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Modeling of Asphalt Concrete Mixing Drum on Matlab® / Simulink®

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Annotation: In this article, a basic energy-intensive drum dryer was simulated using MATLAB® to improve the hot asphalt mix production process and reduce energy consumption. In this case, the results were obtained in the form of 2D and 3D plots by entering the initial data and boundary conditions. The results obtained were compared with the results obtained experimentally.

Keywords: Energy, asphalt, MATLAB® complex, inert material, drying drum, fuel consumption, temperature, technology, highway, gas pressure.

Introduction

The volume of road construction among all branches of construction is increasing every day. Hot mix asphalt is considered one of the main products in road construction. Hot asphalt requires a lot of energy from us. Currently, a number of government decrees and state programs are being adopted for the conservation of non-renewable energy sources and their rational use.

Aims

Efforts are being made to create energy-saving technologies in the production of hot mix asphalt in order to ensure the implementation of decisions and regulations adopted in our republic, to attract advanced equipment and technologies to road construction, in particular, the use of energy-saving technologies.

Our proposed scientific development achieves savings in materials and energy in the production of hot mix asphalt. Automation of all processes in the age of information technology and, as a result, the achievement of high work efficiency and product quality.

Research Methods

The most energy-intensive unit of the asphalt concrete plant is the drying-mixing drum. Several cases can be studied using simulation models to quantify energy consumption.

In this case, the initial and boundary conditions are given to the simulation model based on real conditions, and the result is obtained. The results obtained are analyzed. Another way to obtain calculation results is to use the MATLAB® software package.

The work was carried out on a small model of a drying-mixing drum in the MATLAB® complex. Each problem is solved by introducing initial data and boundary conditions. When solving the problem, we create a model of a drying-mixing drum in the MATLAB® complex and set the initial conditions for it.

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Drum length is Z=3 [m], thermal conductivity of the wall in the drying drum is K=0.1, air flow velocity is v= 1 [m/s], external temperature T_{out}=10 [^{0}C], and maximum internal heating temperature is T_l=160^{0}C], relative heat capacity C =0.85 [MJ/kgK], hot air density is ρ =1.29 [kg/m^3].

