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

Presented by:

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BLACKHAWK ENGINEERED PRODUCTS

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

Galling is…common

…expensive

…& PREVENTABLE!

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!

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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

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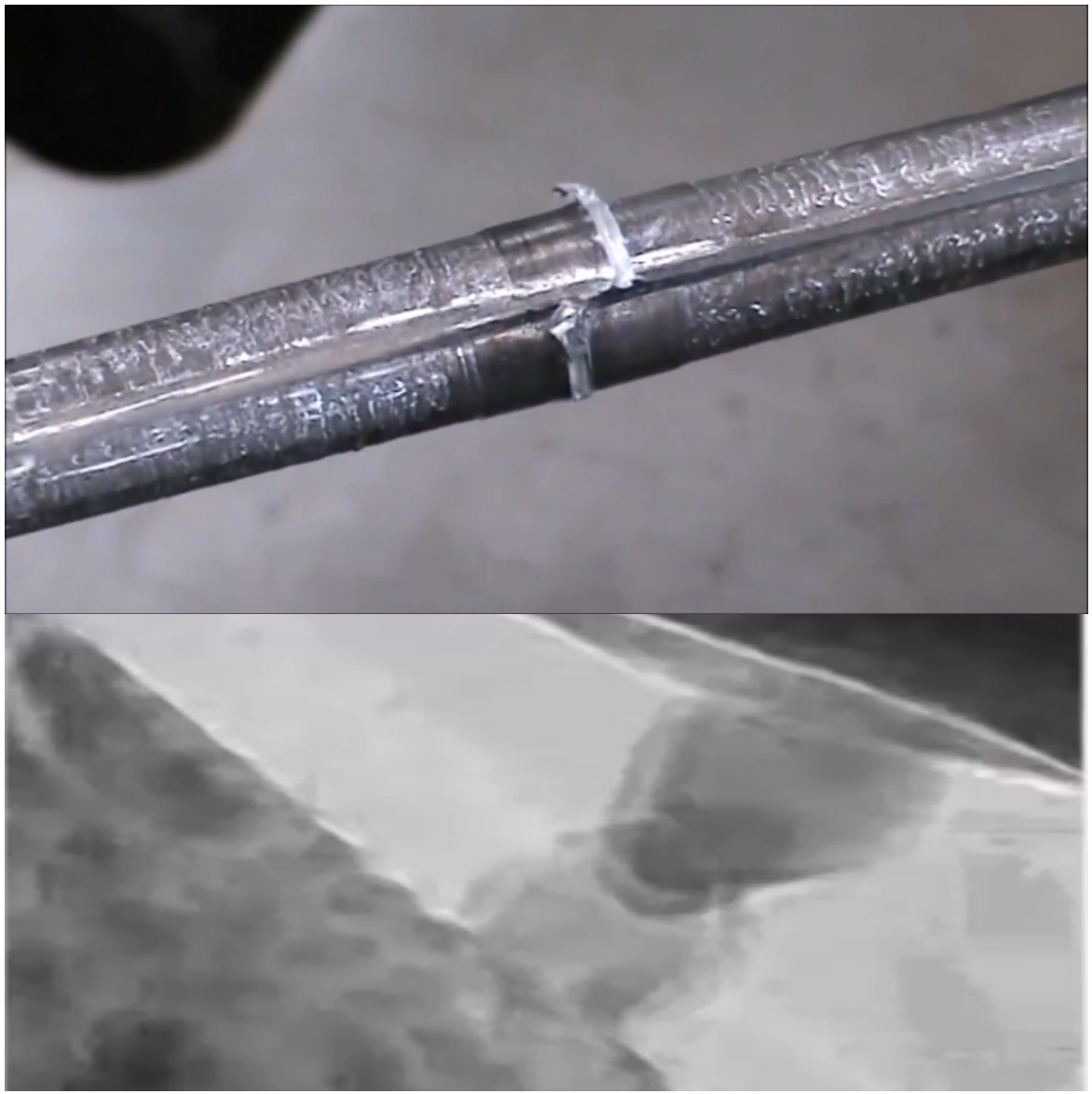
Misconceptions about galling

