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Modernization of Transport Management System upon Conveyance of Bulk Goods

Oksana Olegovna Gorshkova
Industrial University of Tyumen, Russia

ABSTRACT

Insufficient reliability of determination of amount of delivered goods using transport management system (TMS) is an issue of concern. The importance of the study is stipulated by necessity to optimize procedures related with goods conveyance by automation. The aim of the work is to modernize the TMS upon conveyance of bulk goods, to improve measurements of loading and transportation of bulk goods using TMS. This work analyzes the issue of error minimization in operation of accounting system of conveyed bulk goods, the constituent elements for TMS intended for dump trucks and excavators are presented, the expansion variants for TMS aimed at complete and reliable automated accounting are considered. The presented data demonstrate economic efficiency of modernization of TMS upon conveyance of bulk goods.

Key words: transport management systems, RFID tags, RFID reader, transportation of bulk materials.

1. INTRODUCTION

Transportation industry together with other infrastructure constituents provides basic conditions of society activities being an important tool to achieve social, economic, and foreign policy purposes. Transportation is used not only for conveyance of goods and people; it is mainly an intertrade system converting life activities and business [1]. Main advantages of automobile transportation are its economic efficiency, time of delivery, flexible scheduling of routes. In terms of expenses and rates of execution, this type of goods conveyance occupies the second position after air freight operations [2].

Transportation logistics and its constituents play a great role in the modern world. The 21st century is the time of well-developed market relations; optimum delivery of any goods is highly important. Correct arrangement of this process effects directly the final cost of goods, services, quality of deliveries [3]. Global expenses for logistics amount to 10% of global GDP. Money stock in transportation industry is huge, automation of processes is stipulated by growing requirements upon conveyance of any goods [4]. Automation of logistics processes is aimed at provision of rational arrangement of goods conveyance. Automation provides certain advantages, namely: scheduling overall chain of goods conveyance, routing, planning resources required for bulk goods conveyance [5]. Solution to the transportation development is an important condition for steady growth of national economy. Transportation together with other infrastructural constituents creates basic conditions to achieve social, economic, and foreign policy purposes. Transportation is not only a tool for conveyance of goods and people; it is mainly an intertrade system converting life activities and business [6].

2. METHODS

Theoretical methods were used for analysis of publications devoted to the considered issue together with formulation of theoretical backgrounds aimed at studying possibility of modernization of TMS upon conveyance of bulk goods. Empirical methods were based on observations, analysis of vehicle operation upon conveyance of bulk goods. Experimental methods were comprised of modernization of TMS upon conveyance of bulk goods, estimation of economic efficiency of the proposed measures.

3. RESULTS AND DISCUSSION

Automation of production processes is a continuing activity at motor transport companies. Reliable determination of amounts of conveyed goods using a TMS is very important.

Thematic justification is stipulated by necessity to optimize production processes related with goods conveyance by their automation.

The aim of the work is the modernization of TMS upon conveyance of bulk goods, improved measurements of loading and conveyance of bulk goods using TMS.

The study object is the TMS upon conveyance of bulk goods.

The subject of investigation is the modernization of TMS upon conveyance of bulk goods.

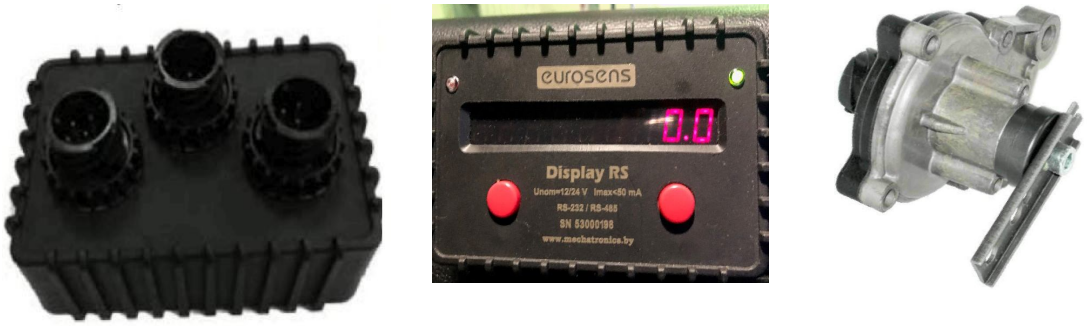
The hypothesis of investigation is the modernization of TMS upon conveyance of bulk goods will be efficient provided that:
- the capacities of TMS are expanded by improved completeness and reliability of automated accounting of machinery operation;
- equipment is installed which would allow to record process variables of transportation means in real time transmitting the data to unified system.

A possible solution to the problem is improved management of loading and conveyance of bulk goods using TMS. This is aided by installation of equipment which in real time records axle loads and transmits the data to unified system.

Aiming at error minimization of conveyed goods accounting, the constituents of weighing system and load monitoring are selected which are installed in dump trucks and excavators. The weighing and load monitoring system (hereinafter, the system) is intended for monitoring load on each vehicle axle, determination of conveyed goods weight. The system is comprised of the following constituents:

1. the controller to acquire data from sensors with analog output and analog to digital converter [7];
2. the Eurosens Difference 02 sensor to determine axle load or goods weight on vehicles with spring suspension by measuring distance from frame to axle [8];
3. the RS display to predict axle loads and goods weight based on data received from the controllers as well as to display axle loads and goods weight in driver cab.

The constituents are illustrated in Fig. 1.



a) b) c)

Figure 1: Onboard weighing system: a) EUROSENS Difference□T controller; b) EUROSENS Display RS; c) Eurosens Difference 02 sensor.

The system informs drivers about excessive axle loads, displays the variables on driver screen, transmits the axle loads to monitoring system.

