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Structural Design and Simulation of Torsion-free-body of Petroleum Tanker

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Abstract: The mobility and security of petroleum tanker is influenced directly by the effect of the fixation between the chassis and truck tank. The butt-joint technology of the chassis and the truck petroleum tank is studied in this study and one new torsion-free-body is designed. The 3D model of the torsion-free-body is established by Pro/E and imported into ADAMS and the dynamic simulation analysis of the complex stress point of the torsion-free-body is done by ADAMS, the new torsion-free-body of truck tanker by rebuilding chassis is tested, experiment results show that its effect of reducing torque is very good.

Key words: Petroleum tanker, design, simulation, torsion-free-body

INTRODUCTION

Truck metal tank, operation cabin and other special equipments are fixed on the chassis frame through a certain way, the effect of the fixation between the chassis and truck tank will directly affect truck mobility and security. At present, the traditional method of connecting truck metal tank and the chassis is using "U" shape bolt or bolt connecting plate and they are rigid connection. Although its surface is connected by rubber pad or cushion wood, the damping capacity is insufficient, the chassis and the upper equipment fixed in form a rigid whole. When the truck drive on field road, the major torque force and vibration of the chassis can be directly transferred to petroleum tank, petroleum tank also constrains normal free distortion of the chassis and increases the stress of the chassis girder, which can decrease the life time of the whole truck tanker because of the fatigue failure in the petroleum tank and the chassis (Li and Feng, 2007). The stability and mobility of the truck are affected badly because the center of gravity of petroleum tank offset large distance and the centrifugal force is great while the truck bump on the field road. To solve this problem, the new technology of connecting the petroleum tank and the chassis is studied in this article (Tong *et al*., 2008), a novel torsion-free-body is designed and the effect of the torsion-free-body is simulated and tested.

STRUCTURE AND WORKING PRINCIPLE

The novel torsion-free-body between truck metal tank and the chassis is shown in Fig. 1. The torsion-free-body is a modularization unit which can be directly mounted on the truck chassis (as shown in Fig. 2). The connection between the petroleum tank and the chassis is flexible with the torsion-free-body (Liu, 2002), which can overcome the shortcoming of the traditional structure of the rigid connection, increase the period of the truck on condition of bumping, improve the reliability and the

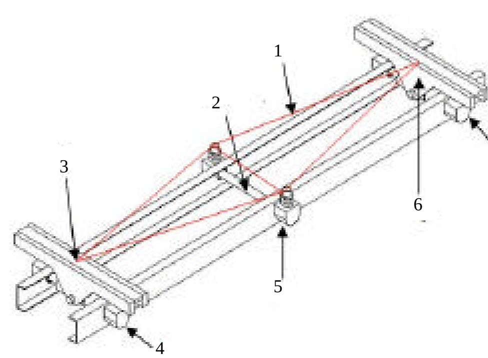

Fig. 1: Torsion-free-body between petroleum tank and chassis, (1) Longitudinal beam, (2) Middle cross beam, (3) Front tank seat, (4) Front composite cross beam, (5) Middle tank seat, (6) Rear tank seat and (7) Rear composite cross beam

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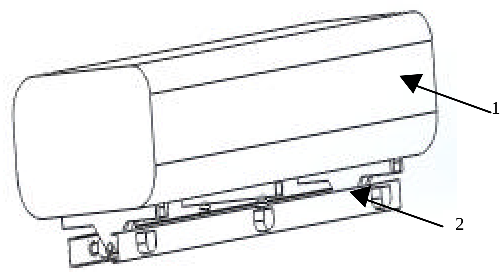

Fig. 2: Chart connecting torsion-free-body with petroleum tank, (1) Petroleum tank (2) Torsion-free-body

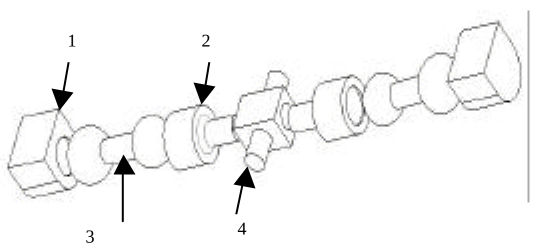

Fig. 3: Structural chart for front beam of torsion-free-body, (1) Spherical sleeve seat, (2) Sperical sleeve shaft, (3) Double spherical shaft and (4) Cylindrical sleeve