- 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



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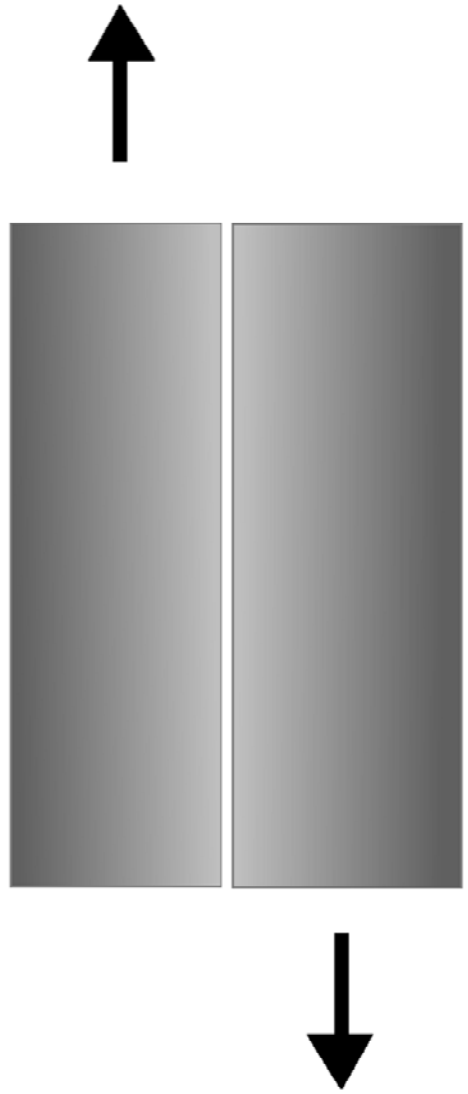
How does galling occur?

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



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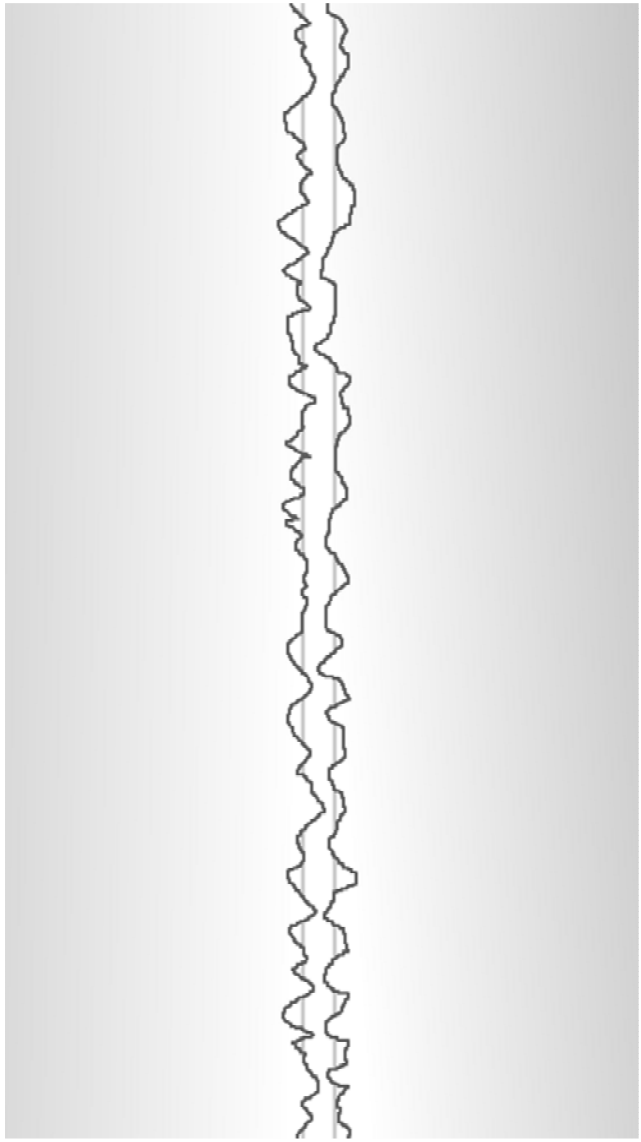

