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Inspection of Selected Gear Reducers

ABC Steel – Anytown, IN Hot Mill



Work performed April 12, 2017
ABC Steel Purchase Order # **xxxxxxx**
Cage Gear Project # **1704011**

Cage Gear Representatives: David Churbock and Michael Mast
Arrived on-site approx 7:45 AM; Left site approx 5:15 PM

ABC Steel contacts: Ron Abcdef, Troy Abcdef, John Abcdef

F1 Pinion Stand

This was the first unit inspected. (The Motor Room is to the left.)



The first thing noted was the seemingly large amount of leakage and pools of oil around the unit. Upon further inspection, for the most part the bores and splits of the housing look okay. The suspicion is that the oil is seeping, when the unit is in operation, from the access doors on either side of the unit. An enhanced sealing system would likely reduce the amount of leakage from this unit.



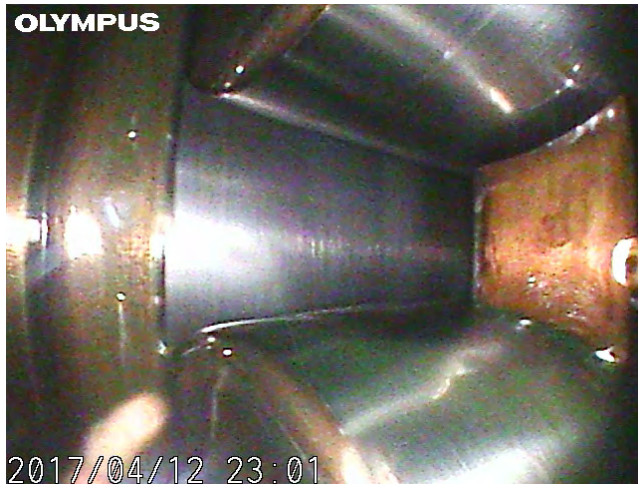
Oil pooling around the base of the unit

The Gear Mesh between the Bottom Shaft and the Upper Shaft looked good, with contact spaced evenly across the entire profile of the drive flanks, except where the teeth were end-relieved by design. All four of the helixes looked good on these double helical Pinion Shafts with no signs of pitting, spalling, plastic-flow or any other discontinuities. These gears exhibited normal, expected wear for the age and use of this unit.



Representative view of the Bottom Teeth of the F1 Pinion Stand

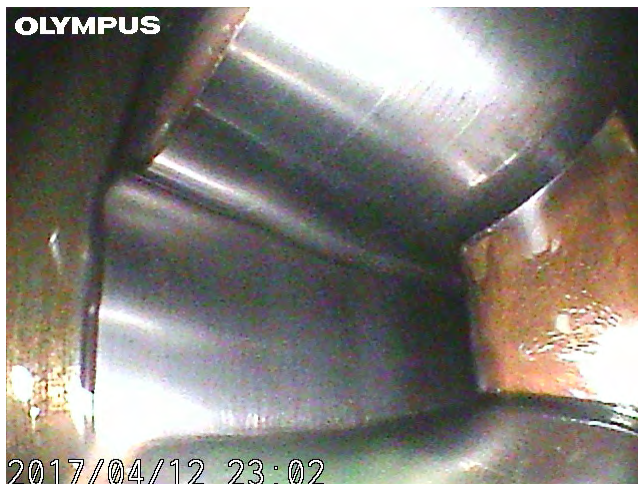
Additionally, the Bearings for this unit also looked pristine on both the Motor Side and the Mill Side of this Reducer.



