DESIGN AND MULTIBODY DYNAMICS ANALYSIS OF HIGH MOBILITY MINERS RESCUE ROBOT

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1. Introduction

Rescuers of miners take a big risk when they enter explosive environments to check the condition of atmosphere in coal mine tunnel, coal excavation or longwall system, where the most accidents occur. Additionally, human rescuers can enter the restricted area only if critical parameters of methane content and temperature, are achieved. Due to the high risk to human life, the rescuers cannot monitor the hazard or perform the rescue operation since they are not allowed to enter the hazardous area [1, 2]. In such a case the best way is to monitor it by using a high mobility miners rescue robot adapted to such a hazardous area.

The Central Rescue Mining Station (CRMS) prepares requirements for robots participating in rescue operations in underground coal mines. Beyond the requirements of fulfilling ATEX directive [3], the main requirement is the ability to pass most of the obstacles present in a coal excavation, except tunnel collapse without any clearance. Another important requirement is that the robot must pass through a passage in the isolation dam with the diameter of 800 mm [4]. To pass this requirement the rescue robot needs high mobility, but it is often in conflict with ATEX standards.

2. Multibody and real-time simulations

The dynamics and kinematics analysis of multi-body systems, such as mobile robot, are a very useful component of Computer Aided Design (CAD) and Computer Aided Engineering (CAE) software. Mechanisms used in all these devices are normally subjected to large displacements and in this case there is possibility of collision between working parts of mechanisms. It is caused by kinematic and dynamic problems, which must be predictable and controllable or eliminated in the design stage. The advantage of numerical simulations performed by CAD and CAE software is that they enable one to predict the kinematic and dynamic behavior of almost all types of multi-body systems from the first concepts to the final product [5].

Another tool to fast prediction of the behavior of a vehicles is software for dynamics simulations of robotics V-REP. It has stricter requirements than video-games solver, where time and dynamical accuracy can be less constraining, but has also lower accuracy than engineering solvers. In games or animations, the laws of physics can be violated; therefore unfeasible forces may not be a problem [6]. Gaming solver is used to simulate the quad copters [7], behavior of humanoids [8] or mecanum wheels vehicle [9].

Most important in this kind of simulations numerical stability is therefore caused strong restrictions on the use of real-time simulations. The simulator must be fast when calculating the dynamics, if it as a prediction means in real time - control loops is useful. It also needs to ensure convergence physically viable solutions within a limited time frame. The analysis of the contact of hard and soft body with rigid and flexible environment has a decisive influence on the simulated interactions between the device and the environment. Support of various types of contacts, for example, deformable materials, flexible and soft surfaces, is essential for the optimization of robot controllers to different environments and objects. Incorrect calculation of contact forces between the contacts in unrealistic or physically impracticable contact forces and the unrealistic behavior of the device may result. Software for dynamic 'simulation often used open source as solvers like ODE or Bullet [6].

3. Design and results of analysis

In the figure 1 is presented final stage of design where rescue robot is driven by four adjustable arms with rubber tracks. In the top of robot is an arm with cylinder where is placed cameras, lightening and sensors. Fig. 2 shows results of passing simple obstacle.

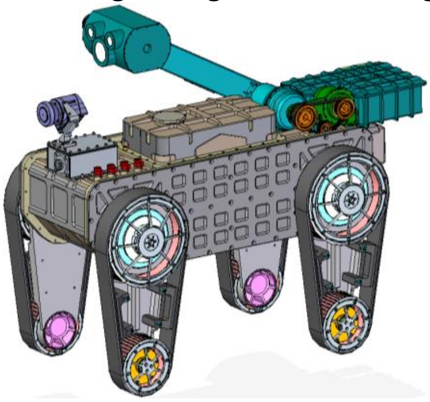

Fig.1. Design of rescue robot

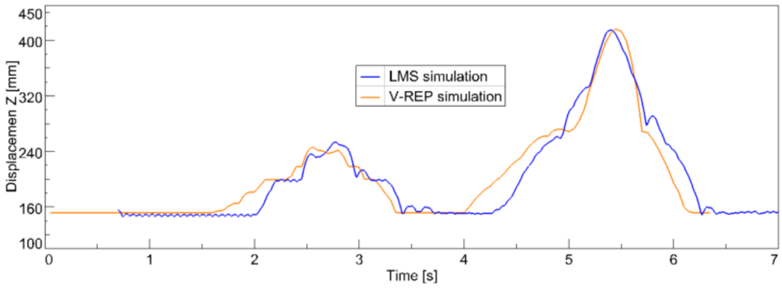

Fig.2. Displacement of hull of tracked platform in Z axis.

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6. References

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