

# Designing a Tracked Running Gear of a Radio-Controlled Harvester

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**Abstract.** This work describes a model of a running gear of the designed tracked radio-controlled harvester intended for clean cutting which has been developed in the applied software package “Universal Mechanism” with use of the “Tracked Vehicles” module. It offers basic characteristics, justifies selection of variable parameters of the model. It describes modelling options of a model travel over variable irregularities, presents the obtained tractive effort torques on sprockets and loads acting on the support rollers.

## 1 Introduction

Today one of the topical issues of the forest industry is how to make harvesting equipment more capable of passing any terrain, more stable and more forest eco-friendly [1-3]. With that they shall demonstrate reasonable performance.

Soil disturbance and vibration of an operator’s workplace are the main problems. Soil becomes strongly compacted under heavy weight of the harvesting equipment (fig. 1 and fig. 2). This results in rutting that may lead to linear erosion [4-7]. Besides, strong vibration of a timber-harvesting vehicle has a negative effect on the operator’s health [8, 9].



**Fig. 1.** Skid trail during passage of a timber-harvesting vehicle.



**Fig. 2.** Skid trail after passage of a timber-harvesting vehicle.

In forest conditions the wheeled running gear is second to the tracked gear in off-road performance (fig. 3). Besides, the tracked gear inflicts less disturbance to soil [10-12]. In this regard designing radio-controlled tracked timber-harvesting vehicles is topical.



**Fig. 3.** Side-by-side comparison of off-road performance of the tracked and wheeled running gears.

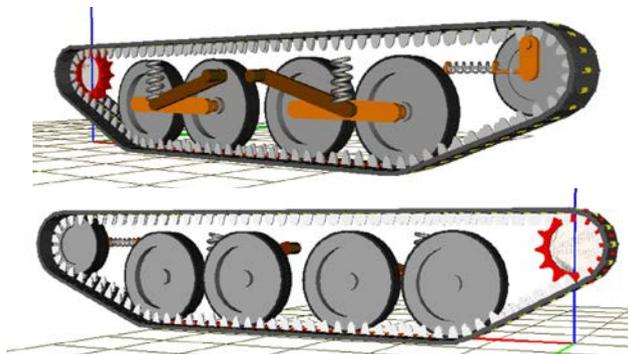
## 2 Designing a running gear

When considering different designs of the tracked running gears of the timber harvesting equipment, we became interested in the principle of operation of a running gear made by Onezhsky tractor plant as it is one of the most reliable and simple in operation (fig.4).



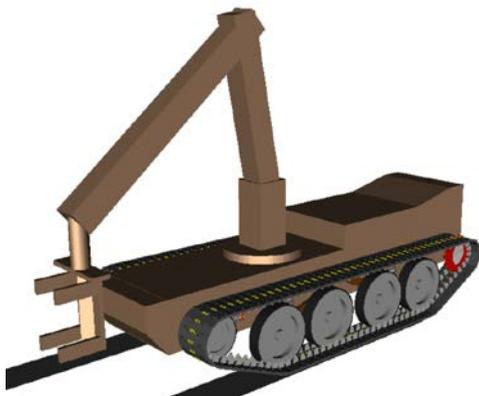
**Fig. 4.** Tractor Onezhets.

A tracked running gear of the designed radio-controlled harvester rests on the spring-lever-centerpoint suspension. It includes four bogies, two on each side of the vehicle. A bogie comprises a lever, an equalizer, a spring element and support rollers. A lever is attached by one side to the vehicle’s frame and by another side to the equalizer, two support rollers are attached to the equalizer axles. The running gear totally comprises 8 support rollers, 2 idler wheels with a spring-type tension devices, 2 driving sprockets and 2 tracks 450 mm wide. Design of a tracked running gear were presented on figure 5. The total weight of the tracked harvester is about 10 tons.



**Fig. 5.** Design of a tracked running gear.

The main results of the research are related to determining kinematics and dynamics of the tracked running gear of the radio-controlled harvester [13-17]. We have generated a 3D model of the harvester with a tracked running gear in the applied software package “Universal Mechanism” [18]. Ready for modelling simulator of a tracked radio-controlled harvester presented on figure 6.



