Solenoid Valve Development Through Coupled Analysis

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A significant reduction in design period is achieved through the coupling of electromagnetic field analysis software with design exploration software or 1D-CAE software

There is a growing global movement toward carbon neutrality, which aims to offset greenhouse gas emissions and achieve a net-zero total, as well as toward a decarbonized society. In addition to renewable energy sources, such as solar and wind power, hydrogen is receiving considerable attention as an alternative to fossil fuels.

Since the mid-1990s, Aisan has been working on hydrogen-based products, some of which have been adopted by the "MIRAI," a car that does not emit carbon dioxide and is attracting attention as the ultimate eco-friendly vehicle. We have now taken on the challenge of developing a new linear solenoid valve (LSV) to expand our line of products for fuel cell vehicles (FCVs).

The LSV is a device that adjusts fluid flow using an electric current. However, it often needs to be examined repeatedly during the magnetic circuit design process, which has made developing it challenging. To address this issue, we used a coupling method based on JMAG electromagnetic field analysis software. We automated the optimal design of the entire product by examining its shape through coupling with design exploration software. We also developed an analysis method that evaluates responsiveness by coupling it with 1D-CAE*. These two new design methods reduced the design period by 68% and achieved a 20% reduction in product size.

We intend to systematize the construction techniques for design methods cultivated through this challenge and apply them to new challenges.

*Design support concepts, methods, and tools that are applicable from the upstream stage

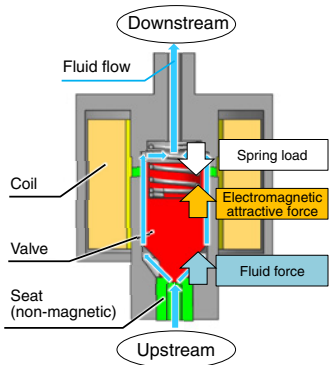
Highlights of Achievements

01

Two issues and countermeasures

There were two major issues, one of which was that coil specifications (wire diameter, etc.) and magnetic circuit shape were examined separately, often resulting in repeated rework.

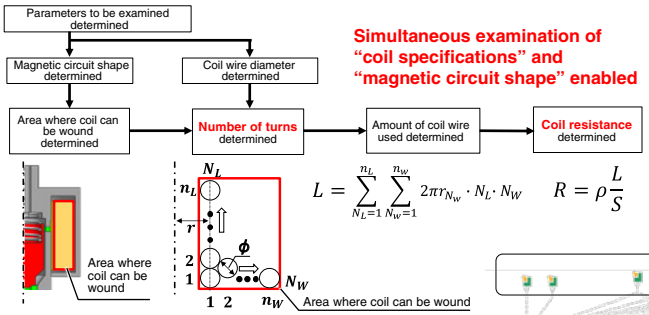
<LSV>



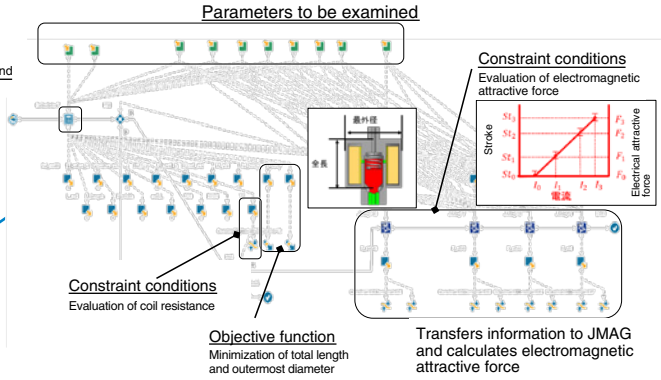
<Solving issues using JMAG>

	Issue 1	Issue 2
	Separately examining "coil specifications" and "magnetic circuit shape" resulted in failure to achieve optimal design for the product as a whole	Transient loads were not formulated, making it impossible to predict performance until actual measurements are taken
Implemented measures	Coupling JMAG with design exploration software ⇒ Optimizing the design of the entire product by simultaneously exploring "coil specifications" and "magnetic circuit shape"	Coupling JMAG with 1D-CAE ⇒ Building a model to calculate transient loads to ensure analytical accuracy that can be used for evaluation

<Calculation of coil specifications>



<Design exploration model>



02

Coupling with design exploration software

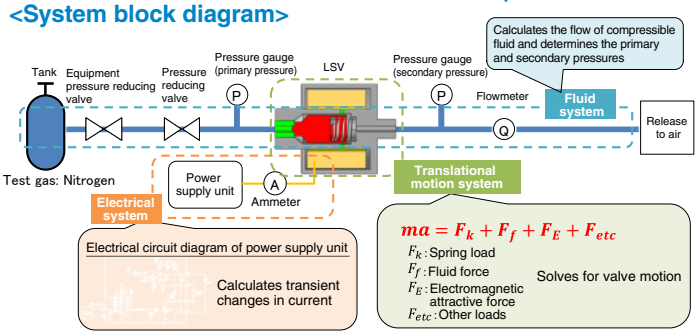
The design exploration software determines the shape dimensions, which are then transferred to JMAG. The analysis model is automatically generated using the Shape Editor function. Using design exploration reduced the magnetic circuit design period by 89%.

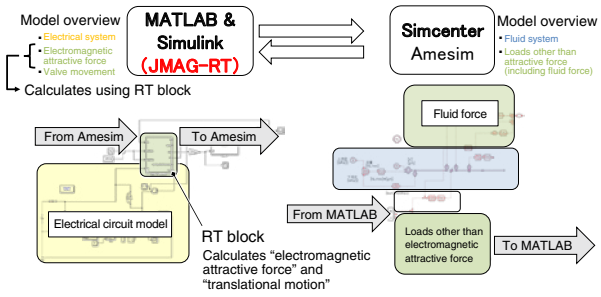
03

Coupling with 1D-CAE

We conducted a response evaluation based on the shapes obtained in 02 (coupling JMAG with design exploration software). The model was created using 1D-CAE to analyze three physical domains: electrical, fluid, and translational motion systems.

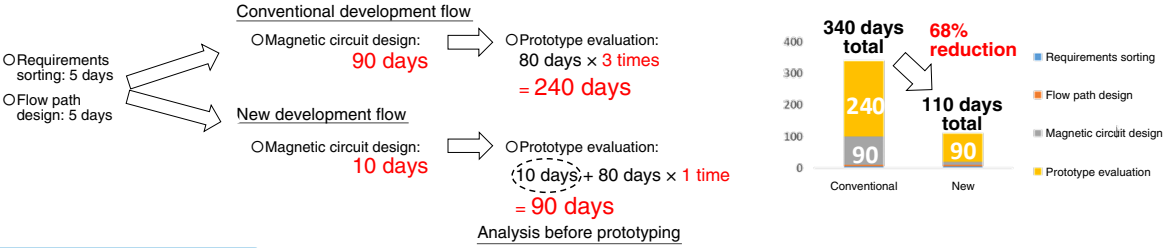
<System block diagram>





Results (Problem Solving)

- Built two design methods using JMAG's coupling technology.
  - Shape examination through coupling with design exploration software
  - Response evaluation through coupling with 1D-CAE
- The optimization of the design of the entire product resulted in a 20% reduction in both the overall length and the outermost diameter.
- Improved the development flow and reduced the design period by 68% (from 340 days to 110 days), as well as development costs by 67%, by decreasing the number of times a prototype is made (from three to one).



Future Developments

- We will apply the analysis technology that we developed this time to other products.
- We will continue developing new analysis technologies aiming to further improve efficiency.