

The Black Ship of Automobile Electrification

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Completed the Electronic-Mechanical Engineering doctorate program at the Nagoya University Graduate School of Engineering in March 1995. Became an assistant at the same university in April of the same year. Became an assistant professor at Mie University in June 2000, an assistant professor at Nagoya University in April 2004, an associate professor at the same university in April 2007, and a professor at the same university in April 2012, a position which he currently holds. Doctor (engineering). Primarily engaged in research related to motor control based on control logic, as well as to pattern information processing, signal processing, and modeling for control, and to applications thereof. Member of societies including The Institute of Electrical Engineers of Japan (IEEJ), The Institute of Electronics, Information and Communication Engineers (IEICE), The Society of Instrument and Control Engineers (SICE), Society of Automotive Engineers of Japan (JSAE), and IEEE.

1. Introduction

The electrification of automobiles is a technology that has already become commonplace, and the spotlight of the automobile industry is now shifting to autonomous driving. At this time, it is a great honor to take this opportunity to submit an article to your journal, and I here would like to look back at the relationship between automobile electrification and my own research (motor drive technology) and record my observations.

2. My Perspective as a Motor Drive Researcher

As my research concerns motor drive technology for appliances and industrial use, the application of this technology to electric vehicles, beginning with the appearance of hybrid electric vehicles, was for me a shock comparable to the arrival of Admiral Perry's ships in Japan in 1853 – the ships known as the “Black Ships”.

In order to install motor drive technology in automobiles, which involve more severe restrictions on weight and volume as compared with household appliances and industrial applications, advances such as the following were required. These were at the time commonly thought impossible from the perspective of household appliances and industrial devices.

- Higher output densities that can support nonlinearization of motor output caused by magnetic saturation
- Active use of over modulation and square-wave in power converters that can support nonlinear amplification in order to draw out power from the power source (battery) to the limit

Although these are technologies for operating the electric motors that I thought were nearing their final form at that time, in fact I had simply been avoiding them because they appeared so difficult. Their arrival in the market was a powerful notice to me that my knowledge was incomplete and there were still matters left to study.

In this way, this “Black Ship,” that is the electrification of automobiles, opened up a number of new worlds in the field of motor drive technology. With the correct application of position sensorless control that actively utilizes the significant inductance fluctuations caused by magnetic saturation⁽¹⁾, and also overmodulation and square-wave drive, it not only became possible to expand the operating range by continually drawing power from the power source, but also produced new ideas that had previously been unthinkable such as improved current control response that is also used in transient states⁽²⁾. For the field of motor drive research as a whole, this also showed that motor drive research was not nearing its end, and is in fact opening up new applications such as electrification of aircraft⁽³⁾.

3. My Perspective as an Automobile Electrification Researcher

At the same time, the introduction of electrification to automobiles may have been a “Black Ship” to the automobile industry also. Because an internal combustion engine runs continuously and is a constant source of power, automobiles had been composed of a variety of devices based on the following assumptions: first that there would be a continuous source of hydraulic pressure, and second that there was so much heat that it could be thrown away.

However amidst the active competition for environmental performance and fuel economy, at some point internal combustion engines began to stop operating when at idle, and began to repeatedly start and stop during driving as they do in a HEV or PHEV, and of course such an engine does not even exist in an EV. A world has arrived in which designers cannot rely on the excess power and heat of an internal combustion engine. The foundations of internal combustion engine-centric systems that past automobiles were built on have been overturned, and as a result it has become necessary to electrify and reconstruct all kinds of devices including power steering, hydraulic pumps, water pumps, and air conditioning compressors.

The difficulties and struggles facing the persons involved are clearly numerous. However, not all the consequences of this “Black Ship” of electrification have been negative. In addition to making auxiliary devices capable of on-demand operation, electrification also makes possible more advanced device operating functions and as a result, is producing new added value⁽⁴⁾. For automobiles, electrification is no longer a question of whether or not to use the technology, it is a question of how to use it.

4. Finally, my Perspective as a Car Lover

People tend to think that in this way, electrification will take hold as an essential technology in xEV (EV, HEV, PHEV, FCEV), and is likely to put an end to the internal combustion engine. However, it can also be said that electrification is bringing a new age to internal combustion

engines as well. Mercedes recently announced the M256 new-model engine. It utilizes a 48V power supply, and includes an electric compressor, electric pump, integrated starter-generator, and electric supercharger. However it is not being openly marketed as a hybrid. I feel that their message is “this is an internal combustion engine for a new age based on electrification technologies”.

Electrification began with EVs and HEVs, however the entity which receives the greatest benefit from the “Black Ship” of electrification may turn out to be the internal combustion engine. Of course, from the perspective of an electrical system researcher and educator, the ultimate goals may be EVs and FCEVs (or so I hope). Nonetheless, I also today am looking forward to seeing what can be accomplished and how much progress can be made by a partnership between electrification technologies and internal combustion engines evaluated from a zero-base perspective.

References

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