Fatigue life simulation with inclusion of forming effects

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Background

- We, at Tata Motors, simulation is not complete without correlation. Recently we faced poor CAE correlation in one of the bench tests.

- Root cause analysis showed forming strains have significant effect on fatigue life.

Objective of Work:

- To account for forming effects into durability simulations

- Standardize process for inclusion of forming effects

Contents

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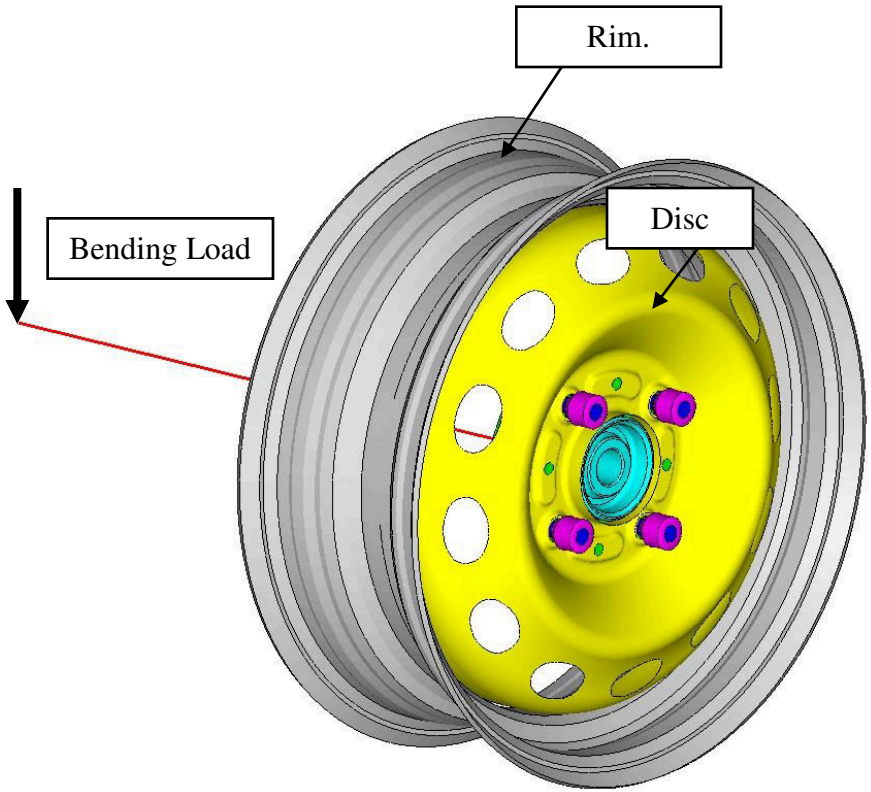
- Fatigue test simulation with conventional approach
- CAE – Test result correlation
- Theoretical Background : Effects of Work hardening during forming
- Process for inclusion of forming effects into durability calculations
- Fatigue test simulation with modified approach
- Conclusions

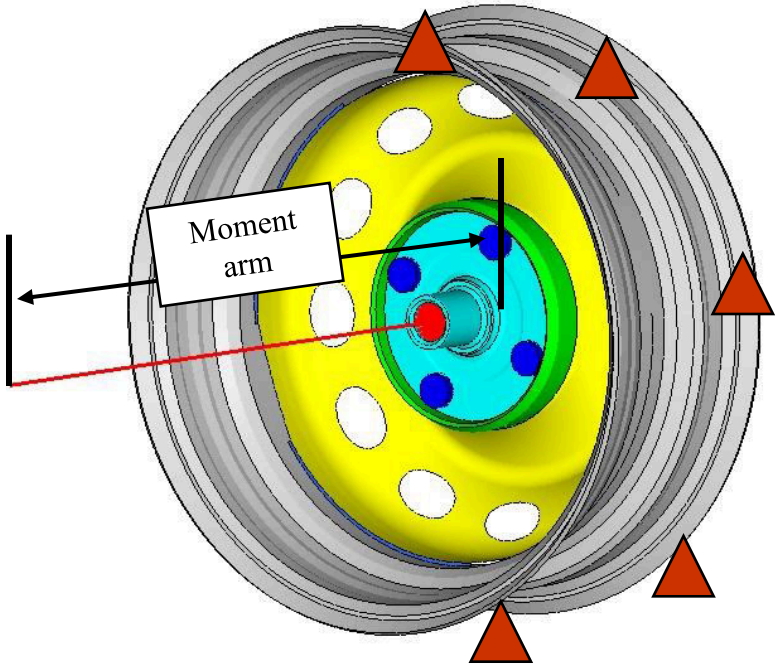
Fatigue life calculation of formed parts

