THE LABORATORY MODEL OF HYBRID PROPULSION SYSTEM OF HEAVY DUTY FORKLIFT

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Abstract. The paper describes a project of laboratory stand of hybrid powertrain of heavy duty forklift. Hybrid drive is divided into two separate subsystems. The first subsystem is driving the vehicle and is a serial interface. The second subsystem is driving the lift mechanism and is a parallel. Both systems can operate in regenerative braking mode. Recovered energy is stored in batteries and can be used in case of sudden demand for power. The laboratory will simulate the lift work in realistic conditions. Data collected during the simulation will help in finding the most efficient algorithms for PLC controllers.

1. INTRODUCTION

Over the past several years we have seen increased interest in pro-ecological engineering solutions in the automotive industry. World's largest producers of passenger cars has introduced prototypes of hybrid vehicles. The best example of this is Toyota, which sold more than one million vehicles of this type. The benefits that accrue from the use of this type of drive caused that the heavy vehicle manufacturers are interested in using this kind of technology in their products. Application of a hybrid propulsion mechanism in the forklift with a high load capacity will decrease fuel consumption and to reduce emissions, while lowering the production cost of the machine at the same time. Regenerative braking mechanism will allow for re-use the energy in next cycles which will reduce the fuel consumption by up to 30%. The use of series hybrid powertrain for forklift drive operation will also allow for main combustion engine downsizing. The smaller engine means smaller fuel consumption, lower production cost and cheaper maintenance. Implementation of the gas–electrical powertrain in heavy duty forklifts will have a positive impact on the environment because it will reduce carbon dioxide emissions.

The paper describes the design of laboratory stand of forklift hybrid propulsion system. The project includes use of permanent magnet motors and ultracapacitors to ensure the powertrain best efficiency. The laboratory stand will be equipped with measuring system. Signals from the sensors will be transmitted to the micro controller, which on the basis of the obtained data and a specially created algorithm manages the flow of energy between the batteries and motors. The simulations will help develop a secure and optimized control algorithms for PLC controllers of real vehicle.
Battery pack is a very important element of the entire system for determining the viability and effectiveness. The advantage of supercapacitors, in contrast to electrochemical batteries is the fact that they are capable of receiving and issuing of large currents with no loss of life. Testing and research of laboratory stand will help to develop the most effective use of the ultracapacitors in complex hybrid powertrain.

2. PROJECT OVERVIEW

The laboratory stand consists of two subsystems which reflect the functionality of the forklift. The first of the subsystems consists of a diesel engine, electric machine and the differential mechanism. This is a serial arrangement, which allows the use of an internal combustion engine of less power and braking energy recovery. The diesel engine and the road conditions will be simulated by an electric motors. The third electric motor with permanent magnets will assist the diesel engine. The layout of this subsystem is shown at Fig.2.
The most important part of the second subsystem is a differential gear which blends the power of two power sources. This subsystem simulates the work of the lifting mechanism of the forklift. The energy which is currently wasted into heat during lowering the load will now be recovered and transmitted to the battery pack through the generator. The accumulated energy will be used in another cycle to rise the load or to drive the forklift depending on the power demand. The main microcomputer will decide on power flow with use of fuzzy logic. The most important parameters taken into consideration during this process will be: state of charge of batteries, batteries temperature, load and user input. To ensure a long life of the batteries their state of charge has to be kept between 20 to 80%. The propulsion system of the forklift lifting mechanism is a parallel arrangement. Use of two most popular hybrid propulsion system architectures in one laboratory stand with one common control system will allow to perform many interesting and valuable researches.
The prototype of the laboratory stand is based on universal aluminum profile system. The aluminum profiles ensure good stability, lightweight construction and ease of further modifications.

Fig. 4. Battery unit

The powertrain model will use two different power sources: an alternating current and direct current. The direct current will be supplied by a set of twelve batteries and will power up the permanent magnet motors. The weight of the battery pack will exceed 240 kg. Since the weight of batteries is significant they will be placed in a separate frame. The construction of lift mechanism is based on linear dynamic elements. The virtual model of the stand is shown on Fig. 5.
The laboratory stand consists of serial hybrid subsystem, parallel hybrid subsystem, lift mechanism, battery pack, AC steering units, DC steering units, measuring system and security system.

3. SUMMARY

The laboratory stand will be controlled by one common steering algorithm based on LabView software. The virtual model of the stand will help to develop optimized steering algorithms. Thanks to use of the LabView software the implementation of forklift real work cycles will be possible. Test results of simulations based on this data will help to understand the energy flow in the system and to optimize the fuel consumption.

REFERENCES

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WIDŁOWEGO

Streszczenie. W dokumencie opisano projekt stanowiska laboratoryjnego hybrydowego układu napędowego ciężkiego podnośnika widłowego. Układ napędowy jest podzielony na dwa odrębne podsystemy. Pierwszy z nich jest układem szeregowym i odpowiada za jazdę pojazdu natomiast drugi jest układem równoległym odpowiadającym za podnoszenie ładunku. Oba systemy mogą działać w trybie hamowania regeneracyjnego. Odzyskana energia jest przekazywana do akumulatorów i może zostać ponownie wykorzystana w przypadku naglego zapotrzebowania mocy. Układ laboratoryjny będzie symulować pracę pojazdu w rzeczywistych warunkach. Dane zebrane w trakcie symulacji pomogą optymalizować algorytmy sterownicze dla kontrolerów PLC, które zapewnią poprawne i efektywne funkcjonowanie systemu w warunkach rzeczywistych.