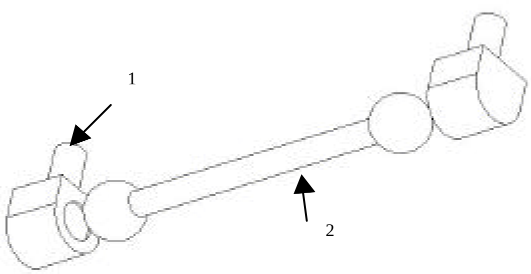

Fig. 4: Structural chart for middle beam of torsion-free-body tank, (1) Spherical and cylindrical sleeve shaft (2) Double spherical-head shaft

security of the petroleum tanker, realize the high efficiency and reliable connection between the petroleum tank and the chassis.

The device is composed of two longitudinal beams and three cross beams, longitudinal beam is made of high strength channel steel, three cross beams are distributed on two longitudinal beams, the front cross beam and the back cross beam (as shown in Fig. 3) is composed of spherical sleeve seat, spherical sleeve shaft, double spherical shaft and cylindrical sleeve ,which can be distorted and telescopic assembled cross beam. There are two cylindrical pins in the side of cylindrical sleeve, which is connected with middle supporting seat in the front and rear of petroleum tank bottom, The two cylinder pins of the middle cross beam are connected with left and right supporting seat in the middle of petroleum tank bottom. Double triangle connection supporting structure (2×3 point type) form between torsion-free-body and the truck petroleum tank (as shown in Fig. 1). When the truck chassis twist, the two longitudinal beams can also correspondingly distort, but the torque is not transferred to the truck petroleum tank, so that the truck petroleum tank can keep in horizontal position, not generating distortion and deformation. Middle cross beam (as shown in Fig. 4) consists of spherical and cylindrical sleeve shaft and double spherical shaft, when the two longitudinal beams distort, the double spherical shaft does not distort.

SIMULATION

The 3D solid model of the torsion-free-body is build in Pro/E, the assembled model is saved as parasoloid (.x_t) type and is imported in ADMAMS/View (Li, 2006). The material is chosen as carbon steel. Spherical hinge pair is built between the spherical sleeve and the double spherical-head shaft in every assembled cross beam, spherical hinge pair is built between spherical sleeve shaft and double spherical-head shaft in front and rear assembled cross beam, cylindrical pair is built between cylindrical sleeve and spherical sleeve shaft in front and rear assembled cross beam (Yu and Cao, 2003), fixing pair is built between the middle transom double spherical sleeve axis and the ground and the other related associate simulation parameters are set. In order to simulate the structure stress of the torsion-free-body (Li and Tian, 2011), ten thousand Newton force is exerted on both sides of the longitudinal beam toward Y direction (vertical direction from the ground), associate simulation parameters are set and the simulation analysis is done on the spherical hinge point MARKER_67 between the spherical sleeve and double spherical-head shaft. Because the stress of the cross beam connected with the longitudinal beam is more complex. Therefore, hinge point MARKER_45 which hinges the front cross beam seat and longitudinal beam, hinge point MARKER_57 which hinges spherical sleeve shaft and tank seat, the hinge point MARKER_76 which hinges spherical-head sleeve shaft and double spherical-head shaft and the hinge point MARKER_77 which hinges the cross beam seat and double spherical-head shaft is simulated, from Fig. 5, we can see the maximum displacement of the longitudinal beam front hinge point MARKER_67 is 14.25 mm, stress and torque is large in the hinge point between front beam seat and longitudinal beam from Fig. 6 and 7, but this place does not touch the petroleum tank, therefore the