Current Practice

Existing approach - Fatigue Test simulation

Boundary conditions details





Maximum bending moment as per test specifications is applied

Bolt preload = as per bolt size & grade

Complete outer edge is constrained to represent clamping of rim on test fixture

Material properties & Influence Parameters

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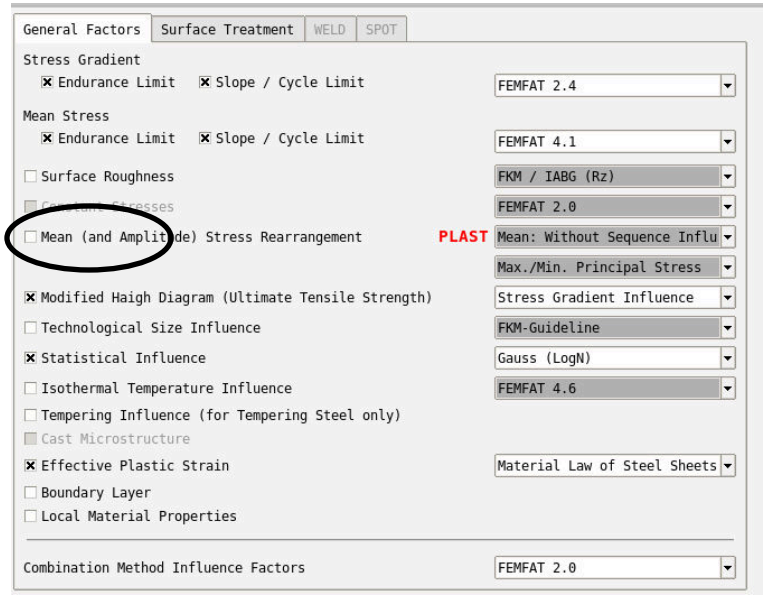
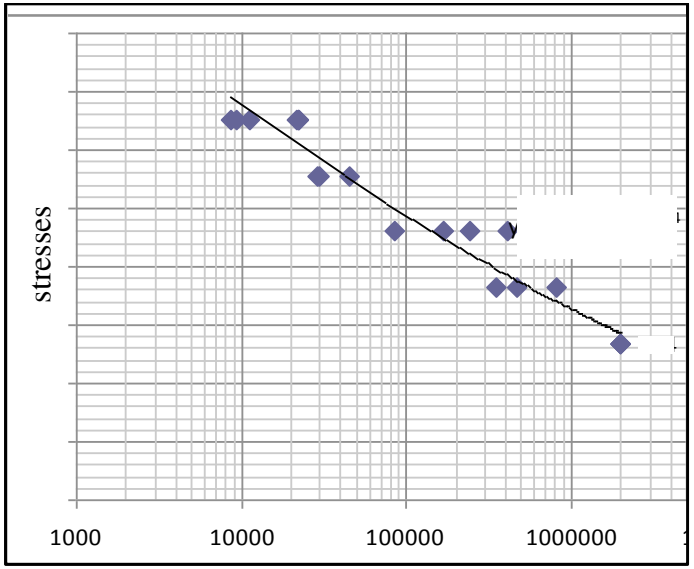
Influence factors for fatigue :-



