SPOT WELD MODELING FOR VEHICLE DURABILITY PERFORMANCE WITH ANSA

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ABSTRACT – Spot welding is one of most widely used technique for metal sheet assembly of automotive industry. Typical BIW steel sheets are joined together by about 4,000 spot welds.
In stage of FE calculation, Spot weld FE-modeling is a trade-off between accuracy and meshing time. but pre-processing tool's improvement gives big advantage to solve this kind of problem.
Accurate CAE prediction for NVH or durability performance can be only obtained when its FE model build-up is exactly performed from CAD data with appropriate spot weld realization method.
The introduction part of this presentation overviews various realization methods of spot weld in CAE pre-processor ANSA and its feature.
Second description focuses on spot weld realization for durability which is most sensitive to fatigue life result and usually wasteful of time and resources.

TECHNICAL PAPER –

1. FATIGUE ANALYSIS FLOW AND ITS TOOL

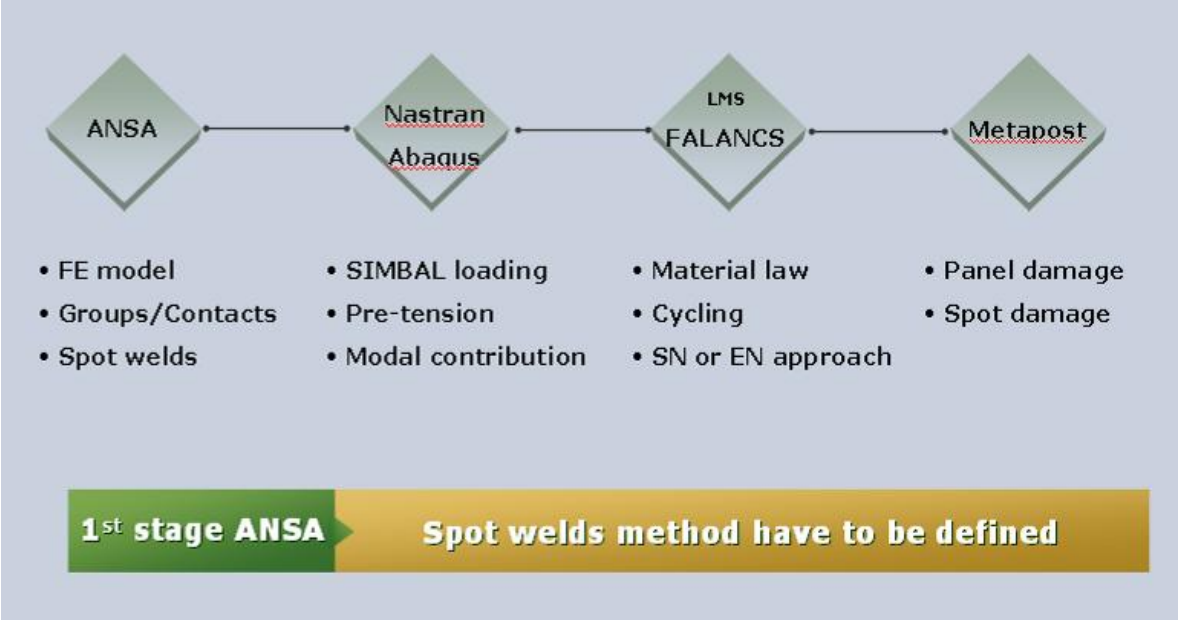

Figure 1 – Analysis flow chart

Figure 1 shows the simple fatigue analysis flow and its tools. In stage of ANSA, BIW FE model is mostly assembled by spot weld.
Spot weld modelling method is usually subject to FE model size, target accuracy and solving resources at the milestone of project.

