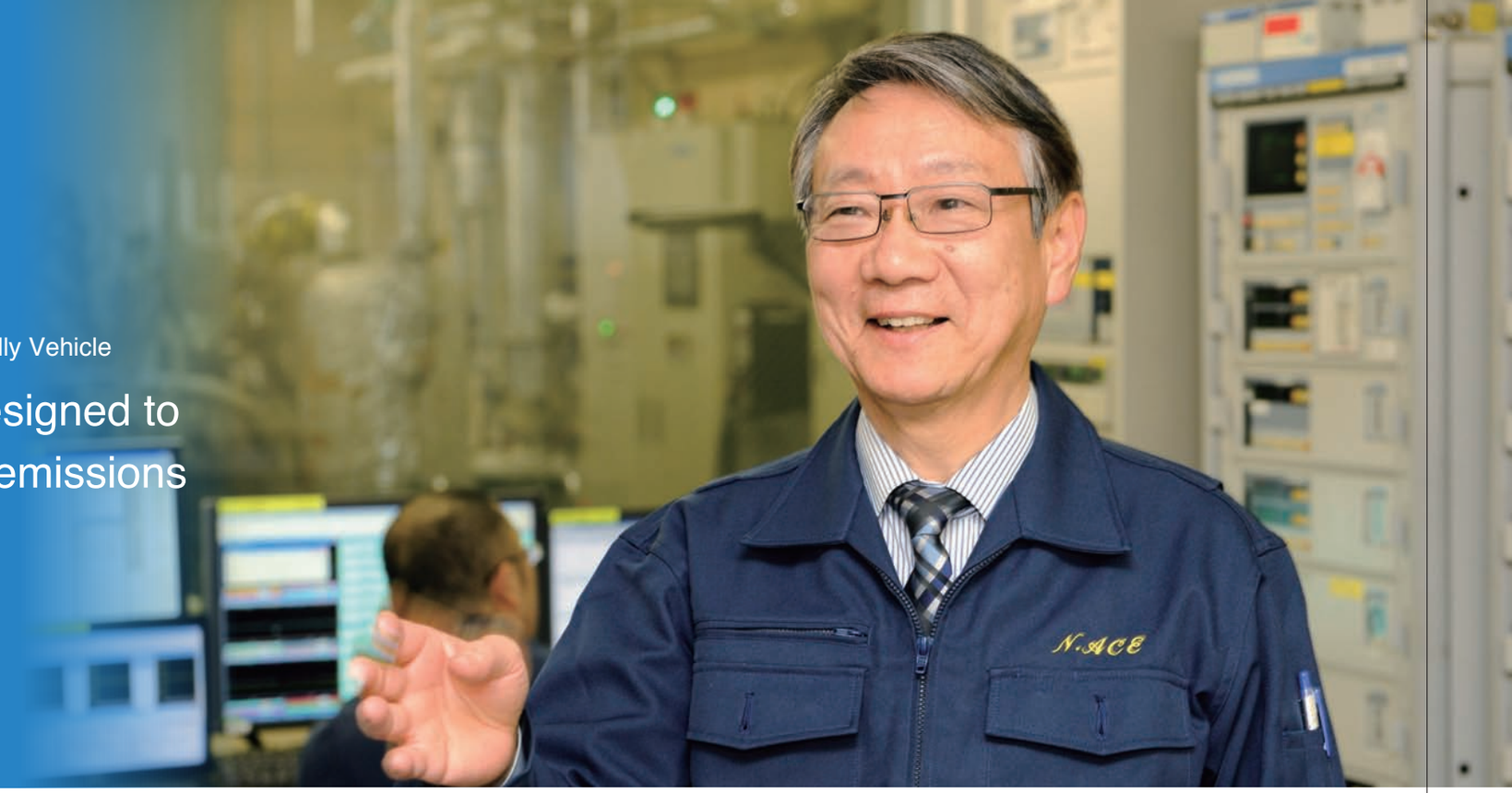
Special Interview

Dr. Yuzo Aoyagi

Counsel andex-President, New A.C.E. Institute Co., Ltd.
Doctor of Engineering



Cutting Edge Technology Supporting Future Environmentally-Friendly Vehicle

R&D on a super-clean diesel engine designed to drastically reduce NOx and particulate emissions

Many Japanese people have a negative image of diesel engines because they think smoke from diesel engine exceptionally pollute the environment. However, in Europe, diesel vehicles are quite popular as environmentally friendly vehicles. What is the true potential of diesel engines?— The following is an interview with Dr. Yuzo Aoyagi, ex-President of New A.C.E. Co., Ltd., who was engaged in R&D on a super-clean diesel engine designed to further reduce pollutants in engine emissions.

Diesel Engines with High Thermal Efficiency and Less CO_2 Emission causing Environmentally Friendly Performance

— In Europe, passenger cars equipped with diesel engines account for a large percentage of vehicles. Why is there such a big difference between Japan and Europe?