Measured Material properties



- Stress gradient influence
- Mean stress influence
- Modification of Haigh diagram
- Statistical influence (90 % SP)
- Stresses from non-linear FEA used – Femfat-PLAST off

CAE without forming effects -Test results comparison

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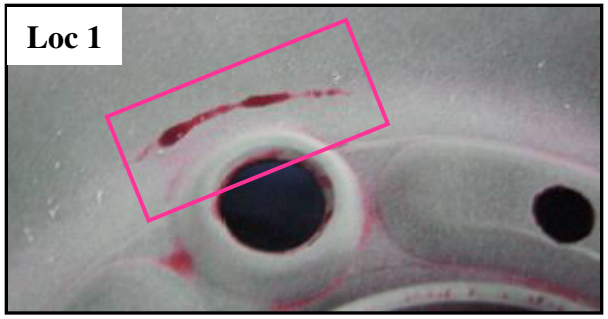
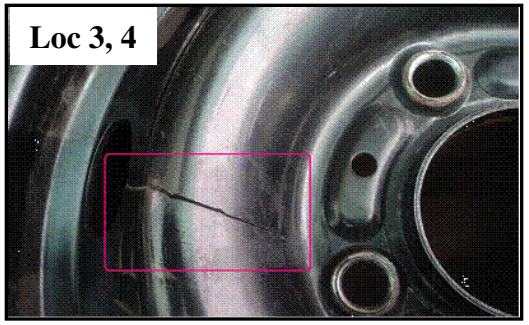
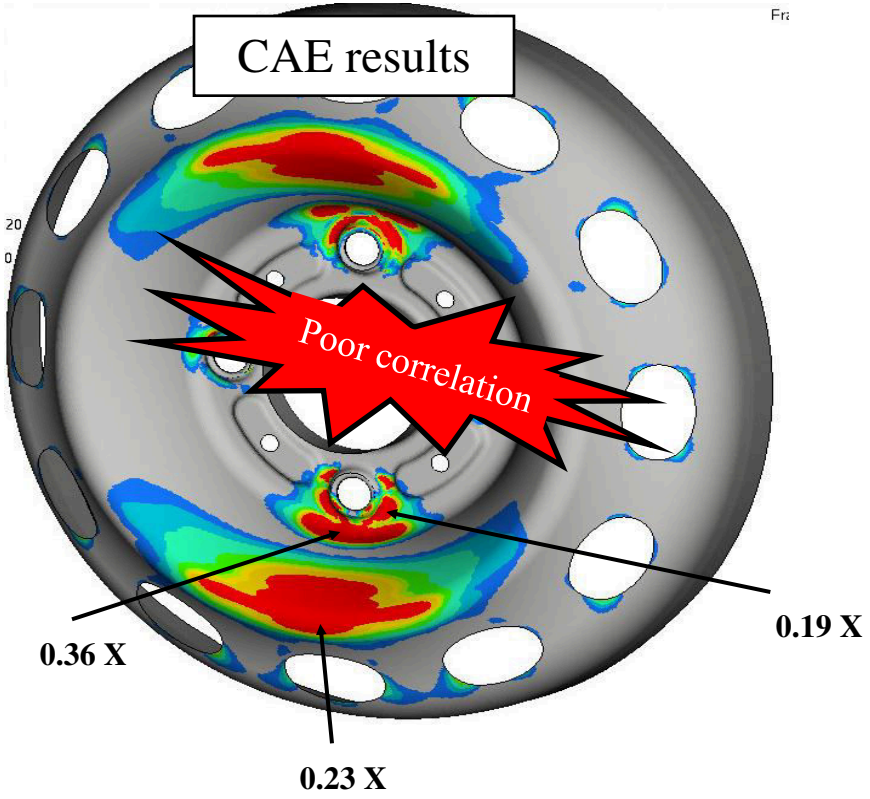