F1 Bottom Motor Side Bearing



F1 Bottom Mill Side



F1 Top Motor Side Bearing



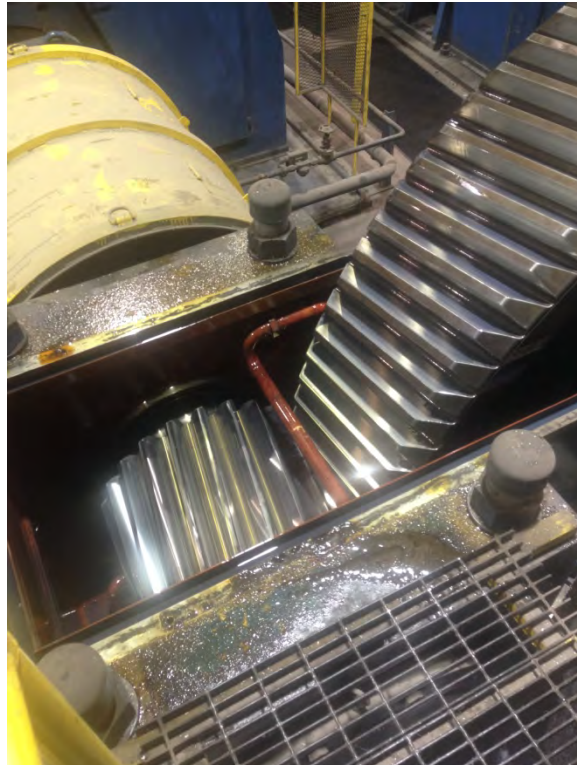
F1 Top Mill Side

F1 Summary

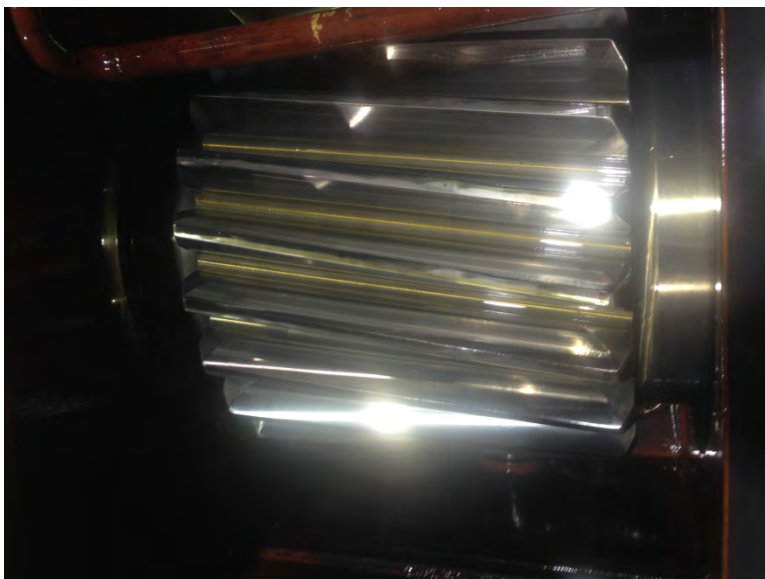
While the leakage may be an annoyance, the Gears and the Bearings in this unit are in good condition exhibiting only normal, expected wear. There are no observable reasons to believe that there is not a substantial amount of useful life remaining with this unit.

#1 Main Drive

This is an SMS Single Reduction Gear Reducer in the Motor Room driving F1 Pinion Stand. This is the next unit we inspected.



The Gear Mesh looked good with well proportioned contact between the elements.



MD1 Pinion Teeth.

It was noticed on the Gear that, sometime in the past, something must have gone through the mesh as there is a blemish on every tooth that we could observe near the mill-side edge of the drive flank. These blemishes have been nicely hand-dressed and appear to pose no detriment to the operation of this gear set.



Notice the hand-dressed blemishes in the dedendum of the drive flank closest to us.



Close-up of the Gear Tooth blemishes on Main Drive 1

While the teeth looked good on Main Drive 1, there was an issue with the Mill Side Pinion Bearing. (The Motor Side Pinion Bearing looked good, as did both Bearings on the Gear.)

With the Bore Scope, we were able to observe some early and minor deterioration of the Race and the rollers. From the photographs, wear and rust are clearly visible.

Photos of Main Drive 1 Pinion Mill Side Bearing showing wear and rust.



Another photo of MD1 Mill Side Pinion Bearing showing rust.



The other Bearings in the unit looked good as shown in the following representative photograph.



MD1 Motor Side Pinion Bearing



MD 1 Gear Bearing – Mill Side

Note: We were able to observe, but not obtain good photographs of the Motor Side Gear Bearing.