Over 50% of new registered passenger cars a year in Europe are diesel vehicles . In some countries, such as France, the percentage of diesel passenger cars even exceeds 70%. On the other hand, the percentage of new diesel passenger cars sold in Japan has remained low and only slightly exceeded 10% during the 2000's. My impression is that there is a widespread misunderstanding of diesel vehicles among Japanese people. I sometimes lecture at universities and find that more than 90% of students have a negative image of diesel engines, thinking that their exhaust gases are very bad for the environment.

One reason for this misunderstanding is that city buses and trucks of old models, manufactured when emission regulations were not as strict as today, still run on the roads, emitting diesel smoke. These vehicles were expensive and have proven durable, so some vehicles that were manufactured several decades ago still remain in service. In addition, black diesel smoke was hot topic of debate in the Tokyo Metropolitan Government's "No Diesel Car Campaign" during the late 1990s, contributing to a negative image of diesel engines.

— What's the difference between diesel and gasoline engines in the first place?

First off, they use different fuels. Gasoline engines use gasoline fuel, which is a high-quality, highly-volatile fraction of petroleum. In contrast, diesel engines use diesel fuel consisting of a relatively low-volatile fraction of petroleum. In addition, gasoline engines use spark-ignition combustion which ignites a compressed premixed air and fuel by means of a sparkplug. Diesel engines use compression-ignition where pressurized fuel injected into compressed air under high-temperature and high-pressure burns by self-ignition and diffusion process. The difference in combustion mechanism results in a characteristic of diesel engines that the air charged into engine is compressed up to very high-pressure level. The higher gas compression ratio leads higher efficiency, that is, higher engine output is obtained from combustion chamber due to greater expansion power. Therefore, the diesel combustion process is generally described as a high-thermal-efficiency process.

Diesel engines are not only recognized for high thermal efficiency, but for their utilization of inexpensive diesel fuel as their fuel in Japan. These two characteristics lead to fuel consumption of diesel vehicles to be approximately 30% less than that of gasoline vehicles of the same weight. Since consuming less fuel is directly related to emitting less amounts of CO_2, diesel vehicles are favorable in Europe with the mindset of preventing global warming.

— Diesel engines have high efficiency and low environmental impact. So, you can say they have excellent engine performance?

That's right. However, they also had problems that took many years to solve. The largest of which was diesel emission. Specifically, the main issue was reducing the amount of air-polluting nitrogen oxides (NOx) and particulate matters (PMs) produced by the diesel combustion process. With gasoline engines, NOx and other air pollutants have been drastically reduced through the use of three-way catalysts. However, these three-way catalysts could not be applied to diesel engines, whose exhaust gas contains excess amounts of oxygen. It was for this reason that new technologies for diesel engines, such as common rail fuel injection and exhaust gas recirculation (EGR), were developed to reduce the amount of NOx and particulate emissions. As a result of such efforts, today we have clean diesel engines with high environmental performance comparable to that of gasoline engines.

Analytical and Measurement Instruments used to Prove Theories of Engineers

— Against such a backdrop, your company, New A.C.E. Institute Co., Ltd is conducting R&D on a super-clean diesel engine to achieve an even higher level of environmental performance.

New A.C.E. Institute Co., Ltd is an R&D company that was jointly established in 1992 by diesel engine manufacturers and an engine parts manufacturer. Our aim was to reduce exhaust gas emissions from diesel engines and improve their thermal efficiency. Using globally- leading research results obtained by the company, we participated in the next-generation low-emission vehicle project launched in 2002 by the Ministry of Land, Infrastructure, Transport and Tourism.

◀ Parts from the super-clean diesel engine being developed by New A.C.E. Institute Co., Ltd.

Through this national project, we took part in developing a super-clean diesel engine. We set a challenging goal of reducing NOx emission to one-twentieth of the level stipulated by the emission standards at the time (2002) and the amount of PM contained in diesel smoke to one twenty-fifth of the level stipulated in the standards. These figures are far below the levels of the subsequent emission standards, and it was a challenge comparable to climbing an unexplored mountain.

— Could you outline the background of your R&D project and the technological challenges concerning your research?

In short, the cleaner exhaust gas is, the better it is for the global environment. That is the reason we started our R&D project—we thought that it was a good opportunity to expand Japan's technologies globally as regulations would continue to become more stringent demanding in countries around the world.

Actually, reducing diesel emissions faces a trade-off between NOx reduction and PM reduction, Combustion at higher temperatures generates more NOx, while combustion at lower temperatures generates more PM. Allow me to speak a bit about the technical details. In our R&D on super-clean diesel engines, we defined the following targets related to combustion: 1. lean burn; 2. high boost pressure; 3. high-pressure injection; 4. high brake mean effective pressure (BMEP); and 5. wide-range and high rate of EGR. More specifically, by combining cutting-edge technologies, "turbo inter-cooler systems" and "wide-range and high rate of EGR", we attempted to reduce both NOx and PM simultaneously. Fortunately, our project led to a variety of achievements that are currently being commercialized by automobile manufacturers today.

◀ Analytical and measurement devices are invaluable tools in reserch.

— In your R&D efforts, you use various analytical and measurement devices. How do your engineers view such devices?

They are absolutely necessary tools. The mutually supportive relationship between an engineer and his or her equipment is similar to that of the relationship of a married couple.

