

Faster and more accurate strength and durability analysis using 3D simulation

Unrestricted © Siemens AG 2019



The Digital Twin allow to



Understand the testing

Design right first time

Include manufacturing and assembly

The Digital Twin allow to

SIEMENS Ingenuity for life

Time 1.0000 mported Result : ev_sc3dmotion_motion1-solution_pothole-chassis-007248_a_sim1-solut Loadcase 1, , 1s Translational Deformation - Nodal, Magnitude Min : 0.071, Max : 1.307, Units = mm Deformation : Displacement - Nodal Magnitude Step 2000 .307 mported Result : e assis-007248_a_sim1-solution_stress Loadcase 1, , 1s Translational Defo Min : 0.071, Max 204 Nodal, Magnitude Units = mm ent - Nodal Magnitude Deformation : 1.307 1.204 .483 0.380 1.101 **Understand** 0.277 0.174 0.071 mm mported Result : ev sc3dmotion motion1-solution pothole-chassis-007248 a sim1-solution the testing Importer Vesari, ev jacantrologi (inducti resoluto) particiero, Ladicase 1, 15 Stress - Element-Nodal, Element-Value, Average, Von-Mises Shell Section : Average Min 1:00, Max : 22.45, Units = MPa Deformation : Displacement - Nodal Magnitude 22.45 20.58 18.71 16.84 14.97 13.10 11.23 0.36

Define Durability Load Data Analysis Tasks





Unrestricted © Siemens AG 2019 Page 5 2019-02-13

Road Load Data Prediction

Earlier access to real-world vehicle loads





Fiat Group Automobiles S.P.A. SIEMENS Using Simcenter Simulation & Test to verify and validate durability virtually Ingenuity for Life



- Reduced margin of error in real loads between 8 and 15 percent
- Reduced overdesign by performing simulation prior to building a prototype
- Diminished costs by developing equivalency between two proving grounds

Conducting complete fatigue analysis



Proving grounds in Turin, Italy



Virtual prediction and use experimental data for model validation

- · Long-term partnership between Fiat and Siemens PLM Software
- The ability of Siemens PLM Software to deliver customized solutions

"Although we can't measure the improvement because we previously didn't use virtual data, the results that we have received by using both Simcenter products are absolutely excellent."

Marco Spinelli, Head of the Chassis CAE Department

Unrestricted © Siemens AG 2019 Page 7 2019-02-13

Ford Otosan Cut time to reproduce 1.2 million kilometers of customer usage

SIEMENS Ingenuity for life



- Reproduced 1.2 million kilometers of customer usage in a condensed proving ground test period
- Developed 4-week accelerated rig test to represent 1.2 million kilometers of customer usage
- Provided opportunity to optimize cost and weight

Conducting customer correlated procedures



Cabin rig test to represent 1.2 million kilometers

- Qualify and quantify the durability potential of vehicle loads with innovative analysis
- Replace time-consuming and costly tests by deriving compressed load time histories with an equivalent damage potential for uniaxial and multi-axial loading conditions

"We selected Siemens PLM Software for its capabilities and experience in durability field testing, load data analysis and test schedule development for virtual simulation and durability track and rig testing."

Vehicle Durability Supervisor

The Digital Twin allow to



Understand the testing

Design right first time Include manufacturing and assembly

Model the real world

The digital twin using real life load data



Model the real world	Challenge		
	 Get real load data Get a realistic digital twin 	H≠ H∰₂ ⊢ Ha Ma ≪a	
	Durability loads in simulation		
Interoperability	can be represented in multiple ways		
Efficient Durability Modelling	Key Points to enable the process		
	 Access to any load data format, and FE data From simple block loads to hundreds of load channels 		
Get the results at fingertip	 and FE cases Transient events 		
	Complex duty cycles		

Model the real world The digital twin using real life load data



The digital twin using real life load data

Unrestricted © Siemens AG 2019 Page 11 2019-02-13

Siemens PLM Software

SIEMENS

Interoperability Get the correct loads – use the current results

ウ・剤・ や 「Switch Window 」 Window・ Simcenter 3D - Pre/Pos Home Results View Specialist Durability Developer 0110 Image: State of the s 🖬 da 🤒 🧐 🍬 🖷 🔳 d Manage Physical Modeling More Materials Properties Objects Q.Q. • SS III S S S • 4 • 4 • 4 • 4 H # # # . dation) MODAL FLEX KNUCLE # v008.sim (Modified 0 _ 🗆 X P. MODAL FLEX INVELER & FrontSurp_Ste CSVS 8 Ph Selection Recipes MODAL_FLEX_KNUCLE_R_v008 : FLEX_KNUCKLE_R_v008 Result 20 P Groups FN Fields Load Case 1, Mode 1, 0.0008834314z Load Case 1, Mode 1, 0.0008834314z Stress - Elemental, Von-Mises Min : 1.25006e-12, Max : 7.52326e-10, Units = MPa Deformation : Displacement - Nodal Magnitude 8 Modeling Object P Regions Ba 7.52326e-10 Constraint Con It Load Container 600 6.89736e-10 - En Results 6.27146e-10 5.64557e-10 All Loant 5.01967e-10 4.39377e-10 \$ 3.76788e-10 3.14198e-10 Simulation File View 2.51609e-10 1.89019e-10 .26429e-10 Get the results at fingertip 6.38397e-11 25006e-12

