

Utilizing MSC VPD to Design a Better Baseball Bat

Applying Rocket Science to the Sporting Equipment Industry

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Abstract

Competition on the sporting world not only applies to athletes. Sporting equipment manufacturers continuously strive to stay ahead of their rivals by enhancing the performance and durability of their products while ever seeking new/advanced technologies to introduce into their designs. While these new technologies may involve the introduction of new materials or radically new hybrid constructions, or a combination of both, some manufacturers still rely on build-test-break methods to evaluate their products.

Utilizing MSC.Software's simulation tools, ESACORP Impact Sports Division has successfully defined and implemented the Virtual Product Development process philosophy in the sporting industry. Using the VPD tools described in this article, ESACORP has defined the most rudimentary starting point, i.e. development of the ball model, included the ergonomic aspects of the design, leading to dynamic performance and durability predictions. Simulation results are used to create a comparative study of incremental stress increases/decreases in the bat material(s) and assess bat performance by determining impact coefficient of restitution as a function of bat design revisions. The stresses are compared to material durability limits and the performance can be compared to the governing body regulations. The resulting processes described in this article not only enables manufacturers to reduce the development cycle and reduce cost, but maintain the competitive lead on their rivals.

Introduction

- **ESACORP**

- A High-tech Engineering Research and Product Development organization headquartered in Phoenix, AZ.

- **Specializing in**

- VPD / New Product Development / Research
- Solid Modeling / Design & Drafting
- Finite Element Analysis
 - Static stress / modal
 - Vibration
 - Heat transfer / CFD
 - Crash / Impact
- Fabrication and testing
- Software and VPD Process implementation and training

Problem Formulation

- **Situation - Sporting equipment manufacturers**
 - Very competitive market - striving to stay ahead of rivals
 - Enhancing product performance and durability
 - Seeking & introducing new / advanced technologies into designs
 - New materials
 - Radically new hybrid constructions
 - Combination of both,
 - Some still rely on build-test-break (BTB) methods to evaluate product performance
 - Seeking to incorporate 'rocket science' into design process
 - Replace current antiquated "build-test-break" methodologies
 - Reduce cost while becoming 'first to market'

Problem Definition

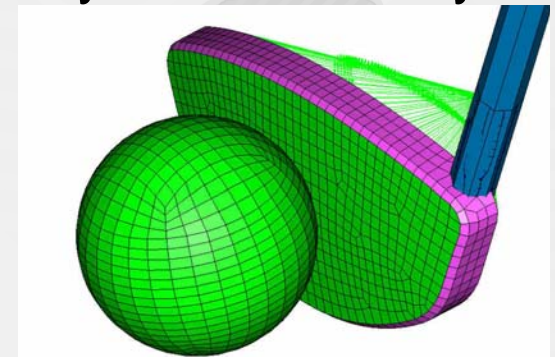
- **Well known sporting equipment manufacturer missed market window on introduction of new product**
 - BTB design methodology expended allotted development schedule & capital
 - Radical new hybrid design required numerous tests to attempt to understand behavior
 - Design 'passed tests' but by how much?
 - Design durability margin?
 - Can it be used as baseline for future product designs?
 - Field tests later produced failures
 - Causes?
 - Avoidance?

Solution

- **Virtual Product Development (VPD)**
 - Impact type sports produce most complex engineering challenges in product design
 - Crash event - very violent and highly non-linear dynamic event lasting milliseconds
 - Produces transient-dynamic loads in the structure sending displacement and stress waves through the structure that are felt by user
 - Significant amount of data in such a short time
 - Lends itself well to VPD simulation
 - Dynamics of the event can be slowed and replayed for detailed analyses.

