SUMMARY OF MASTER'S DISSERTATION

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Title

Trends of Automotive Industry and Needs for Automotive Lubricants Toward 2030, from the Viewpoint of Life Cycle CO_2 Emissions Reduction

Abstract

CO_2 emissions reduction is one of the major drivers of change in the automotive industry and electrification of automobiles has been accelerating in recent years. This trend may bring drastic structural change of the industry. For example, when shifting from conventional internal combustion engine vehicles (ICEVs) to battery electric vehicles (BEVs), it is inevitable that lubricants in use, such as engine oils and transmission fluids, have a large impact. Therefore, trends of the automotive industry and needs for automotive lubricants toward 2030 from the viewpoint of Life Cycle CO_2 ($LCCO_2$) emissions reduction are investigated in this study.

The followings are the significant findings:

(1) A comparative $LCCO_2$ emissions analysis of passenger vehicles was conducted. ICEV, hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV) as well as BEV and fuel cell vehicle (FCV) were investigated, taking into account HVAC energy and energy mix from 2008 to 2030 in Japan. The results show that HEV effectively mitigates $LCCO_2$ emissions with current energy mix (2012-2014 average) which heavily relies on thermal power generation. In contrast, PHEV shows the most competitive $LCCO_2$ emissions in 2030, when nuclear and renewable power generation are expected to replace oil-fired power generation. However, BEV shows higher $LCCO_2$ emissions compared to HEV and PHEV even in 2030 due to high CO_2 emissions in battery pack production. Consequently, it is expected that PHEVs are obtaining considerable market shares.

(2) An investigation of the environmental impact of a comprehensive set of lubricants was carried out following the above LCA. Conventional viscosity lubricants, latest low viscosity lubricants and future ultra low viscosity lubricants, which is assumed to be 4.3 mm^2/s, were considered. It was found that the latest low viscosity lubricants improve vehicle fuel economy by up to 4.0 % compared to conventional viscosity lubricants, and considerably save the vehicle $LCCO_2$ emissions even when subtracting the produced CO_2 emissions from lubricants production. Moreover, future ultra low viscosity lubricants have the potential to improve vehicle fuel economy by up to 2.1 % further, compared to latest low viscosity lubricants. With respect to cost-effectiveness of future ultra low viscosity lubricants, 2.1 % fuel economy improvement generally requires the cost increment of $ 50 (USD) and it is expected that future ultra low viscosity lubricants have certain cost-competitiveness based on the investigated price trends of base oils.