Work with one digital twin – Get the right data

Unrestricted © Siemens AG 2019 Page 12 2019-02-13

Model the real world

Interoperability

Efficient Durability

Siemens PLM Software

SIEMENS Ingenuity for life



Modelling

Efficient Durability Modelling

Model the real world

Interoperability

Efficient Durability Modelling

Complex Durability Setup – easy and efficient

SC B + + H + + + In Setch Window - Window -Sincenter 3D - Pre/Post File Home Results View Specialist Durability Developer PULAD Image: Section State Image: Se 🖁 da 🤒 🧐 😵 👘 🔳 Scenario Report Material Manage Physical Modeling More Material Material Properties Objects Name AMODAL, FLEX, KNUCLE, R, 4008 Jam Sold FrontSusp_Steering_Assemble Sold Stress Selection Recipes MODAL_FLEX_KNUCLE_R_v008 : FLEX_KNUCKLE_R_v008 Result Load Case 1, Mode 1, 0.000983431Hz 合 Stress - Elemental, Von-Mises Min : 1.25006e-12, Max : 7.52326e-10, Units - MPa Deformation : Displacement - Nodal Magnitude + En Groups · FN Fields Modeling Objects 8 7.52326e-10 R The Constraint Containe 6.89736e-10 Load Container Disolver Sets T FLDC RNUCKLE R, v008 6 6.27146e-10 Ð Simulation Object Constraints Bresults 5.64557e-10 Shutturi 5.01967e-10 Results 4.393770-10 3.76788e-10 3.14198e-10 2.51609e-10 1.89019e-10 1.264298-10 6.38397e-11 Get the results at fingertip 25006e-12 [MPa]

Complex Durability Setup – easy and efficient

Unrestricted © Siemens AG 2019 Page 13 2019-02-13

Siemens PLM Software

SIEMENS

Get the results at fingertip

Know the reasons of fatigue and build better designs

imcenter 30 - Pre/Post Home Results View Specialist Durability D The second secon 🖁 da 🤒 🧐 😵 👘 🔳 3 Scenario Report Cente Manage Phytical Modeling More Materials Properties Objects Simulation Navigator A MOON FLEX KNUCLE R. WAR am Tortfutp Steering Assembl MODAL_FLEX_KNUCLE_R_v008 : FLEX_KNUCKLE_R_v008 Result Load Case 1, Mode 1, 0,00983431Hz 8 Selection Recipes Stress - Elemental, Von-Mises Min : 1.25006e-12, Max : 7.52326e-10, Units = MPa Deformation : Displacement - Nodal Magnitude + E Groups . The Fields Modeling Object 8 7.52326e-10 III Simulation Ohio R Constraint C 6.89736e-10 E Solver Sets 6.27146e-10 I FLEX KINUCKLE R VOUS · Caritteint 5.64557e-10 - E Results Structural Cvents Knuckle Flecib 5.019676-10 Knuckle Te 4.39377e-10 - Simulation C Results 3.76788e-10 · P^m Scenario Data Souri 3.14198e-10 2.51609e-10 1.89019e-10 1.26429e-10 6.38397e-11 25006e-12 [MPa]

Know the reasons of fatigue and build better designs

Unrestricted © Siemens AG 2019 Page 14 2019-02-13

Siemens PLM Software

SIEMENS Ingenuity for life





Fatigue analysis of a chassis part



Model the real world	The digital twin using real life load data
Interoperability	Work with one digital twin – Get the right data
Efficient Durability Modelling	Complex Durability Setup – easy and efficient
Get the results at fingertip	Know the reasons of fatigue and build better designs

Unrestricted © Siemens AG 2019 Page 15 2019-02-13

The Digital Twin allow to



Understand the testing

Design right first time

Include manufacturing and <u>assembly</u>

Challenge Geometry and Behavior of a (Seam) Weld ... Not that simple

Simplified Cross-Sections

Asymmetric

Convex

Weld Geometry: Penetration, Convexity, Continuity, Grinding

How to model – as not known before the assembling and scattering

Unrestricted © Siemens AG 2019 Page 17 2019-02-13

Theoretically

Perfect

Concave

Siemens PLM Software



Reality...





Challenge Geometry and Behavior of a (Seam) Weld ... Not that simple



Reality...