Main Drive # 1 Summary

The gear teeth of both elements both look as if they possess a significant amount of remaining useful life. While we do not believe that catastrophic failure is imminent, the Pinion Shaft Mill Side Bearing should be addressed sooner rather than later. It is best to take action on "Planned Outages" rather than on "Unplanned Outages".

F2 Pinion Stand



This unit displayed leakage similarly to the F1 Pinion Stand, just not as bad. The teeth on this unit also showed good contact and normal, expected wear. For some reason, there was a degree of discoloration associated with the teeth of both elements. Generally that indicates a “heat” issue but there were no other signs indicating issues. We detected no pitting, spalling or even plastic-flow on either the top or bottom Pinion Shaft.



F2 Bottom Teeth – Dis-Coloration ?



F2 Top Teeth – Dis-Coloration ?

F2 Bottom Motor Bearings showing rust



F2 Top Motor Side Bearings showing wear



Both F2 Mill Side Bearings, top and bottom, looked okay.



F2 Top Mill Side Bearing



F2 Bottom Mill Side Bearing

F2 Pinion Stand Summary

The Pinion Shaft Teeth on both the Top and Bottom elements looked good, albeit showing some discoloration. The Motor Side Bearings on both the Top and Bottom Pinion Shafts are both showing signs of early stage deterioration. The Mill Side Bearings on both items look good. At this time, we cannot determine if this is new information or if this condition has existed for some longer period of time. We will look at the bearings again in six months to determine if the bearing wear is increasing or not.

#2 Main Drive

This also is a Single Reduction Gear Reducer in the Motor Room driving F2 Pinion Stand.



Both the RH Helical Pinion Shaft and the LH Helical Gear Teeth of this unit look good with no signs of deterioration.

With regard to the **Main Drive # 2** Bearings, both of the Gear Bearings look good with no noticeable issues. The Pinion Shaft Motor Side Bearing also looks good with no issues. However, the **Pinion Shaft Mill Side Bearing** shows signs of early deterioration as the photographs below show.



Here are representative photographs of the other #2 Main Drive Reducer Bearings.