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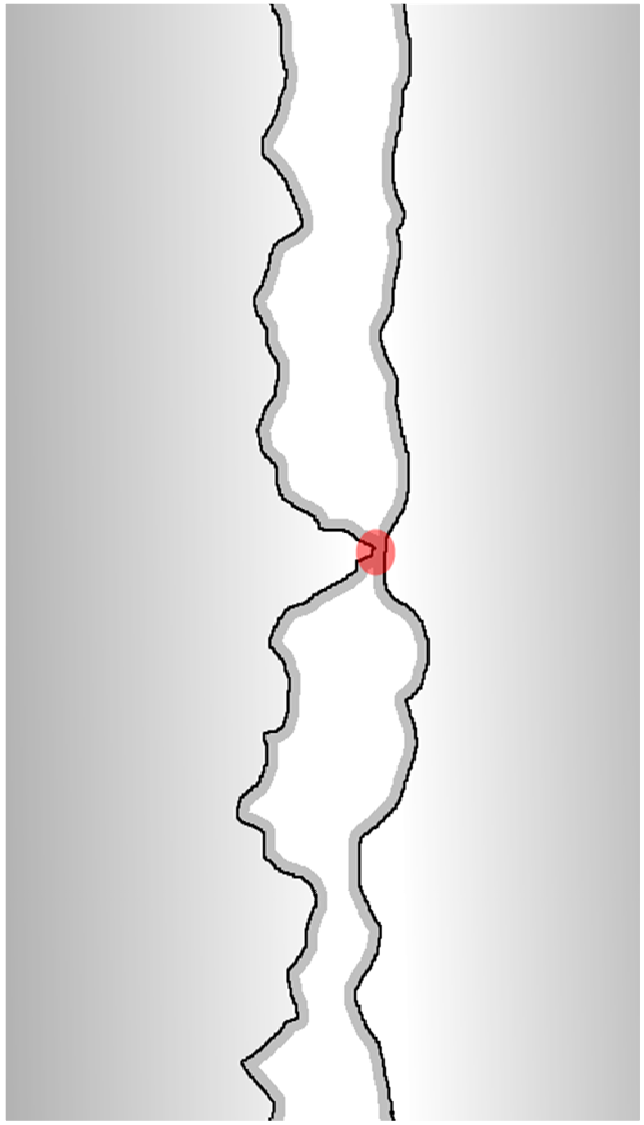

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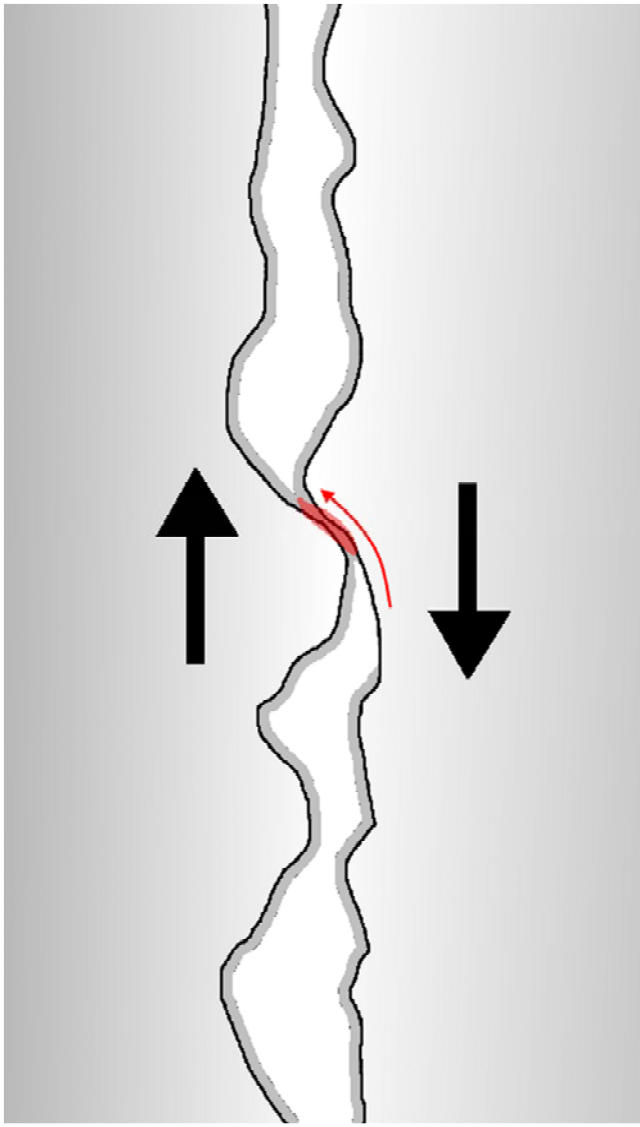
  - Damages bulk material