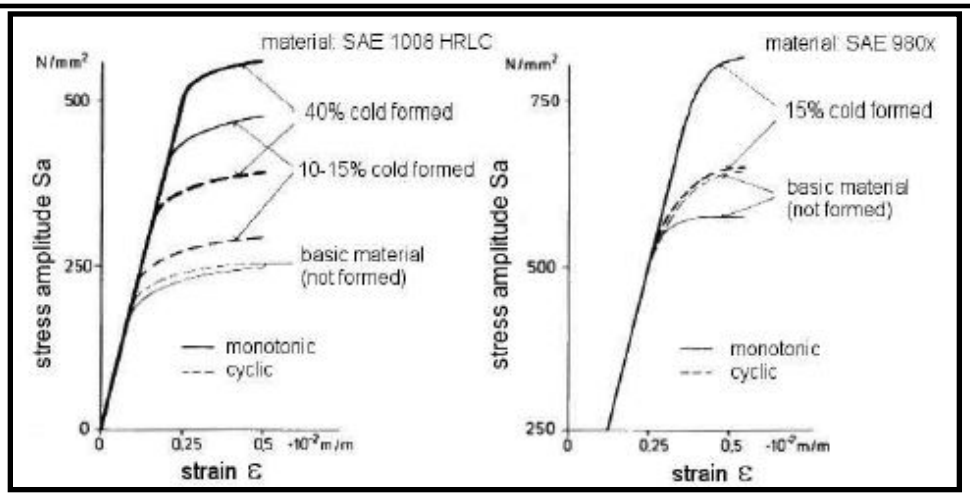
Test results		
Sample No	Cycles	Remarks
1	1.2 X	No cracks/ test stopped
2	1.3 X	No cracks/ test stopped
3	1.5 X	Crack @ loc 1 & 2
4	1.6 X	Crack @ loc 1 & 2
5	1.7 X	Crack @ loc 1 & 2
6	1.6 X	Crack @ loc 1 & 2
2,4,5	1.9 x -3X	Crack @ loc 3 & 4(tests continued by welding @loc 1,2)

