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Smart Ratchet Tie-Down Straps for Monitoring Cargo Safety

Ing. Yuqian WU[1], Dr. Zhichun YAN[1]
[1] BCM SENSOR TECHNOLOGIES bvba, Industrie park, Brechtsebaan 2, 2900 Schoten, BELGIUM;
yuqian.wu@bcmsensor.com

Summary:
Newly designed wireless load pins (WLP) have been introduced here, by which traditional ratchet tie-down straps (RTS) have been developed into a smart ratchet tie-down straps (SRTS) in order to monitor the tension of the straps. Multiple SRTS can work with one monitor to form a Wireless Tension-Detect-and-Alert System (WTDAS) for cargo safety application. In case any SRTS becomes loosened or overloaded during transportation, the SRTS will wirelessly communicate with the monitor for its status change, and the monitor fixed on the dashboard in the driver cabin will alert the driver.

Keywords: cargo safety, wireless, smart ratchet tie-down strap, force sensor, tension monitoring

Background, Motivation and Objective

For safety reasons, it is advantageous to be able to monitor the tensile force of tie-down straps for cargo safety during transportation. For example, this would allow a truck driver to be alerted whenever one of RTS's on the truck becomes loosened or overloaded while driving.

In patent US8847758, the deformable element within the force sensor is a thin walled sleeve concentrically surrounding an axle bolt of a strap ratchet. This solution has a few problems as listed below:

1) If the thin sleeve would rotate slightly, the strain measured by the measuring element for the same force would be slightly different.

2) By being attached to the thin sleeve, the measuring element and its wiring are quite unprotected and can be damaged or corroded in use.

3) This design is an additional component.

In patent application CN101486329A, there is no communication with a remote sensor monitoring device.

Description of New Sensor and System

The WLP as shown in Fig. 1 can function as a bolt of a traditional RTS by fixing WLP in the frame of the RTS where the strap is attached on. In this way, the WLP turns a traditional RTS into a smart RTS (SRTS), as shown in Fig. 2, which can monitor the tension of the strap. Multiple SRTS's can work with one monitor to form a WTDAS. On the monitor, e.g., as shown in Fig. 3, there are several LED's. Each LED uses 3 colors to indicate three statuses of the corresponding SRTS – green refers to fastened straps, red to loosened or overloaded straps, and orange to an error status (e.g., low battery, disconnection, etc.). In case a SRTS becomes loosened during transportation, this SRTS will wirelessly communicate with the monitor for its status change, and the monitor which is fixed on the dashboard in the driver cabin will alert the driver by turning the corresponding LED from green to red color and having its alarm triggered. Once the loosened SRTS is tightened again, the corresponding LED goes back to green color and the alarm stops.

In such the WTDAS, the monitor has been preset to wirelessly communicate with number of specific SRTS (i.e., specific WLP). Therefore, the user can set up the WTDAS without need for any computer, and each of the systems works independently, i.e., different systems do not interfere each other.

Results

Taking a ready-made WTDAS as example, the WTDAS has features as follows:

1) One monitor as shown in Fig. 3 has 16 LED's and can communicate with up to 16 smart RTS (i.e., with 16 WLP);

2) Communication signal: license-free 2.4GHz radio frequency;

3) Communication distance: 20 meters for truck use;

4) Independent system without interference of another system;

5) Capacity of WLP: 5kN;

6) WLP powered by: 2x 1/2AA batteries;

7) Batter life: depending on use conditions (i.e., operating temperature, communication distance and communication rate), if the WLP works at room temperature and communicates with the monitor in distance of 20 meters without any obstacles by rate of 1 time per minute, the battery life is estimated to about 1 year;

8) IP rating of WLP: IP66.

Illustrations, Graphs, and Photographs

Fig. 1. Photo of two WLP's

Fig. 2. Photo of a smart RTS

Fig. 3. Photo of a smart RTS