AN FEM/MBS TECHNIQUE FOR STRESS CONCENTRATION PREDICTION AND ACCELERATED FATIGUE SIMULATION

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ABSTRACT

This work describes a research into a novel FE based process capable to accelerate Transient Dynamic and Durability analysis of large numerical FE models with demanding time integration intervals.

Key to the process is the exploitation of an augmented Craig Brampton Component Modal Reduction technique to allow the identification of a limited set of stress concentration areas, so called Hotspots.

The process allows for accurate and fast simulation of complex mechanical structures typical of transport vehicles and general machinery. Moreover the efficiency of the method would enable the automation and randomisation necessary for DOE studies even in computational intensive dynamic Fatigue solutions.

Motivation

The proposition to analyse a full engineering assembly (car, airplane, ship etc…) for its dynamic behaviour can be a rather daunting task, with the size of the numerical model (e.g. FE) and the length of the integration time histories requiring ever-increasing solution times and storage resources. The models might be linear or nonlinear and typically, a time domain solution could be required for subsequent fatigue predictions; the design investigation has to address and identify areas that under dynamic loads result in high stress concentration.

If high computational power enables the use of FE models of virtually any required size, attempting to store all results from dynamic solutions will easily exceed even the large storage resources currently available.

In order to efficiently address a typical full-scale analysis of vehicle fatigue duty cycle or airframe load spectra, a far reduced data set can be used by acknowledging that only a limited number of regions in the model will be critically stressed.

Scope and questions to be addressed

The purpose of this research is to investigate a novel accelerated simulation procedure through the identification of a subset of critical regions, henceforward termed Hotspots, to be determined prior to resolving the dynamic problem. The reduction to Hotspots produces a dramatic improvement in solution time and model handling while allowing processing of the critical areas in high detail.

Having investigated currently available practices, the aim of this work is to design a process that combines off-the-shelf FE-MBS solutions with purposely designed algorithms capable to facilitate and accelerate fatigue numerical simulations under dynamic loading. The process develops around the a priori determination of model sub-regions.

The application of Component Mode Synthesis (CMS) is the key to the proposed Hotspot prediction methodology.

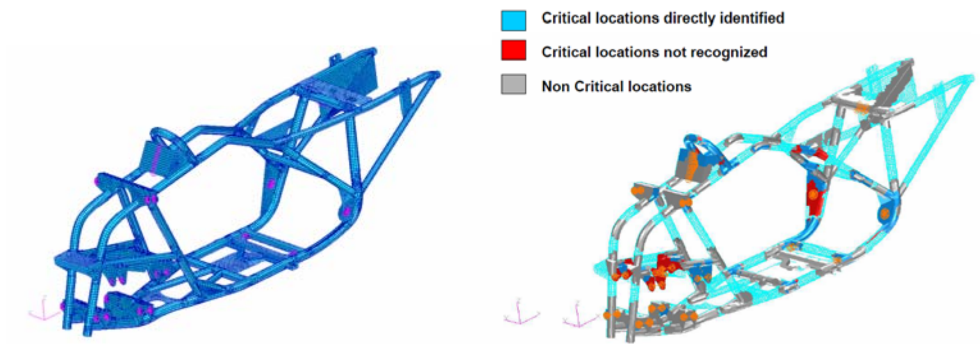
The exposed approach allows fast, accurate and tailored simulation of complex mechanical structures typical of transport vehicles and general machinery. Moreover the method would enable easy automation and replication, as required by popular modern techniques such as variable randomisation and design of experiments.

The study will address the applicability of the proposed algorithm, the underlying assumptions and limitations, the benefits that it might yield for what accuracy. Computational and methodological aspects are developed.

Throughout the research we will be mainly working under common assumptions in applied simulation of fatigue analysis under dynamic loading.

Some of the objectives of the paper are:

- Design and application of predictive algorithms that can simplify the handling of large Dynamic FEM Fatigue simulation data without compromising the solution accuracy
- Analysis of predicting performances of the algorithm and its effects to the ensuing Fatigue simulation
- Investigation into the use of hotspot local strain energy
- Numerical Validation and performance assessment in real life applications



SUGGESTED THEMES

MBS-FEA-Fatigue - Accelerated Fatigue Simulation – Hotspot Prediction-Component Mode Synthesis