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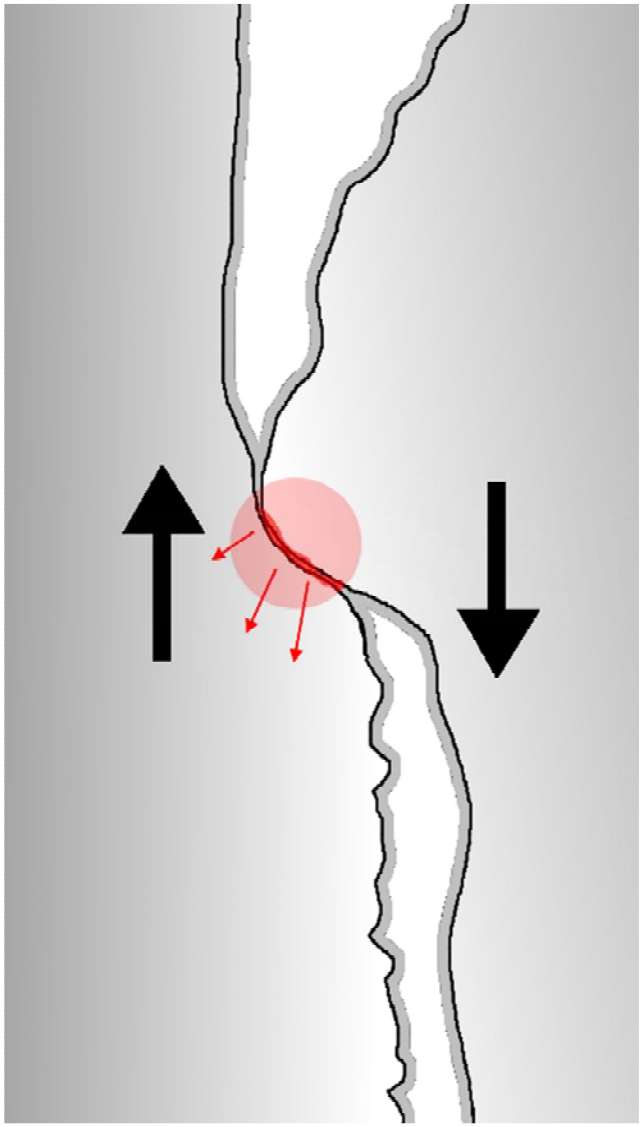

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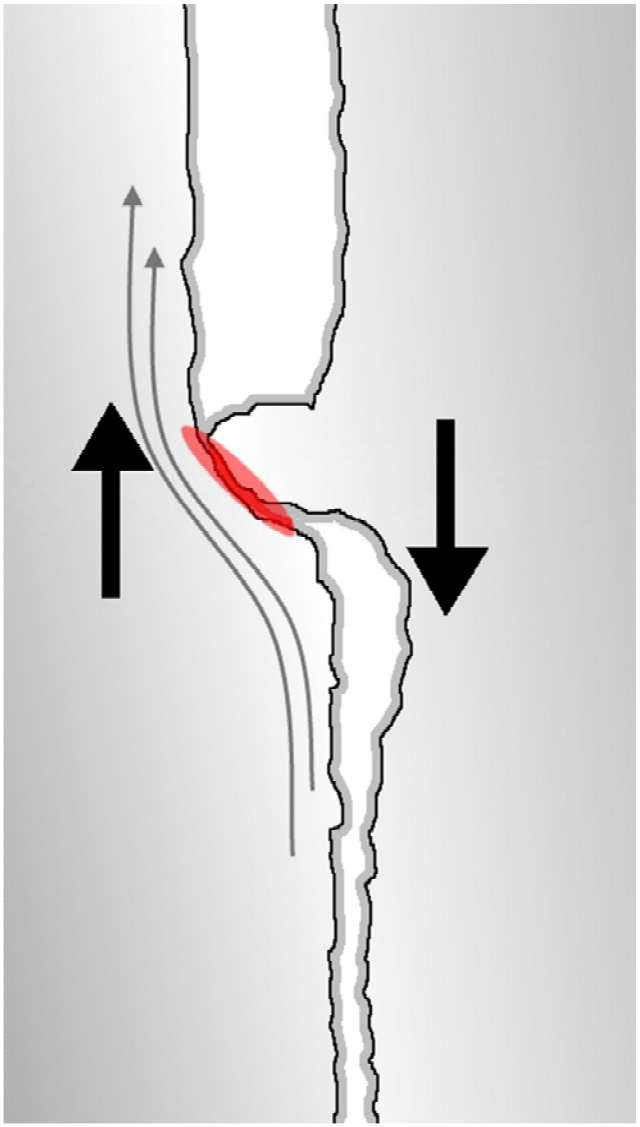
  - Low energy transfer away from lump
  - Clear change in contact and plastic behavior



