Available online at www.sciencedirect.com

ScienceDirect

IFAC-PapersOnLine 49-11 (2016) 385–392

Energy Efficient Control of the Air Compressor in a Serial Hybrid Bus based on Smart Data

Dzmitry Tretsiak, Tim Häberlein, Bernard Bäker

Dresden Institute of Automotive Engineering, Chair of Vehicle Mechatronics, Dresden, Germany (Tel: +49 351 463 39564; e-mail: dzmitry.tretsiak@tu-dresden.de).

Abstract: The development of new concepts for a public transport is motivated by reducing environmental pollution and traffic jams in city areas. Another essential reason for energy efficient vehicle concepts is to reduce transportation costs. Accordingly, a design and production of environmental friendly and emission free vehicles for urban public transportation is an important research and technological task. The architecture of a serial hybrid bus has the big capability to achieve above-mentioned aims because such vehicles have two energy sources (more degree of freedom) and more than one energy storage unit (battery, air tanks of vehicle pneumatic system). Thus, there is a big potential for the development of predictive control algorithms for various systems to enhance the overall energy efficiency and driving performance of such type of public transport.

Today the control algorithms of different systems in hybrid electric vehicles are implemented often as the kind of open-loop control. A typical example is the control strategy of vehicle air compressor. Currently, this unit of vehicle pneumatic system is operated by the principle of two-point controller regardless of the vehicle driving status and location on a route, the traffic situation and battery state, the number of passengers etc. Taking into account modern networking technologies it is possible to achieve a higher level of vehicle systems control with the aim to enhance the overall energy efficiency of vehicle operation. The goal is to develop vehicles on various types of closed-loop control systems (e.g. battery state of charge depending on system- and route parameters) towards smart vehicles (interconnection with the environment, additional history data, prediction etc.).

Authors focus on the development of closed-loop control strategy for the air compressor in a serial hybrid bus, as a first step, to improve the energy efficiency of compressor operation. Furthermore, the paper discusses how to increase the overall efficiency of vehicles including already implemented networking technologies.

© 2016, IFAC (International Federation of Automatic Control) Hosting by Elsevier Ltd. All rights reserved.

Keywords: hybrid vehicle, air compressor, pneumatic system, smart data, cloud-control

1. INTRODUCTION

The motivation for the development of energy efficient technologies and control systems is very sophisticated (e.g. political, humanistic, commercial or economic reasons for instance fossil resources). Nevertheless, all these reasons have a common goal to save energy and reduce emissions.

Environmental conditions in densely populated cities and also operating costs for vehicles with a combustion engine demand the development of new concepts of a public transport. A hybrid bus, as the kind of such transport, is a promising efficient tool to attain the goals of sustainable development and quality of city life.

In recent 20-30 years, the desire to production of fuel-efficiency and low-emission vehicles has driven the rapid development and wide application of hybrid automotive powertrains. In typical hybrid electric vehicles, an engine and additional energy source (usually, an electric motor fed by an electrochemical battery) combine their output power to improve a vehicle fuel efficiency by supervisory control, engine downsizing, cycle optimization, and regenerative braking. (Sciarretta & Guzella, 2007), (Pisu & Rizzoni, 2007)

Vehicle pneumatic system (VPS) is one of the most important and complicated systems. Specially cleaned and prepared compressed air is used for the operation of different systems (e.g. brake system, air suspension, door operating system in busses etc.). Many research works are devoted to the modelling and simulation of separate parts of VPS, for example, a brake system, with the aim to enhance vehicle braking dynamics (Miller, et al., 2013), (Bu & Tan, 2007), (Bowlin, et al., 2006)) and stability control (Kaldas, et al., 2011), (Kamnik, et al., 2003). Software- and Hardware-in-the-Loop simulation are widely used to improve the operation quality of air anti-lock braking systems (Zhang, et al., 2012), (Hongchang, et al., 2010). Other parts of VPS are also the object of correspondent research activities, for example, air suspension (Kim & Lee, 2011), (Roebuck, et al., 2006), (Muijderman, et al., 1999). The operation of single components of VPS is also an important part of research investigations in this area (Kaminski, 2012), (Kaminski, 2011), (Alonso, et al., 2010), (Subramanian, et al., 2004).

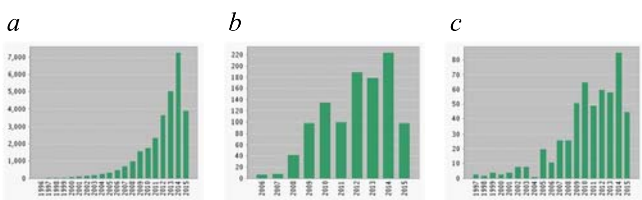
The presence of compressed air in a VPS is the matter-of-course fact in all above cited research works. It should be emphasized, that the preparation and delivery of compressed

2405-8963 © 2016, IFAC (International Federation of Automatic Control) Hosting by Elsevier Ltd. All rights reserved.
Peer review under responsibility of International Federation of Automatic Control.
10.1016/j.ifacol.2016.08.057

air for its usage in correspondent units of VPS is the actual research problem in terms of the energy efficiency of this process.

