The Integration Of Analysis And Test For Full Vehicle Structural Durability

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# The Integration Of Analysis And Test For Full Vehicle Structural Durability

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**Abstract**

**Subject Terms**

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Who & What is Deere?

- De-Centralized Company evolving to global manufacturing of products.
- Mid-sized company - $13B.
- Improved communication & time compression forcing change in processes. Collaboration not an option - rather a requirement.
- Most of products are specialized vehicles operated in a range of off-road conditions at high-power levels for long periods of time.
- Mature products with customer expectations of high durability and availability.
The Challenge - Global Sharing of Technology & Techniques

• Design Anywhere - Manufacture Anywhere
• About 40 Engineering Locations - Depending on Definition of Product Engineering
• Diverse Products - Tractors, Combines, Forage Harvesters, Log Skidders, Dozers, Backhoes, Road Graders, Balers, Lawn & Garden Tractors, Mowers, Chain Saws, Etc.
• Increased Competition
• Faster Pace => More simulation & analysis.
Structural Durability Development
Through Integration Of Analysis
And Full Vehicle Test

What & Why:

- Correlate Fatigue/Finite Element/Dynamic Analysis to the Lab (Field) Test
- “Field Test” the Structural Design in the Computer Before Building the Hardware
- Establish Confidence in Fatigue Predictions By Comparing to Actual Test Fatigue Lives
- Define Subsystem Load Information from the Dynamic Model/Lab Test Load Histories
- Obtain Fatigue Life Contours for Multiple Load Inputs for the Composite Duty Cycle
Optimal Computer Analysis/Test Path to a Structurally Durable Product

Integrated Process

Computer Analysis (Time & Dollars)

Risk: Product Introduction

Production Start Up

Reliable Product

Risk: Product Introduction

Concept Vehicle

Test (Time & Dollars)
Dynamic Model of Telehandler and Correlation with the Lab Test

Dynamic Model
Left Rear Engine Vertical Acceleration Correlation between Dynamic Model and Lab test
Rough Transport Empty
Finite Element Model of Telehandler Chassis and Correlation with Strain Gage Measurement from a Lab Test

Strain Contour of the Finite Element Model

Strain Correlation between Finite Element/Fatigue Model and Lab test

Measurement
Prediction
Finite Element Model of Telehandler Chassis and Multiple Load Inputs
Time Histories Associated with the Multiple Load Inputs
Fatigue Life Contours of Chassis for Truck Load Lime Operation
Lab Rig Operations -
Need Percentages of Test Time

- Normal Transport Loaded  xx%
- Figure 8’s Empty          xx%
- Push Up Silage and Compact xx%
- Truck Load Lime           xx%
- Muck Out Pit              xx%
- Truck Load Gravel         xx%
- ...                        xx%
- ...                        xx%
- ...                        xx%
- ...                        xx%
Fatigue Life Contours of Chassis for Complete Duty Cycle
Structural Design Iteration Process

Original Design → FE Analysis → Fatigue Analysis → Fatigue Contour (complete duty cycle)

Dynamic Model

- Major Change ?
  - No
  - Design Change?
    - yes
      - Redesign
    - done
  - yes
    - Major Change ?
      - yes
        - Redesign
      - no
        - Design Change?
          - yes
            - Redesign
          - done
Fatigue Life of Second Re-Designed Chassis for Complete Duty Cycle
From Competitor Evaluation to Final Build

- **Competitor Evaluation**
  - Field Data Acquisition
  - Lab Test
  - Dynamic Model - Validate
  - Finite Element & Fatigue Analysis - Validate

- **Current Production**
  - Field Data acquisition
  - Lab Test
  - Dynamic Model - Validate
  - Finite Element & Fatigue Analysis - Validate

- **Initial Design**
  - Dynamic Model
  - Finite Element & Fatigue Analysis
  - Prototype Build (for durability evaluation)

- **Design Iterations**
  - Finite Element & Fatigue Analysis

- **Final Design**
  - Lab Test (validation - 3rd production vehicle)
Analysis Highlights

• **Confidence in the Process**
  Excellent correlation between measured (Lab Test) and predicted (Dynamic-FEA-Fatigue) strains.

• **Analysis before Prototype Build**
  Fatigue analysis of initial Deere design highlighted problem areas, enabling re-design before first prototype build.

• **Development of Analysis Process**
  - Dynamic Model - DADS
  - Finite Element Model - Hypermesh
  - Finite Element Analysis - Abaqus (unit load cases)
  - Fatigue Analysis - MSC/Fatigue

• **Enhancement of Analysis Process**
  - Frame : 3 major designs iterations in 6 months
  - Inner Boom : 6 major design iterations in 2 months
  - Outer Boom : 2 major design iterations in 1 month

Primary Re-Design Focus Area
Lessons Learned

• It’s not easy!
• Requires experienced personnel.
• Both test and analysis have equal weight and value in the design iteration effort.
• Acceptance is comparable to any new technology - requires proof and then becomes part of the routine process.
Conclusions

- Full Vehicle Structural Durability Behavior Is Predictable
- Prediction of Full Vehicle Structural Durability Behavior Is Fast Enough to Be Practical
- Prediction of Full Vehicle Structural Durability Behavior Is Cost-Effective
- The Durability of a Structure Can Be Optimized Using Computer Models Before Production