

Dump Truck Debacle

Green Team

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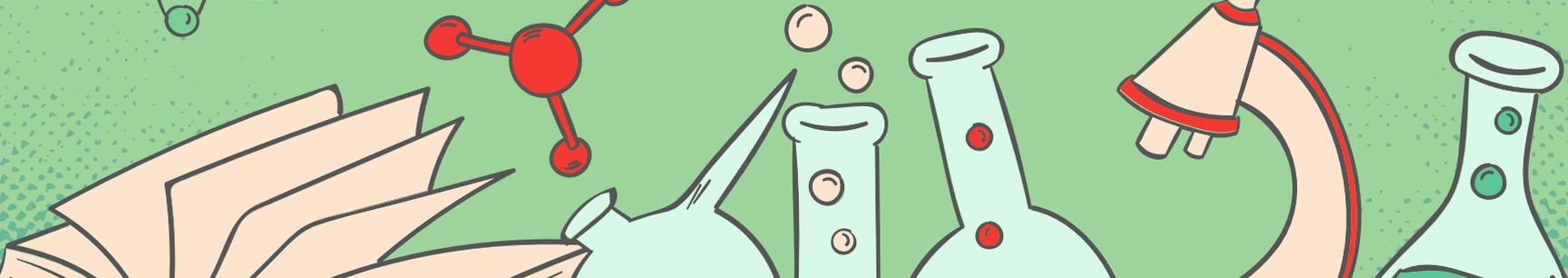
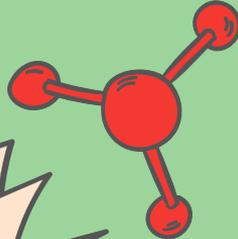
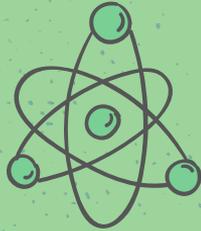
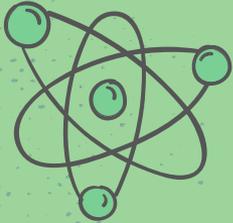
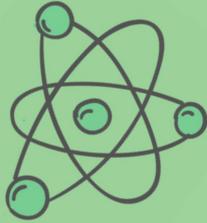
Jillian Frederick - Ohio

Calli Dehnel - Pennsylvania

With mentors:

Eric Cole - Carpenter Technology

Harjot Singh - University of Virginia



what happened?

- Tire fell off of garbage truck while driving
- All the studs holding the tire broke
- The tire with the other half of the studs was stolen
- We were given 3 broken studs, 3 slices of the fracture points, an exemplar stud, and some samples of different grades of steel

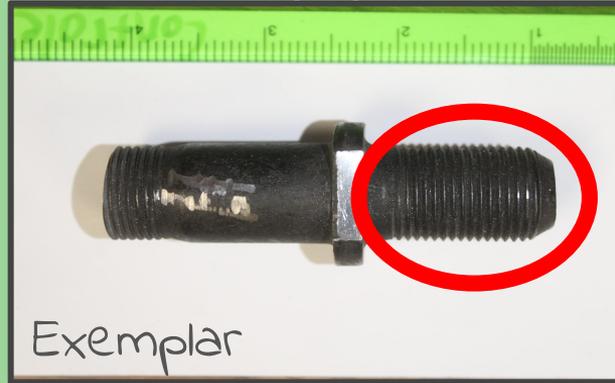
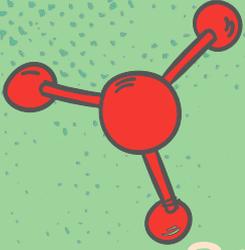


Image retrieved from:
<https://www.enthuze.ca/blog/post/lug-nuts-questions-answers-2>

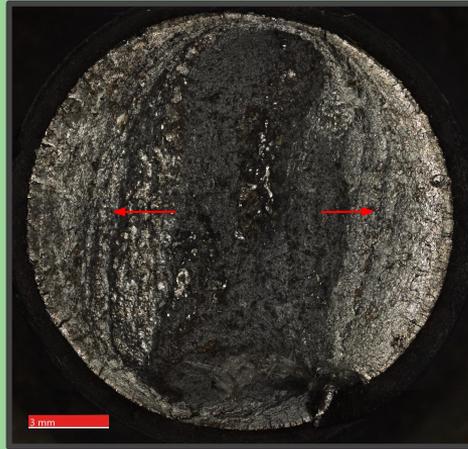
Macro-Photography and Initial observations



