Truck Overloading Monitoring System Based on Beidou Vehicle Network System

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***Abstract* — Truck overloading monitoring system is realized by the truck load information using dynamic measurement networked with vehicle Beidou compatible terminal. The weight measurement is not accurate when the truck is on the downhill. This problem is solved by using the six axis gyro to measure the angle between vehicle and ground. Also, the truck operational weight measurement is not accurate, and this problem can be solved by measuring the truck vibration cycle of each time in the process of the truck running, and using the arithmetic mean method. The experimental results show that the measurement accuracy of truck load is within ± 2%.**

Keywords - Beidou vehicle networking; Six axis gyro

I. INTRODUCTION

In many countries, phenomenon of road vehicles overloading are common in the process of goods transportation. Overload seriously endanger traffic safety, disrupt the normal order of transportation, caused by environmental pollution. Overload detection existing mainly in three ways: fixed detection point detection, motion detection, vehicle dynamic detection.

To September 2015, China has successfully launched 20 Beidou navigation satellites, Beidou satellite navigation systems are becoming more and more mature, and the Ministry of transport regulations heavy cargo trucks mandatory install Beidou compatible vehicle terminal for the effective management of the overload phenomenon provides a good opportunity. Truck overloading monitoring system can be realized by the truck load information by dynamic measurement networked with vehicle Beidou compatible terminal. Itachieve real-time monitoring, and it can solve the truck overloading, speeding and other issues.

II. THE PRINCIPLE OF DYNAMIC WEIGHING OVERLOAD MONITORING

Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times. Avoid using bit-mapped fonts if possible. True-Type 1 or Open Type fonts are preferred. Please embed symbol fonts, as well, for math, etc.

Heavy-duty vehicles are divided into static and dynamic load to each of these two forms of payload analysis to arrive at a more reasonable calculation basis.

A. Static load analysis

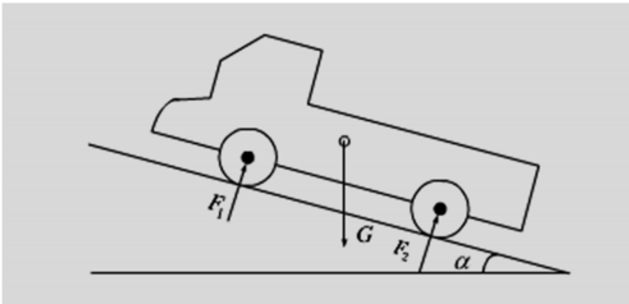

Figure 1. A Schematic View of A Static Car

Mechanics was established equation:

$$F_1 + F_2 = G\cos\alpha \qquad (1)$$

Wherein F_1----Vehicle axle vertical load（N）；
F_2----Vehicle rear axle vertical load（N）；
G----Vehicle rear axle vertical load（N）；

Two front axle leaf spring disposed about a vertical load of F_{11}andF_{12}, the vertical load of the rear axle leaf spring for about two F_{21}andF_{22}, the two leaf springs front and rear vertical load is expressed as

$$F_1 = F_{11} + F_{12} \qquad (2)$$
$$F_2 = F_{21} + F_{22} \qquad (3)$$

The relationship between the leaf spring on each group of formula (2) and (3) can be obtained gross vehicle load and the vehicle can be expressed as:

$$G = \frac{F_{11}+F_{12}+F_{21}+F_{22}}{\cos\alpha} \qquad (4)$$

By the above formula (4) shows that the measured values of the leaf spring in each group to determine a total load of the vehicle.

B. *Steel spring load analysis and calculation*

Relations with the leaf spring vertical surface strain deformation between the leaf spring is known:

$$\varepsilon = \frac{6\Delta x h}{l^2} \qquad (5)$$

Wherein ε----- Leaf spring surface strain

Δx---- Leaf spring vertical deformation（mm）;

h------ The thickness of the leaf spring（mm）;

l-------Span leaf spring moment（mm）。

In（5）,Leaf spring surface strain ε can be installed in leaf spring strain gauge sensor resistance measured vertical deformation of the leaf spring is:

$$\Delta x = \frac{\varepsilon l^2}{6h} \qquad (6)$$

Suppose the vehicle is stationary and the vehicle is in a stable state, then the suspension system may be a single set of modeling, as shown in picture 2.