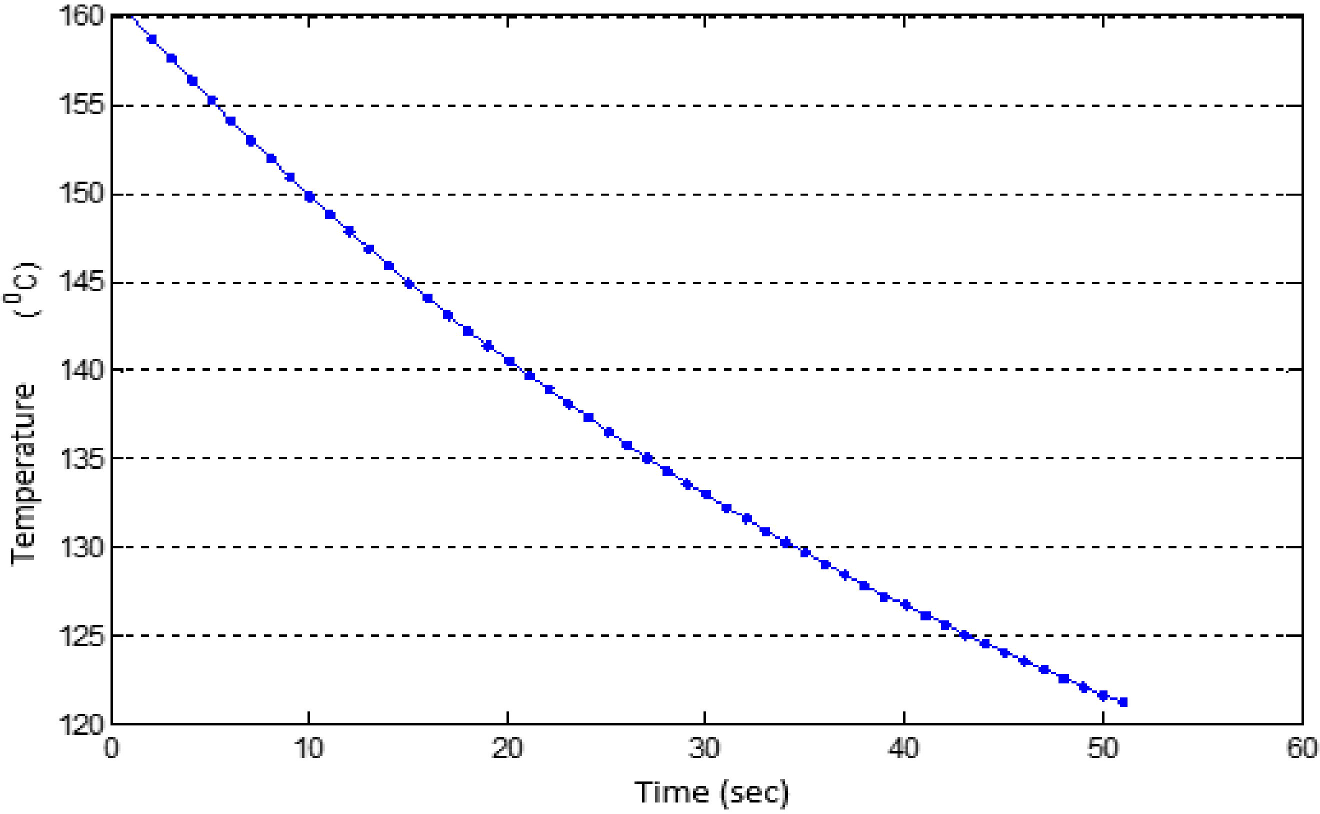

Fig. 1. Dissipation of heat flow in the drum

As you can see in this graph, we can observe the effect of heat on the inert material inside the tumble dryer over time.

In real conditions, the following process of heat removal in the drying-mixing drum can be observed. In this case, we can observe the spread of heat from the flame burner in the region of 700-800 0C with the help of experiments (Fig. 2). High drying efficiency is achieved by direct contact of the surface of mineral materials with a stream of hot gases. To do this, the feathered mineral material is repeatedly lifted and thrown into a jet of hot gases. The more uniformly the bulk material is distributed over the cross section of the drum, the better it is washed by the flow of hot gases, and the heat from the gases to the material passes more completely and faster.

We can divide the process inside the dryer-mixer into 4 zones: the drying process starts in the 1st zone, the heating process starts in the 2nd zone, the heating process takes place in the 3rd zone, and the mixing process with heated inert material bitumen is in 4th zone.

