LOAD MEASUREMENT ON THE AXIS OF THE TRUCK DURING THE LOADING

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Abstract. As the payload of trucks increases due to grow of road haulage and the haulers seeks to the utmost exploit tonnage of the truck there is necessity for complex of measurement system what provides determination of loads to all axis of vehicle and registration of parameters at any position of axis of vehicle or relief area of bearing of axis of vehicle during loading. There are developed load measurement systems with load sensors for two type of truck suspensions with pneumatic chamber and leaf-type springs.

Key words: load, suspensions, load sensor, calibration.

Introduction

The payload of trucks increases due to grow of road haulage by auto transport. In order to decrease costs of road haulage, haulers seeks to the utmost exploit tonnage of the truck, whereby in result very often the maximum allowable load on axis of vehicle is overachieved, what is lead up to damage of road surfacing as well as to diminishing of road safety.

This problem is very actual to those haulers, whose transporting nonstandard loads (sand, wood etc.) or loads with irregular load on area of bearing (deflected centre of gravity), because driver of vehicle practically have no any possibility to control load on axis as well as to determine total weight of load. Taking into account that loads are transported in the body of automobile, semitrailers or trailers, it is necessity for complex of measurement system what provides determination of loads to all axis of vehicle and registration of parameters at any position of axis of vehicle or relief area of bearing of axis of vehicle during loading.

Materials and Methods

Development possibilities of load sensors

For the vehicles provided for transportation of loads, wheel axis with vehicle are constructive connected with suspensions. Distensible elements of suspensions can be leaf-type springs or pneumatic chambers (Fig. 1.).

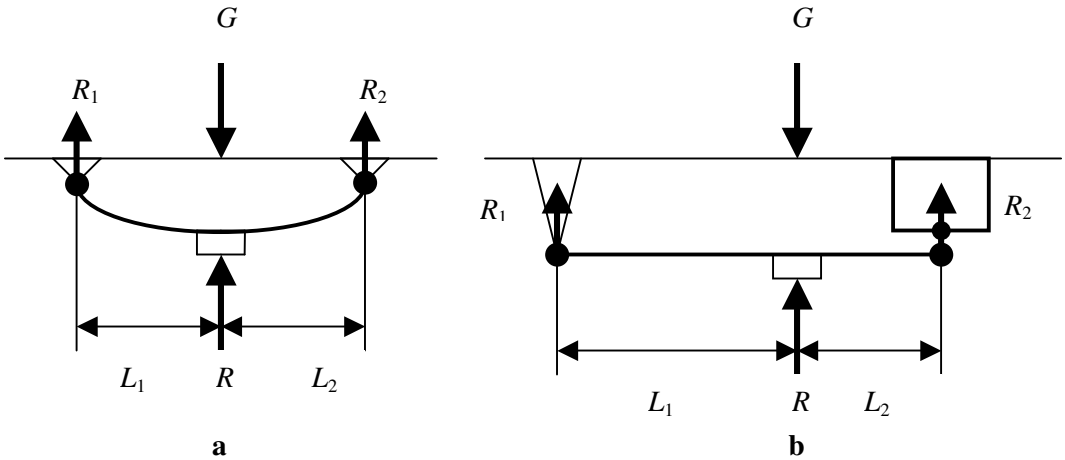

Fig. 1. **Types of suspensions:** a – leaf-type springs; b – pneumatic chamber

There were analyzed constructions of suspensions of vehicles as well as operating conditions of its elastic elements and possibility to create sensors wherewith it could be possible to determinate elastic deformations and pressure changes in pneumatic chamber.

When platform is loaded by freight, elastic elements of semitrailer or sidecar are distensible deformed, but in pneumatic suspension the pressure is changing. These changes are directly connected with changes to accordant suspension, summary to axis of vehicle as well as with total load of vehicle

to all axis what is placed on load platform. Analyzing conditions of operation of trucks' suspensions as more optimal for deformations of values of mechanical deformations of elastic suspensions elements and changes of pressure in pneumatic chambers the micro tenso-resistors are used. When micro tenso-resistors are used, irrespective of different constructions of suspensions and its sensors, unified sensing element of sensors is kept, what in its turn simplify further fixation and remote control of measurable parameters from load sensors of leaf-type springs and pneumatic chamber what are installed an accordant suspensions, preserving single measuring system.