The electrification of vehicle auxiliaries is one of promising solutions to improve a vehicle energy efficiency and driving performance, to adhere to limits of local noise and CO_2 emission and to reduce transportation costs (Steinert, 2013), (Andersson, 2004).

Results of carried out literature survey indicate that the energy management of a vehicle is the actual research area in recent time. Nevertheless, the control of vehicle auxiliary systems is relatively seldom addressed in published studies. Moreover, there is a strong tendency that this research area becomes more and more actual now. To support this statement, Fig. 1 displays statistics of publication citations related to vehicle energy management and its auxiliaries.



a – vehicle energy management; *b* – vehicle auxiliary energy management; *c* – vehicle air compressor control

Fig. 1. Number of publication citations related to corresponding domains for timespan 1994-2014 in Web of Science database.

All auxiliaries in a serial hybrid bus such as the air conditioning compressor, cooling fan(s), vehicle air compressor (VAC), steering pump, are driven by corresponding electric motors. Energy used by auxiliaries, is the significant part of the whole energy amount, which is needed by bus operation. Moreover, for example, in summer auxiliary systems might well consume as much energy as vehicle traction units (Steinert, 2015).

VAC is one of the main consumers of electric energy among auxiliaries in the bus. The data proving this statement are presented in section 2 of the paper. Accordingly, the adaptive intelligent control of VAC has a big potential for the reducing of energy consumption i.e. fuel consumption, CO2 emission and transportation costs in a serial hybrid bus. For example, it is more sensible to use an electrical energy to supply VAC from the traction electric motors during vehicle regenerative braking instead of valuable electrical energy direct from the battery. Thus, a number of charge/discharge circles of the battery could be reduced and its lifetime can be increased.

The main distinguishing features of research work carried out by the authors (DVB AG, 2015) is that there is a concrete research object, a serial hybrid bus, and the specific route for its operation. Accordingly, there is a possibility for the development of predictive control algorithms for various systems to enhance the overall energy efficiency and driving performance of a vehicle.

This paper shows necessary and applied methods to improve the efficiency of VAC control with the focus on a closed-loop control and the possibility of a further stage of efficiency increasing through the implementation of modern networking technologies (cloud-control). On the first stage, a comprehensive data collection is necessary to carry out the analysis of current operation modes of VAC. The corresponding procedure and results of the carried out analysis of VAC operation are described in section 2 of the paper. The proposed strategy based on a closed-loop control for VAC to improve its energy efficiency is discussed in section 3. Section 4 of the paper gives an outlook how to achieve a further step with the global aim to increase the energy efficiency of systems with help of modern networking technologies.

2. SYSTEM ANALYSIS OF THE CURRENTLY INSTALLED AIR COMPRESSOR BASED ON SMART DATA

As already mentioned, a major benefit in the frame of current research activity of the authors is that there is a specific serial hybrid bus, Mercedes Citaro G BlueTec Hybrid, as the research object, and the concrete city route for its operation – the route 64 in Dresden, Germany (Fig. 2).

Fig. 2. Bus and route parameters.

The corresponding vehicle is equipped with 117 additional sensors to analyze the operation of its units and control systems. Hence, a special tool for data acquisition was built in addition to continue scheduled services on the regular route. As a conclusion, the developed tool works with mobile data via cellular networks based on the Internet of Things (IoT) concept. Fig. 3 shows the basic structure and some possible tasks of the tool.

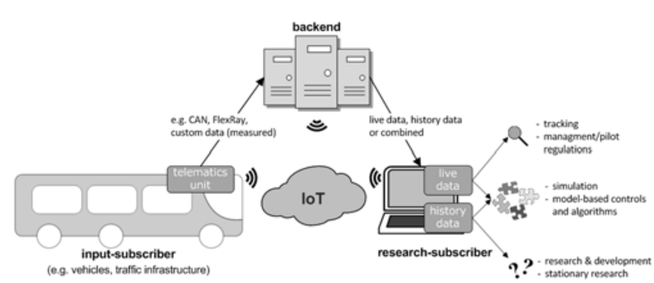


Fig. 3. Structure and possible tasks of the data acquisition tool chain

This acquisition tool could not only record the information from the described research object. It should be underlined that the data from many more input-subscribers (e.g. other vehicles or the traffic infrastructure) can be analyzed under different requirements and aspects. Data about these input-subscribers

Download English Version:

https://daneshyari.com/en/article/714054

Download Persian Version:

https://daneshyari.com/article/714054

Daneshyari.com