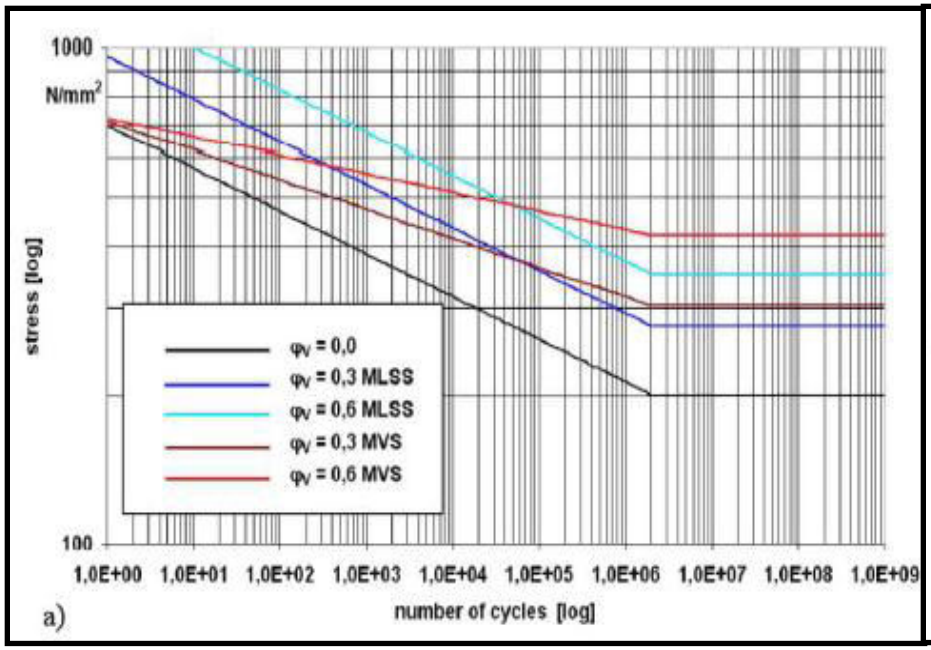


Fatigue life calculation of formed parts

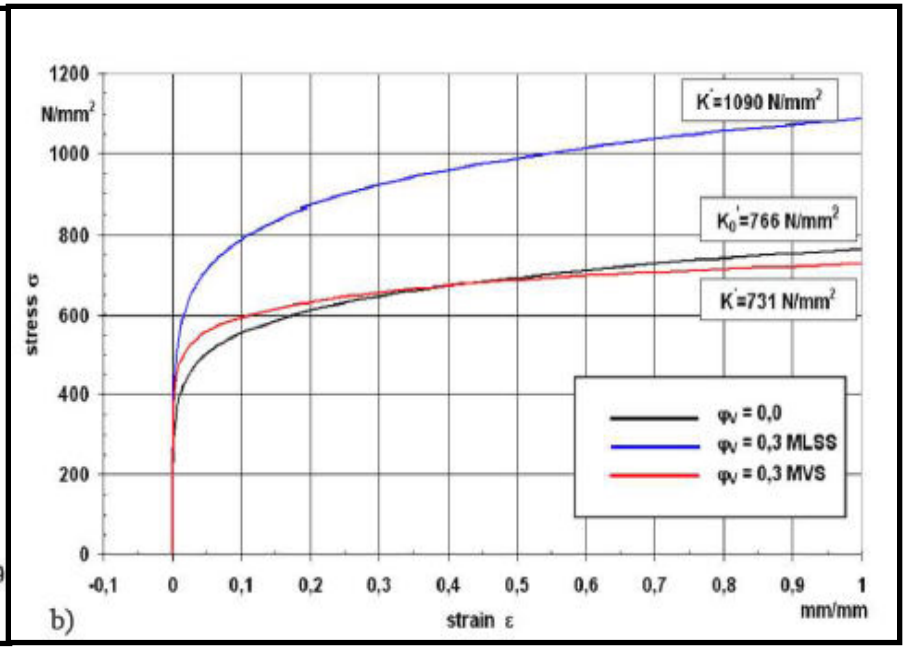
Inclusion of forming effects

Theoretical background & FEMFAT Implementation