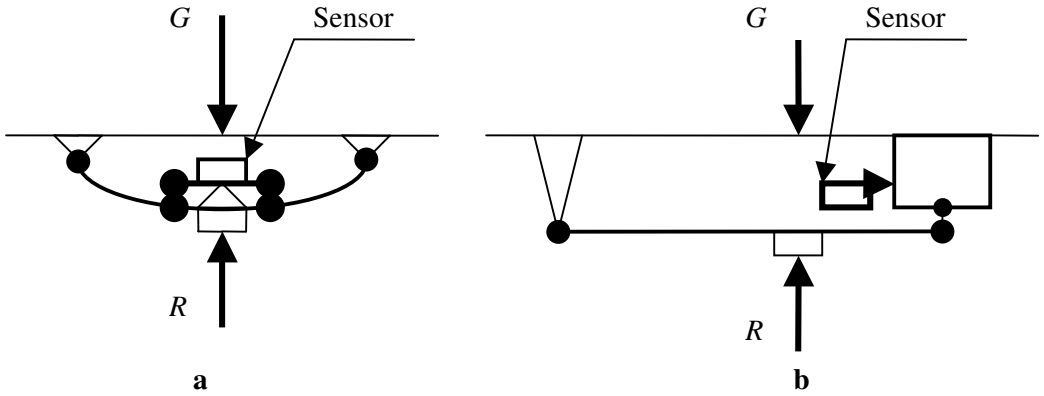

Fig. 2. **Scheme of mounting of load sensors:** a – on suspension of leaf-type springs; b – on suspension of pneumatic chamber

Mounting of load sensors on elastic elements of truck has to be universal in order of possibility to mount them on suspension systems of all trucks, what is provided by Directive 96/53/EK from 25th June of year 1996 by Council of directives of European Union.

Basic working principles of determination system are considered as following.

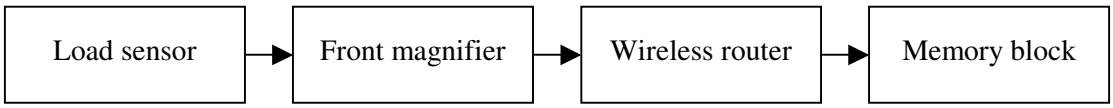

Fig. 3. **Block diagram of determination system**

When cargo is placed on platform of truck, elastic elements of suspension are deformed or pressure in pneumatic chambers of suspension increases. These changes are directly connected with the weight of load. If truck is parked on flat surface and load is placed equable along the entire platform, than changes of elastic deformation of suspension or pressure changes in pneumatic chambers will be equal. At rugged surface or irregular disposition of load on platform of vehicle there will appear various deformations of elastic elements of suspensions as well as pressures in pneumatic chambers.

These deformations of pressures changes also depending on constructive individuality of suspension of vehicle. Taking into account above mentioned, in order to safeguard punctuality of determination system on all elements of suspension system of vehicle, there are installed load sensors and common load of cargo is determined summarizing loads on suspensions.

Applying such scheme of determination of load of cargo, there exist possibilities to determine and correct location of cargo on platform of vehicle in order to notice allowable loads on automobile axis. Mounting of load sensors and others blocks of system on vehicle and calibration has to be performed individual for each vehicle, because constructions of elastic elements of suspensions and platforms of vehicles are various.

Load sensor for suspension with pneumatic chamber

Sensor of load pressure is added to the output of pressure control of pneumatic chamber. Feeding voltage of 12/28 V is delivered to the sensor.

On the base of operating principle of pressure load sensor is linear relevance between air pressure in pneumatic chamber and load on axis: as a base two positions are presumed – clear vehicle and vehicle with allowable load and particular pressure in given points. Error of measurement system

composes of ±2.0 % of maximal load. For the vehicles with two dissimilar contours of leaf-type springs on axis or axis group, air pressure is measured for each contour and results are calculated for each axis. Sensors and measurement system of them are provided for operation in temperature range from -25 till +70 ^{o}C.

