Modeling and Simulation of Tracked Vehicle Based on Pro/E and RecurDyn

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Abstract. The main body model of the tracked vehicle and the crawler system were established by RecurDyn/Track LM and Pro/E , and the assembly was completed in the RecurDyn environment. Using multi-body dynamics software RecurDyn with specific surface parameters for dynamic simulation, to obtain and analyze the tracked vehicle speed, drive wheel torque curve of the body's center of gravity in the vertical acceleration, judging tracked vehicle driving stability and reliability. The result will provide a reference for optimization design tracked vehicle.

Introduction

In the production of industrial and agricultural, the application of crawler vehicles is more and more widely, which is mainly used for loading and unloading, stacking, resource exploration, and short haul. On the basis of a certain road parameters, the development of a stable and reliable tracked vehicle is one of the main tasks of vehicle research.

At present, the software of the dynamic simulation of tracked vehicle is mainly ADAMS/ATV and RecurDyn, which is superior to the former, and is a new generation of multi-body dynamics analysis software. In this paper, the tracked vehicle is used as the research object, according to the design requirement, the use of low-speed track RecurDyn provide professional package (RecueDyn / Track LM) simulation working conditions of tracked vehicles on the hard roads ,obtaining the average speed and the vibration acceleration curve. The measurement results are compared with the theoretical values, and then judges the smoothness and reliability of tracked vehicles driving

Model building

The establishment of the various parts of the whole machine model. Because the whole machine subject does not have a greater influence on the simulation results, so the whole subject will be simplified. From the standpoint of modeling conveniently, this article chooses the professional 3D modeling software-----Pro / E to draw models, then exports and saves the x_t format.

Each track system of the tracked vehicle is main composed of driving wheels, idler wheels, supporting wheels, support rollers and tensioner. It applies the RecurDyn speed tracked package crawler system components and builds the accurate modeling of the various parts by adopting parametric modeling which includes a driving wheel , a supporting wheel, a support roller and a tensioner. The author completes the definition of the track shoe in the process of model building and assembling the components to complete the establishment of the entire track system. The track system consists of 39 track plates , and each track can be independently set up their own system of road parameters. In the machine model, since the right and left track system is completely symmetrical ,so it is necessary to establish the one track system and complete the establishment of the entire track system model by copying, pasting and moving . The single track system model is showed in Figure 1.

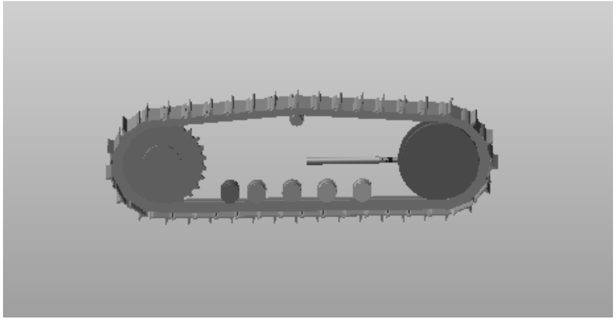

Figure 1. The single track system model

Machine assembly. The author imports the whole subject which has been saved as the x_t format into RecurDyn, then adds parameters such as the quality and moment of inertia of the vehicle body, finally completes the entire assembly of tracked vehicle model through combining the Multi-level subsystem modeling and more contact surface definition module. Machine assembly is showed in Figure 2.

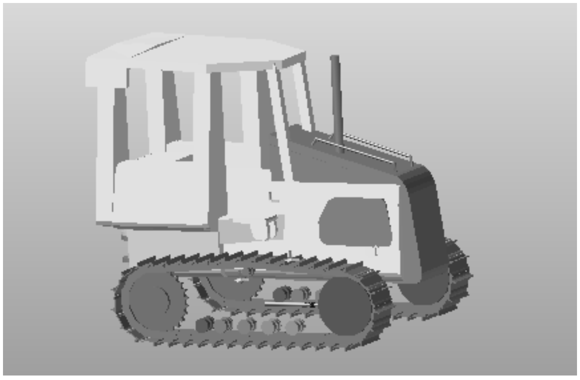

Figure 2. Machine assembly mode

Build Vehicle Dynamic Model

Add Constraints and Drivers. Adding the corresponding constraints for the driving wheel, the thrust wheel, the track roller, the inducer wheel, the tension device of the tension device. Respectively, the driving wheel,the thrust wheel, the track roller to rotate the vice link to the fixed position of the vehicle body, the inducer to rotate the pair is connected with the spring bracket, and spring bracket to translational side fixed in one position of the vehicle body. Each crawler system model consists of 8 rotating pairs, 1 fixed pairs, and 1 mobile vice. Defining the drive function (STEP (Time, t_0, y_0, t_1, y_1)) is STEP (Time, 1, 0, 3, -200D) for driving wheel, the meaning is that from t_0 moment to t_1 moment, driving wheel angular velocity from y_0 to y_1.