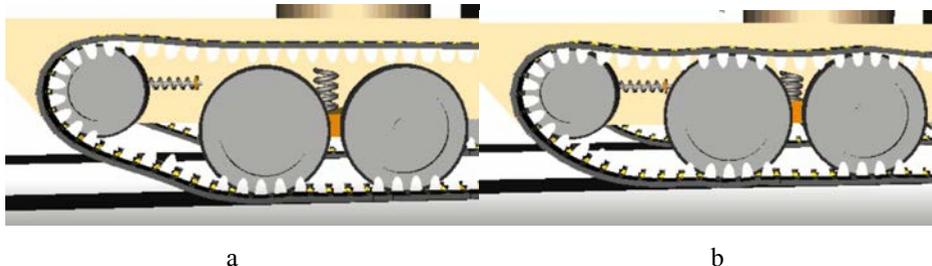
**Fig. 6.** Ready for modelling simulator of a tracked radio-controlled harvester.

### 3 Simulation modelling of a tracked harvester

A number of tests have been performed for correct experiments of travel of a tracked radio-controlled harvester model, including a balance test, a track tension test and an initial speed calculation test. They are resulted in loads acting on the running gear of the designed model as well as a model and its components position in space at the beginning of travel. This allows for maximum accurate results of the model travel research.

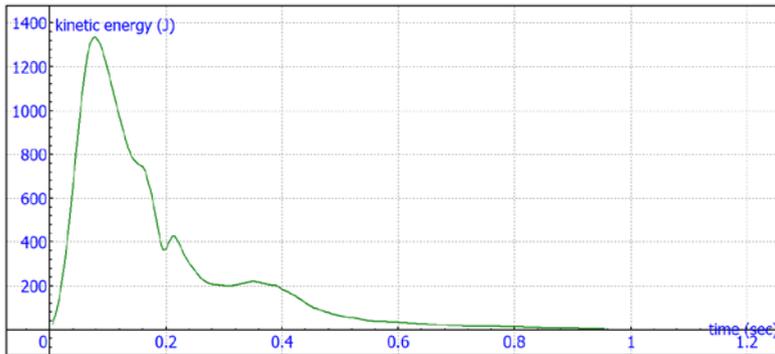
#### 3.1 A balance test

This is a test intended for eliminating transitional processes noted at the beginning of modelling due to inaccurate initial position of the model components. On figure 7 presented position of the tracked assembly components before and after a test.

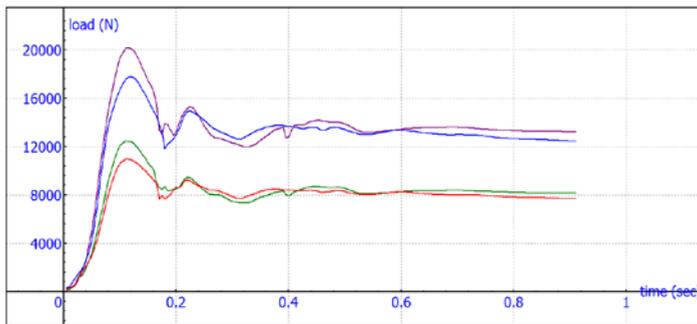


**Fig. 7.** Position of the tracked assembly components before (a) and after (b) a test.

The test results are presented graphically in figures 8 and 9.



**Fig. 8.** Drop in kinetic energy observed during a test. X-axis displays time (sec), y-axis displays total kinetic energy (J).

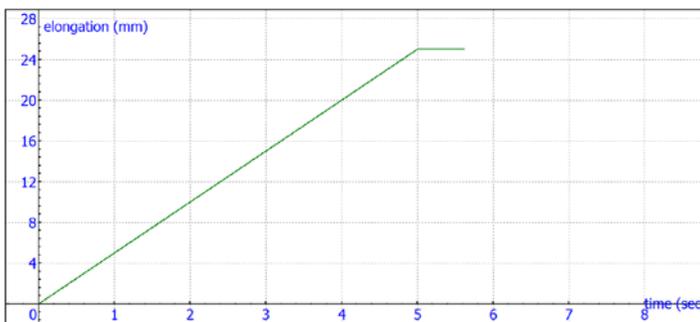


**Fig. 9.** Loads acting on support rollers observed during a test. X-axis displays time (sec), y-axis displays load (N) acting on the support rollers.

