講演番号	047

文献番号	20226047

Set-Based Design Method for Rigid Axle Suspension using Bayesian Active Learning

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KEY WORDS:**Vehicle development, CAE, Design optimization**, Bayesian active learning, Set-based approach [B2]

Data-driven set-based design method using Bayesian active learning (BAL) was applied to rigid axle suspension design in order to discover feasible region that satisfy multiple performances in the early stage of vehicle development. Fig.1 shows the flow chart of data-driven set-based design method. Acquisition function is calculated from the posterior distribution obtained from Gaussian Process (GP) for feasible region search in the multi-objective function using BAL. The next search point is obtained from the calculated Acquisition function and add it to the data to search for the feasible region.

Targeting the two performances of durability and ride comfort, we derive a region of rigid axle suspension (Fig.2) characteristics in which these performances are compatible. Table1 shows the design variables and the objective function. As a result, 8 cases of initial DOE sampling were generated, and 17 cases of additional sampling by BAL were generated. Therefore, a total of 25 cases were generated and the search was completed. Fig.3 shows the result of searching for the feasible region. The blue area indicates the feasible region of design variables that satisfy the constraints of all objective functions. Among them, Fig.3 shows the change of feasible region when the ratio of x_1 is changed. It is observed that the area of the feasible region can be changed. For example, Fig.4 shows the result of searching the feasible region by fixing the ratio of Rr coil spring stiffness to the median value (x_1=1). In this way, the boundaries of the characteristics established by the three objective functions are determined, and can be utilized in the characteristics design at the initial stage of development.

Finally, it was confirmed that the actual test results equipped with the proposed characteristics agree with the calculation results. From the above, it was possible to quantitatively indicate the feasible region of multiple performance by this method, and the tendency was consistent with the consideration by engineering.

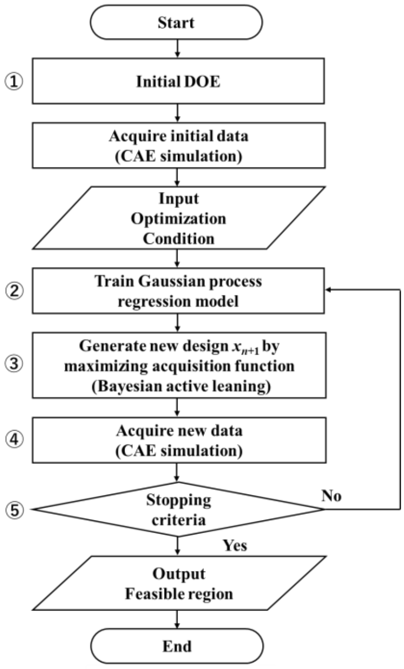

Fig.1 Flow chart of data-driven set-based concurrent engineering method

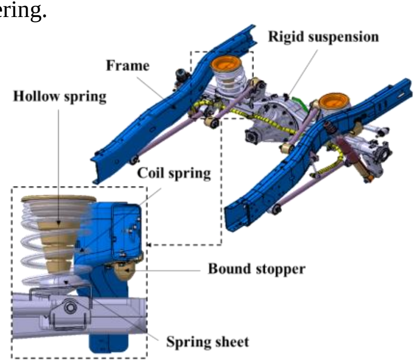

Fig.2 Rigid suspension

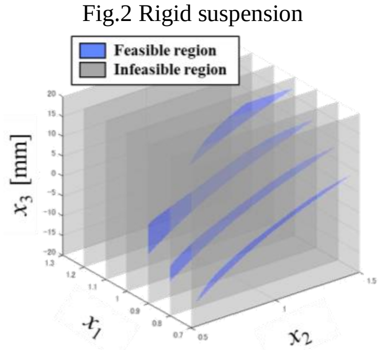

Fig.3 Feasible region of all objective function

Table1 Design variables and objective function

	Design variables	nominal	LB	UB
x_1	Rr coil spring stiffness ratio	1.0	0.7	1.3
x_2	Rr hollow spring stiffness ratio	1.0	0.5	1.5
x_3	Rr hollow spring clearance [mm]	0	-20	20
	Objective function			
f_1	Rr spring sheet force [N]			
f_2	Rr bound stopper force [N]			
f_3	Rr floor vertical acceleration [m/s^2]			

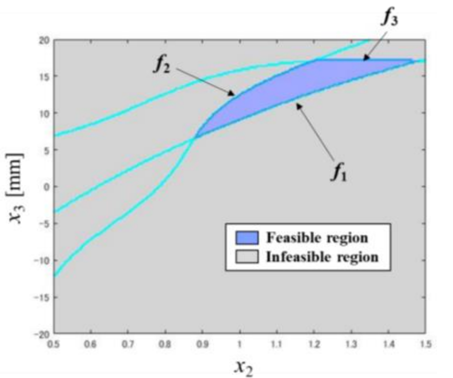

Fig.4 Feasible region of all objective function (x_1=1)