The Automated Development of Casting & Moulding Ribbing Designs through the Application of the Reinforcement Derivation Method®

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Overview

• Introduction to GRM
• GRM Additional Modules for Design Studio
• The Reinforcement Derivation Method (RDM®)
• Application of RDM for casting & ribbing design
• Case Study in Seat Armrest Design
• Summary and Conclusions
GRM

Engineering Consultancy
- Optimisation
- Design Engineering
- Structural Analysis
- Composites

FE Analysis & Optimisation Software
- UK & EU Sales
- Technical Support
- Standard & Bespoke Training
- Software Development
GRM Additional Modules for Design Studio

- Composite Analysis & Optimisation Suite
  - Composite Modeller
  - Composite Reporter
  - Material Library
  - Ply Sensitivity Plotter
  - Global Ply Design
  - Ply Pattern Reporter
  - MultiRun
GRM Additional Modules for Design Studio

- Analysis & Optimisation Process Tools
  - LSPP Mesher
  - Material Library
  - Thickness Sensitivity Plotter
  - RDM®
  - Abaqus Model Import
  - SolidWorks Simulation Import
  - LS-DYNA Export
Sensitivity Plotters

PSHELL Thickness
- Automatically plot and rank stiffness & mass sensitivities to selected shell properties

Global Ply
- Automatically plot and rank stiffness & mass sensitivities to selected global plies
Optimised Engineering Design

Sensitivity Plotter

ID | Name    |
---|---------|
179 | PSHELL 178 |
177 | PSHELL 177 |
139 | PSHELL 139 |
138 | PSHELL 138 |
137 | PSHELL 137 |
136 | PSHELL 136 |
175 | PSHELL 175 |
176 | PSHELL 176 |
166 | PSHELL 166 |
167 | PSHELL 167 |
100 | PSHELL 100 |
132 | PSHELL 132 |
133 | PSHELL 133 |
151 | PSHELL 151 |
43  | PSHELL 43  |
146 | PSHELL 146 |
152 | PSHELL 152 |
61  | PSHELL 61  |
53  | PSHELL 53  |
50  | PSHELL 50  |
60  | PSHELL 60  |
145 | PSHELL 145 |
52  | PSHELL 52  |

PSHELL ID
The Reinforcement Derivation Method® (RDM)

- RDM enables rapid identification of the optimal load path identification and reinforcement pattern development

- Process allows:
  - Idealised load path identification
  - Automatic optimisation of rib patterns

- User has control of candidate rib patterns generated, ensuring feasible designs are developed
RDM Design Space Creation Process

- Eliminates often prohibitive time to create and connect candidate design space mesh
- RDM® tool enables auto creation and connection of design space in seconds
  - Block Search
  - Projection
  - Wrap
  - Offset

Automotive BIW
350,000 elements
RDM Mesh = 216,000 hexas
Created and connected in 80seconds

Casting Candidate Ribs
29,000 elements
RDM Mesh = 174,000 quads
Created and connected in 40seconds
An existing FE structure is our starting point.

The RDM® region is automatically created in Design Studio over the top at user-defined limits.

Genesis carries out an optimisation for multiple load-cases, removing superfluous material and only leaving the most important parts.
**Interpreting the Results**

- The RDM® result is ideal for identifying areas of weakness and demonstrates the most effective solution.
- However, the results need to be interpreted into feasible changes which will satisfy manufacturing and practicality constraints. 3 options apply:
  
  **• Joining (Spot-welds)**
  - No additional mass
  - Minimal cost increase

  **• Geometry Modifications**
  - Minimal mass addition
  - No extra tools or processing

  **• Additional Components**
  - Largest stiffness improvements
Joining (Spot-welds)

- The smaller local RDM® “nuggets” are represented as spot-welds. A total of 10 were created which increased the body stiffness by 1% for no mass change.
Geometry Updates

- Geometry change in upper corner of boot aperture to reduce offset in flow of load-paths.
  - 0.06kg (0.01%) mass increase
  - 3.7Hz (13%) increase in first mode.
Case Study in Casting Optimisation

Hitachi Rail Europe AT 200 Prototype Mock-Up
Armrest Assembly Design
The Design Challenge

• GRM delivered engineering of Hitachi Rail Europe’s next generation train seat designs
• Achieved design significantly lighter than current seats in marketplace, whilst developing cantilever mounting layout
• Achieved through extensive application of Genesis in key components
• Cast armrest assembly suitable for RDM application
  – Lower Armrest Valence
  – Main Armrest
Lower Armrest Valence

- Lower valence casting has requirement to support standing loads along top surface
- Solid RDM space creation used
  - Block Search
  - User Trimming
- Default Topology optimisation set-up of:
  - Minimise Strain Energy
  - Fixed Mass Fraction
  - Casting Constraint applied to design space
Lower Armrest Valence – Design Results

RDM Results

Manufactured Casting
Primary Armrest Casting

- Casting/Moulding model designed without rib pattern.
- The RDM® tool automatically generates candidate ribs based upon user manufacturing & design rules.
- Genesis carries out an optimisation for multiple load-cases, eliminating ribs not required to meet the loading requirements.
Armrests successfully installed on first class and standard seats for Hitachi demonstrator train

Train launch in London in July 2014

There’s even one in our office!
Summary and Conclusions

• Genesis has, for a long time, contained the capabilities to optimise casting and moulding rib patterns

• RDM® tools objective is to enable users to rapidly and easily identify areas for design improvement

• Specific application to castings/mouldings can be achieved using either solid or shell RDM® design space options

• In the case of Hitachi’s seat design Genesis and RDM® proved invaluable in delivering a lightweight design in such a short timescale
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Thank You...