Set Pavement Parameters. Refer to the majority of the tracked vehicles, while considering the accuracy of the simulation data, selected hard dry ground as the crawler's crawling media, Set pavement parameters are as follows: cohesive soil deformation modulus $4.76\times10^{-4}\,N gm^{-(n+1)}$; internal friction soil deformation modulus $7.66\times10^{-4}\,s gm^{-(n+2)}$; soil deformation index 1.1; ground damping $10s/m$; cohesion $1.04\times10^{-3}\,Pa$; angle of shear resistance 28^0; shear deformation modulus 25; sinking ratio 5×10^{-2}.

Driving system calculation and simulation

Theoretical calculation. On the hard road ,the average speed of the tracked vehicle is:

$$v=\frac{120p}{10^6}(1-d)n_q r_q=4.54km/h \quad (1)$$

where n is actual driving speed, n_q is driving wheel speed, r_q is driving wheel pitch circle radius, d is vehicle conversion rate, and $d = 0.05$.

On the hard dry ground, the torque provided by the drive wheel is:

$$T = mgfr_q = 998.62 N gM \quad (2)$$

where f is rolling friction coefficient, and $f = 0.07$.

Engine torque is:

$$T_1 = \frac{T}{2ih} = 53.11 N gM \quad (3)$$

where h is transmission efficiency, and $h = 0.681$, i is transmission ratio, and $i = 13.8062$.

Simulation. During dynamic simulation, the more simulation steps in the unit time, the shorter the step size, the more close to the real results. According to the actual design requirements, the engine speed is converted into the driving wheel by the driving function, and the speed curve of the simulation is shown in Figure 3.

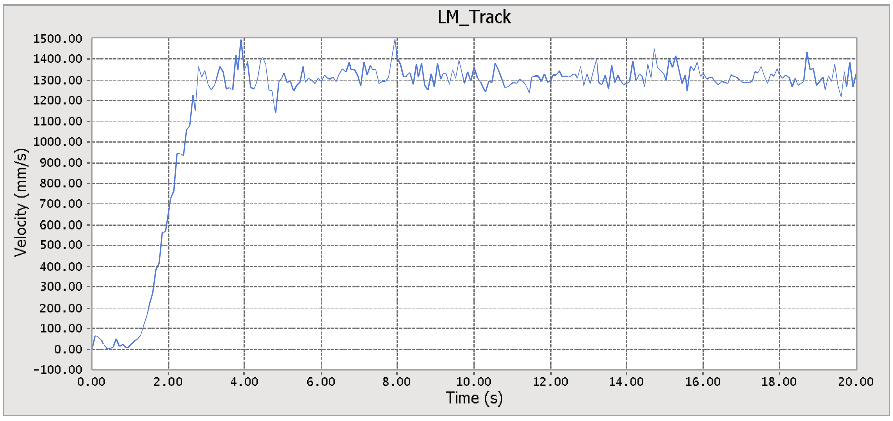

Figure 3. Hard road running speed curve

From the simulation of the speed curve can be seen, the static in 0- 1 seconds, the acceleration phase in 1-3 seconds, and after the eigth second, the presentation around the 1350mm/s, and the fluctuation range is small, with a certain periodicity, which is based on the average speed of 4.68km/h, compared with the calculated value of 4.54km/h, the error rate meet the requirements.

At the same time, it can also get the driving torque curve of the left and right wheel, as shown in Figure 4, Figure 5.