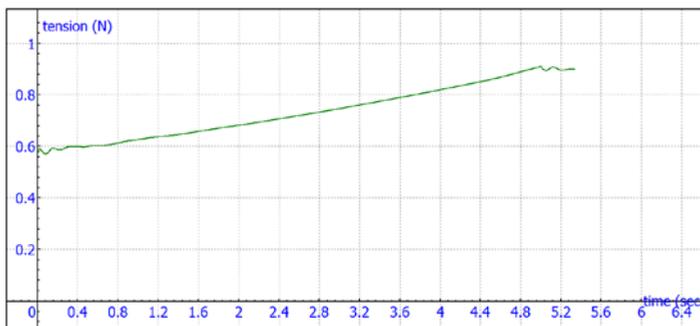
The graphs demonstrate that during the first second the transitional processes attenuate and a model takes a balanced state which was to be achieved.

### 3.2 A track tension test

This is a test intended to determine required tension of a track. Tension can be increased by elongation of a model of a tension device. The test results are presented as graphs of relationship between tension rod elongation and time (fig. 10) and between track tension force and time (fig. 11).



**Fig. 10.** Relationship between elongation of the left and right tension rods and time. X-axis displays time (sec), y-axis displays tension device elongation (mm).

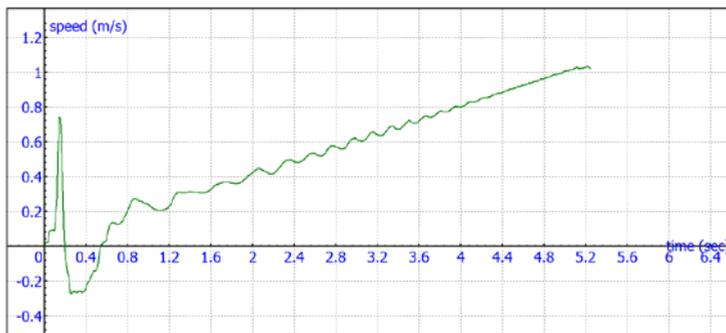


**Fig. 11.** Relationship between tension force of the LH and RH tracks and time. X-axis displays time (sec), y-axis displays track tension force (N).

The graph shows that in the course of the test the tension rod has elongated by 25 mm for 5 sec and track tension force has slightly increased.

### 3.3 An initial speed calculation test

This is a test which simulates beginning of straight travel of a model. It helps to avoid strong load jumps and torques and obtain accurate results in further model travel experiments. On figure 12 were presented relationship between speed of a left and right driving sprockets and time.



**Fig. 12.** Relationship between speed of a left and right driving sprockets (wheel) and time. X-axis displays time (sec), y-axis displays track travel speed (m/s).

The graph shows that a model accelerates to 3.6 m/s for 5 sec and a speed curve gets straightened.

## 4 Simulation modelling of a tracked harvester linear travel

In order to find capabilities of the designed model, simulation modelling of a tracked harvester travel has been done for the following cases: over sinusoidal irregularities and single irregularities which simulate travel over fallen trees [19].

Experiment conditions:

1) Vehicle speed: 3.6 km/h

Surface characteristics: sinusoidal irregularities with an amplitude of 0.2 m, wave length of 15 m and difference in wave periods of 5 m

2) Vehicle speed: 3.6 km/h

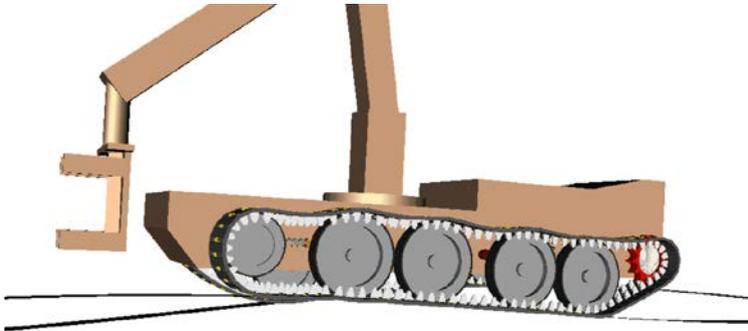
Surface characteristics: single obstacles 0.1 m, 0.2 m, 0.3 h and 0.4 m high  
3) Vehicle speed: 7.2 km/h  
Surface characteristics: single obstacles 0.1 m, 0.2 m, 0.3 m and 0.4 m high

