Ortic Advanced Roll Forming - 3D FE Simulations

Alexander Vigander
Alexander.Vigander@ortic.se
www.ortic.se
Manager Forming Technology
Ortic AB
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Agenda

• **Background**
  • ORTIC AB
  • 3D Roll Forming
  • LS DYNA module for 3D Roll Forming

• **Results**
  • Assembling first forming stand
  • Testing the motions
  • Assembling a machine line
  • First trial of forming a profile with 7 stands

• **Summary / Future work**
Short background Roll Forming

History ORTIC AB
• 2D Roll forming since 1984
• First 3D Roll Forming Machine 2001
• 7 patents on 3D Roll forming
• First own 3D roll forming prototype machine in 2008 for in-house development
• Own second generation 3D Roll Forming Prototype machine 2014
• Ortic Software for roll forming calculations and generation of CAM data (Steering data)

What is roll forming
• 2D Roll forming – Same cross section along the profile length
• 3D Roll Forming – Profile cross section varied along the length
• Why 3D Roll Forming?
  • Flexible and unique designs
  • Several profiles with same set of tooling (within profile family such as U-, C-, hat-profiles and more)
  • Fully Utilize material strength (90° angles possible → maximum stiffness)
  • Reduce profile weight (variable cross section)
  • Increase performance
  • High productivity, (+)15 m/min tested and be produced from coil.
• All cold rolled materials are possible to roll form!
  • "We do not see strength as a limit!"
Background – Project FE Simulation Module 3D Roll forming

- In-house demonstration 3D Roll Former since 2014, generation 2
  - 7 Roll stands
  - ½ to ⅓ of full machine setup. Full scale can be 24 stands. (Depending on profile geometry)
  - Runs 3.7 m long sheets, several profiles per sheet (as from feeding from a coil).
  - Manually carrying the sheet for multiple forming sequence (usually 2 – 6 posts for reaching 90° bends)
- Developed in a EUREKA EUROSTARS project focusing on the automotive industry.

Why develop 3D Roll Forming Simulation module?
- No commercial software today for full virtual verification of the 3D roll forming process.
- Decision to develop it in-house as a complement to our own roll forming software

What will it be used for:
- Verification and optimization of
  - Tools
  - Tool motions
  - Profile shapes and designs
  - Spring back compensation
- Marketing
- Quick analysis of profile feasibility before production or prototyping
Background – Project FE Simulation Module

• DynaMore Nordic offered to help program the UDF (User Define Function) module to handle the complexity (multi joints and motors)
  • Unique solver UDF in LS DYNA Program Manager
• Why is 3D Roll Forming so hard to simulate? Would it even be possible to solve? Very complex machine.
  • 9 electric servomotors / stand, Feed, side, height, turn & tilt. → 49 Load curves for the demonstration machine simulation. Even more for full scale line.
  • Updated CAM data every 1 mm, unique for every stand. → 49,000 cells of CAM data
  • Roll motion as a function of sheet forward movement, not a function of time. Very important! Need to simulate a measuring wheel in the model.
• Pre-study (Phase 1) performed to verify the concept. Big question was if it was possible to simulate roll motions as a function of the sheet forward movement.
  • Successful pre-study! Starting phase 2.
Building up the UDF model – Phase 2

- DynaMore Nordic helped build up one forming stand with rolls.
- More stands are easy to *INCLUDE, automatic generator programmed separately.
- Rolls are easily changed between stands, can be unique if necessary.
- 9 different parts / stand controlled by load curves.
  - Controlling servo motors
  - 6 *CONSTRAINED_JOINT_ROTATIONAL_MOTOR
  - 6 *CONSTRAINED_JOINT_REVOLUTE
  - *INCLUDE – rollers, 4 / stand
- CAM data transformed into LoadCurves (*LCID)
  - Read directly from column based txt.file (excel converted)
  - *DEFINE_CURVE
- Including more stands
  - *DEFINE_TRANSFORMATION
  - *INCLUDE_TRANSFORM
    - , Offsetting node, element part and shell numbers etc.
FE Parameters

Running the program

- keyword file (*.key) runs LS DYNA Program Manager
  Includes (and transforms) several files:
  - Base chair(s).k
  - rollers.k
  - Sheet.k (to be formed)
  - Contact.k
  - Load curves.k CAM data
  - Chair curves.k
  - Control parameters.k
FE Results – First stand / simulation

Result of phase 2: Assembling the first roll stand. It seems to work!
How about integrating motions?

Let's put some load curves to this stand!
FE Results Phase 2 – Motions FE (Movie)

- Motions Z axis – verification CAM data vs displacements in FEM
  - LEFT: start position -> 100 mm -> and back. Over 90 mm length
  - RIGHT: start position -> -100 mm -> and back. Over 90 mm length
  - (one goes up and one goes down)
FE Results Phase 2 – Z motions 3D Roll former (Movie)
More Motions, Z, Y, tilt and turn (Movie)

Z motions
FE Results Phase 2 – Forming test

Complete demonstration line – 7 stands

Now lets try to form a sheet.
Profile type: Single hat.
Profile 3D shape: Wide waist with all segments variable
Flat sheet ingoing, sides are pre-cut shape

Parameters:
Explicit solution, double precision
Speed: (velocity scaled)
Friction: $\mu=0.15$
Contact. *FORMING_SURFACE_TO_SURFACE*
Material: *MAT_PIECEWISE_LINEAR_PLASTICITY*
 Load curve (1100 MPa Tensile stress)

Shell elements, 5 integration points
Rigid bodies; machine and tools
49.000 CAM cells from Ortic Software, on 49 load curves
FE Results - ORTIC Process

ORTIC

TAKES THE ROLL FORMING WORLD TO A NEW DIMENSION
Summary Phase 2 – Forming Process

Complete process from CAD to FEM and Prototyping / Production

- Scanning of CAD model. Generate CAM data from Ortic 3D Software
- FEM simulation
- Prototyping / Production

1. CAD
2. Ortic Software
3. FEM
4. Prototype / Production
Summary Phase 2 – Forming Process Output

- Comparable results to forming
  - Profile is **recognizable** both CAD and reality!
  - Hard to compare, due to FE simulation not finished yet compared to 3D CAD model.
    - Only ½ of forming steps completed
    - Needs **one more pass** to be fully comparable or;
    - Demands a couple of more stands in the simulation (have not yet been simulated as of today).
Future work - Phase 3

- Build module
- Verify movements
- Initial simulations
- Optimize model
- Compare to CAD and physical prototypes

We are here now, Phase 2

Phase 3 in the project
Future work - 24 Forming stands

Next goal in the project,

- Simulate the full scale line.
- Dimensional stability (Compare to parts)
Future work – What needs to be optimized

Optimize simulation performance
• Explicit / implicit?
• Simulation times decreased
• Restart before/after any forming stand
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For realizing the project!

Want to know more about 3D Roll Forming?
Visit www.ortic.se or contact me at Alexander.vigander@ortic.se

And thanks for listening!!