


# Effects on Fatigue of Applying Titanium Nitride Coating to 17-4 PH Stainless Steel

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**Motivation**

- Titanium Nitride (TiN) coatings currently have many applications including prolonging the life of manufacturing tools and being bio-compatible for implants in the medical field.
- Though the process of applying a PVD coat to materials may be time consuming, industries in varying denominations can benefit greatly from its use.



Coated bevel gears



End mill used for manufacturing

**Failure Modes that Influence Crack Initiation**

- Progressive movement of grains under cyclic loading can lead to extrusions or intrusions appearing at the surface.
- A collection of microscopic voids may cause crack initiation to occur internally within the material.
- Different directions of slip that grains can be subjected to will give varying modes of crack growth and initiation.

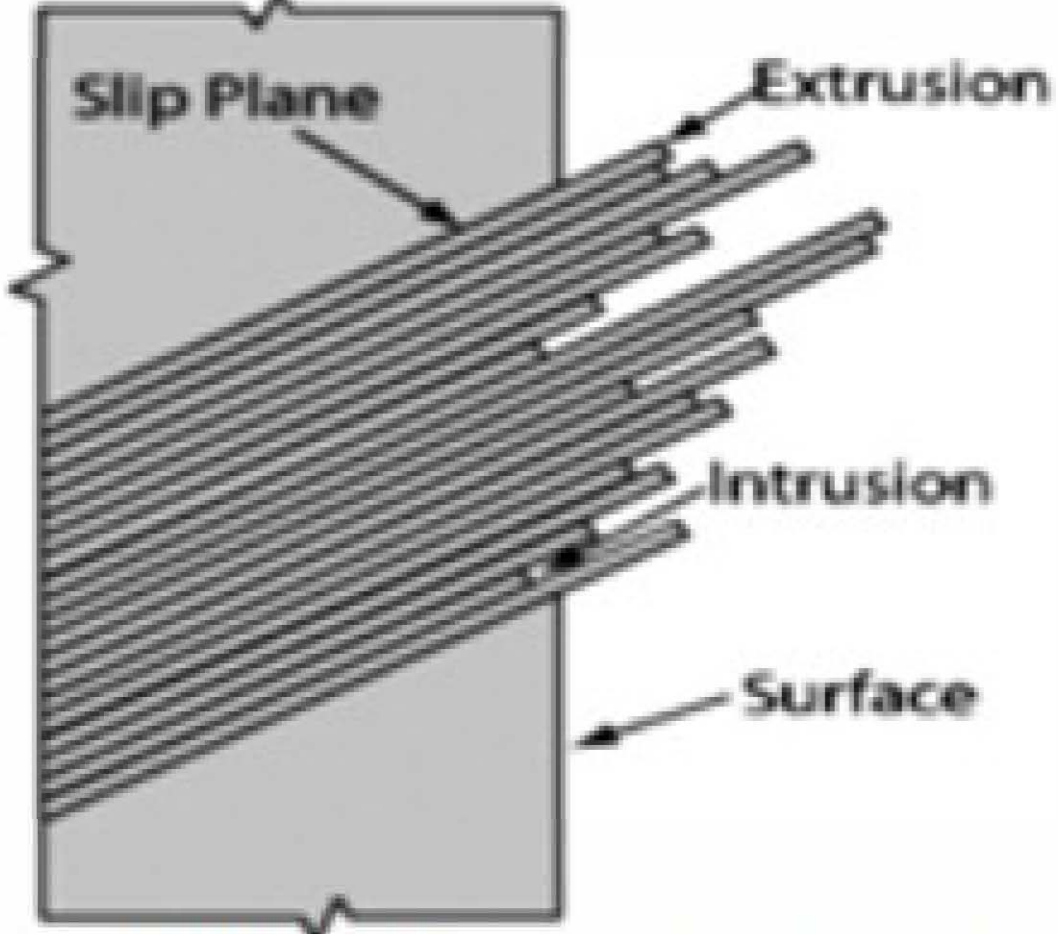
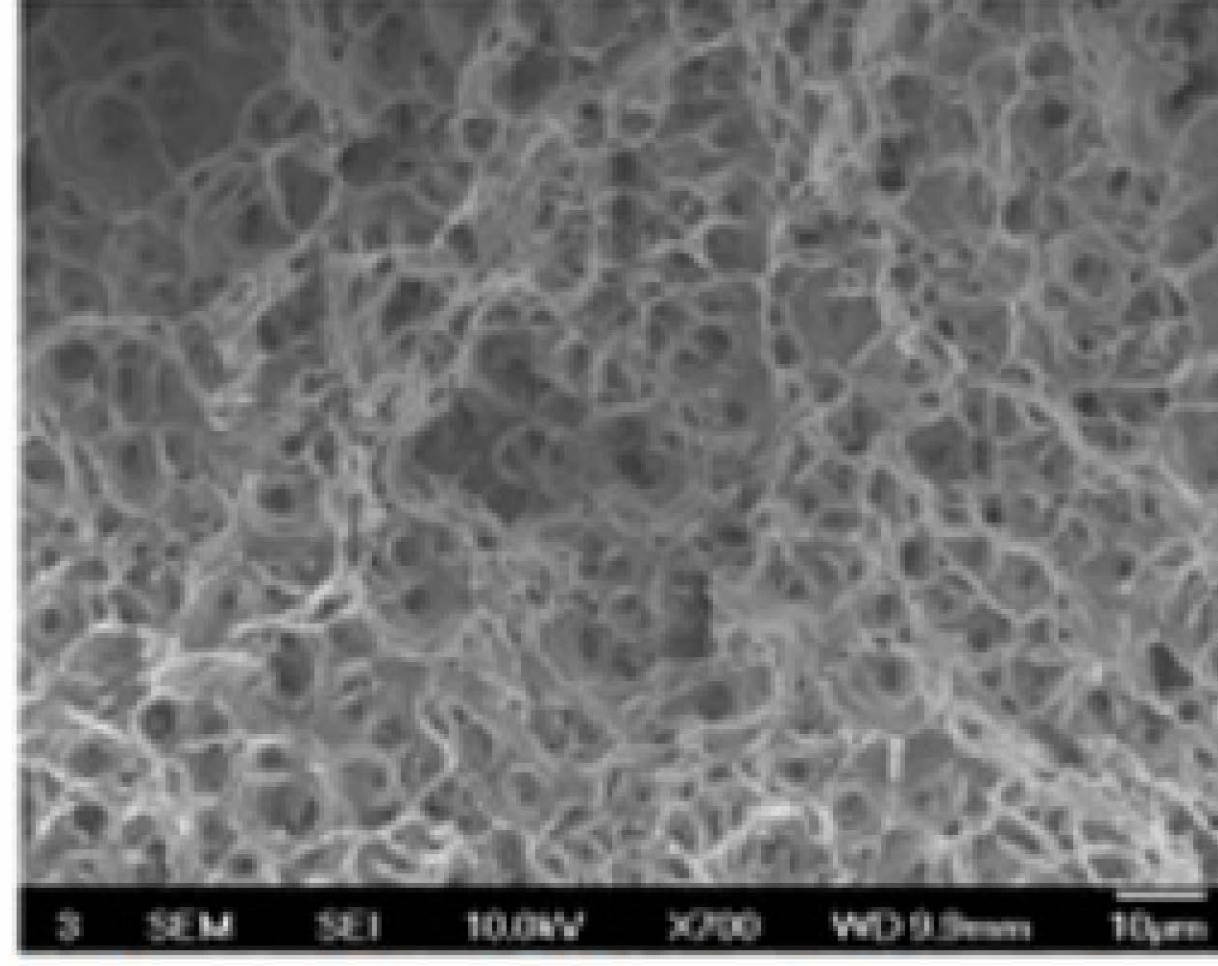
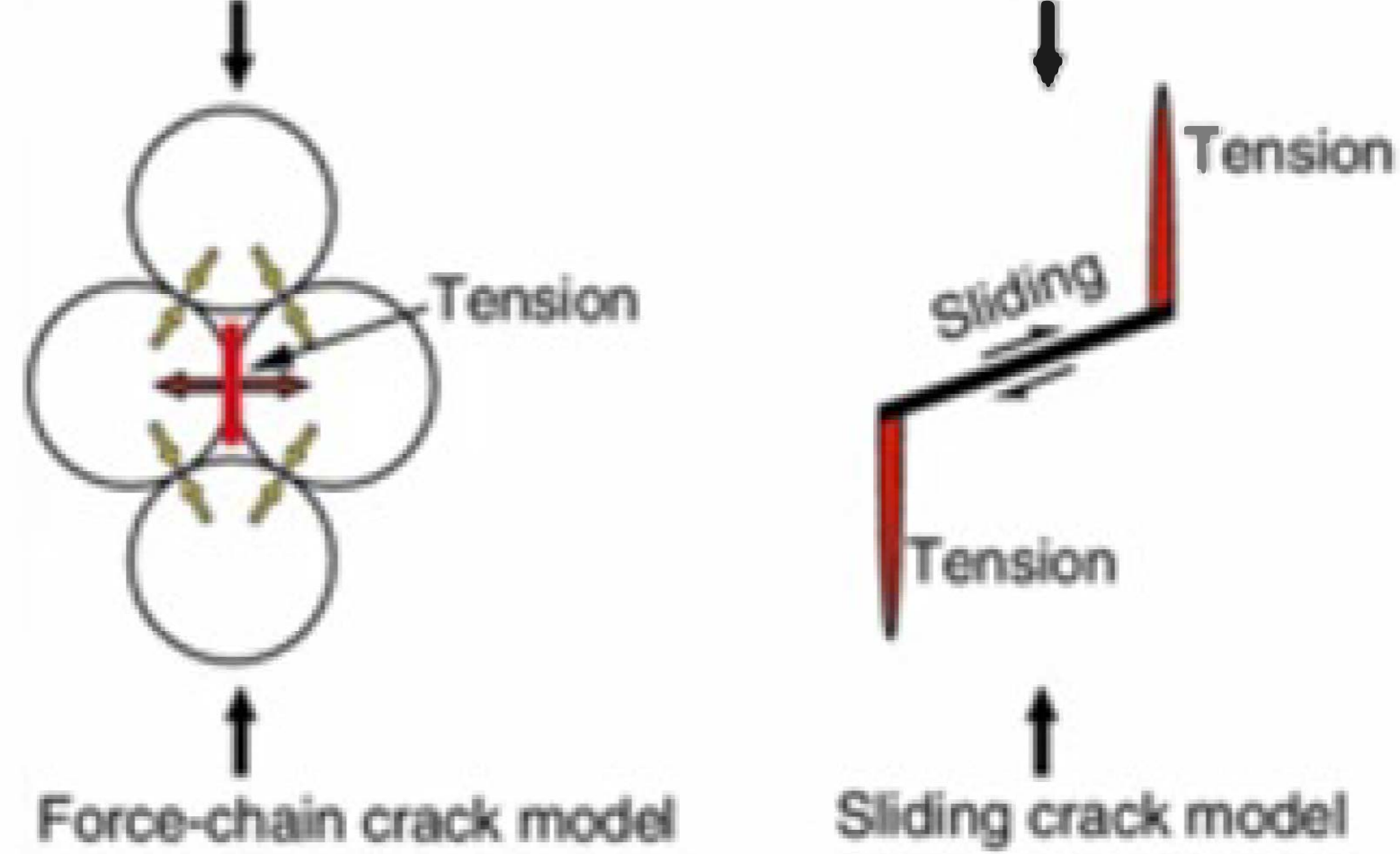