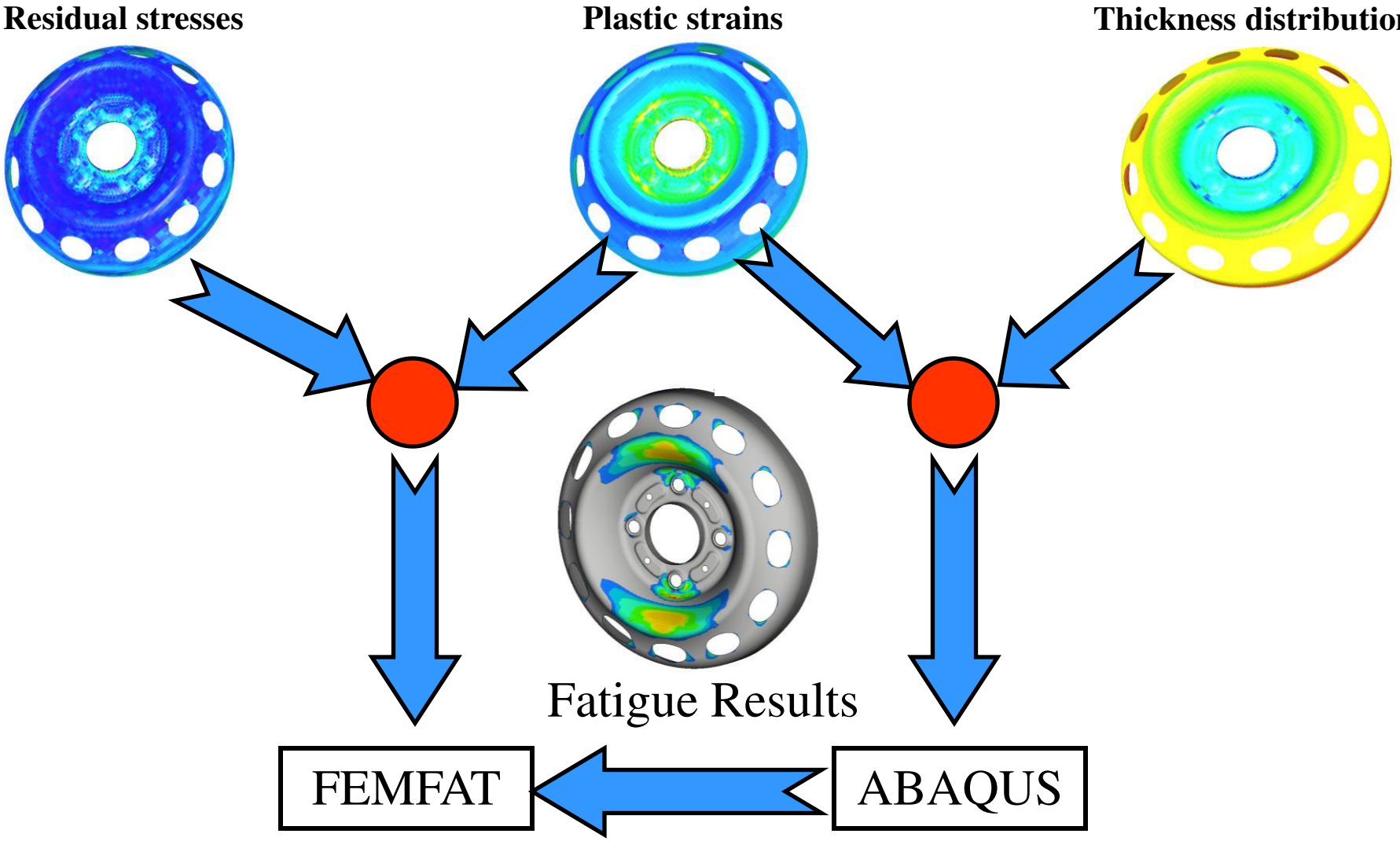


Modified SN curves

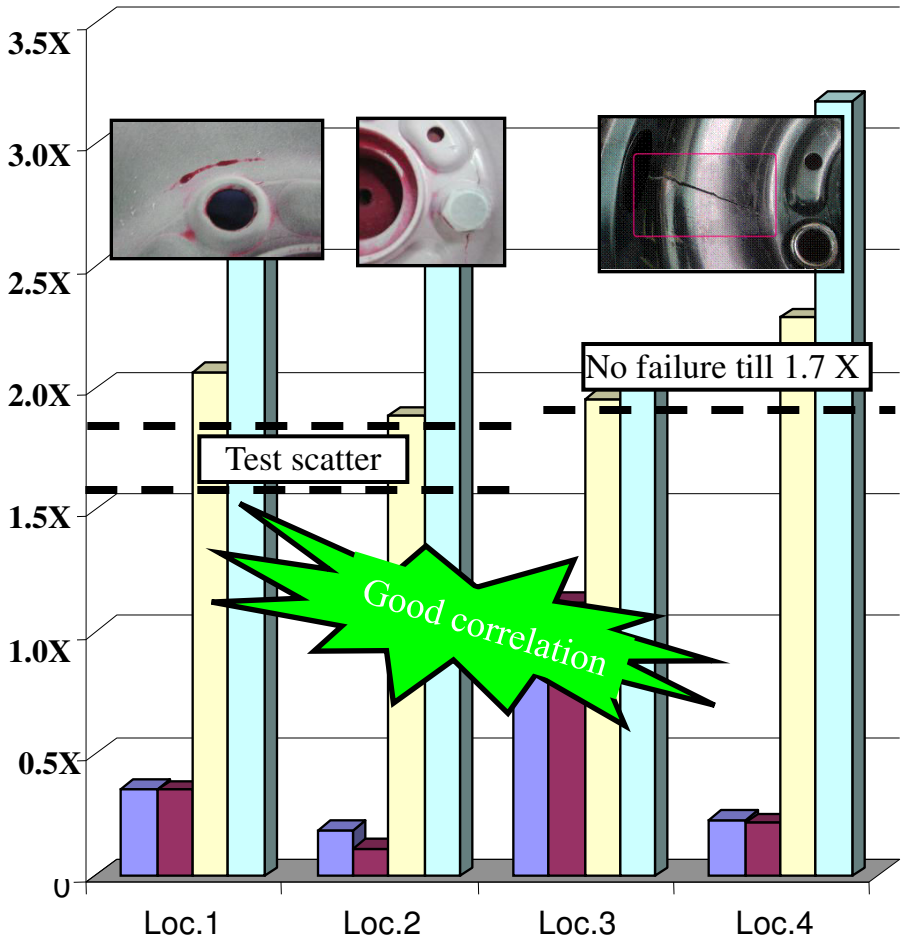


Modified Cyclic stabilized stress-strain curve

Process for inclusion of forming effects into durability



Effect of forming :- Influence Parameters



Critical locations	Life improvement by MLSS	Life improvement by MVS
Loc 1	8.0	7.1
Loc 2	9.0	11.4
Loc 3	1.7	1.8
Loc 4	10.0	14.0

