Fiat Research Center Predicts Fatigue Life up-front in Product Development

LMS Virtual Simulation Compresses Development Time with Six Months

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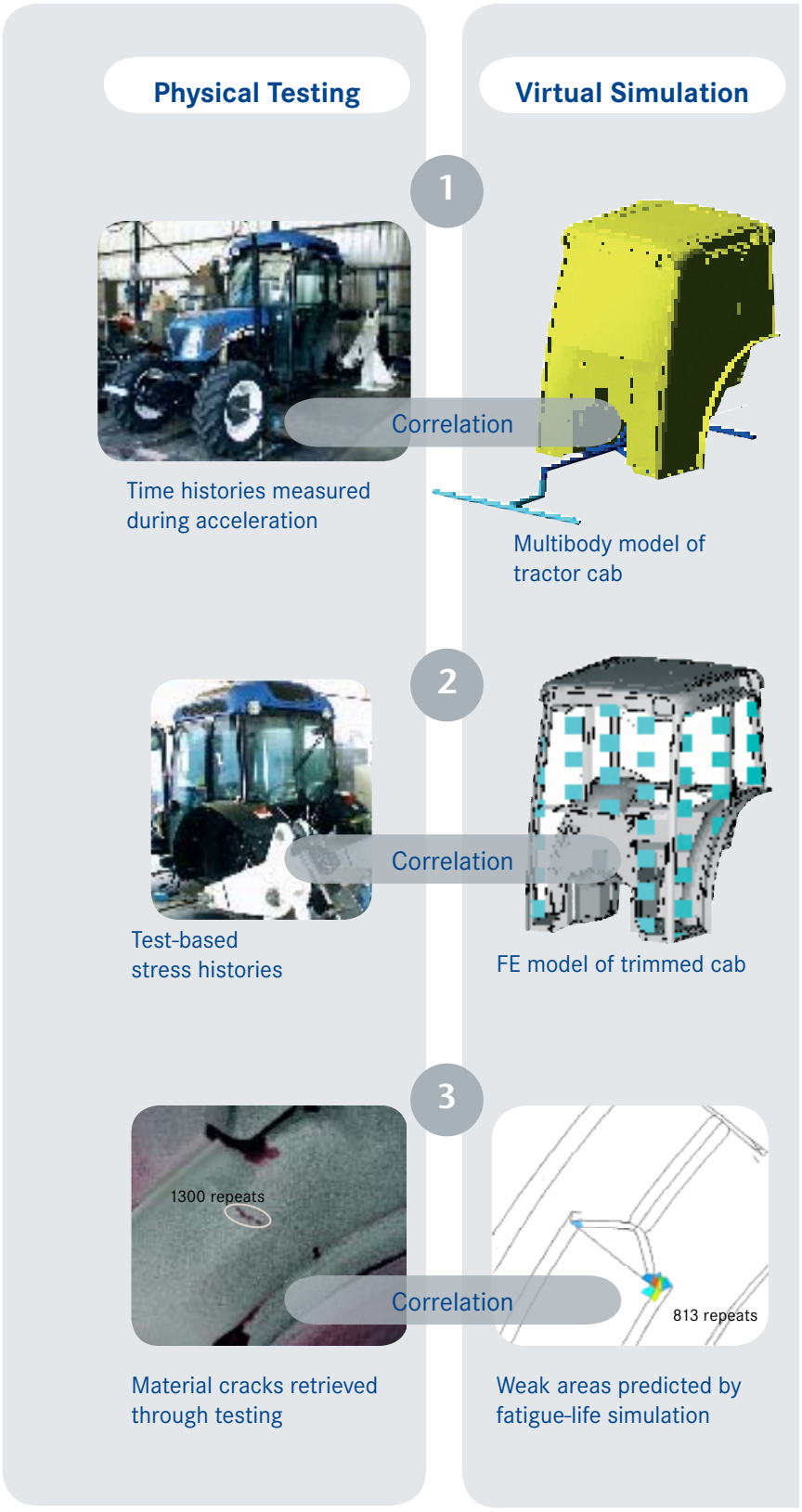
Volkswagen Develop the product, build a physical prototype, run it through fatigue tests to see if parts break, and then hurriedly fix problems by redesigning and retesting the structure until it passes. This requires considerable time and budget, neither of which manufacturers can longer afford. Another option is to over-design the structure from the start, ensuring products pass the durability test by adding needless parts, welds and material. This is how some manufacturers treat durability, but the problem remains that the prototypes that eventually pass fatigue tests are not necessarily the best designs. Fiat Research Center in Turin, Italy, applies an improved approach. On a recent project, it succeeded in developing a much better design by assessing the product's durability performance up-front with the help of LMS FALANCS. This allowed Fiat Research Center to save an estimated 200,000 dollars and to compress the development time with at least six months. Simulation enables to predict fatigue-life early in the development process, providing engineers sufficient freedom to explore several design alternatives and to develop innovative vehicles that meet durability targets without over-design or needless build-and-test cycles.