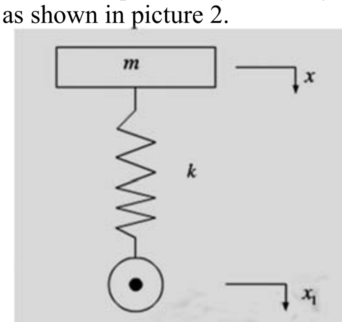

Figure 2. single-arm suspension system model diagram

The figure above m-----Leaf springs sprung mass（kg）;

k------Leaf spring stiffness (N/mm)

x------Sprung mass center of mass displacement (mm):

x_1---- Tire deformation（mm）。

According to Newton's second law can be obtained:

$$\mathrm{k}(\mathrm{x} - x_1) = \mathrm{mg} \qquad (7)$$

Which is:

$$\Delta\mathrm{x} = (\mathrm{x} - x_1) = \frac{mg}{k} \qquad (8)$$

Merge（6）and（8):

$$\mathrm{m} = \frac{l^2 k}{6hg} \qquad (9)$$

Because one kind of leaf spring moment span, stiffness and thickness can be approximated that fixed, so set the sprung mass correlation coefficient$\beta = (l^2)/(6\mathrm{hg})$, So the formula (9) can be simplified as:

$$\mathrm{m} = \beta\varepsilon \qquad (10)$$

Therefore:

$$G = \frac{F_{11}+F_{12}+F_{21}+F_{22}}{\cos\alpha} = \frac{\mathrm{m}_{11}+m_{12}+m_{21}+m_{22}}{\cos\alpha} g = \beta\frac{\varepsilon_{11}+\varepsilon_{12}+\varepsilon_{21}+\varepsilon_{22}}{\cos\alpha} g = l^2\frac{\varepsilon_{11}+\varepsilon_{12}+\varepsilon_{21}+\varepsilon_{22}}{6\mathrm{h}\cos\alpha} \qquad (11)$$

C. *Dynamic load analysis*

Causing the displacement of the road in the direction of the vehicle is mainly vertical vibration of the vehicle, causing the vehicle vibration factor is a vibration of the vehicle itself, the other is a vehicle during vehicle vibration due to road bumps caused. Vehicle vibration of the vehicle to obtain the actual load, the error caused by the vibration of the vehicle should eliminate the amount of load can be effectively. The method used to eliminate vibration axis gyro 6 is measured vibration acceleration, vibration and find the cycle, to obtain the real weight measurement method using the arithmetic mean.

Another issue is the impact of dynamic load measurement vehicle is uphill, downhill measured weight is not accurate. 6-axis acceleration sensor measures acceleration, angular velocity value of the vehicle is running, the algorithm handled by measuring the state of the vehicle body inclination angle α, angle compensation can be obtained by real-time load information.

III. THE SYSTEM HARDWARE

A. *Overall system architecture*

Compass vehicle networking based on real-time monitoring system overloaded trucks, including truck overload detection terminal 4 suspension load detecting CAN node, the owner of the terminal composition. And the terminal transmits data by detecting overloaded truck terminal Beidou-compatible modules or by car to the distance monitoring platform. The particular arrangement shown in Figure 3.

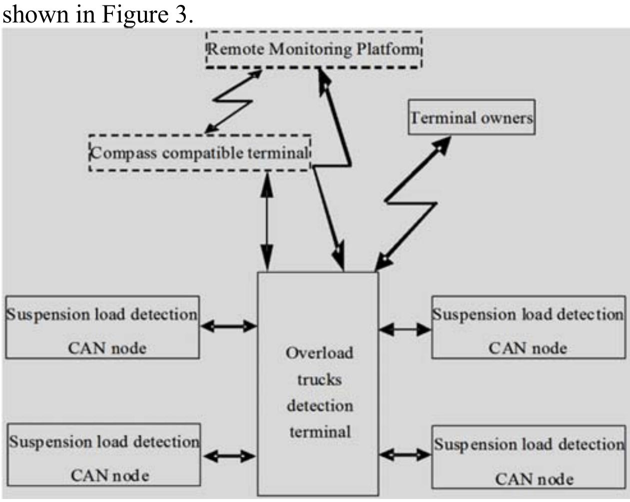

Figure 3. overall system configuration diagram

B. *Truck overloading detected termination structure*

Overload detection terminal trucks, including vans master controller -GPS Compass module, 2 CAN transceiver module, power module, sound and light alarm module, LCD display module, Beidou -GPS module, 2 CAN transceiver module, power module, sound and light alarm module, liquid crystal display modules are directly connected to the main controller, overload detection truck terminal with cAN-bus communication function, and can be Beidou communication. CAN communication terminal having a function, select the MCU with CAN function, the specific embodiment selected STM32F103. Overload Trucks detecting terminal selects a serial TFT2.4 color LCD display. Compass -GPS module selection UM220 modules with serial function by which the module can be informed of the current location, and send and receive SMS messages.