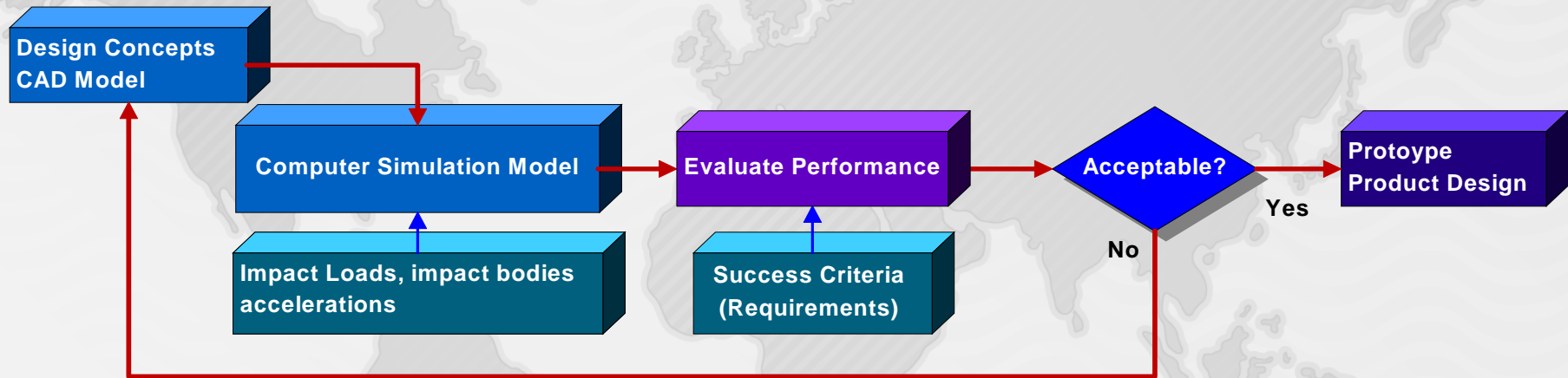
Solution

- **Objective – Implement VPD process that ESACORP Impact Sports successfully utilized in golf-club design**
- **Actions**
 - Convert desired results / performance into measurable engineering parameters
 - Ergonomic feel
 - Durability
 - Design to manufacturing & cost
 - Meet governing body performance parameters
 - Utilize VPD tools perform evaluations quickly and efficiently
 - MSC Patran & Laminate Modeler
 - Pre/Post
 - MSC Nastran - Linear Analyses
 - MSC Dytran - Impact / Dynamics



Analysis

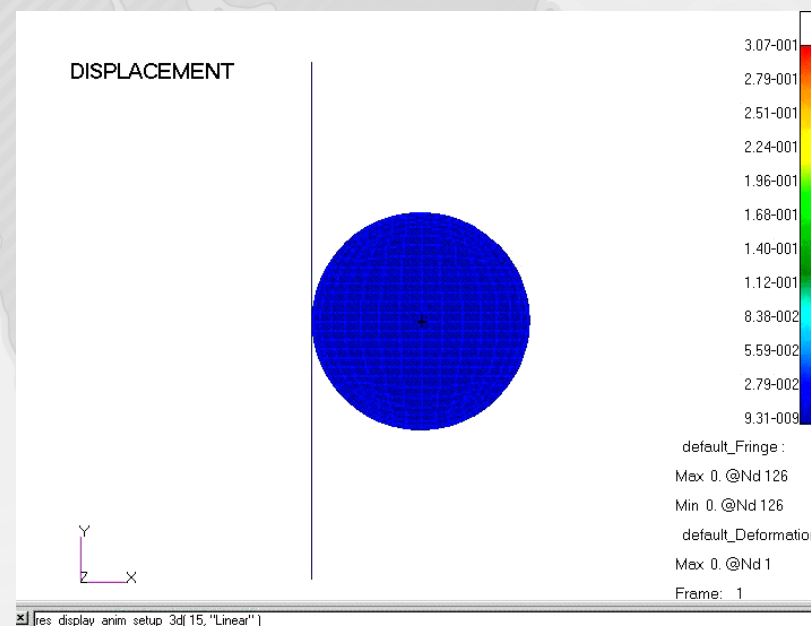
- **Virtual Product Development (VPD) Process**



- **For impact / dynamic analysis, VPD models require an ‘extra step’**
 - Impacting body must be developed and calibrated
 - Inherent viscoelastic behavior

