State-of-the-art FE based Durability Analysis of Spot and Seam Welds

Overview
MSC.Fatigue™ Spot Weld is a module of MSC.Fatigue™ 2003 for predicting the fatigue life of spot-welded sheet connections using static or dynamic FE results from MSC.Nastran™ or MSC.ADAMS® with the S-N (total life) method.

Spot Welds
Modern automotive structures can have 4000-6000 spot welds and approximately 80% of automotive body durability problems are associated with spot welds. Tooling costs for spot welds are high and the need for rapid and accurate predictions of fatigue life on spot welds early in the design stage is very important. Besides the structural importance, durability of spot welds can also have an important effect of perceived quality of a part or component.

Seam Welds
Fatigue failure prediction in welded joints is difficult due to geometric complexities and inaccuracies in the stress and strain results. Often the approach most relied upon is the component SN method which involves the construction of several prototypes followed by fatigue testing to produce a component SN curve. However, component testing is not a viable approach during the product design phase as it is time consuming and often expensive. As a result of a joint collaboration with Volvo, MSC.Software and nCode a new method for estimating fatigue life of welds in thin sheets is used.

Benefits
- Automatic extraction of Spot Weld groups
  - By flange thickness pairs
  - Weld diameter extracted automatically
- 150 Spot Weld analysis groups with no limit on spot welds per group
- Automatic extraction of weld toe elements in seam weld analysis
- 500 load channels
- Can use static & dynamic results from MSC.Nastran™ & MSC.ADAMS®
- Unique Optimization engine
- What If? Analysis
  - Based on design life compute:
    - Scale factor (stress concentration)
    - Spot weld nugget diameter
    - Certainty of Survival (Design criterion)
  - Sensitivity studies for:
    - Scale factors (stress concentrations)
    - Spot weld nugget diameters
    - Certainty of Survival (Design criterion)
  - Graphical display and hardcopy of sensitivity and polar plots
- Material Change Assessments
- Reverse searches on Material to meet Design life

Reduce costs due to re-designs by simulating fatigue early in development cycle
- Easily customize the environment to support existing fatigue processes
- Optimize your designs for durability
- Reduce costs by reducing physical prototyping and testing needs
- Improve quality
- Reduce warranty costs
Spot Weld Modeling

MSC.Fatigue Spot Weld supports results from 3 commonly used modeling methods and uses the Rupp, Storzel and Grubišić algorithm for computing stresses in each spot-weld nugget and in adjacent sheets.

1. Spot welds modeled as stiff beams. The method requires attention to align the spot weld nodes on each flange but is suitable for application to large models as local mesh refinement around the spot weld is not required.

2. MSC.Nastran CWELD elements. The power and modeling flexibility afforded by CWELD element is utilized. The CWELD allows users to model spot welds between dissimilar flange meshes of any refinement. CWELD results are used directly by MSC.Fatigue Spot Weld.

3. Spot welds modeled using CHEX/MPC. This method also allows users to model spot welds between dissimilar flange meshes. MSC.Fatigue computes “equivalent” bar forces automatically and posts fatigue results on the faces of the CHEX elements.

Seam Weld Modeling

The method is based on modeling the weld with “relatively stiff” plate elements that are used as load transducers (right: shown in red) and extracting bending and axial nodal stresses at the weld line nodes from elements adjacent to the weld. The shell toe groups adjacent to the seam lines are automatically extracted in MSC.Fatigue with the addition of a simple GUI to the materials form.

Common nodes on the toe side of the weld are determined and stresses extracted. These stresses are then used to estimate fatigue life using one of two S-N curves (Picture 4) depending on the ratio of the bending to axial stresses. The ratio identifies the seam node as “stiff” or “flexible” and the corresponding stiff or flexible S-N curve is used to estimate damage.

Critical seam weld nodes (Picture 5) are easily identified with the aid of marker plots in MSC.Patran™ and optimization studies may be carried out with the optimization module within the MAG_Weld module.

Spot Weld Solver/Materials/Results

- Analysis of welds joining two metal sheets
- Three sheet correction
- Weld nugget and sheet fatigue life - 108 fatigue calculations performed per spot weld.
- Rainflow cycle counting
- Various matrix (bin) sizes (32, 64, 128)
- Statistical Confidence parameters
- Palmgren-Miner linear damage summation
- Flexible Miner’s sum (>0, default=1.0)

Materials Database

- Spot weld S-N curves - Includes Generic Spot Weld S-N curves for nugget and sheet
- Add, create or modify materials data

Results

- Graphical and tabular reports of Life & Damage in linear & log form
- User Defined Units for Life reporting
- Polar plots of life/damage for nugget and sheets
- Polar plots of stress for nugget and sheets
- Stress Time history output
- Damage and cycle histogram plots
- Failure location – nugget, top or bottom sheet

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