DCU Bolting: A Galling Prevention Case Study at Tesoro Golden Eagle

Presented by:

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Outline

• Basics of galling
  • Definition & importance
  • Process & mechanisms

• Possible solution paths
  • One option for avoidance
  • How it works

• Case study
  • Background & application details
  • Scope & results
What is galling?

• Definition
  • Material wear during sliding
  • Macroscopic transfer of material
  • Driven by adhesion

• In practice
  • Everyone has encountered it
  • Stuck nuts and studs
  • Act as one part
  • Normally on breakout

• Galling is in every plant!
Galling is expensive

- Labor
  - Man-hours spent machining, torching, etc.
  - Standby time
- Time
  - Project creep
  - Scheduling for uncertain outcomes
- Safety
  - Hot work permits
  - Torches and hydrocarbons don’t mix
- Risk to components
  - Can only oversize so much
  - Unnecessary machining

Galling is common

...expensive

...& PREVENTABLE!
Misconceptions about galling

• Common explanation
  • Friction → heat → melting

• In actuality
  • Driven by DEFORMATION rather than friction
  • Fusion due to ADHESION rather than melting

• Galling is a PROCESS rather than an event

• Macroscopic effect of MICROSCOPIC phenomena

Galling is...common
  ...expensive
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How does galling occur?

- Initial contact at high points
  - High local stress, penetrates surface
  - Initiates plastic deformation
  - Stress & deformation increase heat/adhesion

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  - Low energy transfer away from lump
  - Clear change in contact and plastic behavior

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  - Share electron cloud
  - Parts are bonded together

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Factors that affect galling

• Heat promotes galling
  • During movement – increases adhesion
  • In-service – creep penetration

• Ductility promotes galling
  • Brittle material – energy used to create new surface (break bonds)
  • Ductile material – energy also goes into deformation (heat)

• Oxide layer
  • Inhibits galling – brittle fracture, get in the way of metallic bonds
  • Promotes galling – volume change, initiation sites

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Factors that affect galling - Stainless

• High ductility
  • Plastically deforms
  • Generates heat readily

• Low thermal conductivity
  • Heat is trapped
  • Localized storage increases

• Thin passive oxide layer
  • Scraped off or penetrated easily, high self adhesion
  • Low energy requirement

Galling is...common
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Galling solution

• Possible solution paths
  • Change geometry to lower stress
  • Change surface finish to limit asperities
  • Change friction/lubrication to reduce contact
  • Reduce ductility to reduce energy storage
  • Create thermodynamically ideal oxide layers
  • Employ dissimilar metals to lower adhesion

• Our solution...

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• Our solution...

  DON’T TURN THE NUT UNDER LOAD!

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Galling solution

- Installation
  - Slip it over stud
  - Similar to flat washer

- In-service
  - Part of bolted joint
  - Metal in compression

- Breakout
  - Turn Pop-Washer™ till it pops (40 degrees)
  - Take nut off under zero load

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US Patent No. 8,579,572
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US Patent No. 8,579,572
Galling solution

- Pop-Washer™
  - Purely mechanical
  - Only two parts
  - No special tools

- Complimentary steps
  - Stack height dependent on orientation
  - Alleviates bolt stretch
  - Allows rotation in only one direction

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US Patent No. 8,579,572
Field trial - DCU

• Location
  • Tesoro Golden Eagle Refinery
  • Martinez, CA

• Delayed coker unit
  • Four drums
  • 53,000 bpd capacity

• Trial details
  • Began in 2013
  • Breakout every 3 months

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Field trial - DCU

- Overhead line manways
  - 30” 300# flanges
  - (32) 2” bolts on each
  - 150°F - 900°F, 18 hour cycle
  - History of galling issues

- Bolting details
  - B16 studs
  - 111 kip bolt load
  - 40 ksi bolt stress
  - 3490 ft-lbs applied torque

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Scope & Results

• 500+ successful activations
• 1,000,000+ hours combined usage
## Field trial - DCU

### Scope & Results
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- 1,000,000+ hours combined usage

### Before Pop-Washer
- 25% to 75% seizing rate
- Cutting torch used
- Hot work permit required
- Replace hardware every time
- 12+ hours for breakout

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Field trial - DCU

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Before Pop-Washer

- 25% to 75% seizing rate
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With Pop-Washer

- No seizing
- No torches
- All nuts spun off by hand
- Hardware in good condition
- 88 minutes for breakout
“In this case, the critical flange typically took four men around 22 hours to de-torque and disassemble with 50% replacement of hardware.

With addition of Pop-Washers, the job was cut to less than eight hours with only two men and 0% replacement cost.”

-Kalani Cobb, Tesoro Maintenance Supervisor
“Pop-Washers are a truly unique design in solving stud galling issues in critical bolted joints. Typical reduction of manpower has been proven to be upwards of 75%.

Reduction in cost of material, labor, equipment repair from traditional stud removal is greater than 85%!”

-Kalani Cobb, Tesoro Maintenance Supervisor
Field trial – DCU annual cost

• Direct costs (2012)
  • 1408 man-hours
  • $56,300 in labor
  • $19,200 in standby time/equip
  • $51,000 in hardware
  • $126,500 total direct costs

• Direct costs (2014)
  • 260 man-hours
  • $10,400 in labor
  • $2,800 in standby time/equip
  • $0 in hardware
  • $13,200 total direct costs

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Take home points

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  • 1400+ man-hours
  • $126,500 in direct costs

• The bigger concerns
  • Scheduling/planning
  • Damage
  • Safety

GALLING IS PREVENTABLE

• There are options to eliminate the problem

• Incurring these costs, delays, risks, & safety issues is a CHOICE!
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