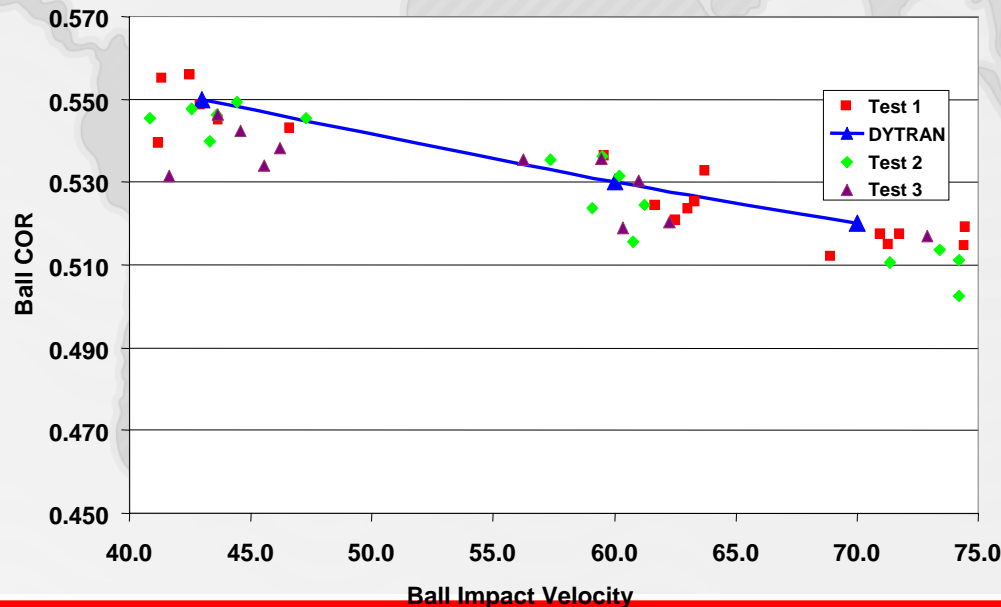
Analysis

- **Impact Sports VPD Process**
 - Impacting body model development – Ball
 - Process presented at 2004 MSC VPD Conference
- **Utilize empirical test data & MSC Dytran to determine ‘proprietary’ non-linear properties for:**
 - Golf ball
 - Softball
 - Baseball
 - Tennis
 - Puck



Analysis

- **Impact Sports VPD Process**
 - Analytical Model Development – Ball
- **Utilize empirical Test data & simulation to determine ‘proprietary’ non-linear properties**
 - Ball material property calibration
 - Match baseball/wall impact coefficient of restitution



Analysis

- **Impact Sports VPD Process**
 - Analytical Model – Product
- **MSC Dytran enables modeling of Composites & Hybrids**
 - Impact modeling of Hybrid metal / Composite equipment
 - Trade studies of performance / durability for various composite material lay-ups & metal thickness
- **Predict dynamic stresses**
 - Capture stress wave
- **Compare against success criteria**



