A new meshing methodology for faster simulation of a Body-In-White dipping process

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Overview of BIW painting process

Pretreatment and Ecoat Paint processes

- Power washer
- Pretreatment
- Electrocoat
- Oven
- Sand
- Seal (UBS/seams)
- Sound deadening pads
- Gel
- Wipe
- Primer application
- Oven
- Repair/wipe
- Base coat application
- Intercoat oven
- Clear coat application
- Oven
- Inspection
- Spot repair
- Cavity protection
- To final assembly

Online painting of trim items
Offline painting of trim items
Simulation method development for dipping process

Goals of method

- Dip-out: Calculation of location of residual paint and their draining time
- Dip-in: Calculation of location of air bubbles
- Fast simulation method to integrate into Digital Prototypeing Process

Constraints on method development

- Minimum mesh preparation time for BIW
- Optimal computational time
- Simulation of complex rigid body motions
- Simulation over long process times
Macro automated mesh pipeline process in STAR-CCM+

1. Imported CAD
2. Surface Meshing
3. Surface Repair [Manual]
4. Volume Meshing
5. Surface mesh and curve creation
6. Offsetting Surfaces
7. Induced intersection
8. Boolean Unite
9. Merging of intersected areas
CAD Import: Information for meshing out of CAD

- Preserve thickness surface during meshing with coarse size (>3 mm)
- Local refinement for Holes
- Translation of only top and bottom surface to induce intersections
Meshing: Surface meshing technique for BIW

→ Surface meshing using Aligned mesher to reduce surface cell count / capture geometry

A – 46300 cells
[ 36 Curv. points ]

B – 14000 cells
[ 8 Curv. points ]

C – 10800 cells
[ 8 Curv. points, Aligned ]

→ Geometry for simulation: Floor assembly

2 Million surface cells
Meshing: Volume meshing methodology

- Trimmed Mesher
- Volume mesh between Cylinder and BIW
- Coarse mesh set on outer cylinder
- Medium or slow template growth rate

4.5 Million Trimmed Hexa’s, No prism or Thin mesh

Outer cylinder

Section view of Volume Mesh: Metal to Metal contact
Simulation of Dip-out process: Physics and Motion model

Physics and Modelling phases

- Eulerian multiphase with VOF model for modelling paint and air phases
- Gravity model for gravitational effects
- Laminar model to include viscous effects

Modelling Dip-out curve

- Rigid body motion model to transform the total volume mesh over time
- Translation in X – Z plane with the help of spline interpolation
- Rotation about moving car coordinate system is superposed with linear motion

![X-Z Plane](image)

![Linear motion in X-Z plane for Dip-out](image)

![Rotary motion about moving car coordinates](image)
Simulation of Dip-out process: Initial Conditions

- Volume mesh is transformed to start of dipping conditions
- Paint level defined as $z < 0$
- Outer cylinder is set to pressure outlet
- BC’s for outer cylinder: Hydrostatic pressure and paint level as field functions

[ 1. Hydrostatic pressure definition ]

[ 2. Paint level definition ]
Simulation of dip-out process for 65s
Tracking volume of residual paint in BIW over time and position

Solution Time 0.5 (s)
Identifying draining holes and the time for complete drain out of residual paint

\[ \Delta t = 23\text{s} \]
Conclusion
Summary and future outlook

Summary

- Faster method for mesh preparation and computation of dipping process is proposed
- Aligned mesh capability of STAR-CCM+ reduces cell count for capturing complicated geometry
- STAR-CCM+ pipeline mesh process with java automation reduces manual effort and time by 75% compared to existing manual and semi-automatic methods
- Rigid body motion along with motion superposition reduces modelling effort to simulate complicated trajectory

Future outlook

- Computation using polyhedrals instead for trimmed Hexahedral cells
- Customize the current meshing method for simulation other paint processes
- Current processes like E-Coat deposition, drying simulation require a complete BIW