Virtual Manufacturing of Light Weight Aero Engine Components

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Agenda

- Volvo Aero product specialization
- Defining the context and motivation
- Computational Welding Mechanics
- Validation
- Knowledge driven design tool
- Examples
- Conclusion
Volvo Aero’s specialization

Target -20% weight reduction on structures

- Fan/compressor structures
- Shaft
- Turbine structures
- Vanes
- Fan Case
- Diffuser Case
- LPT-Case
- Spool
- Turbines
- Nozzles
Virtual manufacturing tools

DESIGN

Tools for functional evaluation

Concept Design → Preliminary Design → Detailed Design

Tools for evaluation of manufacturing effects

Inventory of known methods → Preliminary preparation → Detailed Preparation

Tools for planning of manufacturing

MANUFACTURING
Selecting manufacturing strategy

- Develop an alternative design and manufacturing route
- Single piece casting → fabricated alternative
- Gain
  - Weight
  - Lead time
  - Flexibility
  - Cost
One example: CWM modelling – The needs

- Models describing the physical behaviour of the process
  - The material behaviour
  - The numerical strategy
  - The craft of welding
- Integration between design activity with the manufacturing analysis activity
- Validation in relevant environment
Model for Computation Welding Mechanics

Step 1

Step 2

Step 3

Step 4

Step 5
Validation

An hierarchical validation process

- Material test bar
- Bead on plate
- Sub component
- Full sized component
Engineering Process Automation

1 Engineering Process

2 Develop Knowledge Automation Application

3 Use Knowledge Automation Application
Knowledge driven design tool

1 Engineering Process to Define Weld Assembly Processes

1. Identify Manufacturing Process
2. Define Geometry
3. Idealize Section
4. Apply control Method
5. Generate FE Model
6. Perform Simulation
7. Defined Manufacturing Process

2 Develop Knowledge Automation Application

3 Use Knowledge Automation Application

Automation of Engineering Processes applicable to many areas – e.g.
Enabling Virtual Manufacturing in Product Development
Examples
Application in ”real life”

- Volvo Aero have used virtual environments in several product development projects
- GEnx-engine Turbine Rear Frame (TRF)
- The design solution
  - Fabrication including more than 100 welds
- CWM was used for decision making in a number of different situations
- Close cooperation
  - Welding analyst, Welders
  - Welding engineers and Fixture design engineers
- Result
  - Weight reduction by ~15% compared to existing products
  - A welding sequence that meets the geometrical tolerances
Another "real life" application

- Manufacturing task for the Turbine Exhaust Case of the PW2000
- About 200 welds
- Issue – Robustness of the geometrical tolerances during production
- Several welding sequence were investigated
- CWM shows
  - Residual stresses could be lowered
  - To avoid the issue with geometrical tolerances a pre-deformation could be given
    - Amount of needed pre-deformation was calculated by the welding simulation tool
Gain using virtual tools

- Robust manufacturing built into the component
- Reduction of product development lead-time
- Decrease of repetitive engineering
- Reduction of modelling errors in engineering work
- Reduction of trial and error in production
- Decreased need for hardware and physical trials
Lesson learned - needs for successful implementation

- Continuity and management support
- Selection of a flexible software platform
  - continues improvement
  - open architecture which allow user enhancement through coding of new algorithms
- Correct context
- Involvement of people that owns the problem
  - welding engineers, weld operators, design responsible, project managers, experimentalists, material specialists, …)
- Close collaboration with the research community
- Timing, ….which sometimes are considered as — having luck!