#### 4.1 Modelling of travel over sinusoidal irregularities

Vehicle speed: 3.6 km/h

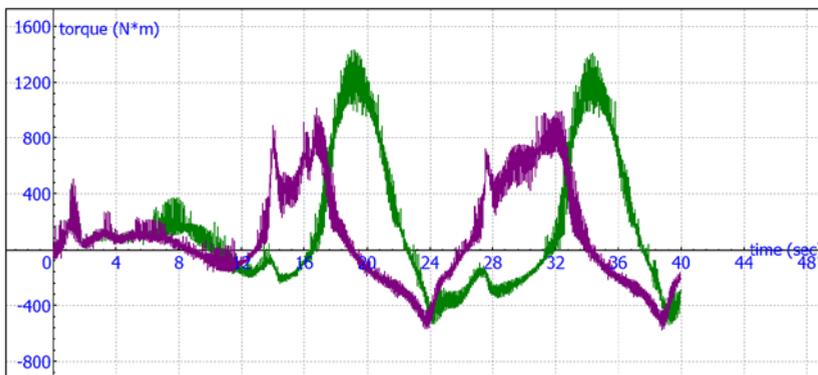
Surface characteristics: sinusoidal irregularities with an amplitude of 0.2 m, wave length of 15 m and difference in wave periods of 5 m.

On figure 13 were presented a model at travel over sinusoidal irregularities.

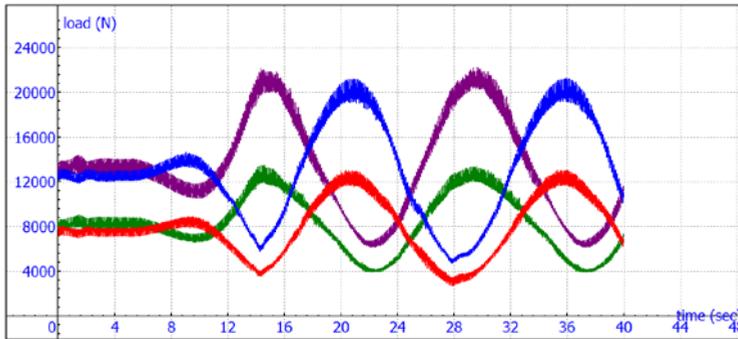


**Fig. 13.** A model at travel over preset surface.

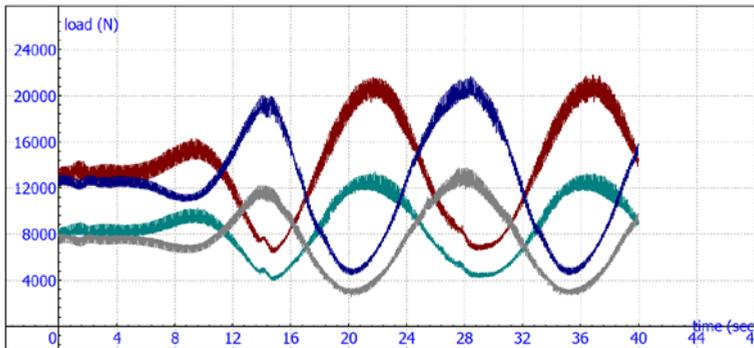
The experiment results are presented as graphs of torques occurring on the driving sprockets (fig. 14) and loads acting on the support rollers (fig. 15 and fig. 16) during a model travel over a surface with sinusoidal irregularities.



**Fig. 14.** Torques on the left and right driving sprockets. X-axis displays time (sec), y-axis displays a tractive effort torque (N\*m). Green color shows a torque on the left sprocket and purple color – on the right sprocket.



**Fig. 15.** Loads acting on support rollers of the LH track. X-axis displays time (sec), y-axis displays load (N) acting on support rollers. Green color shows loads acting on the first support roller, purple – on the second one, blue – on the third one and red – on the fourth one.



**Fig. 16.** Loads acting on a support roller of the RH track. X-axis displays time (sec), y-axis displays loads (N) acting on a support roller. Green color shows loads acting on the first support roller, red – on the second one, blue – on the third one and grey – on the fourth one.