MD 2 Pinion Motor Side Bearing



MD 2 Gear Motor Side Bearing

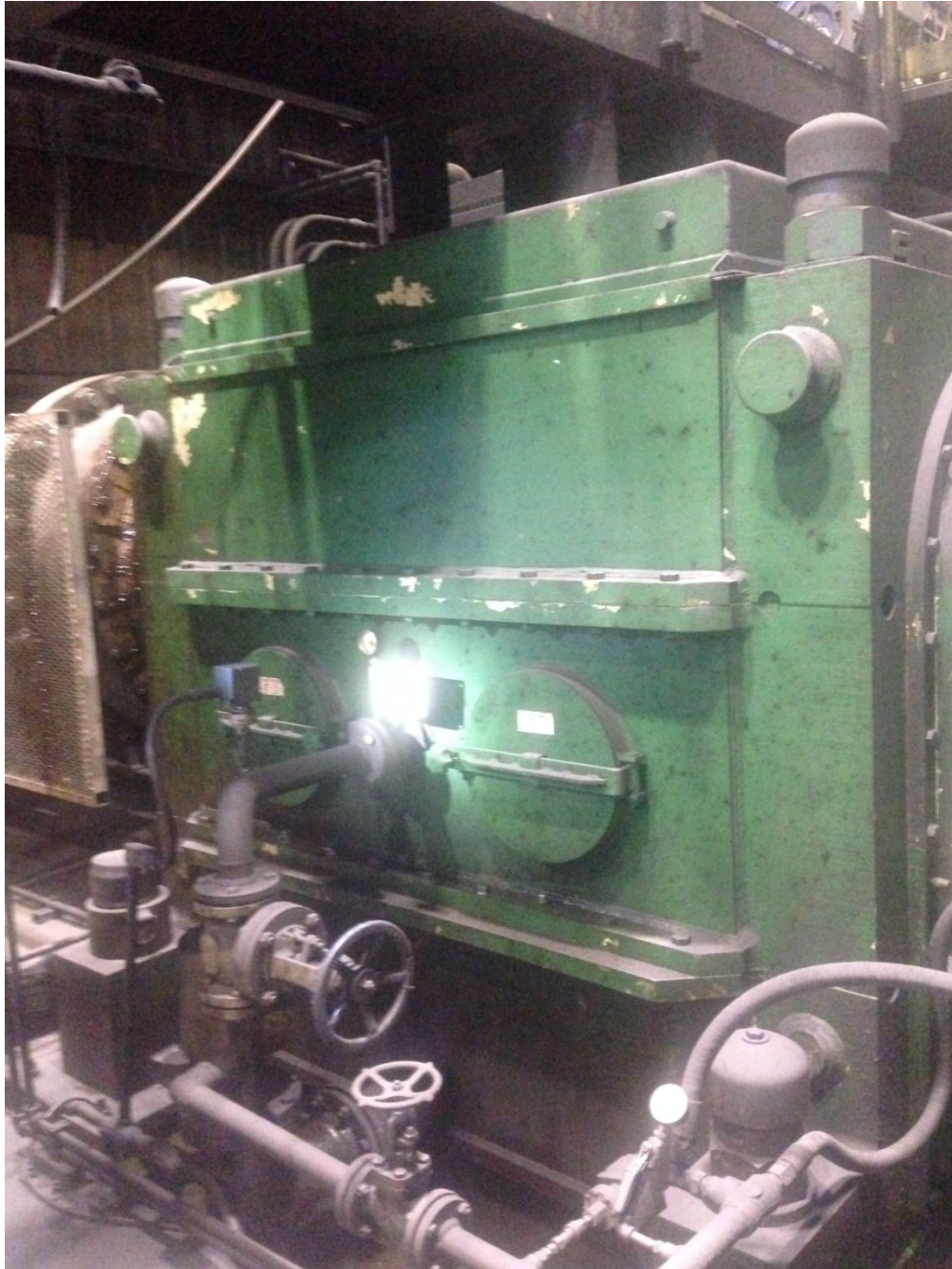


MD 2 Gear Mill Side Bearing

Main Drive # 2 Summary

As with the #1 Main Drive, the gear teeth of both of these elements both look as if they possess a significant amount of remaining useful life. While we do not believe that catastrophic failure is imminent, this Pinion Shaft Mill Side Bearing should also be addressed sooner rather than later. Again, we will look at this next time as well.

F3 Pinion Stand



The Teeth and the Bearings in this unit all look as they should with good, full contact between the elements. No issues were observed during our inspection.



F3 Pinion Stand – Gear Meshes from both hands of the Pinion Shafts



F3 Pinion Stand Bottom (on left) and Top (on right) Motor Side Bearings.



F3 Pinion Stand Bottom (on left) and Top (on right) Mill Side Bearings.

F3 Pinion Stand Summary

No discernible issues were found regarding the Gearing nor the Bearings. The unit appears to be in good, usable condition.

#3 Main Drive

This also is a Single Reduction Gear Reducer in the Motor Room driving F3 Pinion Stand.



The gear mesh between the RH Helical Pinion Shaft and the LH Helical Gear Teeth of this unit looks good with no signs of any issues or deterioration.

The Bearings for this MD #3 Unit also look good as depicted in the following photos.

(Note that there is a gouge in the Race of the Gear's Mill Side Bearing but it does not appear to be impacting the Rollers or performance of the item.)



Main Drive #3 Pinion Bearings; Motor Side (on Left) and Mill Side (on Right)



Main Drive #3 Gear Motor Side Bearing



Main Drive #3 Gear Mill Side Bearing

Note the gouge in the Race that does not appear to be impacting the operation or performance of this Bearing.

Main Drive # 3 Summary

As with the #1 and #2 Main Drives, the gear teeth of both of these elements both look as if they possess a significant amount of remaining useful life. We do not see any issues with the Bearings either, aside from the unexplained gouge in the Race of the Gear's Mill Side Bearing. This unit appears to possess a significant amount of useful remaining life.

F4 Pinion Stand



The Pinion Shafts in this unit, as well as in the F5 and F6 Pinion Stands, are Single Helical Pinion Shafts as opposed to Double Helical design as seen in the first three units.

