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Professional paper

Ways to Improve the Quality of Asphalt Roads

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Abstract – **The system of complex monitoring of the main parameters of road-construction machines and asphaltic concrete mixture during its transportation and laying on the road surface is considered. The implementation of this trend is carried out with the help of the GLONASS satellite system, which provides not only an improvement in terms of the quality of the work performance but also contributes for increasing of productivity and also reduces the human factor on the quality of the finished road surface.**

Keywords – **Monitoring, GLONASS, Road-construction machines, Asphaltic concrete, Quality.**

I. INTRODUCTION

Highways are a complex engineering and technical constructions, one of the most critical elements of which is the road surface. It is the condition of the road surface that determines the quality and service life of the road, and also ensures safe movement of vehicles.

One of the promising areas for improving the quality of roads is the comprehensive monitoring of the parameters of road-construction machines as well as stacked material in the process of performing construction operations.

The concept of monitoring in relation to control systems of road-construction machines includes a remote contactless method of parameter control. In monitoring systems, satellite systems are assigned the function of transmitting information in the forward and reverse direction from operating machines to remote control centers. The monitoring systems allow is accumulation of large volumes of information, which makes it possible to use tools to improve efficiency.

When considering issues related to improving of the quality of asphaltic concrete pavements, it should be taken into account that asphaltic concrete is a multicomponent structure, the final operational properties of which are affected by both factors related to the production of asphaltic concrete mixture at an asphaltic concrete plant (ABZ), as well as an external ones, in relation to production factors [1,2], namely:

Internal (production) factors

- Properties of the asphalt mixture components and their types;
- Recipe and structure of the mixture;
- Technology of the production of asphalt mixture;

External factors

- The quality of the road cover project;
- Quality of the road base;
- Technology of transportation, laying and compaction of the mixture.

Fig. 1 shows a generalized process for the formation of the quality of asphaltic concrete pavement.

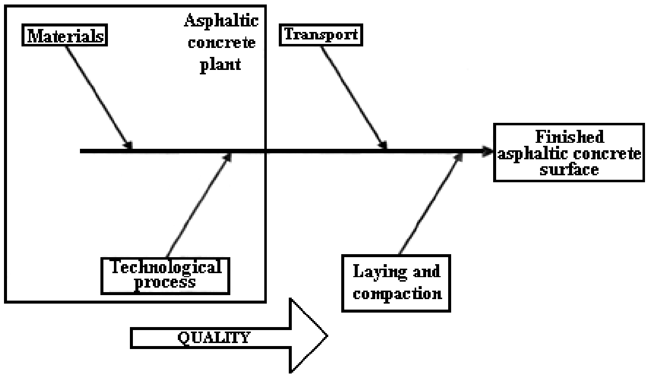

Fig. 1. The generalized process of quality formation of an asphaltic concrete pavement

Now consider the individual components of the presented technological chain, significantly affecting the quality of the finished coating.

II. MATERIALS

This part provides the information on the properties of all components of the asphalt mixture. It consists of the information contained in the passports for the components of materials, and the results obtained by the factory laboratory in the course of experimental studies on the actual properties of materials [3].

We will consider, for example, the manufacture of an asphalt-concrete mixture, the components of which are gravel (G), sand (S), mineral powder (MH), bitumen (B) and additives (D). Then:

$G_{i,j}$ is the *j*th feature of the *i*th type of gravel; $S_{i,j}$ is the *j*th feature of the *i*th type of sand; $MH_{i,j}$ is the *j*th feature of the *i*th type of mineral powder; $B_{i,j}$ is the jth feature of the *i*th type of bitumen; $D_{i,j}$ is the *j*th feature of the *i*th type of additive.

In this case, to evaluate the 1st type of gravel, one can use the following estimate:

$$G_1 = \{ g_{1,1}; g_{1,2}; \ldots g_{1,k_g} \},$$

where k_g is the number of indicators for gravel.

Then, all the gravel (*m* types in total) available in the company can be described by the following matrix:

$$G = \begin{vmatrix} G_1 \\ G_2 \\ \ldots \\ G_m \end{vmatrix} = \begin{vmatrix} g_{1,1} & g_{1,2} & g_{1,k_m} \\ g_{2,1} & g_{2,2} & g_{2,k_m} \\ \ldots & \ldots & \ldots \\ g_{m,1} & g_{m,2} & g_{m,k_m} \end{vmatrix} \quad (1)$$

Similarly for other materials.

