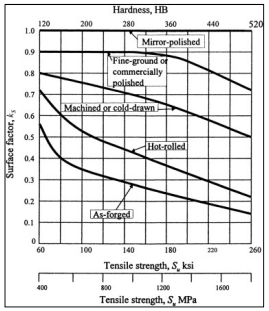
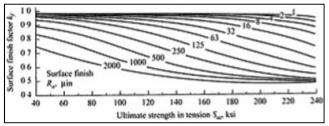
Motivation & Background

- Rougher surface finishes have lower fatigue strength
- Machine components having rough surface finish have lower endurance limit Se'
  - $S'_e = k_a S_e$ where k_a is surface finish factor
- Stress concentrations introduced due to roughness accelerate crack initiation at surface
- In Rolling Contact Fatigue, the failure mode of surface originated failures is often linked to surface finish
  - Interferes with development of EHL film
  - Increased stress level of contacting bodies



$k_a = f(S_{ut}, machining)$

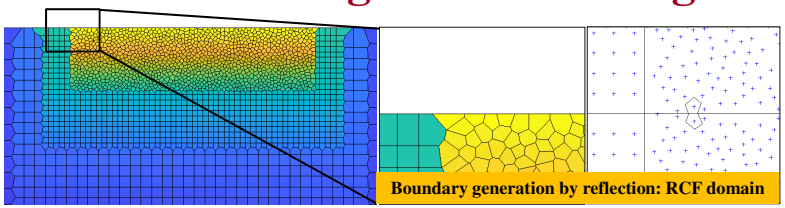


$k_a = f(R_a, S_{ut})$

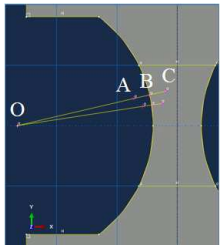
Objectives

- The objectives of this study is to experimentally and analytically investigate the effects of surface roughness on fatigue of tensile specimen
  - Conduct fully reversed fatigue on tensile specimens
  - 3 levels of roughness
  - Model experimentally observed grain morphology using Voronoi Tessellation
  - Model surface roughness using actual R_a obtained from surface profilometry
  - Corroborate experimental and analytical results

Surface Roughness Modeling



Boundary generation by reflection: RCF domain



$$\overrightarrow{\Delta r} = \overrightarrow{OC} - \overrightarrow{OB}$$

For smooth:

$$\overrightarrow{r_{new}}(\overrightarrow{OA}) = \overrightarrow{OB} - \Delta\vec{r}$$

For Rough:

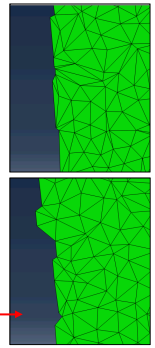
$$\overrightarrow{r_{new}}(\overrightarrow{OA}) = \overrightarrow{OB} - N(\Delta\vec{r}, \sigma)$$

$\sigma \sim R_a$ parameter

Higher $\sigma \sim$ Higher R_a

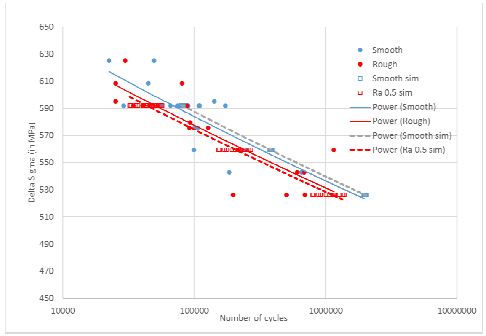
Low R_a 0.7 um

High R_a 2.5 um

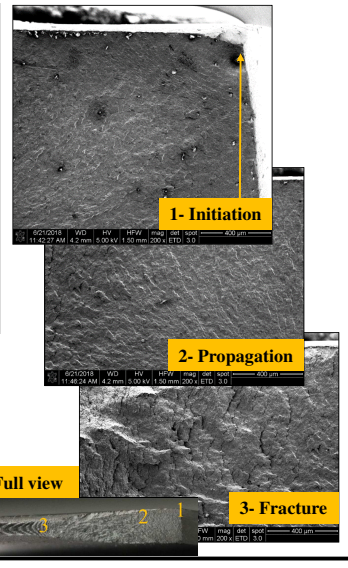


- Smooth surface: Exact reflection at boundary
- Rough surface: Perturbed reflection

Fatigue Failure Results



S-N diagram for R_a = 0.5 um vs Smooth



- As milled specimens ($R_a \sim 0.5$ um) have lower life than smooth specimen, simulations corroborate with experiments
- Crack initiation, propagation and final fracture can be observed in SEM