In the following photograph of the **F4 Mesh**, there is clear, drive flank deterioration across approximately 15% of the addendum (top) of the Bottom Pinion Shaft Teeth. This could be insufficient end-relief cut into the new parts. As expected, there is also a noticeable amount of Plastic-flow associated with this deterioration. This was pointed out to Troy and Ron. At some future off-day, Troy will have the top land of this Pinion deburred to remove the edge that is developing across the top land.

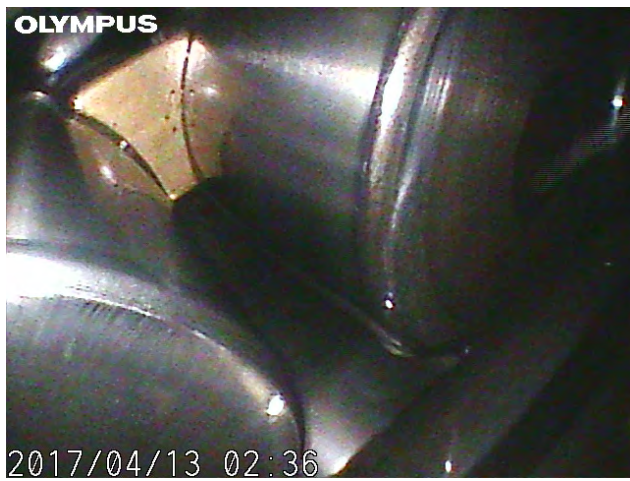


Here is another photograph which also shows the top of the Bottom Pinion deteriorating. We did not observe any corresponding deterioration in the dedendum (below the pitch-line) of the Top Pinion, which is the mating part.





The above photos show **F4 Bottom** (on left) and **Top** (on right) **Motor Side Bearings**.



F4 Bottom Shaft Mill Side Bearing



F4 Top Shaft Mill Side Bearing

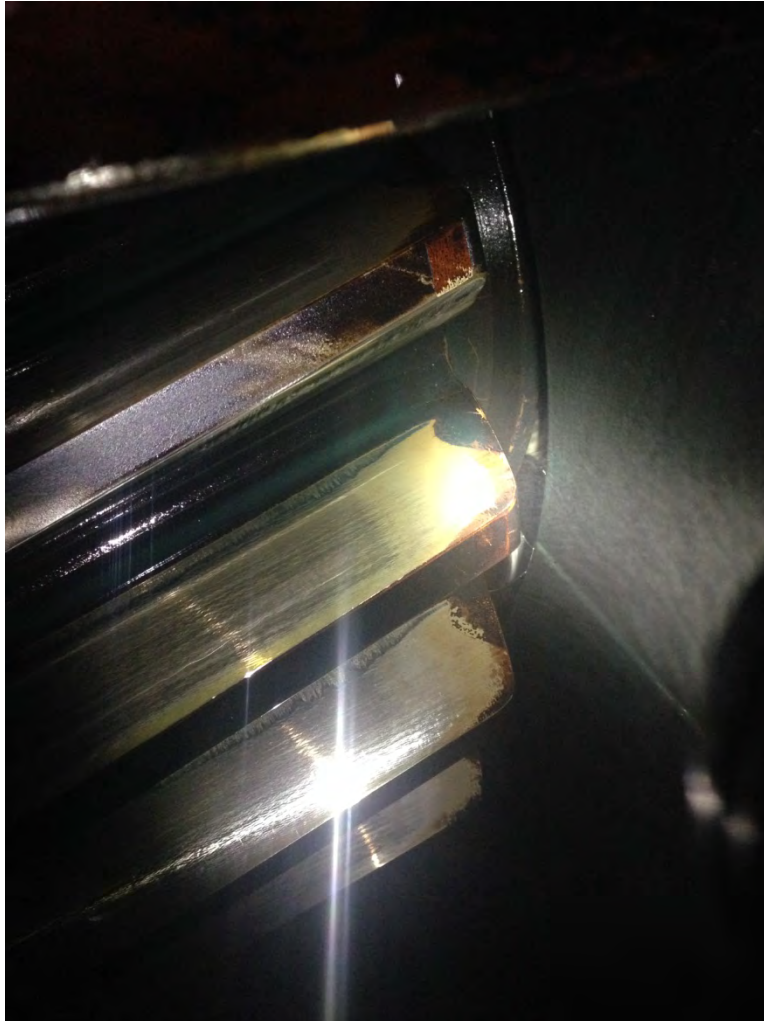
F4 Pinion Stand Summary

The Teeth on the Bottom Pinion Shaft show noticeable wear. This will be easy to monitor during the next inspection to determine whether or not the deterioration is progressing. We would expect to see the beginning of wear showing up in the corresponding root area of the mating piece. The Bearings of the unit look good with no observable issues.

