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Simulation on the Rollover System of Corn Harvester Based on the ADAMS

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***Abstract*—The structural characteristics of our country's corn harvester are narrow-track, high centroid and existence of eccentric distance, so rollover accident is easily to occur when going up and down the hills mountainous and hilly regions for complex terrain. In the previous paper, we introduced the Hydro-Pneumatic Suspension to prevent the roller of the harvester, and took ADAMS simulation on the left and right roller, and obtained that the use of Hydro-Pneumatic Suspension can improve the side angle of the harvester for 5°. At the same time, we continue to use the Hydro-Pneumatic Suspension as the key part of the anti-roller system of the harvester. In the uphill and downhill case of the harvester, we respectively simulated the anti-roller performance on the traditional harvester and the harvester installing the Hydro-Pneumatic Suspension. Finally, we got that the anti-roller angle of the harvester installed Hydro-Pneumatic Suspension is obviously higher than the traditional harvester, which indicates that the anti-rollover performance of the harvester installed Hydro-Pneumatic Suspension is better than the traditional harvester. The data obtained from this experiment will provide technical support for the following structure optimization of the harvester.**

Keywords-harvester; rollover; hydro-pneumatic suspension; ADAMS simulation

I. INTRODUCTION

In the Northwest Mountainous and hilly areas of our country, for the mechanized production mode has not been popularized in large areas, the cost of corn of our country is lack of competitiveness in the international market. At the same time, the design and research work of corn harvester in the domestic is mostly concentrated in the harvest and the peeling efficiency, while the research of anti-roller of harvesters is rarely involved [1]. In the process of our country continuing to popularize the corn harvesters, for the complex terrain and the structural characteristics of our country's corn harvester are narrow-track, high centroid, the unbalance load of front and rear wheel and the poor steering stability, the corn harvester is easily to roll, leading to the casualties and other major economic losses.

The studies about the anti-roller stability of corn harvester at home and abroad are less. There are only a few models such as New Holland CSX7050 mountain style harvester etc. using automatic leveling to realize the anti-roller of the harvester. But the studies on the anti-roller are more, such as the study on the dynamic rollover stability, such as Gibson et al took articulated vehicle as the research object, studying their roller performance when they driving on the slop with low speed, obtaining the slope angle of the vehicle rolling with different articulated steering angle [2] in the condition of steering on ramp. A.J. Novak etc. established the dynamic model of the semi-trailer, by changing the parameters of performance, simulating and analyzing its roll stability in the different working conditions [3].

Whether Dr. Du Yuefeng, China Agricultural University, or Liu Ning, Taiyuan University of Technology realized the anti-roller through optimizing the structure based on the traditional harvester, but it can only increase very small roll angle and it is difficult to fundamentally solve the problem of anti-rollover harvester. In terms of the anti-roller of the Hydro-Pneumatic Suspension, Jia Huixing studied the the roller stability of the Hydro-Pneumatic Suspension construction vehicles, and found that the peak value of the LTR of the the Hydro-Pneumatic Suspension is 0.45, the peak value of LTR of leaf-spring suspension system is 0.52. The peak value of the LTR of leaf-spring suspension system is higher about 15.6% than the peak value of the LTR of the the Hydro-Pneumatic Suspension. From that we can see the steering roller stability of the Hydro-Pneumatic Suspension is better than it of the leaf-spring suspension system [6]. Deng Zhaoxiang [7] inferred the expression of the vertical stiffness and roll stiffness of the left and right interconnected type Hydro-Pneumatic Suspension in the roll plane and gave the design method of this kind of the Hydro-Pneumatic Suspension.

On the basis of applying the Hydro-Pneumatic Suspension into the anti-roller of the harvester, this paper established the virtual prototype of the harvester based on the Hydro-Pneumatic Suspension by using ADAMS, and established the experiment platform at the same time to simulate the climbing, downhill of the harvester and the auto-turning of the Hydro-Pneumatic Suspension, to verify the influence of the Hydro-Pneumatic Suspension on the anti-roller of the harvester by simulating and measuring the roll angle of the harvester in different condition and provide technical support for structural optimization of the following harvester.