Analysis

- **Impact Sports VPD Process**

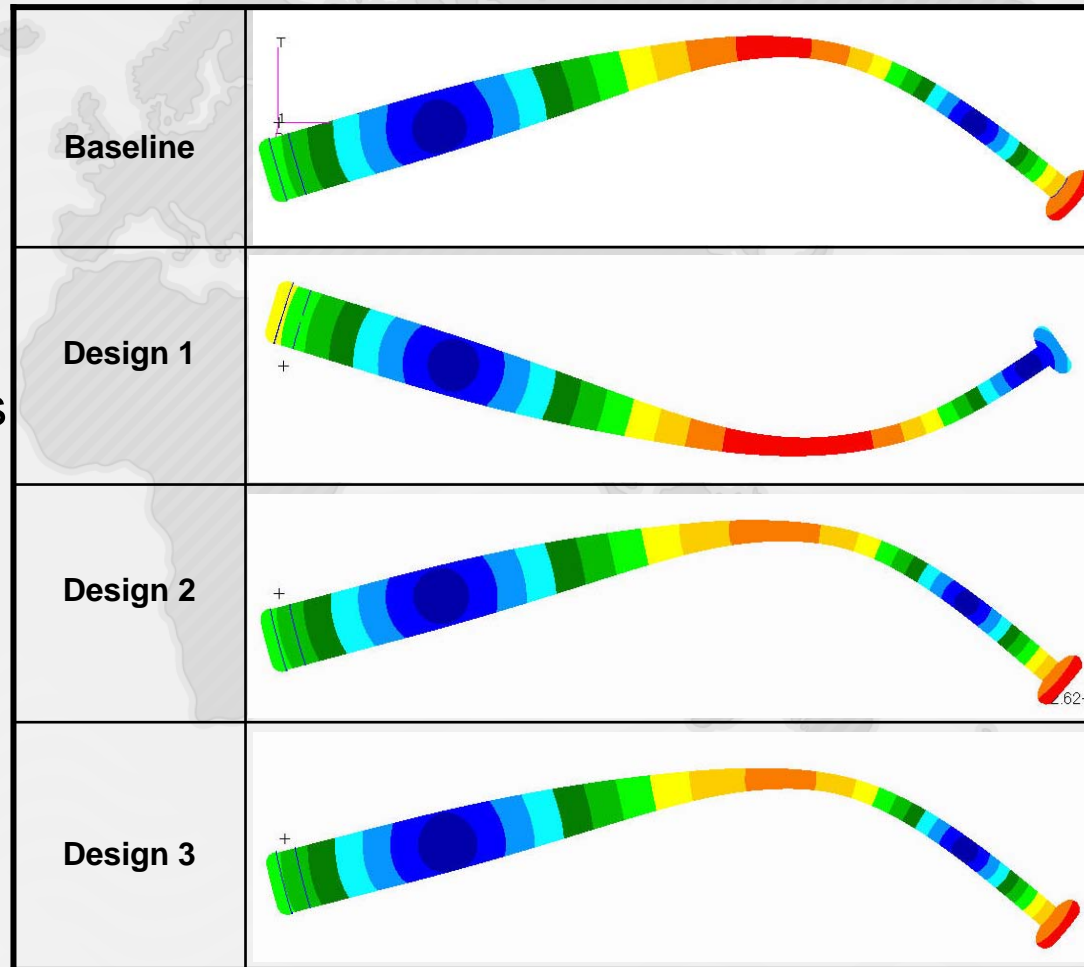
- Success criteria

- **Ergonomic feel**

- **Sweet Spot**

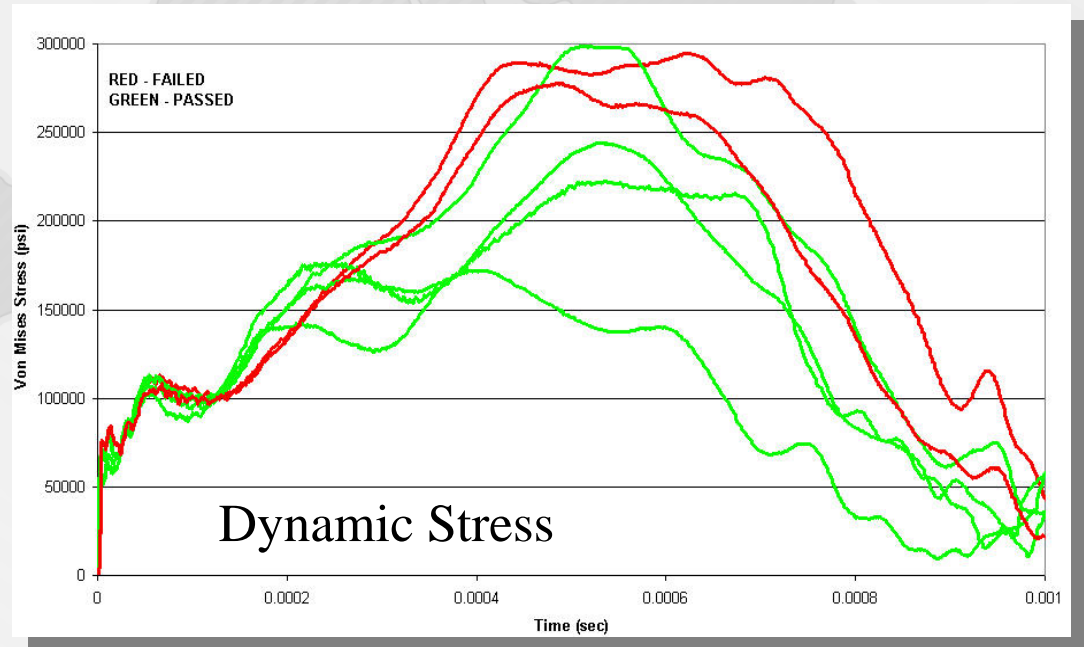
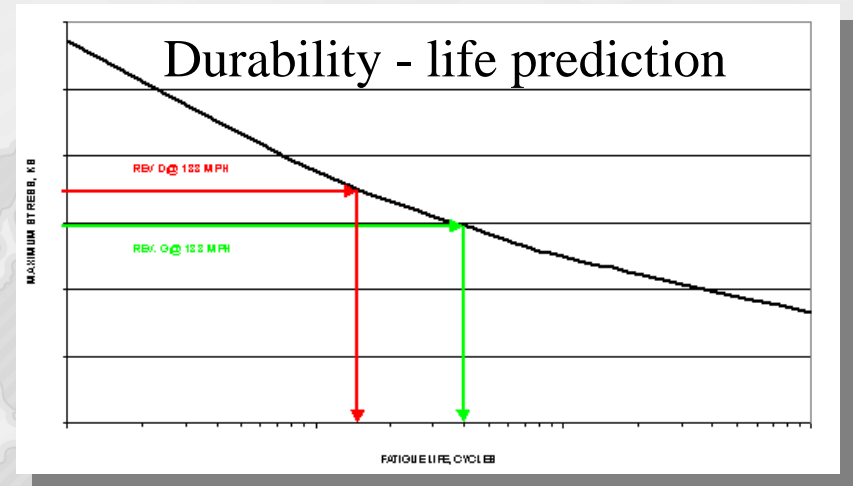
- **Governing Body**

