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IFAC-PapersOnLine 49-25 (2016) 448–453

Electric Drive and Energy Storage System for Industry Modular Mobile Container Platform, Feasibility Study

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Abstract: The optimal energy balance and effective using of mobile electric devices supplied from traction power supplies is the most limiting qualities in practice. The inconvenient combination or choice of different motors, batteries or supercapacitors is very often designed from the view of functionality mainly and energy balance is solved as the second step. This paper shows power-energy design of all-purpose mobile container platform for application in factory buildings. This presented design will be realized in interoperation logistics in manufacturing.

Keywords: autonomous mobile container platform, electric drive, energy storage system, lithium battery, supercapacitor

1. INTRODUCTION

The interior material transport is common problem of all factories. Many factories use autonomous systems of container, which are supplied from the line for all time. Our problem is concern to designed robotic container platform for input material transport in large factory buildings. This platform will be moved on the flat floor with areal navigation. The power charging from the station is possible during loading in terminal only. The platform drives with the full container of material to machine and it returns back with empty one. The travel speed is 8 $km \cdot h^{-1}$. This speed is limiting for safety operation to avoid very dangerous collisions between mobile platform and staff. The weight of fully loaded container is 100 kg, empty weight is 10 kg and the mobile platform weight is predicted to 100 kg too. The container is higher than wider therefore drive stabilization is very bad. Acceleration and braking is limiting to 1.11 $m \cdot s^{-2}$.

2. FEASIBILITY STUDY

This feasibility study brings general terms. It is presented starting points how to choose optimal strategy of HW and SW design for mobile modular robotic platform. The proposal follows from our long time electro mobility experiences. The most important aim is to achieve right and safety operation with maximal energy storage utilization.

2.1 HW and SW design of mobile container platform

The modular mobile platform will include only one superordinate master control system and several slave control blocks. The serial communication will be applied. Each module will be assembled from independent autonomous control blocks:

- Control of travelling electric drives built-in wheel

The block controls optimal acceleration, deceleration and optimal speed with the stress on minimization of rolling and electromagnetic losses (Ferková and Richter, 2014).

- Control blocks of batteries and supercapacitors management

Two types of energy storage systems (ESS), supercapacitors (SC) and lithium batteries (LiB) will be used in mobile platform only. The capacity of LiB will be significantly higher than capacity stored in SC. The SC will be used for short-term compensation of power peak during acceleration and deceleration.

- Master predictive control system

This control block coordinates working of control slaves. The important duty is prediction of next action. This information is fundamental for optimization of energy consumption.

The master control system secures common function of platform, for example: Navigation, prediction of speedy with conversancy next trajectory, safety, manipulation with load and so on.

2.2 Mechanical construction of modular undercarriage

The right concept of mechanical solution is principal for design of autonomous motor and energy storage space specification (Kyslan and Ďurovský, 2014). The moving of mobile platform will be on smooth surface only. The suspension system will not be necessary. There are two possibilities placing of electric drives.

The first is to install electric motors into the wheel hub. It is possible to use discoid or cylindrical motor. At the identical

10.1016/j.ifacol.2016.12.056

power we can suppose the same volume of both variants. The cylindrical motors more reduce space of battery box but the height of mobile platform can be lower than in applying of in-wheel motors.

The second alternative is the motors are placed on the chassis. Disadvantage of this design is smaller space for battery box than in first construction. The construction will be also more complicated if it will be used steering.

The rolling resistance will be reduced by the special design of tubeless hard and narrow tires.

A proposed design of modular mobile platform will not be equipped with active gears nor servomechanism for steering of wheels. The yawing on trajectory of mobile platform will be steer by different speed of outer wheels only.

The basic module of mobile platform has four independent driven wheel. The mobile platform build from two and more modules will be driven with the peripheral wheels. The wheels in the middle will freewheeling.

3. FUNDAMENTAL CONCEPT OF AUTONOMOUS CONTAINER PLATFORM

There are two fundamental techniques of handling the material in the industry. The first utilize containers with own wheels which are towed by mobile platform to the target position. The second one utilizes containers without wheels which must be transported onboard the mobile platform. The automatic loading/unloading mechanism is mostly designed as a mobile lifting platform which passes under the container. This technique generally requires a low cargo space, usually up to 300 mm. For this reason, there is a limitation on the maximum diameter of the wheel of 10" including the tire. Also acceleration and speed limits should be considered for the stability of transported cargo. Speed limit up to 10 $km \cdot h^{-1}$ is suitable for many applications.

