USER STORY

Nissan Develops Emission Reduction System for Mass-Production Vehicles Using MathWorks Tools

Meeting new emission standards and satisfying environmentally conscious car shoppers is critical to success for today's automobile manufacturers. Arriving first to market with a gas-powered vehicle that meets these standards requires new yet proven engineering design approaches.

By replacing their paper-based design process with MathWorks tools for model-based design, Nissan Motor Company, LTD. (Nissan) designed an emission reduction system that was first implemented in their 2000 Sentra Clear Air (CA). Sentra CA became the first gasoline-powered vehicle to be certified by the California Air Resources Board (CARB) for the Partial Zero Emission Vehicle (PZEV) standard.

"If you drove ten miles to work, then home in the Sentra, you would still produce less pollution than an ordinary car sitting in a driveway all day with its engine off," says Shigeaki Kakizaki, assistant manager, Engine Management System Engineering Group No. 2 at Nissan. "Without MathWorks tools for model-based design, Nissan would not have become the first company to meet the CARB PZEV standard."

CHALLENGE

To design an emission reduction system certified by the California Air Resources Board (CARB) for the Partial Zero Emission Vehicle (PZEV) standard

SOLUTION

Use MathWorks tools for model-based design to design an emission reduction system that was certified by CARB for the PZEV standard

RESULTS

- Development time reduced by 50%
- Environmental Protection Agency award received
- Number of sensors reduced

THE CHALLENGE

Nissan sought to be the world's first automobile manufacturer to deliver a vehicle to market with an exhaust emission reduction technology that met the CARB PZEV standard.

Historically, Nissan relied on a lengthy, paper-based development process that used real engine hardware. This process required redundant design steps and thousands of iterations to achieve the desired system performance.

The Nissan 350Z.

"It is difficult to reduce development time and costs with a traditional development process," says Mr. Kakizaki. "We had reached the limit of our capabilities and needed a new process."

To achieve their objectives, Nissan would need to reduce development time while implementing a new, sophisticated controls strategy.

Finally, Nissan would need to minimize system costs by reducing the number of sensors to achieve low emission.

THE SOLUTION

Using MathWorks tools for model-based design, Nissan reduced development time by 50% when creating the world's first exhaust emission reduction system to be certified by CARB for the PZEV standard.

"MathWorks tools have been essential for reducing our development time and costs, while enabling us to deliver a high-quality product," says Mr. Kakizaki.

> *Model-based design with MATLAB and Simulink is fully proven and indispensable to our engineering process, and gives us an advantage over our competition.*
>
> *Shigeaki Kakizaki, Nissan Motor Co., LTD.*

Nissan used MATLAB®, Simulink®, and Stateflow® to develop models of their emission control strategy. These models became the main specification for the system, which engineers reused throughout the development process.

Using Simulink, engineers first created a plant model of the engine to validate designs and refine the PZEV emission control strategy for the 2000 Nissan Sentra CA.

"Simulink enabled us to perform simulations early in the design process," says Mr. Kakizaki. "This helped us quickly validate our design ideas and refine our control strategies."

Kakizaki's team validated their algorithms on real engine hardware and met the emission requirements. They then began implementing their design and developing software.

For the third-generation emission control, Nissan used Simulink to implement a "Sliding Mode Control" strategy—one of the latest advancements in emission control. Nissan applied this strategy to their Maxima, Quest, Murano, Z-car, and Titan trucks, and was able to reduce the number of sensors without losing any control capability.

"The capabilities in Simulink helped us to move an advanced control strategy like Sliding Mode Control from research to implementation in production vehicles," says Mr. Kakizaki.

Nissan is currently improving testing and verification by applying a concept they call "model-based testing." By generating test cases from Simulink models and comparing the results against the actual implementation in hardware, model-based testing will reduce program verification time and software quality quantification efforts. Nissan is working with MathWorks Connections Partner, Reactive Systems, on the development of this technology.

"Evolving model-based design further into the testing phase will provide substantial improvements to the overall efficiency of our development process," notes Mr. Kakizaki.

THE RESULTS

- **Development time reduced by 50%.** "When applying advanced control theories, MATLAB and Simulink are far superior to in-house tools for analysis and design," says Mr. Kakizaki. "MathWorks tools helped reduce our programming by half and improved communication among our engineering teams."
- **Environmental Protection Agency award received.** For their innovations in improving fuel economy and reducing ozone-depleting hydrofluorocarbons, Nissan received the U.S. Environmental Protection Agency's Climate Protection Award. Nissan is the only automaker to receive such a commendation.
- **Number of sensors reduced.** Using Simulink for their emissions control strategy, engineers reduced the number of sensors without losing any control capabilities. This technology was then applied to all 2003 Nissan Sentra models.

To learn more about Nissan, visit **www.nissanmotors.com**

APPLICATION AREAS

- Automotive
- Control design automation
- Model-based design

PRODUCTS USED

- MATLAB
- Simulink
- Stateflow

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