vegetation is dependant upon the soil for food, nutrients, gases and moisture, as well as for root support. The soil formation process takes time, and the soil structure can easily be damaged. Non-damaged soil: almost half of the volume is occupied by pore space that ensures good growth, and a continuous supply of water and air (Fig. 3). Packed soil is less porous and sustains less vegetation, which leads to damaged root systems for growing trees (Fig. 4).

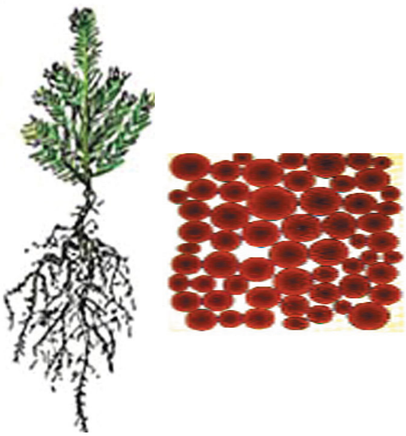


**Figure 3**. Non-damaged soil

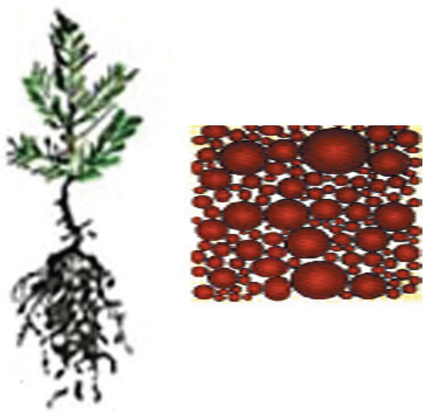


**Figure 4**. Packed soil

Standard bogie tracks are comprised of interlocking tracks connected by rings, i.e. an open joint (Fig. 5).

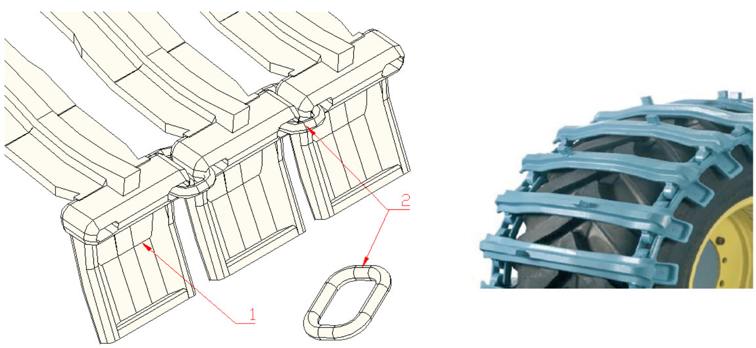



**Figure 5**. Standard bogie tracks. 1 and 2 – connecting ring

The open joint deteriorates very quickly due to contact with abrasive soil elements, such as sand, ground, etc. (Fig. 6).

**Figure 6**. Wear of connecting link and track lug

After a while the track begins to stretch, then sag and deform under the pressure of the vehicle load, and the ground deformation. It appears that in such cases where the track is installed on the balance truck, the second wheel consistently suffers from increased travel resistance, e.g. uphill movement (Fig. 7).

**Figure 7**. Standard bogie track sagging

Taking into consideration the large number of vehicles with different loads and methods of use, it is very difficult to pinpoint the exact service life of the tracks. The tremendous tension and loads that affect the tracks must also be considered. The average service life of a standard track with an open joint is around 3 to 4 thousand hours.

A vehicle that is not equipped with the tracks has an exceptionally negative impact on the soil, and can cause critical levels of soil compaction. This is due to the high ground pressure, which is around 75 kPa [3, 9].

Considering the above, we decided to improve the joint elements of the standard bogie tracks in order to:

1. Decrease the ground pressure;
2. Reduce the travel resistance factor;
3. Reduce the fuel consumption;
4. Improve the track service life;
5. Improve the maintainability.

We have reviewed the existing technical solutions in this field [6] and come to the conclusion that the most rational method for solving the task would be via the use of enclosed metal-rubber mountings inside the track (Fig. 8).