Basic technical parameters of the concept of a modular chassis of autonomous container platform are listed below:

• Basic module dimensions is 200x250x100 mm.

• Wheels are with integral drive or passive wheels with a diameter of 180 mm and width of 150 mm.

• Interconnection between the modules can be hinged or fixed. Wheels suspension can be fixed or hinged too.

• Directional control of the conveyor is with the differential control of wheels along the axis of symmetry. Using steered wheels can be realized in specific application.

• Two modules will be always reserved for an ESS and the control system other modules can be passive.

• Each module will have cover that will form a base for the installation of functional extensions or cargo area.

• Maximum load capacity per system (one module with two wheels) is 50 kg.

• Maximum speed is up to 20 $km \cdot h^{-1}$.

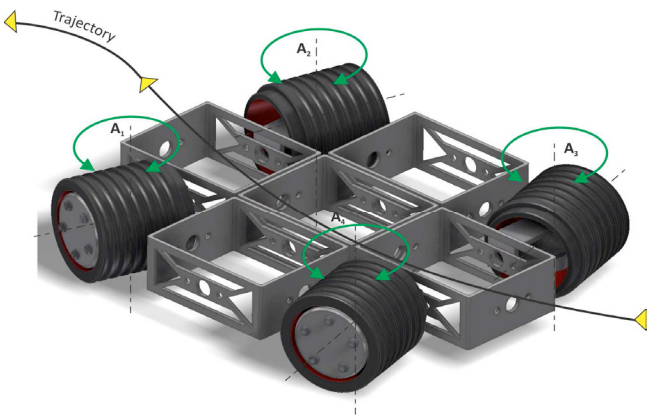

Fig. 1. Basic module of autonomous container platform.

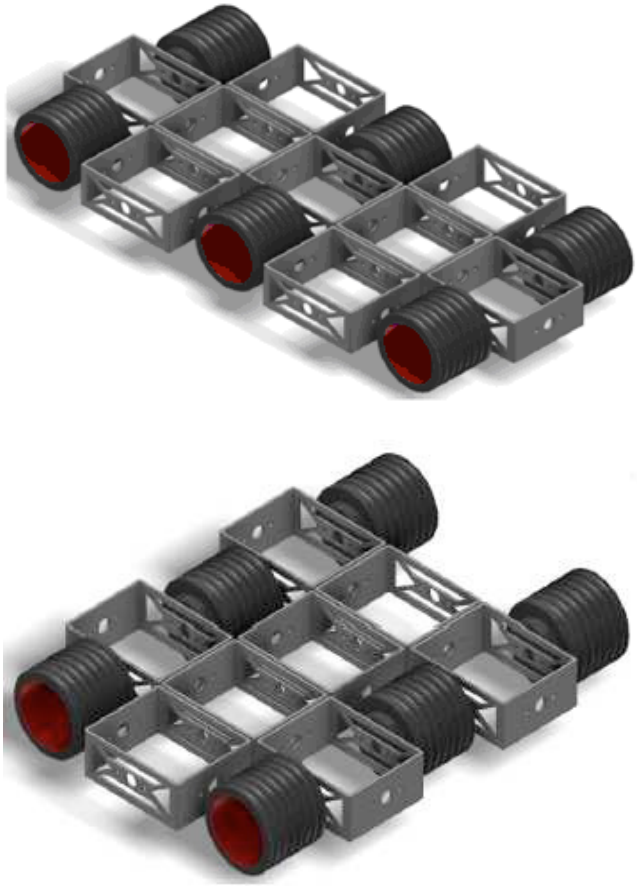

Fig. 2. Illustration of possible twin-module connections.

4. SIMULATION OF TOTAL ENERGY COMSUPTION OF MODULAR MOBILE CONTAINER PLATFORM

For designing the high efficiency drive of the mobile container platform it is necessary to know all technical parameters of platform and the cargo itself as well as a precise description of the driving cycle of the platform (Kubín and Ferková, 2015).