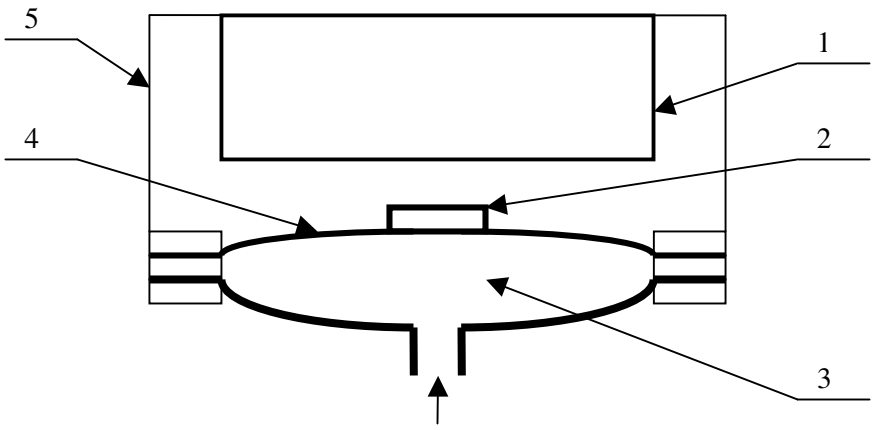

Fig. 4. **Principal scheme of load sensor for pneumatic chamber suspension:** 1 – front magnifier; 2 – micro tenso-resistors; 3 – pressure chamber; 4 – membrane; 5 – casing of sensor

As load sensor has very hard operating conditions, in order to provide stable output parameters of sensor, the sensitive element of sensor, front magnifier and wireless router are placed in one casing. Casing of load sensor has airproof accomplishment.

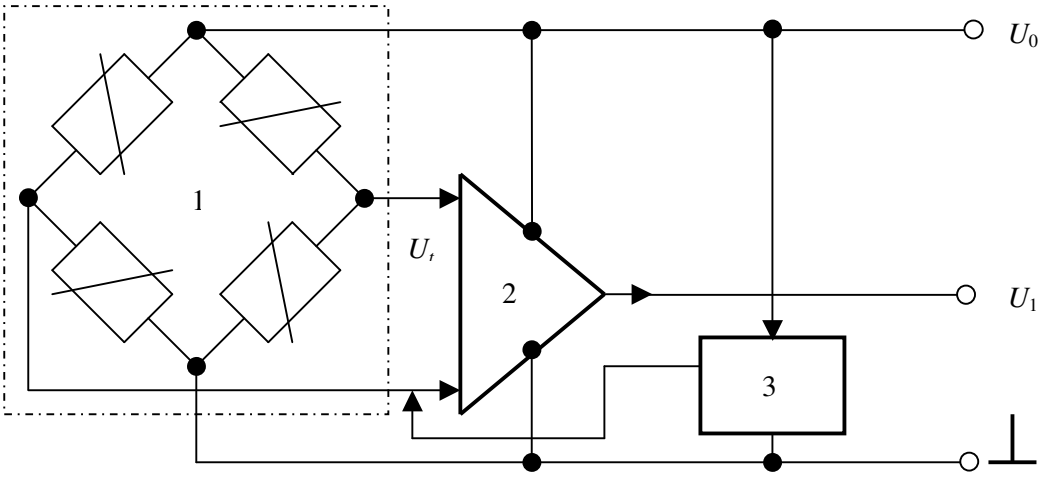

Fig. 5. **Principal circuit of pressure load sensor:** 1 – block of micro tenso-resistors; 2 – converter of signal; 3 – temperature compensator; U_0 – feeding voltage; U_1 – output digital signal; U_t – output analog signal

Load sensor for suspension with leaf-type springs

Fastening of the load sensor is designed so, that practically it is possible to adjust sensor on all kinds of leaf-type and parabolic springs in most of all loaded places, what, in its turn, provide high precision of measurements. Since the sensors are working in very hard operating conditions, it is installed in airproof coating and covered with synthetic fiber.