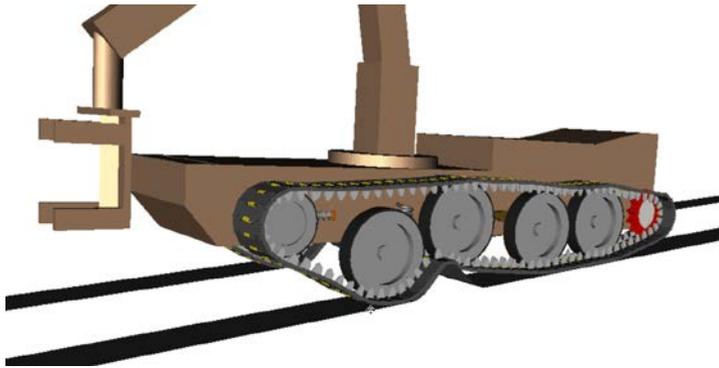
During modelling it has been found out that loads acting on the support rollers did not exceed 21.5 KN, and their average value was within 10 KN. A sprocket torque has reached 1.4 KN\*m.

## 4.2 Modelling of travel over single obstacles

During operation a timber-harvesting vehicle shall be capable of negotiating variable obstacle, including fallen trees, stubs, pits, etc. In this regard it is necessary to conduct an experiment of modelling negotiating of such obstacles.

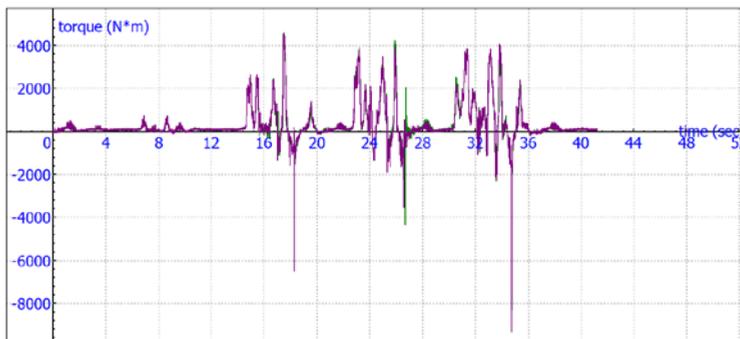
A surface with single obstacles 100 mm, 200 mm, 300 mm, and 400 mm high simulating fallen trees has been selected for this experiment. On figure 17 were presented a model at travel over single obstacles.

Case 1: vehicle speed of 3.6 km/h

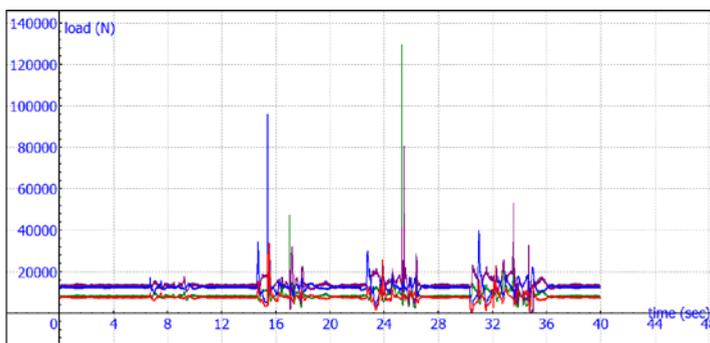


**Fig. 17.** A model during travel over preset surface.

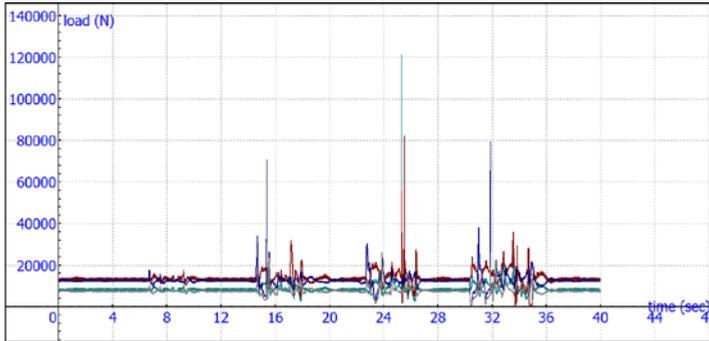
The experiment results are presented as graphs of torques occurring on the driving sprockets (fig. 18) and loads acting on the support rollers (fig. 19 and fig. 20) during a model travel over surface with single obstacles.



**Fig. 18.** Torques acting on the left and right driving sprockets. X-axis displays time (sec), y-axis displays a tractive effort torque (N\*m). Green color shows a torque on the left sprocket, purple – on the right one.



**Fig. 19.** Loads acting on the support rollers of the LH track. X-axis displays time (sec), y-axis displays loads (N) acting on the support rollers. Green color shows loads acting on the first support roller, purple – on the second one, blue – on the third one and red – on the fourth one.

