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The tunnel ventilation system in MATLAB in cooperation with TuSim

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Abstract

The paper deals with an influence of the ventilation system to the tunnel tube parts according to the traffic intensity. Simulations have been made by the PLC based tunnel simulator TuSim and the tools MATLAB and Simulink. The connection between MATLAB and TuSim has been made by free OPC server. The aim of this paper is to demonstrate dependence between base tunnel inputs like traffic intensity, lighting, atmospheric condition, air and car velocity and output pollutions. The obtained model is used to predict the output pollution values to the future.

Keywords: Tunnel simulation; simulation; ventilation; MATLAB; OPC server

1. Introduction

Road tunnels are important part of a traffic infrastructure. They shorten the paths in the mountainous regions and in towns. Shorter travel times lead to higher economical effectiveness. The occurrence of traffic accidents in the tunnel is less common, but consequences can be more serious. A lot of technological equipment is necessary to provide the tunnel system safe in any circumstances. Simulation experiments concerning optimization of technological equipment and control algorithms cannot be realized during 24/7 operation in real tunnel, therefore Tunnel Simulator (TuSim) has been developed. Models can be used to simulate expected process behavior with a proposed control system. The

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model requirements are a function of the usage of the model. The system is the tunnel tube. Emissions from cars are determined not only by the way they are built but also by the way they are driven in various traffic situations. Gases emitted by engine combustion contain mostly the oxides of nitrogen (NOx), carbon monoxide (CO), steam (H_2O) and particles (opacity). We are going to describe the dynamic behaviors of the system. Relation between a traffic intensity, a vehicle velocity and an air velocity is also needed to describe this system. In this paper we pointed on the concentration of CO, NOx and opacity inside the tunnel tube, because this type of pollution is the most dangerous for human organism. Using the model we can predict concentration of CO, NOx and Opacity.

2. Simulation tools

2.1. TuSim

TuSIM is a PLC based system running on the B&R Automation embedded PC (PLC [7]) with the UPS unit. TuSIM hardware is displayed in Fig.1 from top to bottom: Masterview LCD switch, visualization server, UPS unit on the bottom left part of the figure and B&R industrial PC on the bottom right part of the figure.

Fig. 1. TuSim hardware

All-important devices of the tunnel technological subsystem equipment are simulated by the software inside the PLC [1]. Equipment of three tunnels is implemented: City tunnel, Motorway two-tube and Motorway one-tube tunnel all with a length of 1km. TuSim supports in addition to the simulation of the technological equipment also the control of the traffic sequences. Fig.2 shows the part of the visualization traffic screen with the status of the traffic sequence together with implemented devices of traffic control equipment. Each tunnel tube can operate in the following traffic sequences: tunnel tube open, left lane closed, right lane closed, speed limit 60km/h, accommodation lighting failure, tunnel tube closed. Switching from one sequence to another follows the time requirements which allow all vehicles to adapt to the new conditions.

Control of the tunnel reflexes is the last important functionality implemented in the TuSim. Tunnel reflex is a reaction of the control system to a relevant event in the tunnel. The whole source code concept from the PLC software to the visualization screens is open for model enhancements, e.g. the traffic model can be easily implemented. There are many graphical screens to visualize the state of each subsystem of the technological equipment – at least one for each subsystem. Handling of the screens and separate connections to the simulator are realized by the visualization server and two client PCs with HMI/SCADA CIMPLICITY software which uses the client/server architecture. The server is responsible for collection and distribution of the data from the PLC; clients allow interacting with the data distributed by the server and perform control actions. There is detailed description of the operation inside the TuSim in [2].