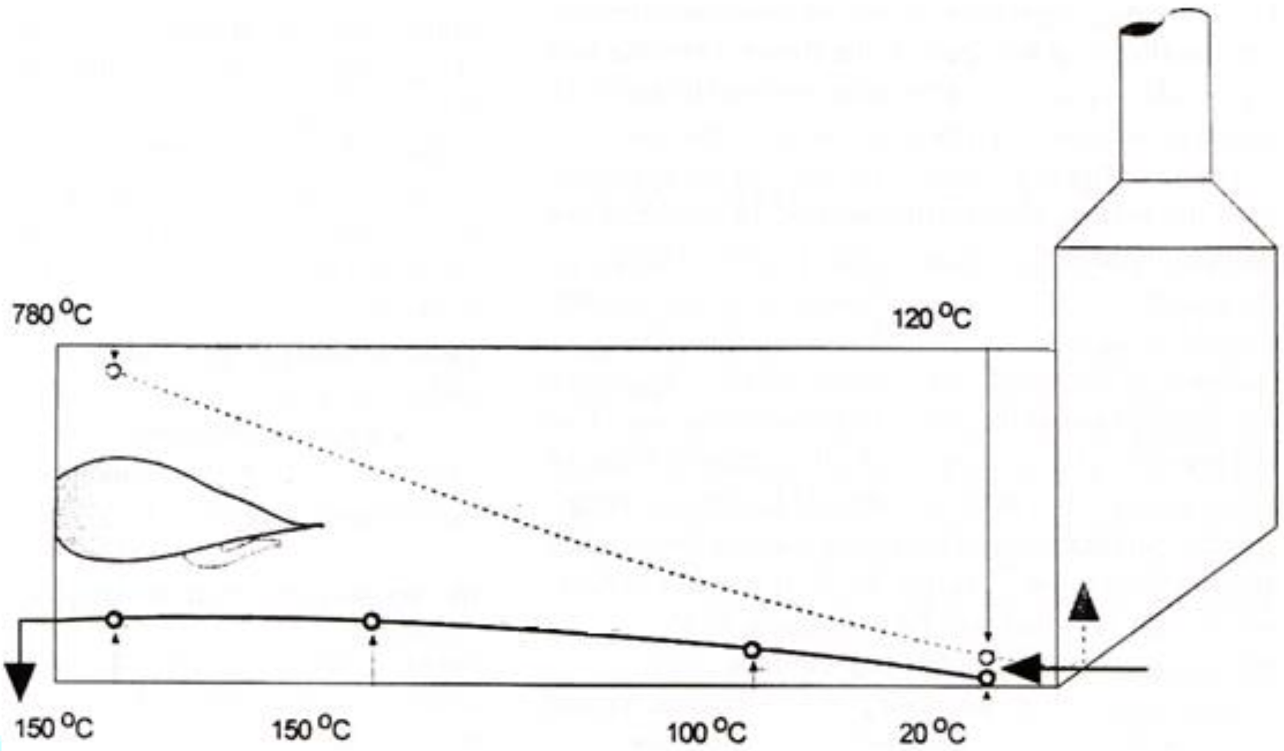

Fig 2. Tumble dryer

If compared, the lines of the results obtained by the model and the results of the graph are close to each other. We determine the errors and polynomial equations of the 5th degree of the following graph using the MATLAB® complex. With the help of certain equations, initial conditions and boundary conditions are introduced, and we get a graphical result. This is shown in Figure 3..

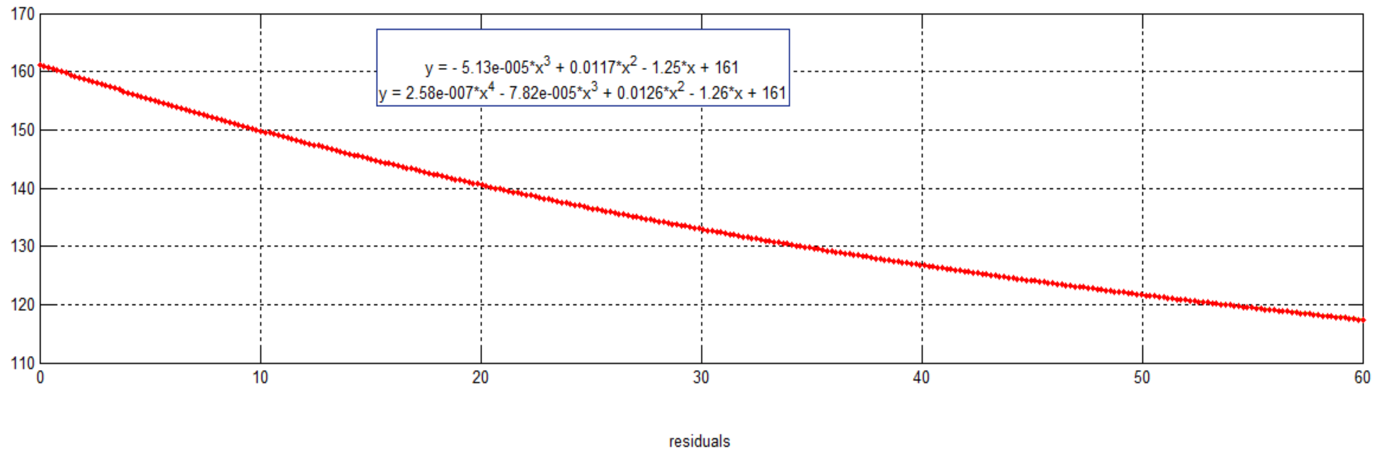

Fig. 3. Dissipation of heat flow in the drum

According to this graph, the errors made during the experiment and the temperature distribution are determined by 5-degree polynomial equations. [2]

To calculate heat flow using the pdetool section of MATLAB®, we need to know the following:

The parameters of the drying-mixing drum are given.

