WATER-COOLED CHARGE AIR COOLER MODULE DEVELOPMENT

Radzicki, Jonathan*, Asano, Taichi, Yasuda, Takashi, Hasegawa, Manabu
DENSO Corporation, Japan

KEYWORDS
Water charge air cooler; intake manifold; thermal strain; simulation; visualization

OBJECTIVE
Due to continuous environmental improvement trends in recent years, the use of turbocharged engines is expanding worldwide. The water-cooled charge air cooler (WCAC) has the merit of simplifying the intake air path and is the current mainstream use of charge air coolers (CAC). In this report, we introduce a newly-developed plate-type WCAC module that is integrated with the intake manifold and mounted directly onto the engine. This type of WCAC experiences more severe thermal strain conditions, so we must compare simulation versus actual measured thermal strain data to improve our future design process.

METHODOLOGY
Our previous WCAC technology utilized a tube structure, which is similar to a radiator, but the tube structure tends to have relatively low thermal strain durability. As system temperatures and tube lengths increase, thermal stress also increases. To meet this increased customer demand, DENSO designed a new plate structure WCAC. However, simulations alone cannot accurately predict the transient thermal stress. To help quantify this, we used simulation and visualization technologies. The computer simulations obtained the theoretical thermal stress values and locations while the visualization technology provided actual data during the transient condition. This allowed us to observe the thermal stress mechanic and compare compressive and tensile thermal stresses. The core sizes and test conditions were kept constant between the tube structure and plate structure WCACs.

RESULTS
Our simulations and testing concluded that for a similar-sized WCAC core under the same conditions, the DENSO plate structure experiences approximately 70% less thermal strain than the old tube structure. When our plate structure is utilized, this reduction of thermal stress either allows for larger WCAC cores with similar durability or same-sized WCAC cores with increased durability. The visualization technology revealed that the WCAC experiences both compressive and tensile thermal stresses. These opposite stresses are primarily caused by the effects of the crimp plate and plastic tank interaction with the core.

LIMITATIONS OF THIS STUDY
Thermal strain is dependent on geometry, material choice, manufacturing capability, and vehicle operating conditions, so new designs will need to be evaluated separately. The methodology of this study can serve as a guideline for future DENSO design considerations.

WHAT DOES THE PAPER OFFER THAT IS NEW IN THE FIELD INCLUDING IN COMPARISON TO OTHER WORK BY THE AUTHORS?
We utilized our previous SAE report (2016-01-0651) to evaluate thermal strain durability differences between WCAC cores constructed from our tube technology and our new plate technology. The final design was refined with real-world data measured by visualization technology for thermal deformation and accurate strain measurement at high thermal stress locations.

CONCLUSION
A new DENSO WCAC product was developed with a focus on two-stage cooling performance and intake-manifold integration. During this development, our methodology for comparing simulated and measured thermal strain was further refined. This increased understanding of thermal strain should improve our future products and help reduce development time.