The dispatch monitoring system with integrated GPS, radio communication, and computer aided tools provides centralized traffic monitoring of all vehicles of transportation company. Each vehicle is equipped with GPS receiver and radio equipment to communicate with dispatch station. The dispatcher monitor displays electron or digital map of the premises of a company serviced by vehicles [9].

In addition, the vehicles are equipped with RFID (radio frequency identification) system for identification and accounting of goods. The RFID systems are comprised of a reader and transponder (RFID tag) [10]. Dump trucks are equipped with RFID tags and RFID readers mounted on vehicle cabs to read data from the tags, recording data about truck shell position, data transmitting to the system. RFID tags and RFID reader are illustrated in Fig. 2.

a) b)

Figure 2: a) RFID tags; b) RFID reader.

The RFID systems are characterized by numerous advantages:
- direct contact with data carrier is not required;
- simultaneous data reading from several tags;
- identification of objects at significant distances;
- RFID tag support remote access, its position is not limited with human vision, thus, its signal can be read across various obstacles: snow, ice, mud, paint, metal, etc.

The RFID systems are classified in terms of reading distance:
- short-range identification (up to 20 cm);
- middle-range identification (20 cm–5 m); and
- long-range identification (5 m–300 m).

A RFID tag is a small memory device comprised of data storage microchip and antenna transmitting and receiving data.

The RFID tags are classified as follows:
1) in terms of power source: active, passive, semi-passive;
2) in terms of material of marked object: for metallic objects; for nonmetallic objects; universal;
3) in terms of operation frequency: LF (ISO/IEC 18000-2:2009); HF (ISO/IEC 18000-3:2010); UHF (ISO/IEC 18000-63(C));
4) in terms of embodiment: tag–label; integrated tag (tag, label), packaged tag [11].

An advantage of RFID systems is impossibility to falsify RFID tag. Signals are read at high speeds under any weather conditions. The tags are protected against impacts, wear, action of chemically active media, moisture, higher and lower temperatures, they can operate on metal objects. The RFID readers are the devices reading and writing data from/to the tags. The readers are connected to accounting system and operate independently. The RFID readers are capable to read data without direct vision of RFID tag at the distance higher than 15 m.

Operation of the equipment is monitored by data output to the driver monitor using CAN busbar displaying the number of trips, weight of conveyed goods, fuel consumption, vehicle speed, operability of TMS, vehicle location in the loading area, shell lifting and other variables (adjusted as required). When a truck reaches the point of discharging, the information about empty shell is displayed. Driver video identification system is being developed in combination with satellite navigation aimed at accounting of driver operation and recreation which includes video cam in vehicle cab [12]. Excavators are also equipped with specialized tools in the form of LoRa sensor for data receiving via radio channel from truck devices and data transmitting via terminal to unified system, such as Navigator.

The LoRa sensor is characterized by certain features: wide range of radio signal; high rate of data transmitting; high resistance against interferences; high accuracy of time synchronization.

The unified Navigator system displays online operation of all vehicles of a company, which facilitates rapid monitoring and continuous operation of vehicles. Images from Navigator-S software are displayed; using vehicle plate number and time interval, it is possible to trace process variables of the vehicle, that is:
- front axle load;
- middle axle load;
- rear axle load;
- goods weight;
- soil volume;
- number of shell liftings.

When a truck reaches the point of discharging, the information about empty shell is displayed. The information about empty shell in online mode is also displayed in the Navigator system.

Economic efficiency

The economic efficiency of modernization of TMS upon conveyance of bulk goods (Table 1) is achieved on the basis of the following performances:
- reliable information about performed trips;
- volume of goods conveyed by vehicles;
- rapid accounting for conveyed goods in online mode.

Comparison of economic performances demonstrates that before implementation of the equipment, total soil loss from the trucks was 762.75 thousand cubic meters. Since the cost of one cubic meter of soil is 300 rubles, the lost profit of soil loss is 228,825 thousand rubles. Implementation of the proposed equipment includes certain expenses, that is, costs of acquisition and installation of the equipment: 45,878.50 thousand rubles, annual costs of equipment operation: 6,554.07 thousand rubles, thus, the cumulative annual expenses are 52,432.57 thousand rubles. Therefore, the economic efficiency of modernization of TMS upon conveyance of bulk goods is 176,392.43 thousand rubles. The data are summarized in Table 1.

Table 1: Economic efficiency of the equipment

Performances	Units	Variants	
		Before	With supplemental equipment
Initial data			
Total loss of soil by dump trucks	thous. m^3	762.75	0.00
Predictions			
Cost of 1 m^3 soil	rub	300	300
Predicted economic efficiency			
Lost profit of soil loss	thous.rub	228,825	0.00
Expenses for acquisition and installation of the equipment	thous.rub		45,878.50
Annual expenses for management of soil transportation	thous.rub/year		6,554.07
Cumulative annual expenses	thous.rub		52,432.57
Economic efficiency of modernization of TMS upon conveyance of bulk goods	thous.rub		176,392.43

4. CONCLUSION

The experimental results of modernization of TMS demonstrate that the formulated purpose has been achieved, the hypothesis has been verified, that is, modernization of TMS upon conveyance of bulk goods makes it possible to expand capacities of TMS by improvement of completeness and reliability of automated accounting of equipment operation, thus promoting implementation of equipment for recording process variables of transport in real time and transmitting data into unified TMS upon conveyance of bulk goods. Implementation of the proposed measures and equipment for logistics would minimize losses upon goods conveyance, eliminate human factor upon determination of amounts of conveyed goods, thus improving operation efficiency of transport agencies and implementing the most advanced procedures of automation of TMS upon conveyance of bulk goods.

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