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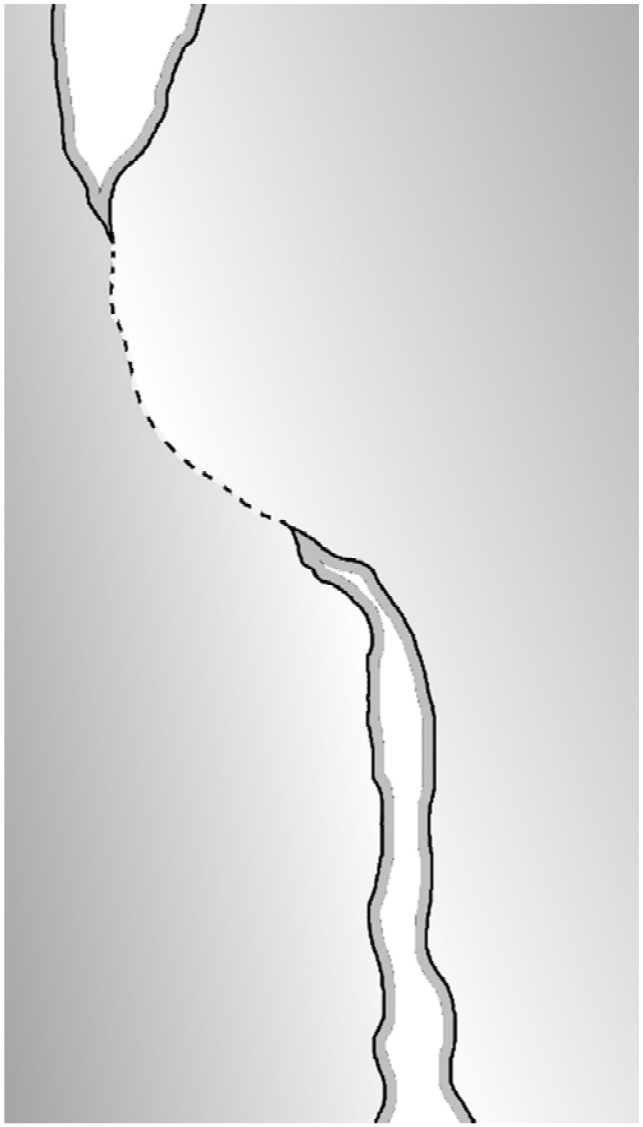
- Fusion
  - Share electron cloud
  - Parts are bonded together