II. CHASSIS STRUCTURE DESIGN OF CORN HARVESTER BASED ON HYDRO-PNEUMATIC SUSPENSION

The author of this paper mentioned that this harvester applied front-wheel drive, rear wheel steering, and Hydro-Pneumatic Suspension technology, connecting the front axle, rear axle by using the hydraulic cylinder of Hydro-Pneumatic Suspension, and using the hinge joint in the connection joint [8]. The angle sensor is used to measure the heeling angle of the corn harvester, and the control system can adjust the balance of the whole body by controlling the expansion of the hydraulic cylinder. At the same time, between the front and rear axle and frame, adding lateral rod and longitudinal rod to limit the relative movement of the axle and frame in the vertical and horizontal direction. According to the latest study found that Hydro-Pneumatic Suspension movement between the frame and axles, engine and transmission when connected via a belt, belt tension will lead to change at any time, it does not work, so harvester Hydro-Pneumatic Suspension based on the use of hydrostatic drive, connected to the engine variable pump, the mechanical energy is converted into hydraulic energy, variable pump after adjusting device is connected to the quantitative motor through hydraulic tubing, the motor connected to the gearbox, will be an excellent solution to belt conveyor tension changes in real time problem by pipeline transport energy .

III. THE SIMULATION OF THE ROLL STABILITY BASED ON THE ADAMS

A. *The Climbing of the Harvester*

This paper used ADAMS to take dynamics simulation on the anti-roller system based on the Hydro-Pneumatic Suspension, and used Solideworks to establish the model of components and parts and assemble, and completed the assemblage of the vehicle, and then imported it in Adams-View. For the virtual prototype simulation of the vehicle, the model as shown in the following Figure 1.

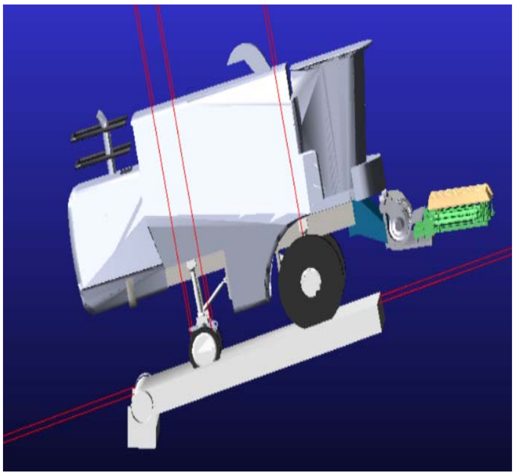

FIGURE I. THE SIMULATION OF THE CLIMBING OF THE CORN HARVESTER

In the course of ADAMS simulation, to simulate the roller angle of the actual condition, we established the roller test-bed model which can take flip horizontal, just as shown in Figure 1. Adding revolute joints to one side of the test-bed and ensuring that the axis of the revolute joints coincides with the sideline of the test-bed, which can make the test-bed rotate around its side; To make the test-bed rotate in a certain angular velocity uniformly, the rotation driving law we added the roll platform is 2.0d*time, the harvester inclined to rollover without other external influence, and the measured angle of the roll platform is the maximum stable roll angle [10]. It must be noted that in order to prevent the corn harvester sliding in roll platform, when we set to let the four wheels contact with the test-bed, for the Friction Force, we used coulometry, and set the static coefficient of 2, increasing the friction to prevent the sideslip, and at the same time, gave smaller drive to the four wheels along the forward direction. Finally, we measured the rollover time of the corn harvester by measuring the contact force between the four wheels and roll platform, and then we obtained the roll angle of the corn harvester.

The above is the simulation process of traditional corn harvester. In the simulation process of the anti-roller ability of corn harvester based on Hydro-Pneumatic Suspension, and in the flipping process of the roll test platform, we provided driving to the Hydro-Pneumatic Suspension. When the sensor measured the horizontal angle of corn harvester, the Hydro-Pneumatic Suspension automatically level to adjust the centroid of the corn harvester and make the corn harvester be in stable. We can solve the roll problem of corn harvester fundamentally by setting the collapsing length of the suspension hydraulic cylinder. In this paper, we set that the stretched out and drew back length of being harvester 10.0mm to test its anti-rollover performance.