Effect of forming on Fatigue Life : Results

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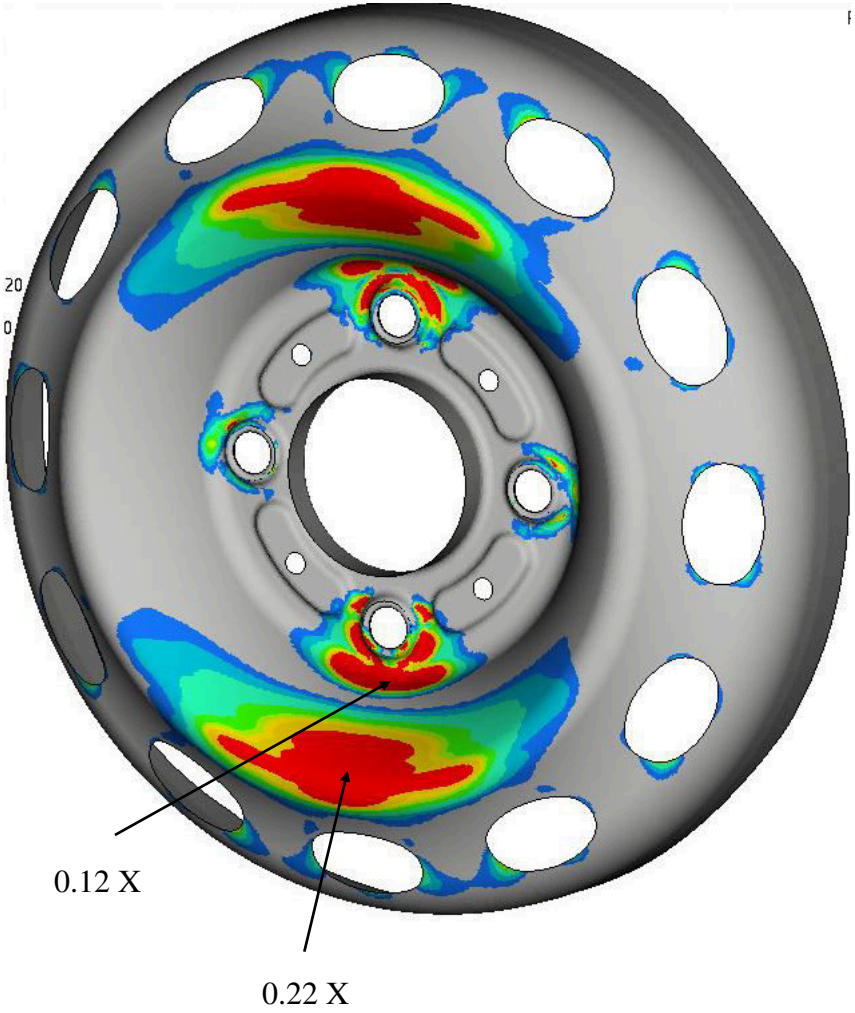
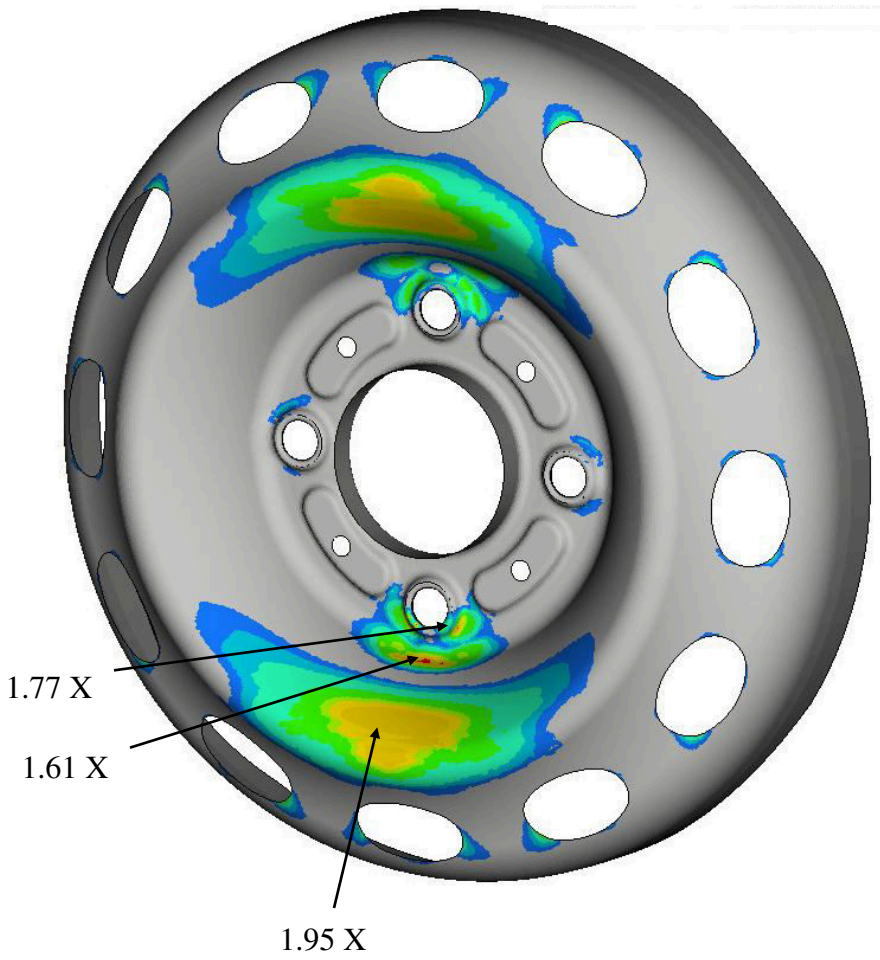
With forming effects (Thickness)



With forming effects (Thickness + Plastic strains)
MLSS



90 % Survival Probability

Conclusions :

- Methods available in FEMFAT help improve correlation with test results.
- Fatigue results are sensitive to plastic strains
- Plasticity correction is not adequate – Non-linear analysis required

Future scope :

- More test cases required to build the confidence
- Standardize the process for forming simulation & mapping of results

THANK YOU

ANY QUESTIONS?