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Model reduction of structure-changing multibody mechanism with clearances used in a circuit breaker

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Abstract

To fulfill their function as overcurrent protection devices, circuit breakers must exhibit highly transient dynamics between stable „On“ and „Off“ states [1]. Predicting the health status and remaining lifetime of these devices by monitoring changes in state („Condition monitoring“) remains an open area of investigation. Digital twins are used for condition monitoring of engineering systems and devices [2]. Usually computationally expensive multibody simulation models with large number of degrees of freedom are used to simulate the mechanism of circuit breakers. This study describes attempts to create simplified mechanical models for potential use as digital twins. The quality of a reduced model is judged by its ability to recreate transient dynamics of the mechanism and its sensitivity to mechanical parameters such as clearance, stiffness and dissipation coefficients. Two kinds of reduced models of the mechanism are considered, namely white-box and grey-box model. The white-box model is created by neglecting noncritical degrees of freedom from the multibody model. Grey-box models are designed to replicate functionally important kinematics (so called „travel-curves“) with minimal set of coordinates. Here clearances within joints of the mechanism are lumped into a single concentrated clearance, thereby reducing degrees of freedom and computational expense considerably. Hitherto unknown parameters of the reduced models are identified using optimisation methods. The target function is choosen as the deviation between travel curve of a reduced model and reference travel curve generated from multibody simulation. Key kinematical quantites in the travel curve for each phase of operation of the circuit breaker are identified and their changes in the parameters are evaluated and compared in order to choose the most appropriate model.

References

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Categories

TND: Transient and Non-stationary Dynamics