At our company, we use a variety of measurement devices in order to evaluate diverse parameters, including those of emissions, fuel efficiency and engine performance. We perform measurements to prove our theories and hypotheses through experiments. For example, that was certainly the case with our R&D on a new EGR system. Theoretically, the diesel engine that we produced was designed to reduce NOx emission to less than one-tenth of the conventional level, a truly epoch-making achievement. However, what is important is not the NOx emission such an engine can theoretically reduce but to what extent the diesel emissions can actually be made cleaner. Therefore, it is always necessary to conduct experiments to measure emitted gas components. In our experiment, the measurements conformed exactly to our expectations, so I was extremely pleased with the results.

Measurement devices are rarely spotlighted in R&D, but as I said earlier, they are our invaluable tools and measurement results sometimes lead to even new development concepts. I believe the emission measurement system installed in our company is the best in the world for diesel engine R&D.

— Do you have any expectations or requests for analytical and measurement device manufacturers?

Measurement systems are to be built by combining our needs and the features of individual devices. Therefore, it is essential that we communicate closely with manufacturers. We would like to further promote such collaboration. In particular, the test methods used to measure engine emissions are changing, and in recent years, so-called transient tests, in which measurements are conducted under the simulated driving conditions of actual roads, have become required. Changes in test methods require corresponding changes in measurement systems. We expect that more efficient and easier-to-use measurement systems will be developed in the future and we would like to share many specific requests to make this happen.

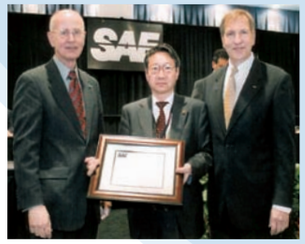
Intensive Discussions are the Source of Innovation

— You have been engaged in R&D on diesel engines for a long time. Is there anything that you regard to be particularly important in your research?

Generally speaking, mechanisms that show outstanding performance in some limited aspects, while having problems in other points are rarely accepted in practice. Therefore, diesel engines that are focused only on reducing NOx emission are not of much use. It is also necessary to reduce the amount of PM as well as to achieve high levels of performance in terms of thermal efficiency. To commercialize a diesel engine, it is necessary to strike a balance between these different factors. Basically, technologies are developed to be utilized in some way. Therefore, technologies show their value when they are practically utilized. In sum, we emphasize the importance of overall consistency and applicability in R&D. Also, my personal research style cherishes the power of focusing. By nature, I tend to absorb myself in my work. My friends often tell me that I am stubborn because I pursue my interest or whatever inspired me until I'm fully satisfied, with no compromise.

— If you are stubborn, perhaps you have many disagreements with others.

Yes, I often do (laughs). When starting a large project, I always ask all members to share the thoughts and thoroughly discuss the project. Though these discussions may sound like quarrels to outsiders, we cannot achieve truly satisfactory results without sharing honest opinions. I have an impression that today's young people tend to avoid having arguments or confrontations with others. However, while expressing our opinions to one another, we often not only discover new problems, but also develop confidence in each other. It is impossible to achieve the world's highest level of performance without extremely strong motivation. Therefore, I think engineers must have heated discussions among themselves.



◀ Dr. Aoyagi was nominated as an honorable SAE Fellow by the Society of Automotive Engineers (SAE), a distinguished U.S.-based professional association with a long history, for his many years of research achievements related to reducing diesel exhaust emissions (FY2005).

— Finally, please tell us about your goals and dreams for the future.

What is most important in the development of engines from the viewpoint of mechanical engineering is improving thermal efficiency. Therefore, I have no doubts that diesel engines will continue to be mainstream internal-combustion engines. In addition to hybrid systems, there are also many related technologies that draw my interest, such as turbo compound technology as well as Rankine cycle systems and thermoelectric elements which convert waste heat into power or electricity. So, I will continue to engage in R&D in order to further improve thermal efficiency. Some researchers in Europe who love cars tell me that once you drive a diesel car, you can't leave it. The greatest charm of a diesel car is its high engine performance, which has outstanding acceleration at low speeds. Noise levels have also greatly improved compared to older models. I hope we can contribute to the development of future environmentally friendly cars by further reducing emissions using our technologies.

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After graduating from the Tokyo Institute of Technology in 1971, Dr. Aoyagi joined Hino Motors, Ltd., where in the Engine Research Department he engaged in R&D on technologies for reducing pollutants in emission and fuel consumption for heavy duty diesel engines. Dr. Aoyagi completed his education at the Graduate School of the Tokyo Institute of Technology in 1980. In October 1998, he was appointed as Managing Director and General Manager of the Research Department at New A.C.E. Institute Co., Ltd. and was CEO and President from 2011 to 2013. Now he has been in his current position since June 2013 . In 1982, he received the Technical Paper Award of the Japan Society of Mechanical Engineers. In 2006 and 2007, he also received the Best Paper Award by the Society of Automotive Engineers of Japan. Dr. Aoyagi is a fellow of the Society of Automotive engineers of Japan, the Japan Society of Mechanical Engineers fellow and also an SAE fellow.