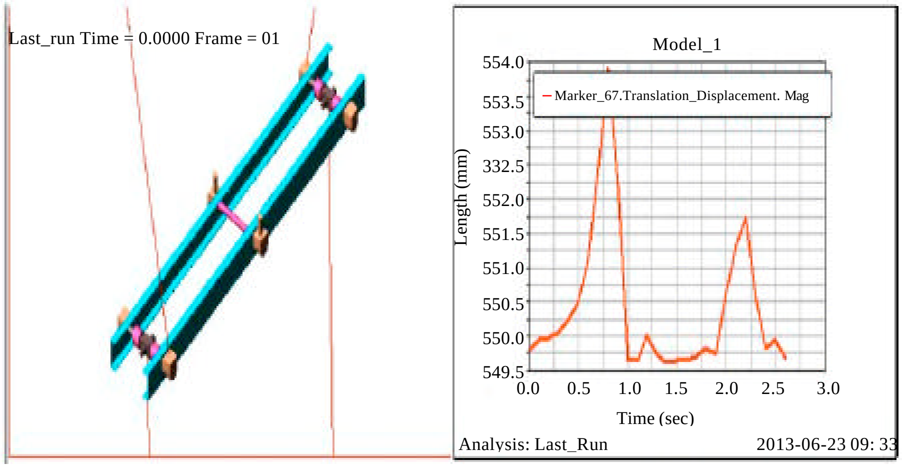

Fig. 5: Displacement chart of hinge joint MARKER_67

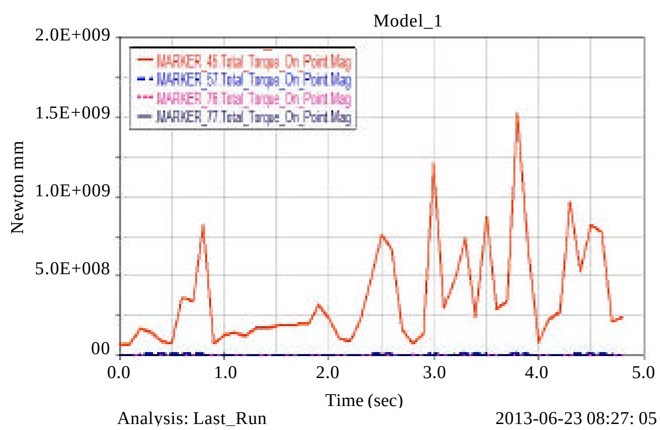

Fig. 6: Torque chart of hinge joint MARKER_45, 57, 76, 77

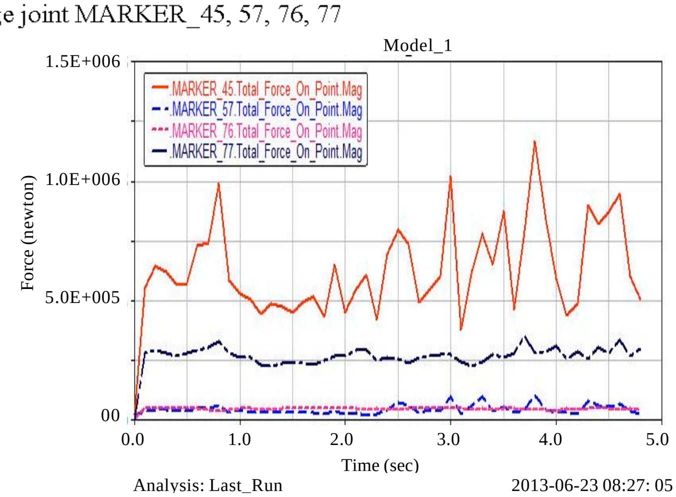

Fig. 7: Force chart of hinge joint MARKER_45, 57, 76, 77

torque will not be transmitted to the tank. The above simulation analysis shows that the torsion-free-body can reduce stress and torque between the truck petroleum tank and the chassis frame, but the structural strength in

Fig. 8: Test of torsion-free-body of 5 tons petroleum tanker

Fig. 9: Test of torsion-free-body of 7 tons petroleum tanker

the place which hinges the front and rear cross beam seat and longitudinal beam should be increased.

EXPERIMENT

Novel torsion-free-body of truck petroleum tanker modified with 7 tons truck chassis and 5 tons truck chassis is tested (as shown in Fig. 8). When the longitudinal beam of chassis twists no more than10 degrees the torque will not be transmitted to petroleum tank, therefore, when the chassis twists the truck tank can maintain in the basic horizontal plane. The experiment indicates the novel torsion-free-body is effective and feasible.

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