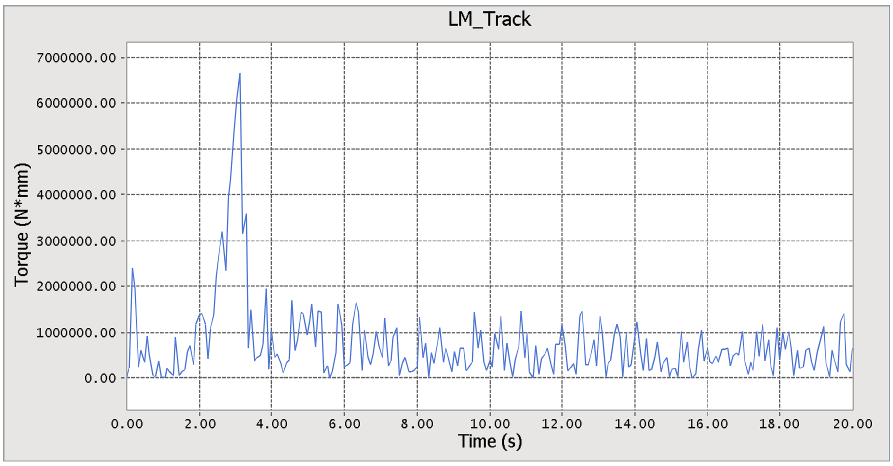

Figure 4. Drive wheel torque of the left track system

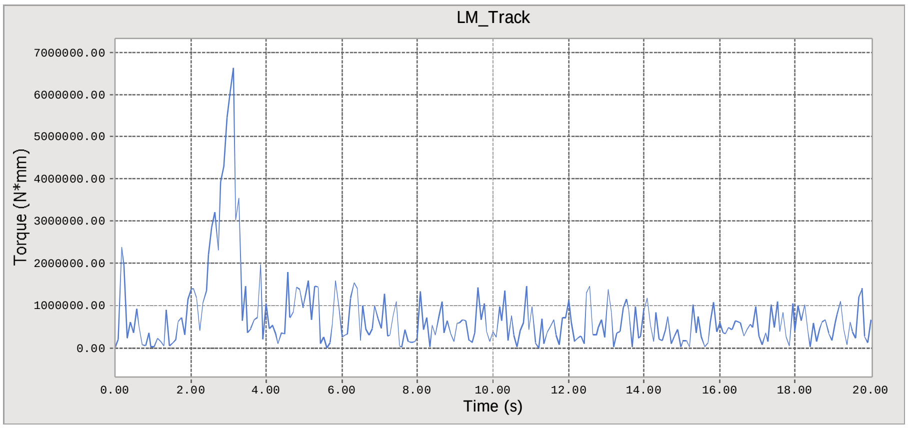

Figure 5. Drive wheel torque of the right track system

From the simulation of the left and right wheel torque curve, when the track of the vehicle is running, on both sides of the driving wheel torque is basically the same, when the vehicle starts to accelerate, the driving torque is increased, and the average drive torque of two sides of the track is about $500.5NgM$.

In order to better analyze tracked vehicle speed's ride comfort in the period of stability, the simulation gets a vibration acceleration curve in the vertical direction of the whole center of gravity in the vertical direction. As it is showed in Figure 6.

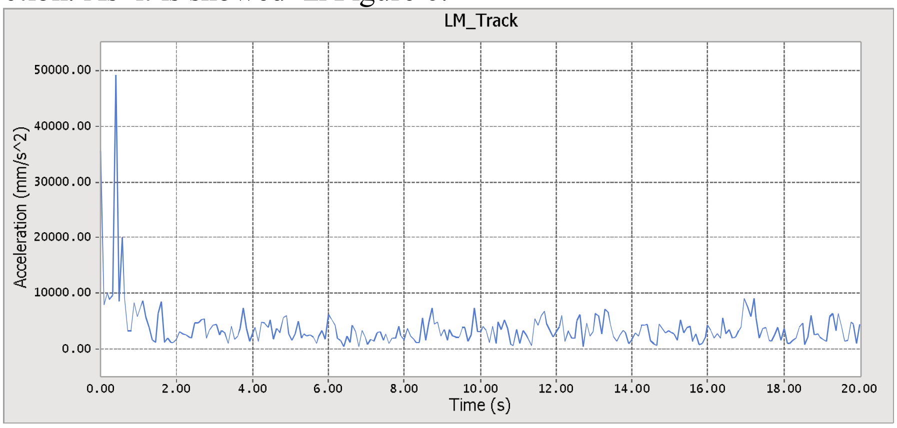

Figure 6. Vibration acceleration curve of the center of gravity in vertical direction

As can be seen from the vibration acceleration curve in the vertical direction of the whole center of gravity in the vertical direction .After driving the vehicle in a stable time, the vibration acceleration varied from 0.48*M/s* to 9.13*M/s*, and the whole process mean acceleration is 4.325*M/s* which changes as a center from top to bottom. There are two reasons about the relatively large fluctuations of the acceleration when the vehicle has just started. One is the tracked vehicle's larger instantaneous torque when it starts. Another is the assault between the track and the road is much large.

Conclusions

The article adopts the Pro / E and RecurDyn jointly to establish a simulation model tracked vehicle and corrects the theoretical values of speed travel system and driving torque. By Kinematic simulation, author obtained the following data about tracked vehicles: traveling speed on hard dry ground, driving wheel torque and a vibration acceleration curve in the vertical direction of the whole center of gravity in the vertical direction. Based on simulation results, the article concludes that the tracked vehicle can work stably but the speed curve is not entirely smooth, and the engine has met the basic requirements ,and the vibration acceleration range is more reasonable. Generally speaking, the vehicle body structure and internal transmission and other parts of the need for a better improvement. The results of theanalysis has a certain significance for carrying out further studies.

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