F5 Pinion Stand

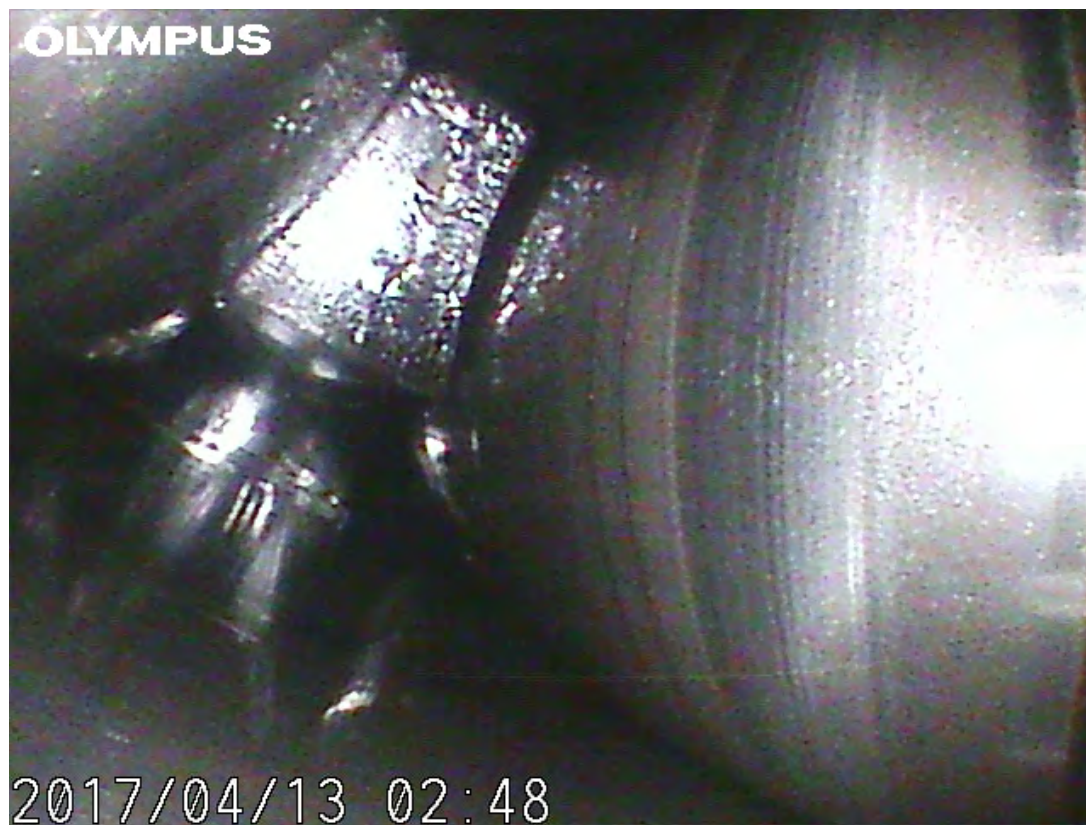


F5 Pinion Stand Gearing: The only remarkable thing to note regarding the teeth, is that there was a mis-machining of the Top Shaft, Mill Side, Drive Flank that resulted in a gouge in each tooth. Obviously, this did not affect the performance of the unit as it continues to run today with that error not with-standing. The Bearings are another story.



There is obvious wear in the tip and root areas of the teeth but nothing that is out of the ordinary or unexpected. No pitting or spalling or severe plastic-flow was detected. It appears as if the tips of these teeth have been re-deburred at some point (or points) in the past.

F5 Pinion Stand Bearings: All four of the Bearings are Rough. This page shows the Motor Side Bearings; first the Bottom Shaft and second the Top Shaft.



