Robotic spot welders perform 1270 welds in each of these Ford white bodies as they start down the assembly line at Ford Motor Company’s St. Thomas, Ontario, plant. This spot welding process takes less than 4 minutes with automatic welding machines.
Fatigue assessment of weld in automotive body

Fatigue Viewpoint;
- Most of structure is notch than continues ambient
- Typical distance of 1 – 3 inches comparing ¼ -1/2 inch spot size
- Cracks are Whole trough and sharp
- Welding micro-structure usually lost toughness properties.
- Residual stress is significant
- Subjected to variety of cyclic loading including tension, shear & torsion
Fatigue assessment of weld in automotive body

Failure of Spot Weld:
A competition between crack mechanics and plastic collapse

Spot weld can fail in two different modes

*Interfacial failure;*
The fracture by crack propagation through the weld nugget, often occurring in smaller weld for a given sheet thickness.

*Pullout failure;*
The weld nugget is pulled from one piece of the sheet metal leaving a circular hole on the other sheet. This *may occur in larger weld* for a given sheet thickness.
Fatigue assessment of weld in automotive body

**Governing Equation for Interfacial failure:**

\[ K_1 = \frac{P}{d^{3/2}} \sqrt{\frac{2}{\pi}} f(\beta) \]

\[ f(\beta) \approx 0.5\beta \]

\[ \beta = \frac{2t}{d} \]

\[ P_f = 1.25K_c \frac{d^{3/2}}{t} \]

**Governing Equation for Pull-out failure:**

\[ \tau(\theta) = \tau_{\text{max}} \cos(2\theta) \]

\[ P = \int_{-\pi/4}^{\pi/4} \tau(\theta) \cdot 2\pi d\theta = td\tau_{\text{max}} \]

\[ P_f = td\tau_f \]
Fatigue assessment of weld in automotive body

For a given spot weld, the failure mode will depend on which condition is met first.

\[ d_{cr} = 0.86\left(\frac{\tau_f}{K_C}\right)^{\frac{2}{3}}t^{\frac{4}{3}} \]

Interfacial failure, which has a less load carrying capacity, is considered unsatisfactory and industry standards are often designed to avoid its occurrence.
Fatigue assessment of weld in automotive body

Radaj 1998

Component Loading

Weld spot resultant forces
Formulae, FEM

Specimens

Plate fracture
Model: Plate with rigid core (or strain gauge)
Structural stress in plate
$\Delta\sigma_{fr\ max}$

Nugget fracture
Model: Beam cross section
Structural stress in nugget
$\Delta\sigma_{1\ max}$

Structural stress S-N curve

Load spectrum
Component F-N curve and service life curve

$\Delta F$
Fatigue assessment of weld in automotive body

References;