Other influences

Carbon, Manganese, Hydrogen	
Weld, Preheat, Cooling	
Porosity, Composition	
Uniformity, Property Degradation	
(Ductility)	
at perimeter of Weld	
after cooling	
Surface Finish, Alignment, Warpage	

Need for a simplified but still accurate approach

Unrestricted © Siemens AG 2019 Page 18 2019-02-13

Seam Weld Analysis Traditional methodologies

Nominal Stress

Traditional approach In several certification processes Read/measure stress in distance to weld – Compare results with prescribed SN curves





High safety factors Expensive and heavy over design

Unrestricted © Siemens AG 2019 Page 19 2019-02-13

Siemens PLM Software

SIEMENS

Seam Weld Analysis Traditional methodologies

Notch Stress

Use local stress values In IIW guidelines High accuracy Includes local geometry effects and load dependency





High effort Not applicable to large structures

Unrestricted © Siemens AG 2019 Page 20 2019-02-13

Siemens PLM Software

SIEMENS

Seam Weld Analysis Accurate and efficient solution

nter 10 - Pre/Por PUADO 23 明 HI. No modelling resrictions Applicability All certified methodologies PPT-PSHELL 4 PPT-PSHELL S PPT-PSHELL 6 PPT-PSHELL 70 PPT-PSHELL 1 PPT-PSHELL 1 Notch PPT-PSHELL 1 stresses Accuracy Effective stresses Weld definition **Combine the accuracy of the notch stress** Robust approach with ease of use of traditional definition Weld nominal stress methods detection Unrestricted © Siemens AG 2019

Page 21 2019-02-13 SIEMENS



Siemens PLM Software

Magneti Marelli Sistemi Sospensioni

Enhancing strength and durability of suspension structural components



- Enhanced strength and durability of components
- Optimized design before developing a prototype
- Enabled company to accurately predict the lifespan of components and assemblies

Using Simcenter solutions for durability analysis



- Validate more design variants for fatigue life within shorter development cycles
- Use durability analysis to simulate performance of large and complex systems

"What we appreciate about the Simcenter solution is reliability of the results. With the Simcenter solutions, for the first time we were able to accurately correlate with the bench test results"

Andrea Santini, Head of CAE and Innovation

SIEMENS

Ingenuity for life

Unrestricted © Siemens AG 2019 Page 22 2019-02-13

The Digital Twin allow to



Understand the testing

Design right first time

Include <u>manufacturing</u> and assembly

Challenges Materials and Manufacturing and Weight

- New materials
 - New challenges
 - Need new methods



Source Mark White, JLR, Global Automotive Lightweight materials Conference, London, 2012

Unrestricted © Siemens AG 2019 Page 24 2019-02-13

Siemens PLM Software

SIEMENS

Industry challenges Traditional idea fatigue simulation



Unrestricted © Siemens AG 2019 Page 25 2019-02-13

Siemens PLM Software

SIEMENS

Production processes define material behavior Composites - examples

 Ω^m

Injection molding of random fiber re-enforces plastic

Production process leads to locally statistically distributed fibers.

UD or woven composites not only fatigue behavior depends on manufacturing, but also damage modelling depends on different damage modes and materials.



Using worst case apporaches leads to over design

Unrestricted © Siemens AG 2019 Page 26 2019-02-13

Siemens PLM Software

SIEMENS

Production processes define material behavior Additive manufacturing

1000



Challenge

Fatigue behavior of 3D printed parts depends on many process parameters.

Solution

- Isolate the influence of the parameters
- Simulation of the process to get the parameters



Literature Study – Fatigue Behavior of Ti6Al4V

- **Different Stress Conditions**
- **Different Geometries**
- **Different Post treatments**
- **Different Build Orientations**
- **Different microstructures**
- Different surface roughness -



Unrestricted © Siemens AG 2019 Page 27 2019-02-13

Siemens PLM Software

KU LEUVEN

Ready for experts

Open Solver - Used in research and customer projects

Open Solver

- One GUI
- One Pre and Post
- All interfaces to load and FE
- User defined methods
- User defined parameters



Fatigue Results

SIEMENS

Ingenuity for life

Open but easy to apply for the end user No overdesign



Unrestricted © Siemens AG 2019 Page 28 2019-02-13

Honda R&D Co., Ltd.

Innovation for progressive damage analysis in composite design





- Predictive damage models at the coupon level and at composite subsystem design concept level
- Development of the parameter identification procedure, based on a limited amount of physical tests on coupons

Target: reaching 50 percent weight reduction by 2020 or 2030



Damage of a specimen after test

analysis of composites

- Simcenter Samcef non-linear finite element solvers for accurate modelling •
- Simcenter Engineering Services for composite damage model identification

"Not only at Honda, but many engineers in this field think that we can still make vehicles that have a 50 percent lighter body structure using composites while maintaining the mechanical properties of the replaced metallic parts."

Yuta Urushiyama, Composite body innovation programs Honda R&D Co., Ltd.

Simcenter for Vehicle Performance Engineering

Vehicle Strength & Durability





Page 30 2019-02-13

The new era of durability engineering Deliver lighter, stronger and more durable vehicles





Simcenter solutions

- end-to-end durability engineering approach
- accelerate time to market
- balance weight, strength & durability
- avoid vehicle recalls
- meet customer's expectations.

Unrestricted © Siemens AG 2019 Page 31 2019-02-13

Thank you! Want to know more?





Unrestricted © Siemens AG 2019 Page 32 2019-02-13