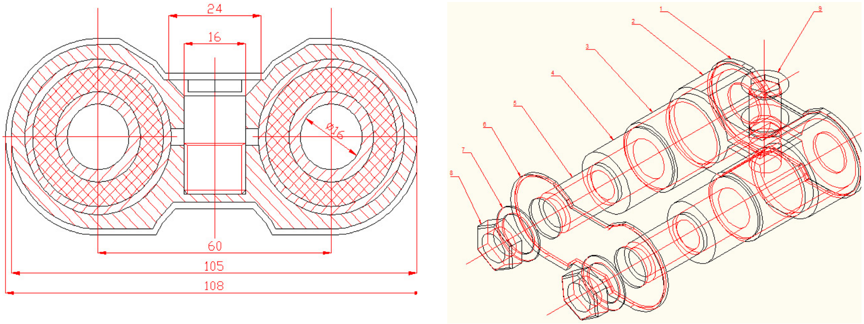



**Figure 8**. Metal-rubber mounting. 1 – rear gasket; 2 – case; 3 – metal bushing; 4 – elastic insert (rubber, grade IRP-1357); 5 – metal bushing; 6 – front gasket; 7 – washer; 8 – nut; 9 – bolt

This design is based on a silentblock (Fig. 9). The rubber bushings and guides are cured and pressed into the joint housing of the press, and then the ready joints are inserted into the links on the track.

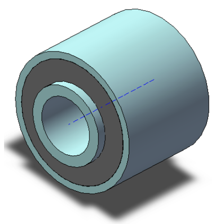


**Figure 9**. A Silentblock

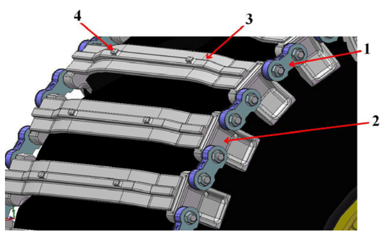



**Figure 10**. Developed bogie track. 1 – metal-rubber mounting; 2 – side support; 3 – track; 4 – grouser

Figure 10 shows a bogie track being developed.

Heavy duty operations, and operations where the wheel load varies, create extra tension for the tire bearing capacity. In such conditions the tire pressure value becomes especially important for multi-purpose vehicles [4]. In order to improve the tire strength and service life, it is necessary to follow the manufacturers' recommendations. As the inner part of the track was left unchanged, it was possible to retain the recommended tire pressure values.

Torsion and cranking resistance were also incorporated into the silentblock design order to reduce ground pressure [7]. This allowed the strength of the metal-rubber mounting to direct the track towards the contact area with the ground. In addition, this also resolves the issue of reducing travel resistance: as the contact area with the ground becomes larger, the force of metal-rubber mounting continually remains level with the contact area, and the second wheel of the balance truck can move with the least travel resistance, thus significantly improving fuel consumption.

We have manufactured and tested a prototype bogie track. These bogie tracks with the metal-rubber mountings were tested on a Ponsse Beaver timber-harvesting machine. The machine belonged to the Murashinsky logging company, which is located in the Kirov region. The testing took place from February to April of 2014.

**Table 1** gives data of the bogie track.

| Manufacturer | Track type | Tire size | Tracks tested. pc. |
|---|---|---|---|
| Olofsfors | ECO-TRACK | 600/55-26.5 | 2 |
| Developed | ECO-TRACK with metal-rubber mountings | 600/55-26.5 | 2 |

## Test Conditions

The tests were performed in winter conditions when the tire traction on the snow surface is at its lowest and must be increased by improving the running performance of the wheeled vehicles [10]. All of the winter tests were performed in air temperatures between -2 and +5°C and were carried out on three different types of terrain conditions: on virgin snow 16–25 cm deep and with density of 0.2– 0.26 g/cm$^3$, on a snow road with a pressed snow layer depth of 9–15 cm and a density of 0.45–0.51 g/cm$^3$ and on a snow-ice covered road with upper layer density of 0.64–0.66 g/cm$^3$. During the snow surface testing, the temperature was between -2.5 and +0°C. The selected routes used for the passes were horizontal and without visible inclines or rises. Due to the sparse snowfall we could not find sections of terrain with deep snow for the tests. During the tests the air and snow were measured using a graduated thermometer. Snow density was determined by taking samples with a gage glass at different points along the route. The snow was melted, after which a measuring tube was used to determine the volume of the water, and hence the weight of the snow sample.

In the spring the tests were performed on dry (W = 15–17%) and wet (W = 28–33%) loamy roads. The moisture and density of the soil were determined with a Kovalev meter.

The tests were performed by reading the pulling characteristics of the vehicle fitted with two types of bogie tracks (standard and with metal-rubber mountings) as well as without tracks. The pulling characteristics were recorded during steady trafficking along a 50 meter stretch of ground. For the tests, the tested vehicle carried an additional 2000 kg load.

The pulling loads were created by towing a K-703 tractor. The loads were measured by using a pulling strain-gage link inserted into the towing cable. Wheel spinning of the tested vehicle was determined using a sensing probe to measure the number of wheel rotations. The measured values were recorded with a decoder. The recording equipment was located in the cab of the K-703 tractor.

The tested vehicle only had tracks on the tandem dolly.

