Knowledge Base

Information

QA Article: QA(
Last Update Date: 03.
Rating:
Views: 886

Plug-in utility to compute Component Contribution Factor (CCF) and Component Modal Contribution Factor (CMCF) for quantifying brake squeal modes

Portfolio / Domain: SIMULIA Abaqus Unified FEA / n/a
Product: n/a

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QUESTION

What is the CCF/CMCF plug-in and how does it work?

ANSWER

Together, the CCF (Component Contribution Factor) and CMCF (Component Modal Contribution Factor) plug-ins are used for quantifying brake squeal modes:

- The CCF plug-in is used to compute and display the contribution of each component to each of the system unstable modes
- The CMCF plug-in is used to compute and display the contribution of each component real mode to each of the system unstable modes

A disc brake is operated by pressing a set of brake pads against a rotating disc. The friction between the pads and the disc causes deceleration, but it may also induce a dynamic instability of the system, known as brake squeal. Abaqus provides a straight forward brake squeal analysis capability by building up a common ground in terms of friction coupling matrix and contact effects. Starting from preloading the brake, rotating the disc, and then extracting natural frequencies and complex eigenvalues, this new approach combines all steps in one seamless run. In addition, since contact surfaces are used to define the disc-lining interface, no coincident nodes are required when building the model.

The brake squeal phenomenon often involves modal coupling between various component modes. In order to reduce or eliminate squeal (predicted as an unstable mode found in a complex mode analysis), it is very important to find the key contributors to the unstable mode. Making this determination by only visually inspecting the animated shapes associated with the predicted unstable frequencies can be difficult. The CCF and CMCF plug-ins simplify this task by quantifying the component and component modal contributions. The coupling mechanism can therefore be identified and design modifications such as changes in the geometry or material properties of the brake components can be tested numerically to evaluate their effectiveness for squeal reductions.

For example, when a system unstable mode is dominated by the rotor motion, its natural frequency can be shifted by changing the Young's modulus of the rotor material. If the pads are the dominant components, their thickness or stiffness can be tuned to decouple the modal interaction and hence eliminate the dynamic instability.

The detailed usage and installation instructions are in the attached file ComponentContributions.doc. The plug-in code is in the attached file CCF_CMCF_PlugIn.zip. An example example_input.zip input file is attached to this Answer.

Revision history

17 June 2014	Release 1.1-1 qualified with Abaqus/CAE release 6.13 and 6.14.
6 April 2016	Release 1.2-2 (qualified with versions Abaqus/CAE release 6.14 or later) Minor update :- Starting from Abaqus/CAE R6.14 , the format of certain element set name being written to the odb has changed. The plugin has been modified to account for this change. This only affects the weighting factor calculations. Note that the plugin is also compatible with versions prior to Abaqus /CAE R6.14 .
19 Nov 2018	Release 1.2-3. Fixed a bug related to component name. A single VOL value was used to calculate CCF for all components, instead of using VOL value of each component separately.

For more information see:

- "Automotive Brake Squeal Analysis Using a Complex Modes Approach," Abaqus Technology Brief, 2005
- "Brake Squeal Analysis," Abaqus Example Problems Manual
- How to verify an Abaqus brake squeal analysis
- Kung, S.-W., Dunlap, K. B., and Ballinger, R. S., "Complex Eigenvalue Analysis for Reducing Low Frequency Squeal," SAE paper 2000-01-0444
- Kung, S.-W., Saligrama, V. C., and Riehle, M. A., "Modal Participation Analysis for Identifying Brake Squeal Mechanism," SAE paper 2000-01-2764
- Bajer, A., Belsky, V., and Zeng, L.-J., "Combining a Nonlinear Static Analysis and Complex Eigenvalue Extraction in Brake Squeal Simulation," SAE paper 2003-01-3349
- Kung, S.-W., Stelzer, G. Belsky, V., and Bajer A., "Brake Squeal Analysis Incorporating Contact Conditions and Other Nonlinear Effects," SAE paper 2003-01-3343
- Bajer A., Belsky V., and Kung, S.-W., "The Influence of Friction-Induced Damping and Nonlinear Effects on Brake Squeal Analysis," SAE Paper 2004-01-2794

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KEYWORDS python, custom, customization, nvh, noise, brake, braking, stop, vibration, plugin, plug-in, plug in

ATTACHMENT example_input.zip ComponentContributions.doc CCF_CMCF_PlugIn_v1.2-3.zip

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