Steel – Factors That Affect Reliability, of Sucker Rods From Mill To Well

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Goals of Presentation

Sucker rod manufacturing and reliability starts from steel mills, sucker rod manufacturer and end user.

The overall goal of this presentation is to eliminate QMS and application issues through awareness and education of steel reliability.
Traditional Ingot Casting

Ladle refining (Alloying elements are added at this stage)

Steel is poured into a series of molds of desired dimensions forming ingots

Rolling to semi finished form of billets, slabs and blooms

Conditioning and cooling to prime semi finished steel
Steel is poured at the top of an oscillating mold at a steady rate.

Castings are withdrawn at a controlled rate from the mold.

The cast billets are sprayed with water and solidify further to achieve desired mechanical properties.

Moving shear or torch cuts the castings.
Ingot and Continuous Casting Summary
Advantages of continuous Casting

- Continuous casting has better metal yield than conventional practice (94 to 98% vs 87%).

- Quality of cast steel is uniform and excellent.

- Product is free from macro segregation, grain sizes are easy to control and uniform.

- Steel cleanliness is equal or better than obtained in ingot-mold practice.
Induction Heating

- Rods are cold straightened and eddy current tested before upsetting process.
- Induction heating takes place when electrically conducting object is placed in a varying magnetic field.

**Typical advantages:**

a. Clean environment and consistent heating.

b. Allows to heat a portion of the part

c. The flexibility and cleanliness of induction melting cannot be duplicated by conventional methods.
Induction Heating

- Temperature control is very critical when heating rods to forging temperature.
- Over-heating / burning occurs when rods are exposed to excessive temperature.
- Segregation at austenite grain boundaries.
- Incipient grain boundary melting.
- Burning induces undesirable changes in physical properties of steel.
Upsetting

• Hot forming or forging is done at a temperature of 2100 to 2300 °F (Above recrystallization temperature). Induction heating techniques are used for uniform and consistent heating.

• Important parameters are die condition, die control and die life tracking.

• Forging induces residual stresses which affects the strength and toughness of sucker rods.

• Dimensional accuracy and in-process inspections are very critical to achieve overall reliability of steel rods.
Toughness: Amt of energy absorbed before failure - Area under the curve

Two important factors which go into the equation of toughness - Load & Elongation.
Heat Treatment

Atoms or molecules are in unstable state after forging

Soak the atoms in the austenizing range (Normalization)

Transformation to brittle martensite (cool down)

Transformation to tempered martensite (Tempering), represented by ferrite-pearlite
Shot Peening Vs Blast Cleaning

• Shot Peening: It is the process of bombarding steel shot on the surface of the rod.

• This induces compressive stress on the surface of the rod thereby negating any tensile loads which would be applied in the prior manufacturing processes.

• Typically this would increase the strength (bending fatigue) by 20%.

• How does it apply to sucker rods (used and new)?
CNC machining

- Roll threads.
- Dimensional accuracy extremely important
- Importance of QMS.
- Preservation of surface quality to oxidation and rust.
- Transportation, care and handling of sucker rods.

Note: Preservation of surface quality, straightness, and dimensional accuracy are critical reliability factors.
Stats about field failures

- Gulled threads: 29%
- Over displacement: 2%
- Loss of displacement: 16%
- Unilateral bending fatigue due to corrosion: 24%
- Unilateral bending fatigue (Mechanical reasons): 29%
Gulled Threads

- Some of the factors which causes gulled threads failure:
  - Improper care and handling of sucker rods (Dirt and debris in threads, improper cleaning techniques and improper lubrication).
  - Inaccurate calibration and torque usage for make up.
  - Lifting rod string during make up.
  - Products that does not meet specifications.
Mechanical Bending Fatigue Failures

- Well head misalignment.
- Subjecting the rod into compression.
- Fluid pound
- Tagging bottom
- Stuck pumps
- Polished rod misalignment
Loss of Displacement Failures

- Compression (Rod buckling)
- Tubing contact
- Using wrong CD cards
- Lack of calibration of power tongs.
Graph of dry vs wet face

Dry face

Wet face

Normal Strain

Shear Strain

Torque

Yield


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Torque variation in make up process

Torque at Minimum Displacement - 1"

Torque at Maximum Displacement - 1"

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Recommended Make-up Practice

- Torque Requirements vary with a lot of factors (New run vs re-run, size, grade of rod, thread lubrication).
- There is a potential variation of 70% in torque values based upon the choice of thread lubricant.
- There is 23% variation in torque values based upon new vs used rods.
- It is very important to constantly monitor and calibrate power tongs and making sure the correct torque (based on CD) is applied on rod coupling joints.
Conclusion

• Sucker rod failures are time consuming and costly.
• Sucker rod reliability starts from steel mills.
• Rod manufacturer play vital role in final reliability of the product.
• Good field practices and procedures will help in improving field performance dramatically.
• Overall intent of this presentation is to improve overall reliability through awareness, education and process improvement.
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