2. SPOT WELD PROPERTY

Three regions of spot weld

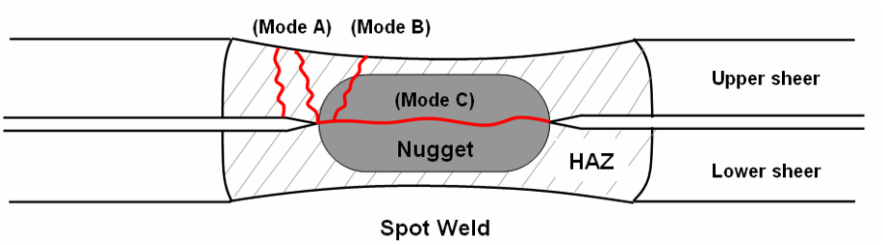

Figure 2 – Spot Weld Area

A spot weld consists of three regions, which have different material properties – weld nugget which is melted zone, a heat-affected zone (HAZ) and the base material sheets.
These spot weld's regions are generated by resistance welding process (pressure, heating temperature distribution, spot weld cooling). The nugget corresponds to the melted areas between the plates. This melting depth generates a thickness reduction of the welded plates, phenomena called indentation.

Spot weld fatigue failure modes

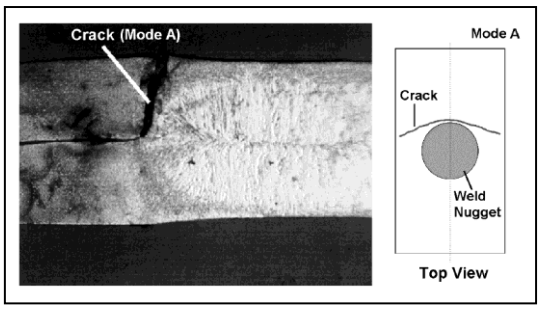

Figure 3 – sheet failure (Yi Gao[3])

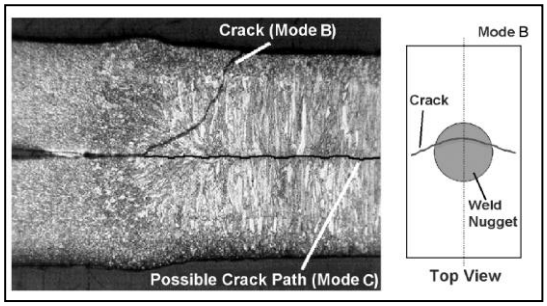

Figure 4 – nugget failure (Yi Gao[3])

Mode A. The crack grows almost perpendicular to the metal sheet and emerges from one side without penetrating into any part of the weld nugget, Figure 3.
Mode B. The crack propagates into the weld nugget but eventually emerges from one side, Figure 4.
Mode C. The crack propagates into the weld nugget, remains parallel to the two sheets, and eventually cuts through the weld nugget, Figure 4.
Mode A normally occurs in spot-welded lap joints with large nugget sizes and under a predominantly shear fatigue loading. Automotive engineers generally prefer this mode of failure to other modes [3]
Stress concentration may occur at the edges where a change of thickness takes place, which may result in crack initiation.

3. SPOT WELD MESH MODELS FOR DURABILITY ANALYSIS

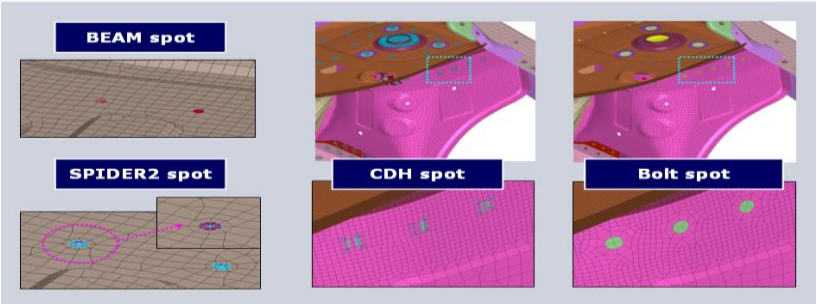

Figure 5 – Spot welds in CAE analysis

There is many kinds of spot weld mesh models which has been still developed to get more accurate result of each performance like NVH, durability, crash.
This mesh method and quality improvement has assistance from remarkable pre-processor progress.