This page shows the F5 Mill Side Bearings; first the Bottom Shaft then, second, the Top Shaft.



F5 Pinion Stand Summary

The Gear Teeth on both the Top and Bottom Shafts, while showing wear, are certainly in satisfactory shape to continue running into the foreseeable future.

All **F5 Pinion Stand Bearings** display significant wear with quite visible grooves worn into the rollers. These need to be on the list for change-out during an upcoming outage.

F6 Pinion Stand

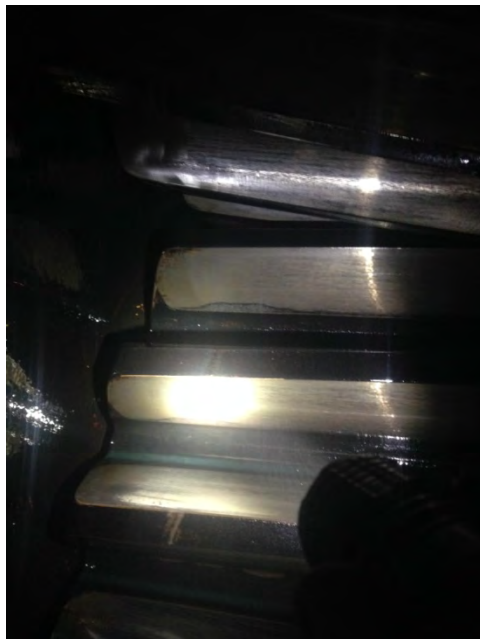


The Teeth on both the Top Pinion and the Bottom Pinion display areas of wear and deterioration. The Bearings all appear to be in satisfactory condition. The following photographs document conditions found.



These photographs show the wear on the **F6 Top Pinion Shaft** approximately 10-15% across the top of the drive flank, from the top land to about half way to the pitch-line, on the Mill Side of the unit.

This photograph shows corresponding wear in the root area of the **F6 Bottom Pinion Shaft**.



F6 Pinion Stand Bearings: There were no significant problems detected.



F6 Pinion Stand Motor Side Bearings; Bottom Shaft (on left) and **Top Shaft** (on right).

F6 Pinion Stand Mill Side Bearings; Bottom Shaft (on left) and **Top Shaft** (on right).



F6 Pinion Stand Summary

This unit's Gear Teeth display some obvious wear which can be monitored and addressed as required. The Bearings appear to be in satisfactory condition. The unit is not in danger of catastrophic failure any time in the near future.

One last note regarding this inspection... Although we were able to access both sides of the Pinion Stands, we were not able to see all of the gear teeth or all parts of all the bearings. The information provided corresponds to what we were able to see and we believe that the photographs are representative of the overall conditions of the Reducers. We need to note that there may be areas that we did not view that contained problems that we could not identify.

Down Coiler #1

Top Gear



We were able to see very little of the Coiler parts. The units were filled with oil which prohibited us from any Bore Scope photos of any items below the oil levels. Basically, we could only see an approximately 30 degree arc of the top gear teeth; a similar section of the top of the Change Gear Teeth and the Top Shaft inside Bearing.

Coiler #1 Change Gearing



From the limited vision field we could see, we detected no issues with the Gearing or Bearings that we could view of this unit.