Sample 1

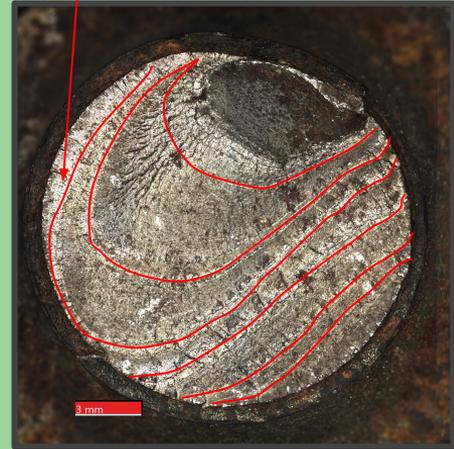


Sample 2



Beach Marks

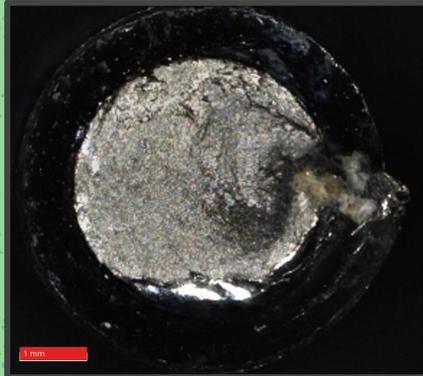
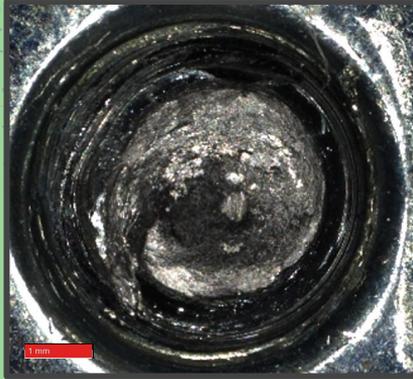
Sample 3



On sample 3 the beach marks start at the original point of the break, however the lines in sample 2 are not beach marks and point away from the final break point

Narrowing it down

Over-Torqued



Bent

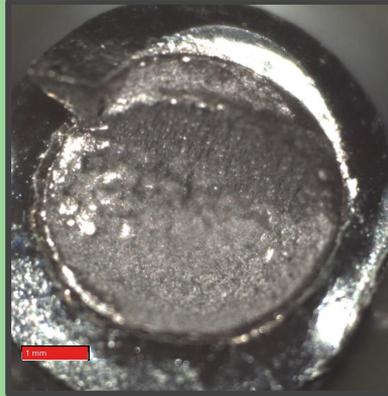
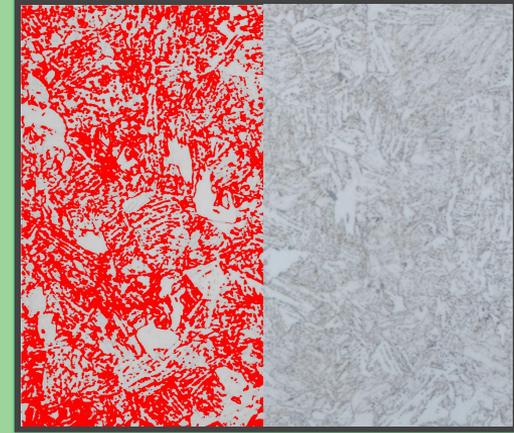
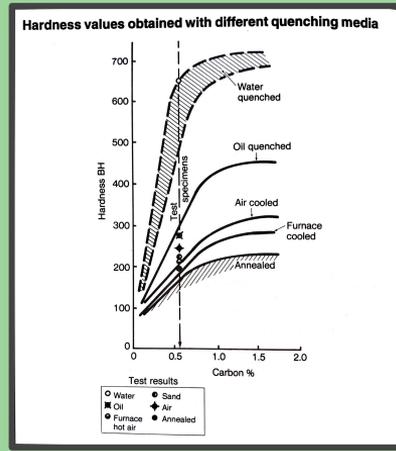
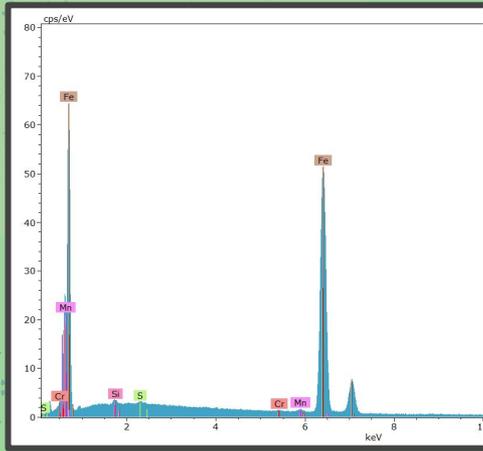


Table 1: Hardness Testing Averages

Sample:	Average Hardness
Exemplar	38.67 (HRC)
1	98.00 (HRB)
2	98.20 (HRB)
3	98.18 (HRB)
Exemplar After Quenching	58.00 (HRC)
1 After Quenching	45.87 (HRC)