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where: drum length L=10 [m], diameter B=2 [m], thermal conductivity k=1.2, fluid (heat) flow rate v=1 [m/s], outside temperature T_{out} =10 [^{0}C], outdoor air temperature and the humidity level of the inert material have a great influence on the change in energy consumption. Hot air density in the drum $\rho = 1.29\ [kg/m$, heat transfer coefficient, C=0.85 [J/kg s^0], amount of heat supplied Q=2000 [kJ].

Research Results

The amount of heat in the proposed dryer-mixer drum can be controlled and regulated. A decrease in air temperature or an increase in the humidity of the inert material can cause a change in the temperature of the finished asphalt mix. Through the given boundary conditions, we can obtain the following two-dimensional representation of the heat flux distribution from the model.

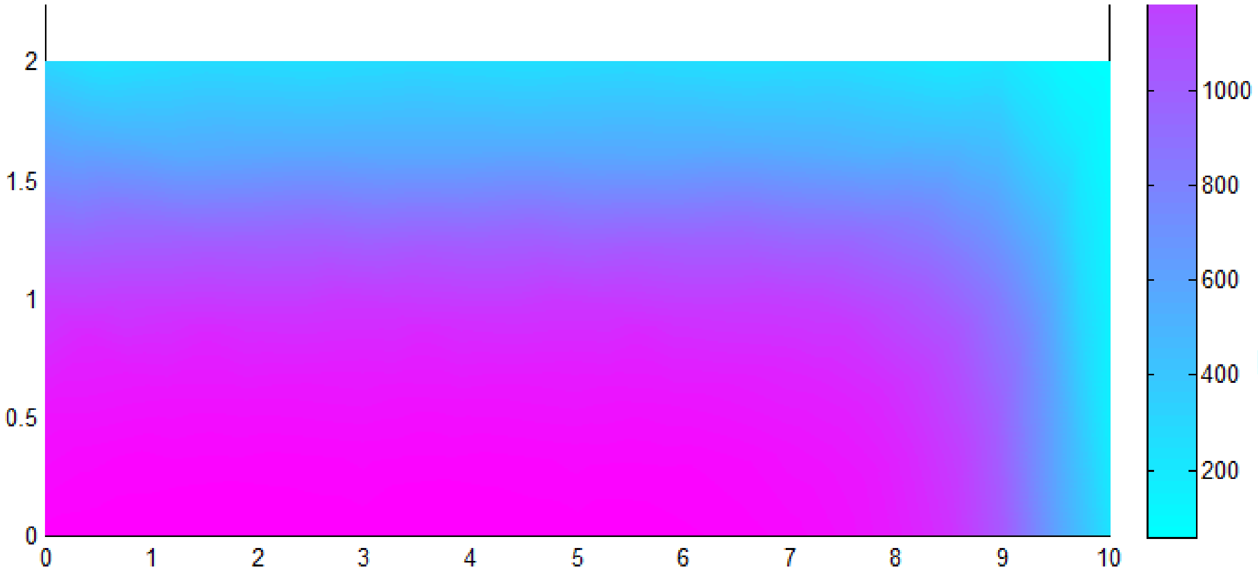

Fig. 4. Two-dimensional view of the distribution of heat flow in the drum

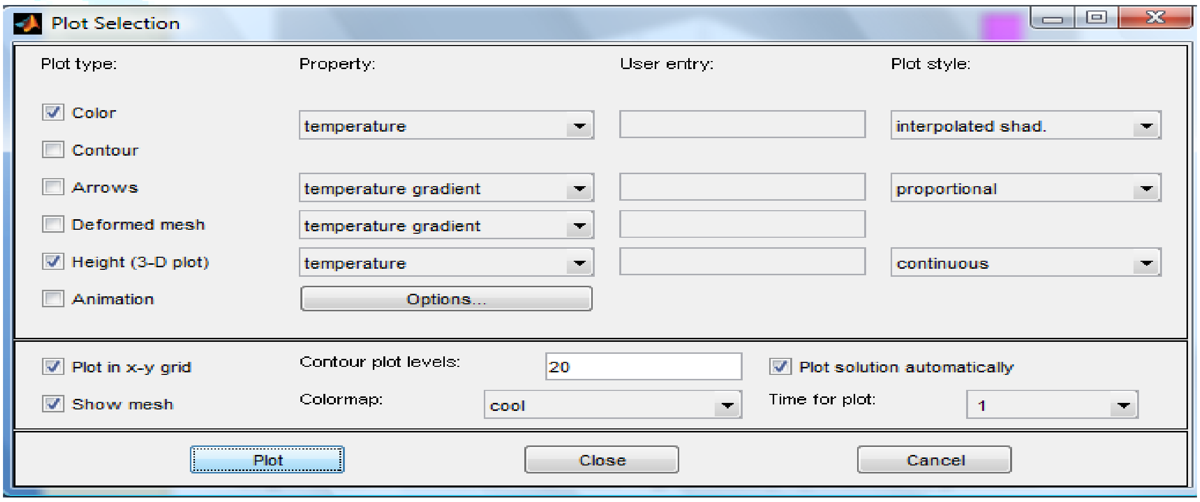

Fig. 5. Scheme for obtaining a three-dimensional image of the heat flux distribution in the drum

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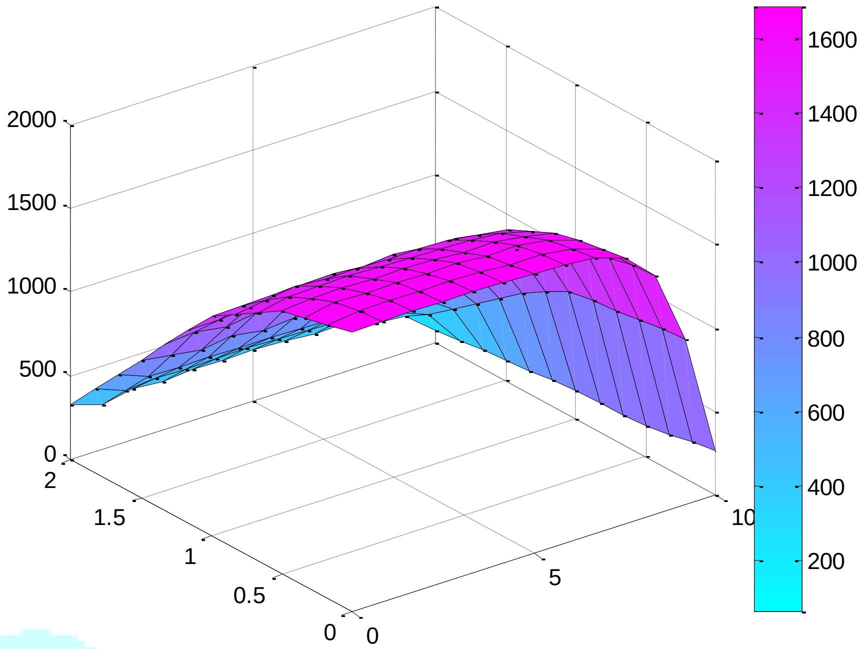

Fig. 5. Three-dimensional image of the distribution of heat flow in the drum

Conclusion

With the help of the software package, it is possible to introduce boundary conditions, physical and mechanical properties of the drying drum into the problem, and at the same time, the results can be obtained and analyzed in the form of graphics and 3D graphics. The errors and polynomial equations of the process of temperature propagation were obtained by plotting the obtained numerical solutions.

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