Coiler #1 Top Shaft Bearing

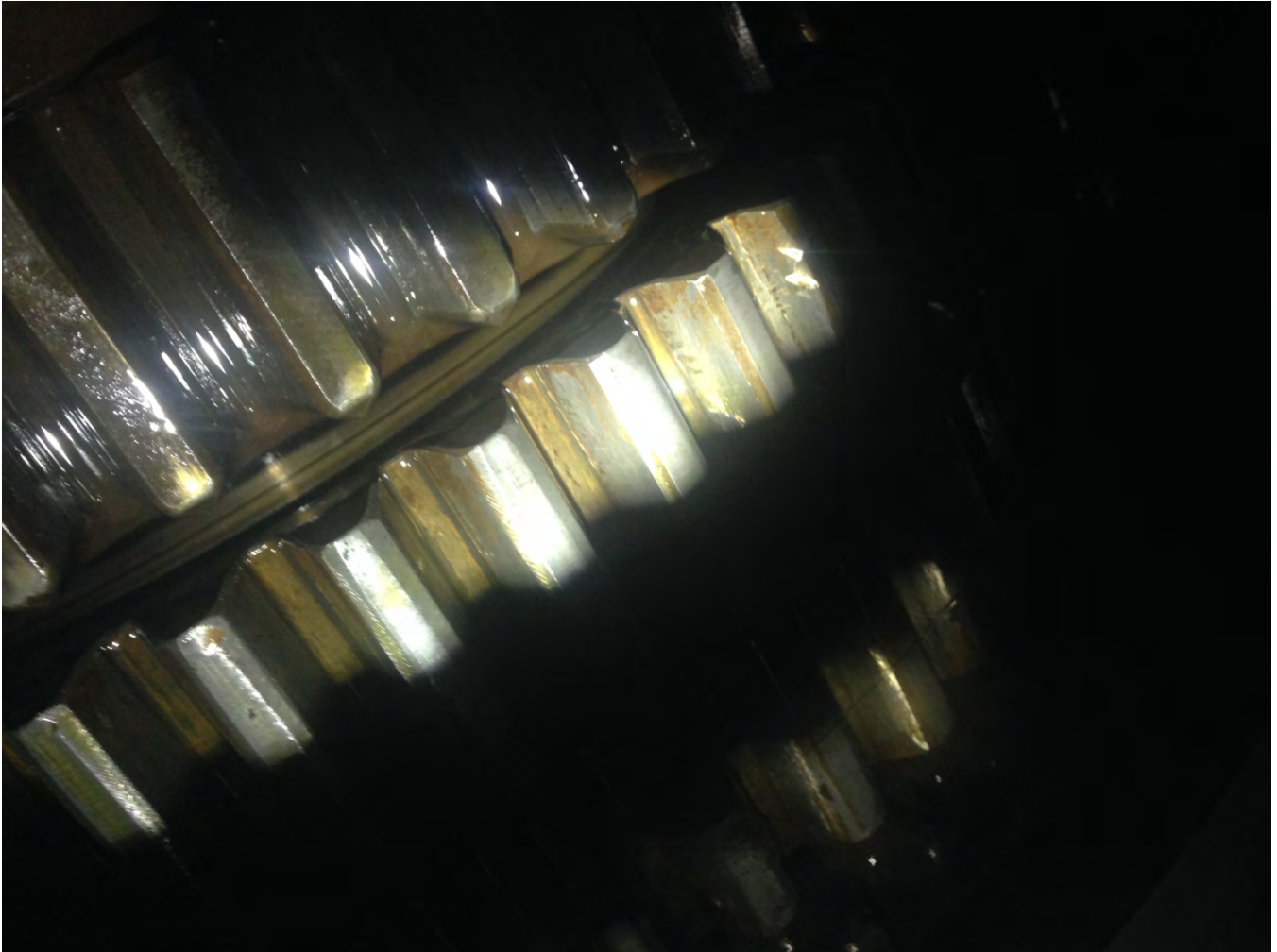


These photographs are representative of the view that we had of the Top Shaft Bearing on Down Coiler #1. There were no visible discrepancies that we noted during our visit to this unit.



Down Coiler #2

On this unit, although we still could not perform anything other than a cursory inspection, we did see issues with the Change Gearing Teeth and we saw what appeared to be scratches on the Top Shaft Bearing.



Although the photographs are not terrific, because the damage was not directly under the inspection cover on top of the unit, looking at the TOP LEFT, and at the farthest teeth to the RIGHT on the next two rows of teeth, it appears that something has gone through mesh within this unit as the top lands of those teeth are show non-uniform damage.



Down Coiler #2 Top Shaft Bearing. Note the Scratches. Something going through mesh ?

The Roller Surfaces look fine but the sides appear scratched.



If there are any questions or comments about anything in this report, please do not hesitate to contact me.

The **Cage Gear & Machine, LLC Staff** appreciates the business that **ABC Steel** has awarded us. We look forward to working with you on many of your future gear-related requirements. Always work safely.

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