EDS and Carbon Content

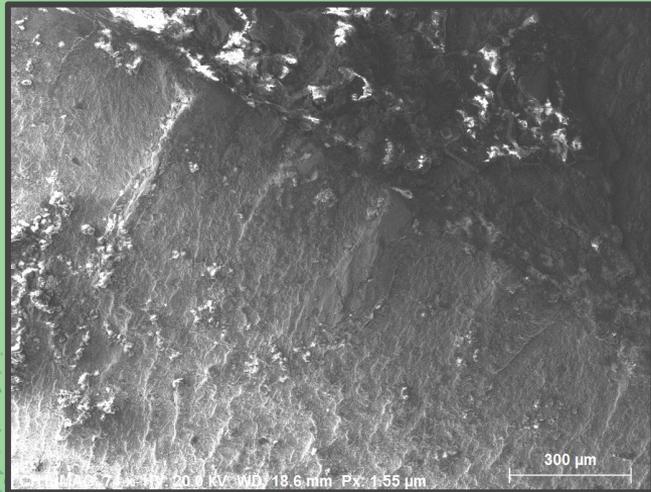


- Performed EDS and discovered
 - Primarily Fe, C, Mn
 - Trace amounts of S, Si, Cr impurities
- Quenched and tested the hardness of Sample 1 (430.9 BH) and Exemplar (615.0 BH)
- Found carbon content utilizing the chart above*
 - Exemplar ~ 0.6%
 - Sample ~ 0.4%
- Determined volume phase fraction using point counting
- Utilizing the lever rule, carbon content was confirmed at 0.4%

*Heat Treater's guide. (1995). ASM.

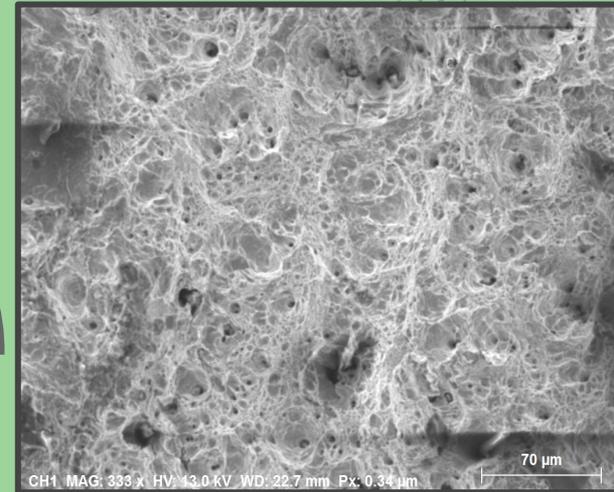
SEM & Multipoint Initialization

Ratchet marks, which form when tiny fractures grow and join together

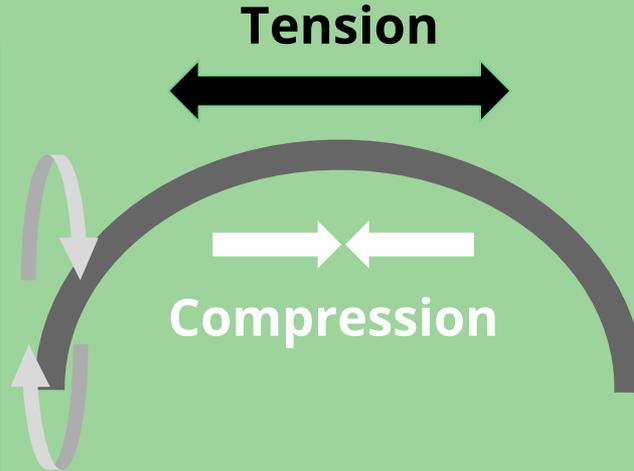


Edge of the fracture surface of sample 3

Microvoids caused by plastic deformation which points to a ductile fracture

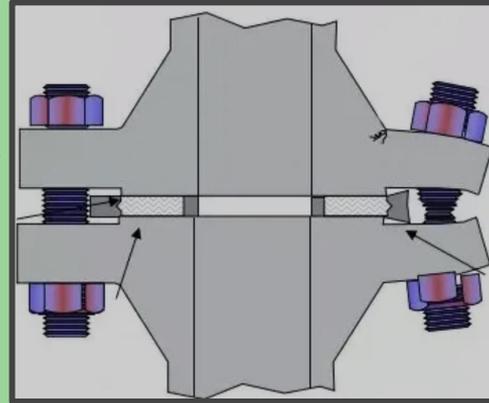


Center of sample 2

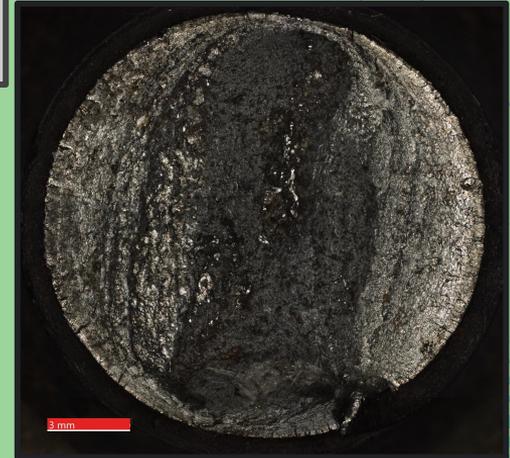


Final Conclusions

- The fracture started with the bolts not getting heat treated properly making them more soft and ductile. 1040 steel instead of 1060 steel
- The bolts were under-torqued.
- Repeated stress on the bolts lead to fatigue
- Improper manufacturing and user error on the torque led to this failure



Under-torque Over-torque





Thank You!