Development of Total Integrated Analysis Technology for High-Pressure Automotive Fuel Pump

†Norihiko Nonaka[1], Kazuyuki Sugimura[2] and Kenichiro Tokuo[3]

[1]Research & Development Group, Hitachi Ltd., 832-2, Horiguchi, Hitachinaka, Ibaraki 312-0034, Japan
[2]Research & Development Group, Hitachi Ltd., 1-6-1, Marunouchi, Chiyoda, Tokyo 100-8220, Japan
[3]Hitachi Automotive Systems, Ltd., 2520, Takaba, Hitachinaka, Ibaraki 312-8503, Japan

†Corresponding and presenting author: norihiko.nonaka.qr@hitachi.com

Abstract

Automotive emission regulations and fuel regulations are strengthened in order to decrease global environment loads by global heating problems. Automotive internal combustion engine combusts miniaturizing fuel injected by high pressure in order to increase combustion efficiency. Therefore, fuel injection control of high-pressure fuel pump becomes a key technology and it is necessary to predict valve motion in the pump precisely in order to satisfy such regulations. In general, mechanism analysis tools based on 1D analysis are used to predict pump behavior. Accurate prediction of fluid force acting on the valve is a key issue. However, it is difficult to construct 1D mechanism analysis models with high accuracy because fuel flow and valve behavior become complex due to high pressure.

Therefore, authors have developed total integrated analysis technology which combines 1D mechanism analysis with performance table obtained by 3D flow analysis. A response surface method has been proposed as performance table. There are several response surface models such as quadratic function, artificial neural network etc. We employed Kriging model which has been widely used since the last decade. Kriging model yields high accuracy for the approximation of global space containing non-linearity.

The effectiveness of the proposed technology is demonstrated by applying it to a high-pressure fuel pump. Figure 1 shows a total integrated analysis system. Evaluation of fluid force acting on the valve is a very important issue. Therefore, response surface model called Kriging model is used for predicting fluid force. We used 3D flow analysis to obtain fluid force acting on the valve at several displacement of the valve. Response surface model is created using 3D flow analysis results obtained. Figure 2 (a) shows a comparison between the result obtained by the proposed system and by the previous mechanism analysis tool. Result by developed system shows different aspect compared to that by previous 1D mechanism analysis tool. Measurement result is shown in fig. 2 (b) as well. We compared the start of closing valve and the end of closing valve shown by Δt. Good agreement between the results by proposed system and by the measurement result is obtained. It is found that the propose technology can obtain results within 2% error.

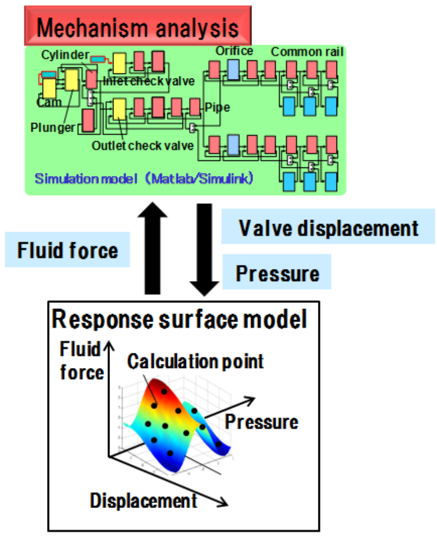

Figure 1. Total integrated analysis system

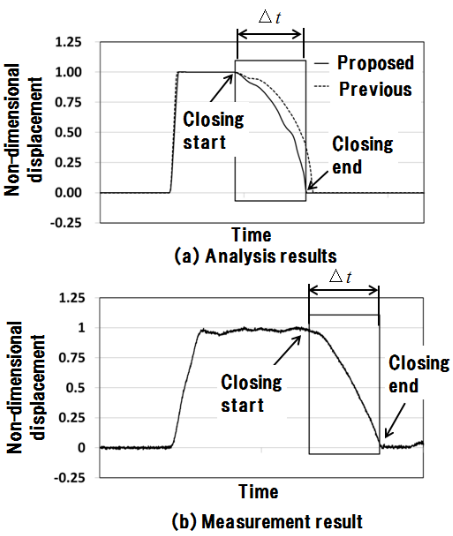

Figure 2. Comparison of results