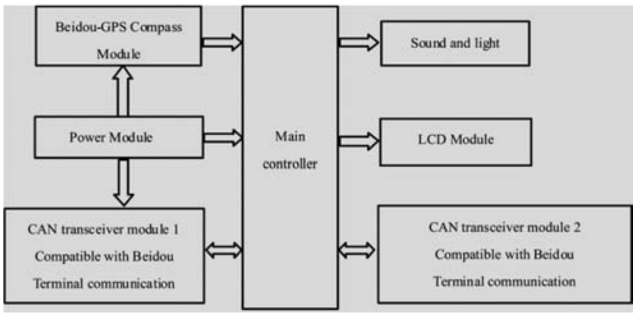

Figure 4. truck overload detection terminal chart

C. *Suspension Load Detecting CAN Node Structure*

Suspension load detection CAN node, including sub-controllers, resistance strain sensor with zoom function AD module, 6-axis gyroscope, power modules, CAN transceiver module, sensor resistance strain by magnifying AD module is connected to the sub-controller, 6 axis gyroscope, power modules, CAN transceiver modules are connected directly to the sub controller, the suspension load detection CAN node with the CAN bus communication. Resistance strain sensor to the plate spring set millivolt output voltage signal, amplification and post-amplification module AD analog-digital conversion to the sub-controllers, while the child collection controller 6-axis gyroscope signal to give the vehicle angular velocity, acceleration information angle and vehicle speed data processing obtained by the vehicle and the horizontal plane, and finally get this leaf spring bear weight. The weight information and vehicle speed information via CAN bus to send trucks to overload detection terminal. Speed 6-axis gyroscope selection information MPU6050, after data processing available angles; node magnifying AD module, use ADS1256, maximum magnification of 128 times, 24 high-precision AD converter.

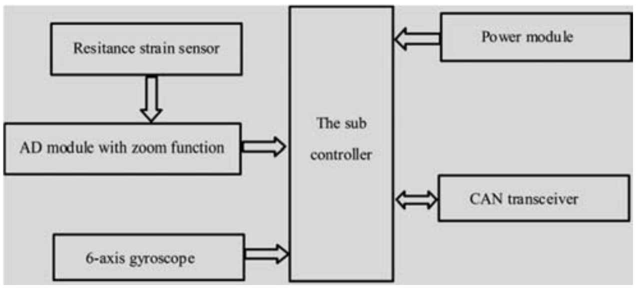

Figure 5. suspension load detecting CAN node structure diagram

D. *Owners termination structure*

The owner of the terminal, including the sub controller, Compass -GPS module, display module, power module, sound and light alarm module, all modules are directly connected to the sub controller, the owner of the terminal Beidou having a communication function; by truck owners terminal receives -GPS Compass Module overload detection terminal sent by a car load information, location information, and speed information displayed on the display module, if speeding, overloading the sound and light alarm.

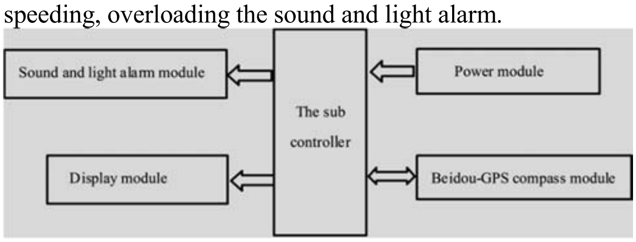

Figure 6. owners terminal structure

E. *The Working Principle of the system*

Overload detection truck freight terminal installed in the vehicle cab; suspension load detection CAN nodes installed on freight vehicle leaf spring suspension; the owner of the terminal owners own place. Suspension load detection CAN node weight information collection, speed and other information transmitted via the CAN bus terminal to detect overloading of goods vehicles, truck overload detection after a four-node data collection terminal, truck load information obtained through the arithmetic processing by Compass -GPS module obtaining vehicle position information, and load, speed, truck terminal position information through the LCD display module display while load, speed, location information sent to the vehicle via CAN bus compatible terminal Beidou compatible by the terminal is connected to a remote monitoring platform , load, speed, position information is sent via trucks overload detection terminal module to the owners -GPS Compass terminal can also be connected to a remote monitoring platform. Should overloading, speeding, overloaded trucks detection terminal through sound and light alarm warning to the driver module, synchronization information is uploaded to a remote monitoring platform and terminal owners.

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IV. EXPERIMENTAL ANALYSIS

A. Product real car installation test

The test vehicle uses a series of models for the liberation of J6 CA4180P63K2A1E diesel trailer towing vehicle, automobile front leaf spring specifications for 1700 × 90 × 12mm-10, the main spring rear suspension plus Deputy spring form, the main leaf spring specifications for the 1600 × 90 × 12mm-10 Vice-leaf spring specifications for the 1150 × 90 × 10mm-9, spring 1035mm center distance for the first spring after 830mm, thickness of 9mm. Truck load calculation based on leaf spring parameters and deformation. The following figure shows the experimental data during testing and installation in the form of pictures.

