

Improvement of the Control Calibration Process for THS Engine-Start Vibration Using MBSE

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Control parameter design for transient dynamic performance often relies on sequential adjustment against final performance indices. Different parameters affect these indices through different mechanisms, so adjusting one parameter may require another to be readjusted and may obscure the design rationale. This study applies MBSE (Model-Based Systems Engineering) to the calibration of THS (Toyota Hybrid System) engine-start vibration. In THS, the MG1 torque profile is primarily defined by five parameters, x1–x5, to balance requirements including engine-start vibration and power consumption (Fig.1). SysML (Systems Modeling Language) is used to structure requirements, physical and control mechanisms, and control parameters. The physical and control mechanisms are connected through intermediate-state requirements, enabling the contribution of each parameter to final performance to be traced (Fig.2). Relationships obtained from the system model are converted into design-sequence rules, and the parameter sequence is reconstructed using a DSM (Design Structure Matrix). The reconstructed sequence is x5, x2, x1, and then x3 and x4 concurrently. Dependencies below the diagonal show that the return to preceding design stages is eliminated (Fig.3). CAE results show that candidates can be narrowed stepwise using intermediate-state indices without revisiting previously determined parameters. Vehicle measurements confirm improvements in intermediate-state and final performance indices (Fig.4) and the required design effort is reduced by 50%.

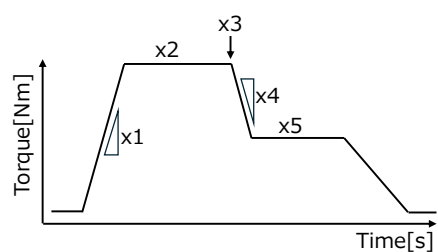


Fig.1 Control Parameters Defining the MG1 Torque Profile

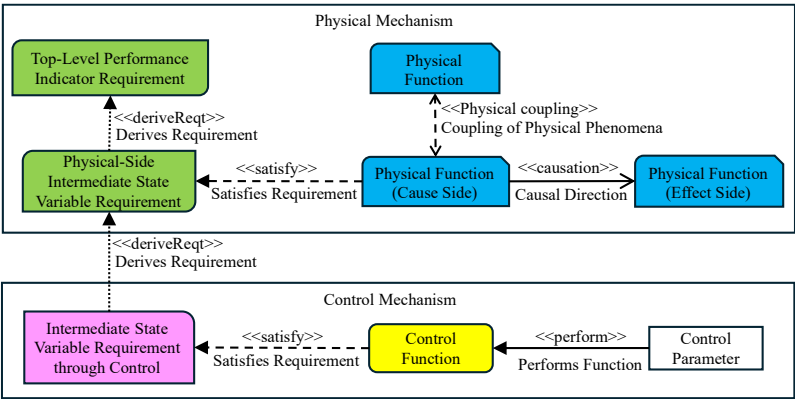


Fig.2 Structure of the System Model in SysML

	x5[F]	x2	x1	x3	x4
x5[F]					
x2	.		.	.	.
x1	.	D		.	.
x3	.	D	D		C
x4	.	D	D	C	

Fig.3 Parameter DSM for the Reconstructed Design Sequence

F : Fixed First
D : Order Dependency
C : Concurrent Design

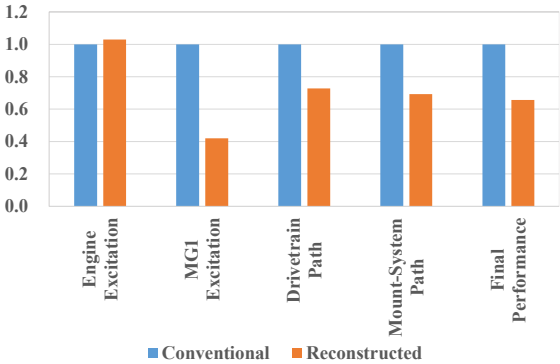


Fig.4 Comparison of Measured Indices between the Conventional and Reconstructed Design