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Here, k_m, k_s, $k_{\text{МН}}$, k_b, k_d is the number of regulated parameters for gravel sand, mineral powder, bitumen and additives, respectively; m, d, c, e, f is the number of different types of these materials in the company's warehouse. On the basis of this representations we can introduce a generalized record of the aggregate of properties of the asphalt-concrete mixture components and parameters of the technological process:

To display the properties of the asphalt-concrete mixture, we will use the following set:

$$ACV = \{acv_1, acv_2, \ldots \mathrm{acv}_{k_{ACV}}\} \qquad (2)$$

where acv_i is the ith indicator of the asphalt-concrete mixture quality;

K_{ASV} is the maximum number of indicators of the asphalt-concrete mixture.

Moreover, the properties of the asphalt-concrete mixture at the outlet of the ACP can be represented as a mathematical model [4]:

$$ACV = \varphi\,(M,\ TP,\ F_{TP}) \qquad (3)$$

where F_{TP} is the perturbation affecting the technological process.

During transportation of the asphalt-concrete mixture from the ACP to the object ($TR_i = \{ tr_{i,1}, tr_{i,2}, \ldots tr_{i,k_{TR}} \}$ operation), its properties are modified

$$ACV_{TR_i} = \psi\,(\,ACV, TR_i, F_{TR_i}\,). \qquad (4)$$

Similarly, the properties of the finished asphalt-concrete pavement can be written as:

$$ACV^{B}_{i,j} = q\,(ACV_{TR_i}, PL_i, F_{PL}), \qquad (5)$$

where $ACV^{B}_{i,j}$ is a set of properties of asphalt concrete for the ith facility and jth supply of materials; PL_i – a set of indicators of the quality of laying and compaction of the mixture for the ith object; F_{PL} is the perturbation.

III. TECHNOLOGICAL PROCESS

This part provides information on the actual values of the process parameters [5], among which the most important are:

- Granulometric composition of each components of the asphalt mixture.
- Dosing error.
- Actual mixture composition for each batch.
- Temperature of bitumen, mineral materials, finished mixture at the outlet.
- Accuracy of control.
- Frequency of control.
- Systematic error of the control system.
- Methods and algorithms for processing of measurement results.

Transportation of asphaltic concrete mixture to the place of laying («Transport»):

- Monitoring of the vehicle parameters - dump truck (cargo mass, speed and direction of movement);
- Monitoring of the parameters of asphalt mixture (temperature in the upper and lower parts of the dump truck's body, in its side parts);
- The time of loading, delivery and unloading of the mixture;
- The rhythm of supplies;
- Fuel consumption level;
- Environmental conditions.

«Laying and compaction» of asphaltic concrete mixture:

- Monitoring of paver's parameters (paving speed, fuel consumption level);
- Monitoring of the parameters of the asphalt mixture during installation (temperature and thickness of the layer to be laid);
- Monitoring of the parameters of the compacting machines (speed of the rollers, amplitude-frequency characteristics, the number of passes on one track, the level of fuel consumption);
- Monitoring of the parameters of the asphalt mixture during compaction (temperature, density);
- Environmental conditions.

To implement the presented structure of the integrated monitoring of the parameters of the asphalt mixture and road-construction machines, they are equipped with the GLONASS-tracker satellite system, which ensures the real-time recording of the above parameters and the data transferring to the Central computer server (Center of an integrated control system).

This server, taking into account the current situation along the route of vehicle, as well as during the laying and compaction of the mixture, adjusts the operation mode of the factory equipment and ensures that the required quality of asphalt mixture is obtained at the outlet of asphaltic concrete plant.

The GLONASS-tracker system determines the coordinates of the location of vehicles by using the satellite signals. Sensors that determine the temperature of the mixture, fuel consumption, cargo mass and others are also connected to the tracker.

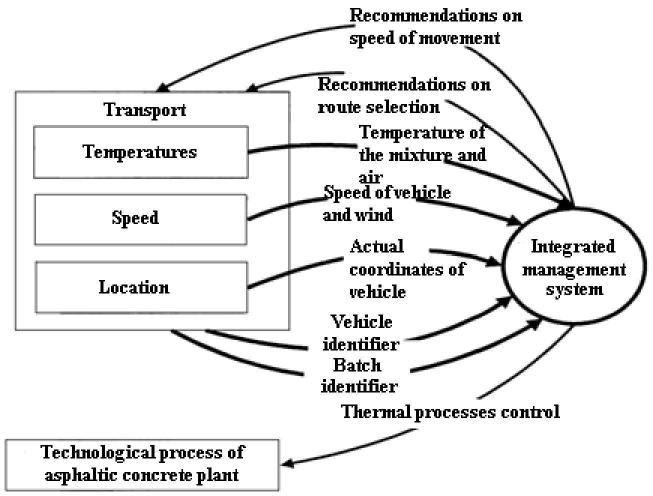

Fig. 2. Interaction of an integrated management system with the subsystem «Transport»