Figure 7. Product real car installation test picture

B. Static data processing and analysis

One problem is the impact of the load measuring vehicle is uphill, downhill measured weight is not accurate. 6-axis acceleration sensor measures acceleration, angular velocity value of the vehicle is running, the algorithm handled by measuring the state of the vehicle body inclination angle α, angle compensation can be obtained by real-time load information, measured data as shown in Table 1. Through testing, the static measurement error is within ± 2%.

TABLE I. STATIC LOAD MEASUREMENT DATA

The actual load	1.1t	1.1t	1.1t	4.0t	4.0t	4.0t
Measured voltage value	0.312	0.301	0.319	0.893	0.887	0.897
Road surface gradient measurement	0	-10	+10.1	0	-10	+10.1
Load measurement	1.09t	1.08t	1.11t	3.97	3.96t	4.02t

C. Dynamic data processing and analysis

Causing the displacement of the road in the direction of the vehicle is mainly vertical vibration of the vehicle, causing the vehicle vibration factor is a vibration of the vehicle itself, the other is a vehicle during vehicle vibration due to road bumps caused. Vehicle vibration of the vehicle to obtain the actual load, the error caused by the vibration of the vehicle should eliminate the amount of load can be effectively. The method used to eliminate vibration axis gyro 6 is measured vibration acceleration, vibration and find the cycle, to obtain the real weight measurement method using the arithmetic mean. The actual truck load 1.5t, when 80km / h constant speed measured data are as follows:

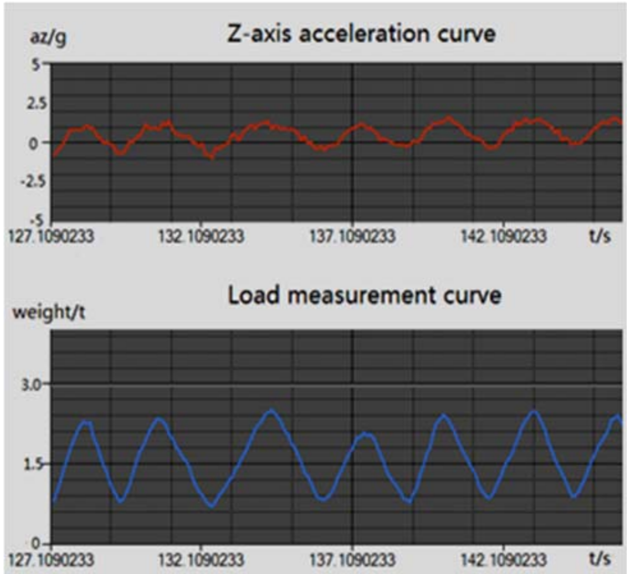

Figure 8. vibration acceleration and load curve PC interface image.

TABLE II. DYNAMIC LOAD MEASUREMENT DATA

time	127.1s	127.5s	127.9s	128.3s	128.7s	129.1s	129.5s
Measured voltage value	0.335	0.331	0.337	0.341	0.336	0.332	0.334
Measuring vibration acceleration	-1.0	-0.2	0.8	1.1	0.2	-0.1	-0.2
Load measurement	0.80t	1.11t	2.12t	2.20t	1.71t	1.20t	0.89t
After the period average of the measured load	1.50t	1.51t	1.49t	1.49t	1.50t	1.51t	1.50t

By experimental data and PC software analysis shows that the vibration waveform in the period of oscillation, vibration acceleration (positive or negative) the greater the greater the deviation from the actual load, by the arithmetic average measurement will produce a dynamic vibration period of the vehicle load error is reduced to ± 2%, to meet the load requirements for the monitoring system.

V. SUMMARY AND CONCLUSION

Compass vehicle networking based on real-time monitoring system overloaded trucks, vehicle dynamic load measurement information compatible with Beidou vehicle terminal network overloading of goods vehicles to achieve real-time monitoring, can solve the truck overloading, speeding and other issues, and by the six-axis gyroscope measurements and ground vehicles the angled measuring the weight allowed to solve the problem when the truck downhill; measured with trucks during each vibration cycle time to solve the problem are not allowed to truck operation by the arithmetic mean of the measurement method, the measurement accuracy of within ± 2%.

This design uses advanced electronic and information technology tools capable of real-time detection system for trucks overloaded, not only for trucks overloaded prompt the driver, but also does not interfere with cargo vehicle under normal driving conditions and illegal conduct forensic work load checks , for the management of freight vehicle overloading overrun provide a new, effective and efficient method for the detection and enforcement tools for effective governance to provide further technical support overloaded.

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