## Test Results

Following the test data processing, we plotted the pulling characteristics of the Ponsse Beaver harvester when it was fitted with the standard tracks, then with the prototype bogie tracks, and finally with no tracks at all. Figures 11, 12, 13, 14, and 15 show the results. The diagrams shown in the figures were obtained through computer analysis of the test data, and demonstrate that the averaged values of the pulling loads depended on the amount of wheel spin.

**Table 2** gives values of the grip coefficients of the vehicle when fitted with standard tracks, with the prototype tracks, and, with the tracks removed.

| **Background** | **Grip coefficient** | | |
|---|---|---|---|
| | **Experimental 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 |

It follows from the given figures that a vehicle equipped with the prototype tracks is 40–50% more efficient at pulling. The prototype bogie tracks are more efficient than the standard ones by 14–18%.

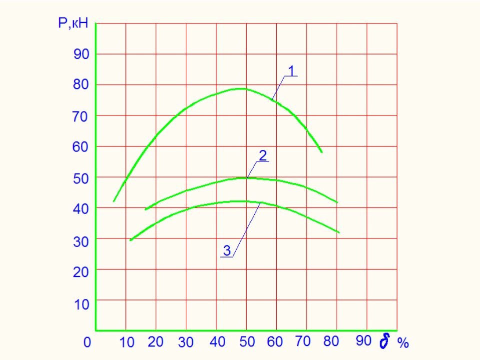



**Figure 11**. Vehicle pull depending on wheel spin (virgin snow of 16–25 cm, $\rho$ = 0.2–0.26 g/cm$^3$). 1 – with the prototyped tracks; 2 – with the Olofsfors tracks; 3 – without tracks

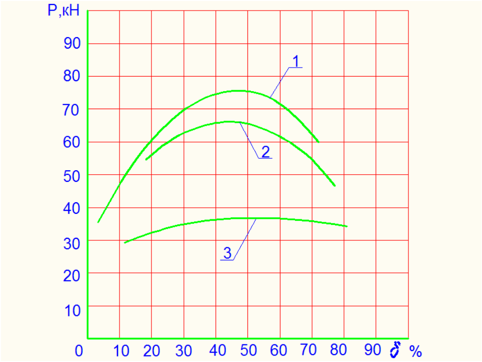



**Figure 12**. Vehicle pull depending on wheel spin (snow road of 9–25 cm, $\rho = 0.45–0.51$ g/cm$^3$). 1 – with the prototype tracks; 2 – with the Olofsfors tracks; 3 – without tracks

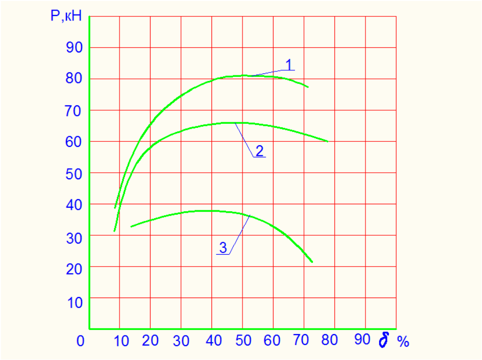



**Figure 13.** Vehicle pull depending on wheel spin (snow-iced road, $\rho = 0.64–0.66$ g/cm$^3$). 1 – with the prototype tracks; 2 – with Olofsfors tracks; 3 – without tracks.


**Figure 14**. Vehicle pull depending on wheel spin (wet loamy road). 1 – with the prototype tracks; 2 – with the Olofsfor tracks; 3 – without tracks

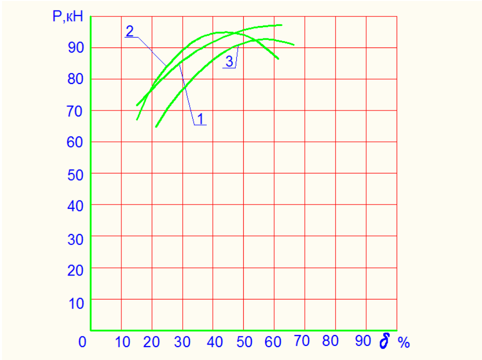



**Figure 15**. Vehicle pull depending on wheel spin (dry loamy road). 1 – with developed tracks; 2 – with tracks Olofsfors; 3 – without tracks

## Outcome

1. The use of the metal-rubber mountings for the joints of the bogie tracks makes it possible to reduce ground pressure, travel resistance, and fuel consumption, as well as improve the service life of the track, and ease its maintainability.
2. During operation on very soft soil it is necessary to use a metal-rubber mount together with tracks of special shape. These alterations will protect the soil and the subsurface cover from damage.
3. It follows from the given data that a vehicle equipped with the prototype tracks increases pulling efficiency by 40–50%. The prototype tracks are 14–18% more efficient than the standard tracks.

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