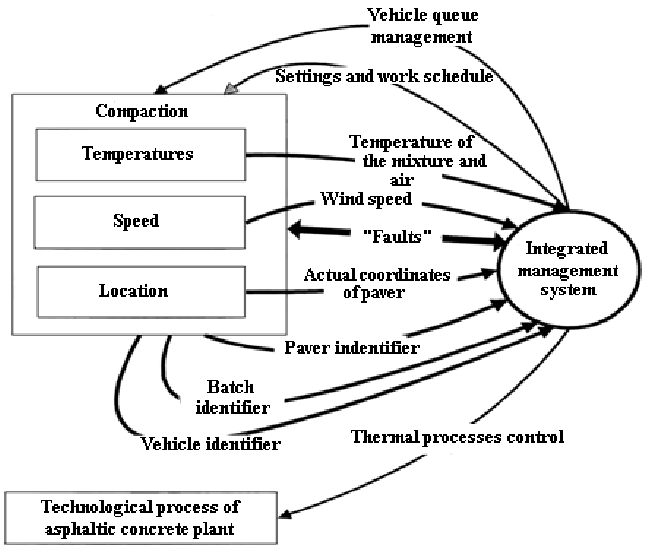

Fig. 3. Interaction of an integrated management system

Fig. 2 and 3 show the interaction in the process of monitoring of an integrated control system with the subsystems "Transport" and "Laying and compaction".

To implement the above program, the dump truck must have the following additional equipment:

-computer control unit,

-Falcom F 35-XXL and antenna system Glonass / GPS,

-dump truck position control subsystem,

-dump truck identification subsystem,

-communication subsystem,

-mixture temperature control subsystem,

-ambient temperature control subsystem,

-wind speed sensor,

-automatic system for covering the mixture with a tarpaulin in the body of a dump truck,

-memory bloc.

Figure 4 shows a KamAS 55118 dump truck with a system for monitoring parameters of asphalt concrete mixture during its transportation.

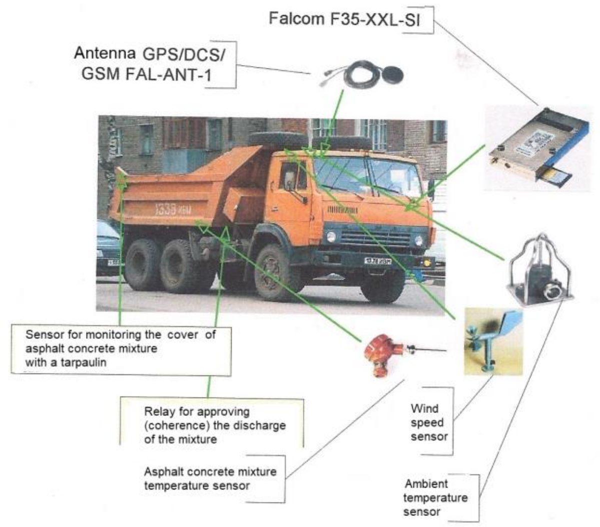

Fig. 4. KamAS 55118 dump truck

It should be noted that as a result of monitoring, a significant array of data is generated, and its processing requires lengthy computing resources. So, for each truck after receiving its actual coordinates, it is necessary to determine the position on the ground, the average speed in the last segment, the average speed from the start of movement, as well as the presumable total delivery time and temperature fields in the truck body.

The software allows the user to receive the satellite monitoring data from the «Asphaltic concrete plant (ABZ) – Road-construction machines - Asphaltic concrete» system in the form of visual reports, graphs and tables.

IV. Conclusion

Integrated monitoring of the parameters of road-construction machines and asphalt mixtures with using of the GLONASS system provides an increased productivity of the work performance, reduces the influence of the human factor on the quality of the finished road surface, and it becomes possible to carry out the remote control of the main parameters of not only the vehicles, but also the laid material, as well as operational response to the adjustment of the «Asphaltic concrete plant (ABZ) – Road-construction machines - Asphaltic concrete» system parameters in case of emergency.

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