The assessment of the tractor cab durability performance consisted of multibody simulation, finite-element modeling and fatigue-life prediction, respectively.

Fiat Research Center (CRF) used a fatigue-life prediction methodology in the development of a tractor's cab structure that is being designed by Case New Holland (CNH). This is a manufacturing company of Fiat Group, which leads the market of agricultural machinery and construction equipment. Dr. Kamel Bel Knani, Head of the Structural Durability Team at CRF, says that by using LMS FALANCS simulation early in design process, it was possible to achieve the outstanding durability target required by CNH and to cut out at least three prototype testing cycles. CRF engineers also used fatigue-life prediction in trimming manufacturing costs of the cab structure while meeting the durability target, thus improving product profitability and CNH's bottom line. With this success as a foundation, the same approach may be used with fatigue-life prediction on other Fiat vehicles, including truck cabs, automobile bodies and chassis structures.

"Durability assessments of the tractor cab design were performed through virtual simulation because of the need to ensure high reliability of a complex structure under harsh operating conditions for a long service life. Agricultural equipment must withstand severe dynamic loads, often coupled with vibration excitations during field operations," explains Bel Knani. "The work carried out in close cooperation with Case New Holland aimed at bolstering the CNH brand image, which customers around the world know and respect as one of exceptional quality, reliability, endurance and comfort."



Three-step process

According to Bel Knani, LMS FALANCS was selected for this effort because of several compelling reasons. In particular, benchmarks ran by CRF showed that LMS FALANCS is user-friendly and accepts direct import of component loads and stresses from a variety of other analysis programs as well as physical test measurements. Also, the software has a flexible architecture and complies with specialized capabilities needed by CRF for its advanced durability simulations, enabling engineers to obtain calculation results that are closely correlated with experimental data. Moreover, LMS technical support personnel are highly qualified and provide prompt answers to user queries and suggestions.

For the assessment of the durability performance of the tractor cab structure, Fiat Research Center followed a three-step simulation process, consisting of MultiBody Simulation (MBS), Finite-Element Modeling (FEM) and Fatigue-Life Prediction (FLP):

1 Running multibody simulations of the reference dynamic mission of the tractor, and accounting for cab structure flexibility, yielding the determination of the load time histories acting on the cab.
2 Application of the computed loads to a finite-element model of the cab and analysis with MSC.NASTRAN establishes the resulting vibration modes and stresses throughout the structure.
3 Using LMS FALANCS, which, on the basis of loads and stresses previously simulated and proper fatigue criteria selected by the user, determines areas of likely damage and helps make fatigue-life prediction of the cab structure.

The tractor model being analyzed consists of a driveline framework connected by suspension bushings to a space frame of arc-welded steel parts (formed sheet metal and extruded beams) that makes up the skeletal structure of the cab. Also included in the simulation models were secondary vehicle components, such as seats, the air conditioning system and the steering system. Input for the simulation was a combination of symmetric and staggered vertical bumps to represent typical operating conditions of the tractor. Analysis determined the primary natural frequency of the cab structure to be far away from the excitation range of the external loads.

The most critical areas of the cab structure, where fatigue failures are most likely to occur, were seam welds; therefore, specific modeling guidelines were adopted for welded joints. Calculating fatigue-life of arc-welded joints is usually a hard task, mainly because of the difficulty to determine local damage parameters in presence of wide variations in manufacturing processes, thermal effects and small notches. Fiat Research Center successfully overcame this through a “hot-spot” approach, in which fatigue-life prediction is based on extrapolated structural stresses at the weld toe. These stresses are calculated by FE analysis using appropriate shell and rigid elements to model the welded joints.

Applying fatigue-life prediction helped FIAT Research Center to save 200,000 dollars and 6 months in development time.

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