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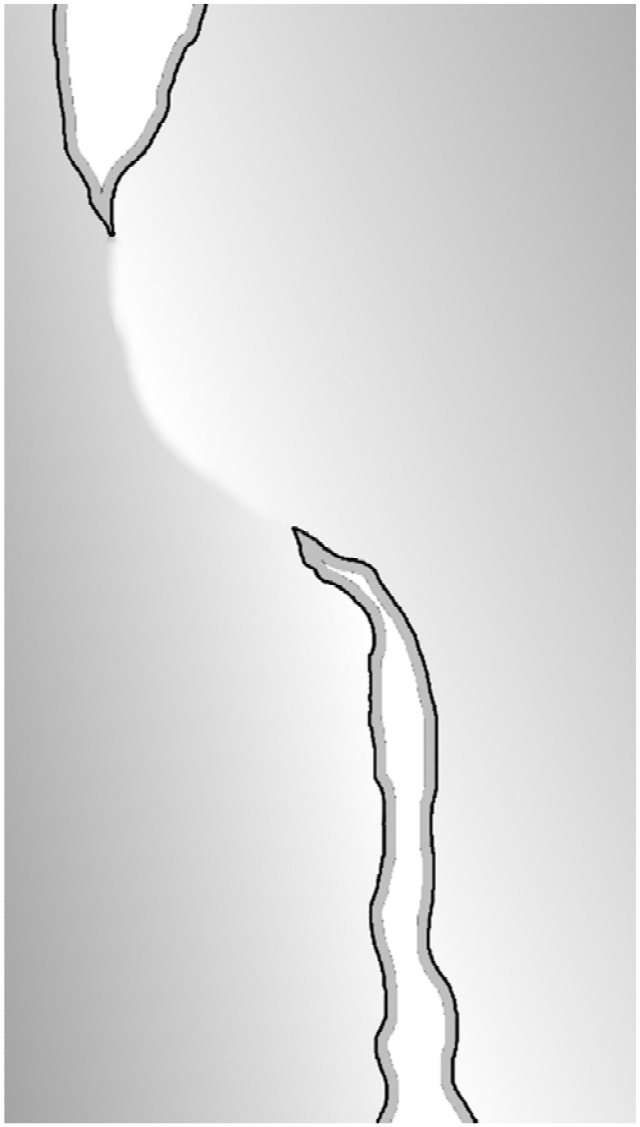

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Factors that affect galling

- 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

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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

US Patent No. 8,579,572

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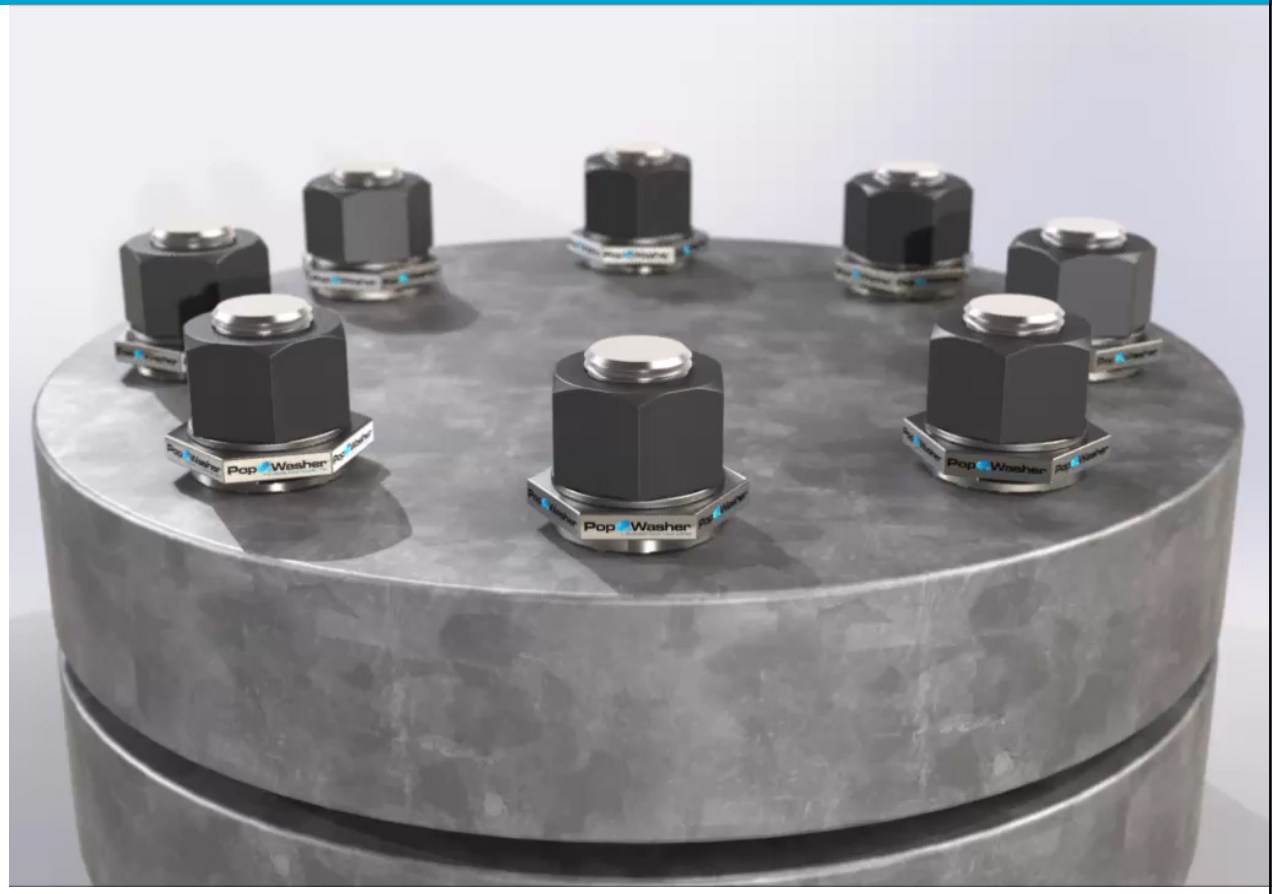

