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NUMERICAL SIMULATIONS OF CONTINUOUS MINING MACHINE

The main goal of the project is to remove presence of humans from dangerous enviroment by moving the control systems of the machines to control centers located above the ground. With the use of PLC drivers to control mining machines it would be possible to develop control algorithms which would fit parameters of the machine in relation to environment conditions to ensure best efficiency and save live of the machine. Therefore a virtual simulator program was created. Simulator program allows to simulate different types of continuous mining machines.

Основной задачей работы является перенос систем управления машинами в центры управления на поверхности с целью устранения людей из опасного производства. С использованием программируемых логических контроллеров (PLC) становится возможным разрабатывать алгоритмы, которые бы управляли параметрами горной машины в соответствии с текущими условиями ее работы для достижения наилучшей производительности и повышения срока службы. Была создана программа виртуального моделирования, которая позволяет моделировать различные типы горных машин непрерывного действия.

One of the most dangerous jobs in mining industry is operating of continuous mining machine which includes work at front of mine corridor and with very close contact witch heavy machinery. Those are two of many reasons of many accidents which happens in this unfriendly and unpredictable area. The main goal of the project is to remove presence of humans from this dangerous environment by moving the control systems of the machines to control centers located above the ground. Although the idea seems to be very complicated especially considering practical implementation it's not impossible. The first step of this process is already done . Mechanization of coal drilling process have already improved efficiency and lowered the final costs. Replacing power of human muscles with machines also lowered the rate of accidents. For example the rate of registered accidents in Germany has fallen by 89,5 % from its highest rate in 1958. The next step would be the automatization which once again should better the efficiency and safeness of miners. Use of PLC drivers to control mining machines would give even more advantages. It would be possible to develop control algorithms which would fit parameters of the machine in relation to environment conditions to ensure best efficiency and save live of the machine. Because continuous miners are very complicated and expensive machines it's almost impossible to use them for testing purposes. That's why a virtual simulator program was created. The first step was to create a computer model of the machine. The model was built on the basis of documentation delivered by Polish company KOMAG CMG. As an example the AM-50 continuous mining machine was modeled. It's design to drill corridors with cross-section of 16,4 m^2 in rocks with strength under compression up to 80 MPa. The model was created in Catia environment, it includes full simplified kinematic chain. Simulator program allows also to simulate different types of continuous mining machines. The main feature of the program is possibility of simulations of drilling process. It was developed with use of programs available under General Public License. It also allows for communication with Microsoft Office software for reporting purposes and TwinCat platform for real time Programmable Controller testing.

Blender is an Open Source program which was used as a graphic environment. It allows to create interactive presentations and is available under General Public License. One of the features of the program is Logic Panel which was used to create the first basic prototype of the program. To allow for communication with external programs such as PLC drivers an script-

ing programming language was used. Python is an Open Source project which includes dynamic system file and automatic memory management. As another example simulation of KR-150 continuous mining machine was performed. Changing the object of simulation is possible thanks to a graphic program interface where user can change main technical parameters of simulated machine.

The program allows for manual or automatic control. Saving the manual tracking is also possible. This helps to establish an optimal route for cutting head which further can be used as a cycle in automatic steering. The rock hardness is random. It's not based on any experimental data because non of test in real life conditions were performed. However user have some influence on strength and type of dynamic forces occurring during simulation. Also implementation of algorithms simulating real conditions can be done in a very simply manner.

As the first implementation an automatic positioning system was simulated. The system is based on set of sensors. There are four sensors present in this system. The main sensor is fixed to wall of the corridor the rest are reference sensors and are fixed to the frame of the machine. Computer algorithm calculates the position of the machine in all three dimensions including angular movement in relation to position of the main sensor. Although system is predicted to run with use of actual sensors which are already in use in mining industry it wasn't tested and is just an example of the idea how simulator program could be used to help develop algorithms for computer autonomous steering software.

The most advanced feature of the program is PLC communication. The program is connecting with TwinCAT platform through dynamic link libraries. TwinCAT software turns any compatible PC into a real-time controller. This means that any algorithm which was created, implemented and tested in virtual environment can be uploaded to the PLC driver and tested in real life conditions. That possibility should help engineers to design faster and provide more reliable products. But the most important thing is cost reduction. Having control algorithm already tested in virtual reality reduces amount of tests on real machines to minimum.

Another advantage is that different additional subsystems can be tested separately or all together as one system under all range of possible conditions. A presented example of automatic positioning system shows this possibility. Another step should be modeling of all equipment which is present in front of mine corridor for collision detection and some experimental tests to the correlation between hardness of rocks and power requires and miner position.

Summary

The program was designed as a tool which should help engineers to develop effective and reliable control algorithms for continuous mining machines. Thanks to use of graphic interface designer have better understanding how the machine will react under specific conditions. Also in next stage of the project the software will speed up the testing process. As a result the automated continuous miners should have better efficiency. Moreover the presence of the operator will no longer be necessary so the rate of accidents should be lowered.