Figure 2 is the change of the contact force when the traditional harvester on the roll platform, Figure 3 is the change of the contact force after automatically leveling by using the Hydro-Pneumatic Suspension. The four lines in the figure, the solid red line from top to bottom represents the contact force of the left front wheel along the forward direction of the harvester, light blue dashed line represents the contact force of the left rear wheel along the forward direction of the harvester, the red dotted line represents the contact force of the right front wheel along the forward direction of the harvester, and the last dark blue dotted lines represents the contact force of the right rear wheel along the forward direction of the harvester.

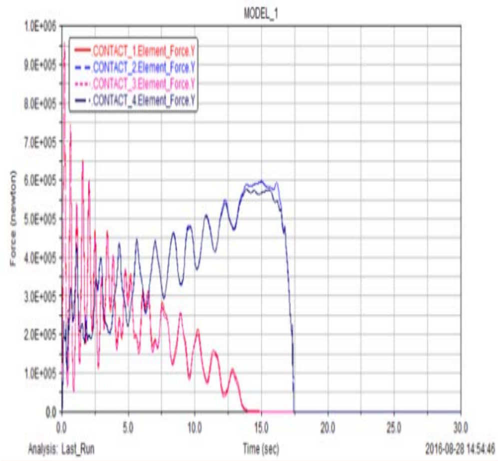

FIGURE II. THE CHANGE OF EACH WHEEL OF THE TRADITIONAL HARVESTER

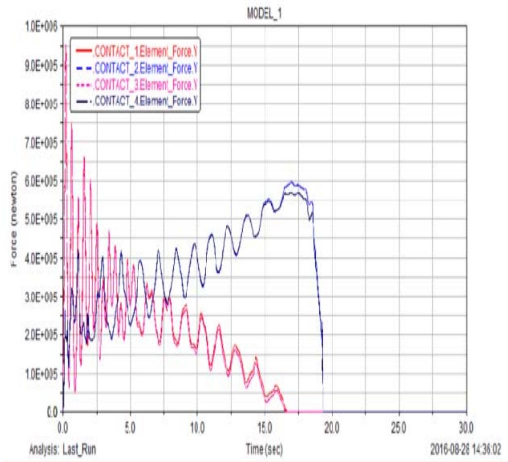

FIGURE III. THE CHANGE OF EACH WHEEL AFTER USING THE HYDRO-PNEUMATIC SUSPENSION

From Figure 2 and 3 can be seen, in 14.25s, namely the rotating platform turning to 28.5 degrees, the front wheels on both sides left the rolling platform, the traditional harvester began to roll; while the front wheels on both sides of the harvester installed the Hydro-Pneumatic Suspension left the rolling platform in 16.75s, namely the rotating platform turning to 33.5 degrees. This proved that the Hydro-Pneumatic Suspension greatly improved the rollover stability of harvester in climbing.

B. The Downhill of the Harvester

Let the roll platform make reverse drive by using the simulation method described above, then the driving suspension cylinder automatically leveling, and finally, in order to prevent the harvester slipping, we provided the anti-driving of climbing to four wheels. For Function (time), we used -2.0d*time to respectively simulate the roller of the traditional harvester and the harvester installed the Hydro-Pneumatic Suspension with the automatically leveling function, the model being shown in Figure 4.