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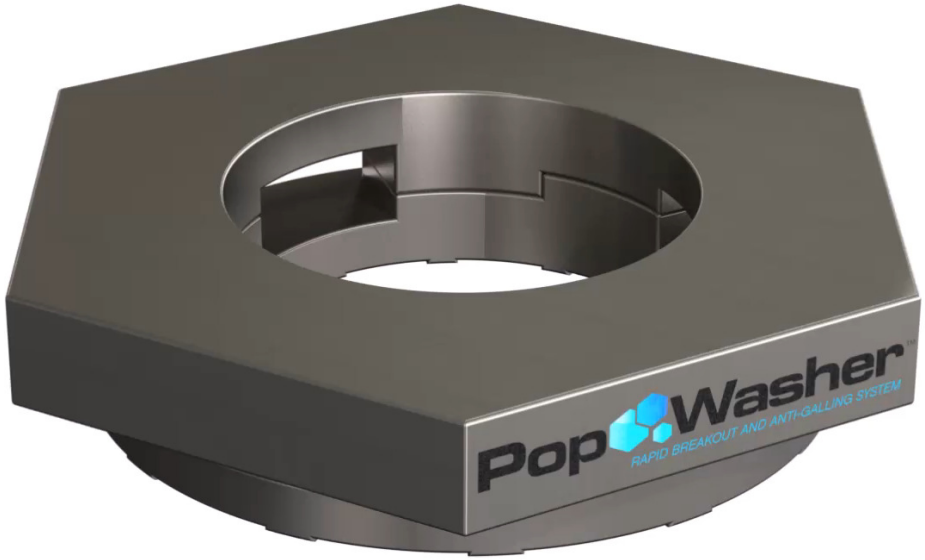
Galling solution

- 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

US Patent No. 8,579,572

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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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Field trial - DCU

Scope & Results

- 500+ successful activations
- 1,000,000+ hours combined usage

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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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Before Pop-Washer

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- Cutting torch used
- Hot work permit required
- Replace hardware every time
- 12+ hours for breakout

With Pop-Washer

- No seizing
- No torches
- All nuts spun off by hand
- Hardware in good condition
- 88 minutes for breakout

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Field trial – DCU

"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

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Field trial – DCU

"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

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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

GALLING IS EXPENSIVE

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Take home points

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- "It's just nuts and bolts"
  - 1400+ man-hours
  - $126,500 in direct costs
- The bigger concerns
  - Scheduling/planning
  - Damage
  - Safety

GALLING IS PREVENTABLE

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GALLING IS PREVENTABLE

- There are options to eliminate the problem
- Incurring these costs, delays, risks, & safety issues is a CHOICE!

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