Circuit of load sensor is analogue to circuit of pressure load sensor (Fig. 5).

In a base of working of load sensor is displacement of leaf-type springs in impact of load to the axis. Flexible displacement of springs from load of cargo in not linear, for that reason calculation of load on vehicle axis have to be done gradually from deadweight of carrier till maximum allowable normative quantity. If the step of measurement range of load sensor calibration is less, more precise will be the calculation of load on axis of truck.

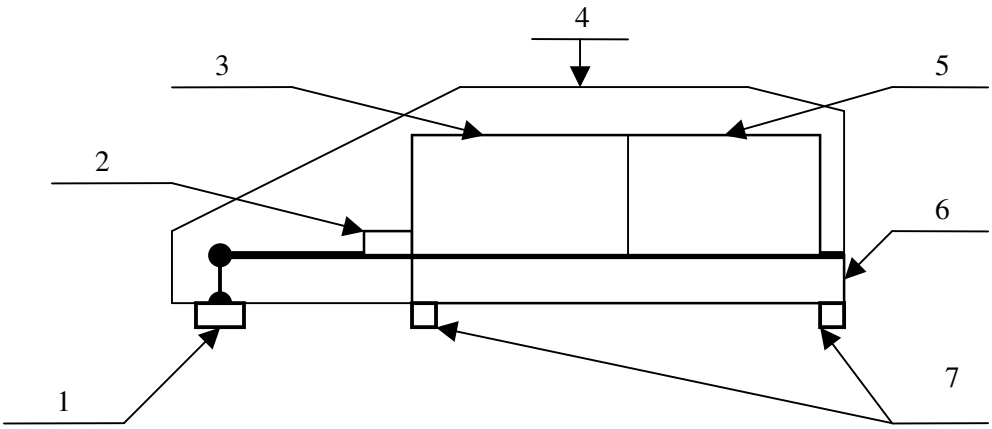

Fig. 6. **Principal scheme of load sensor for leaf-type spring suspension:** 1 – fastening of flexible dipstick; 2 – micro tenso-resistor; 3 - front magnifier; 4 – coating of sensor; 5 – wireless router; 6 – base of sensor; 7 – fastening places of sensor

Results and Discussion

Calibration of load sensor

In developed method of determination of vehicle load on its axis and total weight on vehicle platform, there were regarded factors that substantially could affect on accuracy of developed measurement system. More essential factor is stability of load sensors at sustained operation conditions. To provide that, in load sensor were utilized axle connection of micro tenso-resistors in sensibility element of sensor as well as in one body located converter of signals, front magnifier of signal and wireless router.

During performing of calibration of measurement system before loading of maximal load, there get fixed all output parameters of load sensor and they get reduced as base point. As load pressure sensor (Fig. 4) has linear coherence between cargo weight and pressure in pneumatic chamber of suspension, there must be fixed just parameters of maximal cargo weight load sensors. With algorithm of work of measurement system there is calculated load on each axis of platform, as well as total load of cargo on platform of vehicle in all range of measurements.

During performing of calibration to leaf-type springs, especially to parabolic suspensions, it must be regarded, that quantity of flexible deformations is nonlinear against increment of load on platform of vehicle. That is why next to calibration of sensors it has to utilize gradual imposition of fixed load on platform of cargo, let centre of gravity of cargo be located as much as possible in the middle of platform of vehicle. Minimal unity of loading has to be 1000 kg. At the imposition of each new unity of weight there are fixed parameters of load sensors and recorded in memory block, after whose data during exploitation of vehicle there will be calculated weight on axis and total weight of cargo on platform of vehicle. Such calibration of sensors is commendable also for pressure load sensors, because this method gives more accurate results of calculations during diapason of measurements.

Conclusions

Designed measurement device for determination of load on axis of the truck during the loading is designed for installing in innovative device for vehicle dynamic parameters registration, which is planned mount on the truck, provide accumulation and saving the data as well as transferring them by GPS. This measurement system is developed in the frame of ERDF project “Innovative vehicle dynamic parameters registration and analysis system” with the support EU.