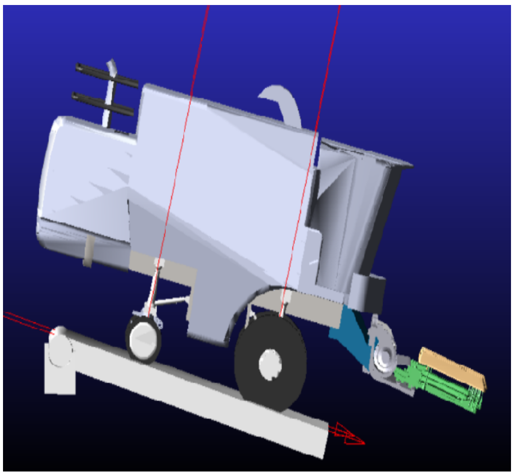

FIGURE IV. THE SIMULATION OF THE DOWNHILL OF CORN HARVESTER

Figure 5 is the change of the contact force when the traditional harvester on the roll platform when it go downhill, Figure 6 is the change of the contact force of harvester after automatically leveling by using the Hydro-Pneumatic Suspension. In Figure 5 and 6, the contact force the four lines represent is same with climbing, in the frame, the solid red line from top to bottom represents the contact force of the left front wheel along the forward direction of the harvester, light blue dashed line represents the contact force of the left rear wheel along the forward direction of the harvester, the red dotted line represents the contact force of the right front wheel along the forward direction of the harvester, and the last dark blue dotted lines represents the contact force of the right rear wheel along the forward direction of the harvester.

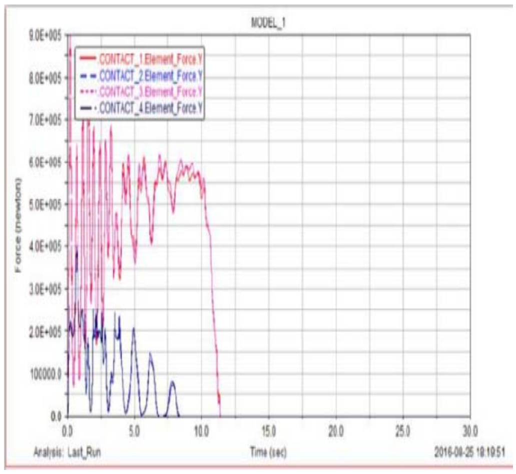

FIGURE V. THE CHANGE OF EACH WHEEL WHEN THE TRADITIONAL HARVESTER GOING DOWNHILL

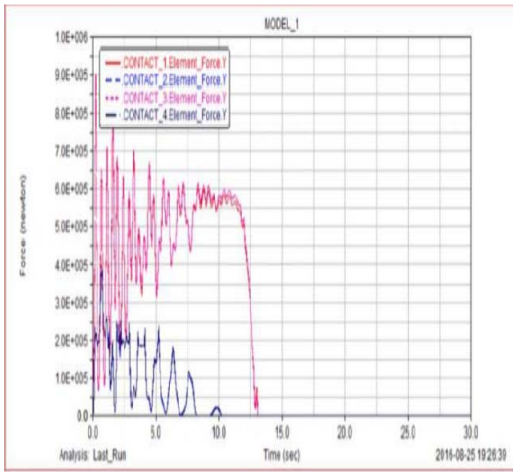

FIGURE VI. THE CHANGE OF EACH WHEEL AFTER USING THE HYDRO-PNEUMATIC SUSPENSION WHEN THE TRADITIONAL HARVESTER GOING DOWNHILL

From Figure 5 and 6 can be seen, when going downhill, in 8s, namely the rotating platform turning to 16 degrees, the rear wheels on both sides left the rolling platform, the traditional harvester began to roll; while the rear wheels on both sides of the harvester installed the Hydro-Pneumatic Suspension left the rolling platform in 10s, namely the rotating platform turning to

20 degrees when going downhill. When going downhill, for the engine, tanker, header are all in the front, the roll angle is less than it in climbing. In future research, this problem still needs to be further optimized, and we will install the engine and the tanker in the front as far as possible. From Figure 5 and 6 we can see, although the influence of the Hydro-Pneumatic Suspension on the roll stability is less when the harvester going downhill, it played the role of anti-roller.

IV. CONCLUSION

This paper simulated the climbing, downhill of the harvester by ADAMS, and respectively compared the anti-roller ability of the traditional harvester and the harvester installed the Hydro-Pneumatic Suspension, and obtained that the anti-roller performance of the harvester installed the Hydro-Pneumatic Suspension is obviously better than the traditional harvester, and measured the roll angle in different condition to provide technical support for the study of the anti-roller of the harvester and the structural optimization of the harvester.

ACKNOWLEDGEMENT

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