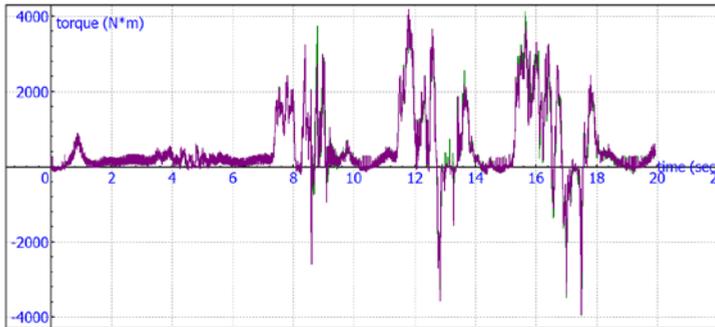


**Fig. 20.** Loads acting on the support rollers of the RH track. X-axis displays time (sec), y-axis displays loads (N) acting on the support rollers. Green color shows loads acting on the first support roller, red – on the second one, blue – on the third one and grey – on the fourth one.

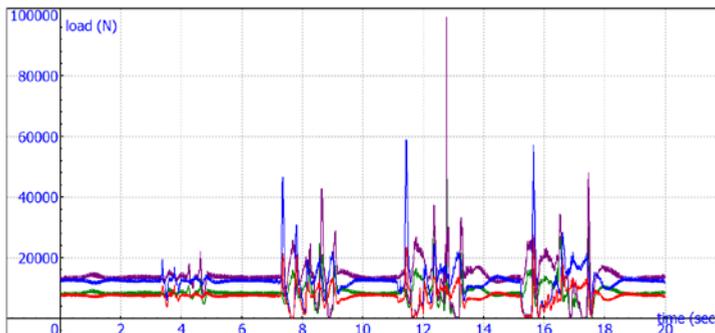
During modelling it has been found out that loads acting on the support rollers reached 35 KN in average, and their average value was within 15 KN.

Case 2: vehicle speed of 7.2 km/h

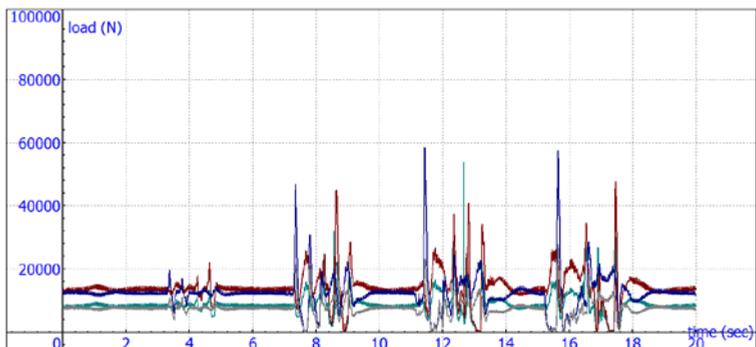
The experiment results are presented as graphs of torques occurring on the driving sprockets (fig. 21) and loads acting on the support rollers (fig. 22 and fig. 23) during a model travel over surface with single obstacles.



**Fig. 21.** Torques on the left and right driving sprockets. X-axis displays time (sec), y-axis displays a tractive effort torque (N\*m). Green color shows a torque on the left sprocket, purple – on the right one.



**Fig. 22.** Loads acting the support rollers of the LH track. X-axis displays time (sec), y-axis displays loads (N) acting on the support rollers. Green color shows loads acting on the first support roller, purple – on the second one, blue – on the third one and red – on the fourth one.



**Fig. 23.** Loads acting on the support rollers of the RH track. X-axis shows time (sec), y-axis shows loads (N) acting on the support rollers. **Green** color shows loads acting on the first support roller, **red** – on the second one, **blue** – on the third one and **grey** – on the fourth one.

During modelling it has been found out that loads acting on the support rollers reached in average 40 KN and their average value was within 18 KN.

## 5 Outcomes

The modelling has provided the results of loads acting on the support rollers at respective modes of travel, as well as speed and torques occurring on the driving sprockets, which in future will help to choose optimal transmission for a tracked harvester. The running gear model of the designed tracked radio-controlled harvester for clean cutting which has been developed in the applied software package “Universal Mechanism” with use of the “Tracked Vehicles” module has proved its efficiency through tests.

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