1D spot

- ✓ Usually CBAR or CBAEM
- ✓ Very easy to define property
- ✓ Automatic mesh modified for coincident node
- ✓ Too flexible
- ✓ Under-estimated force and moment
  → Over-estimated durability

CDH(RBE3-HEXA-RBE3)

- ✓ Need not to modify the panel mesh
- ✓ Good correlation in NVH
- ✓ A little Stiff, affected by shell mesh size
- ✓ Over-estimated force and moment
  → Under-estimated durability

Spider 2 (Beam & RBE2 Head)

- ✓ Automatically modify local mesh around spot weld
- ✓ Thickness increase, more higher stress
- ✓ Over-estimated stress than bolt
  → Under-estimated durability

Bolt spot (Beam & Shell Head)

- ✓ Well realized with real spot-weld
- ✓ Concept from self-piercing rivet model
- ✓ Multi-usage for Rupp and Panel
- ✓ Special method needed for local stiffness

4. FATIGUE LIFE ASSESSMENT TECHNIQUES

Load-on-weld approach

Fatigue life predictions based on the level of a carefully selected nominal stress rages that is calculated based on forces and moments acting on each spot weld nugget [2]

Stress-in-panel approach

Fatigue life estimations based on the level of stresses in the surrounding sheet metal close to a spot weld nugget [4]

5. HOW TO BUILD BOLT SPOT MODEL

Bolt spot model's component

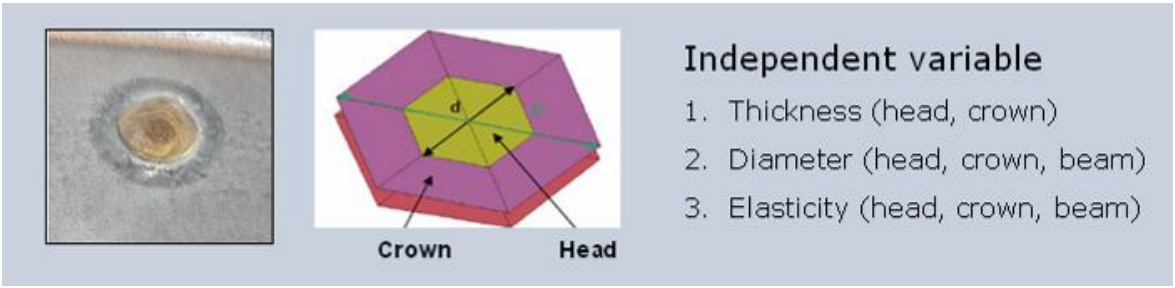

Figure 6 – Bolt spot weld model

Bolt spot model makes up for Head, Crown and Beam and there is too many variable for realistic description of real spot weld property

Manual building of bolt spot weld by ANSA

If there are ABAQUS quarter BIW model which has 6 kinds of spot welds diameter (3.0 ~8.0mm) and 10 kinds of panel thickness (0.6mm~2.8mm) that time we have to define the 8 Beam's PID and maximum 80 Shell's PID and MID for BOLT realization.
This is very long time consuming and human error possibility work.

Automatic building of bolt spot weld by ANSA

- In-house Script :
  Fatigue Bolt Type SPOTWELD Realization

  ✓ Developed by RENAULT and BETA
  ✓ Automatic assignment spot diameter by Diam Map Rules from ANSA.defaults
  ✓ Automatic creation of PID and MID for BEAM and SHELL
  ✓ Easy restore to the original mesh without loss of panel information

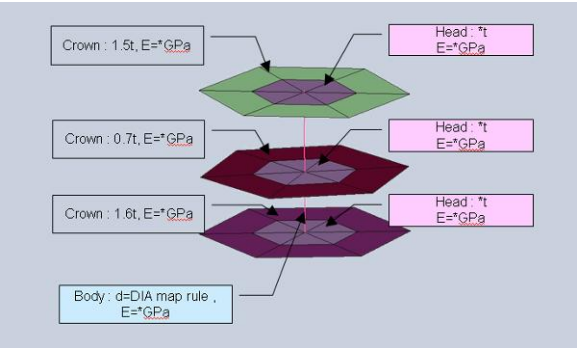

Figure 7 – variables of 3layer spot weld

6. CONCLUSIONS

Automatic BOLT spot weld by ANSA gives

- Precise description of real spot characteristic and propery
- Better restoration of mesh than manual bolt spot modeling
  easy modification of spot definition
- Various correlation factor and mesh quality warning by script function
- Possibility to use BOLT spot weld in automotive industry by reducing meshing time and modeing errors
- Both load-on-weld and stress-in-panel approach are enable

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