- Performance restrictions
- COR restrictions
- Weight
- etc



Analysis

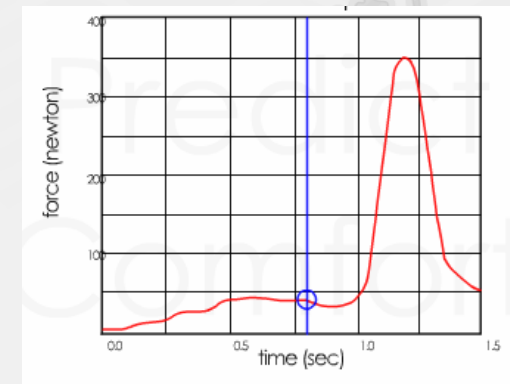
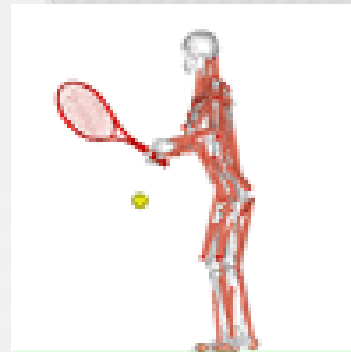
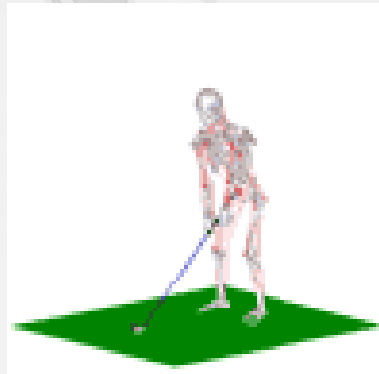
- **Impact Sports VPD Process**
 - Success criteria
- **Durability & Design to cost**
 - Production & Mfg studies
 - Material trade studies
 - Surface finish



Analysis

- **Impact Sports VPD Process Improvement**

- Implement BRG LifeMod™
 - Convert engineering data into measurable product requirements
 - Better predict product 'feel'



Summary - Conclusion

- **Virtual Product Development process philosophy successfully defined and implemented in the sporting industry using MSC Software products**
- **Defined rudimentary starting point**
 - Development of impacting body (ball) model
 - Ergonomic aspects of the design
 - Dynamic performance and durability predictions
- **VPD results create a comparative study of incremental stress increases/decreases in the bat material(s)**
 - Dynamic stresses determined - stress wave captured
 - Stresses compared to material durability limits
 - Predict product life

Summary - Conclusion

- **Virtual Product Development process philosophy successfully defined and implemented the in the sporting industry using MSC Software products**
- **Assess performance by determining impact coefficient of restitution as a function of design revisions**
 - Compared to the governing body regulations
- **Resulting processes described enables manufacturers to reduce development cycle and cost**
 - Maintain the competitive lead on their rivals
- **ESACORP is continuously improving the process**