Diagram of Extrusions/Intrusions Present at Surface



A Representation of Microvoid Coalescence



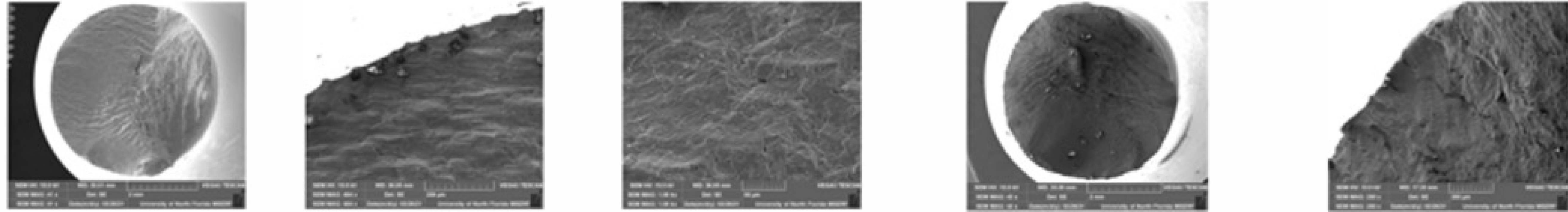
Force-chain crack model      Sliding crack model

An Image of Microscopic Movements That Cause Internal Cracks to Form

**Objective**

To investigate the effect of surface hardness on fatigue behavior of 17-4 PH stainless steel (SS)

**Experimental Results**



Fracture Surface of TiN Coated Specimen Tested at 650 MPa      Crack Initiation Site of TiN Coated Specimen Tested at 650 MPa      Striae on TiN Coated Specimen Tested at 650 MPa      Fracture Surface of Wrought Specimen Tested at 650 MPa      Crack Initiation Site of Wrought Specimen Tested at 650 MPa

**Experimental Methods**

**Material and Specimen Fabrication**


**Process:** Physical vapor deposition (PVD) via vacuum chamber

**Environment Ratio:** Argon to Nitrogen 20:1

**Coating Duration:** Groups of five specimens exposed to 1 hour and 2 hours

**Equipment:** Vacuum chamber, Rotating Bending Machine, Scanning Electron Microscope (SEM), Keyence Optical Microscope

**Surface finish:** Highly polished specimens

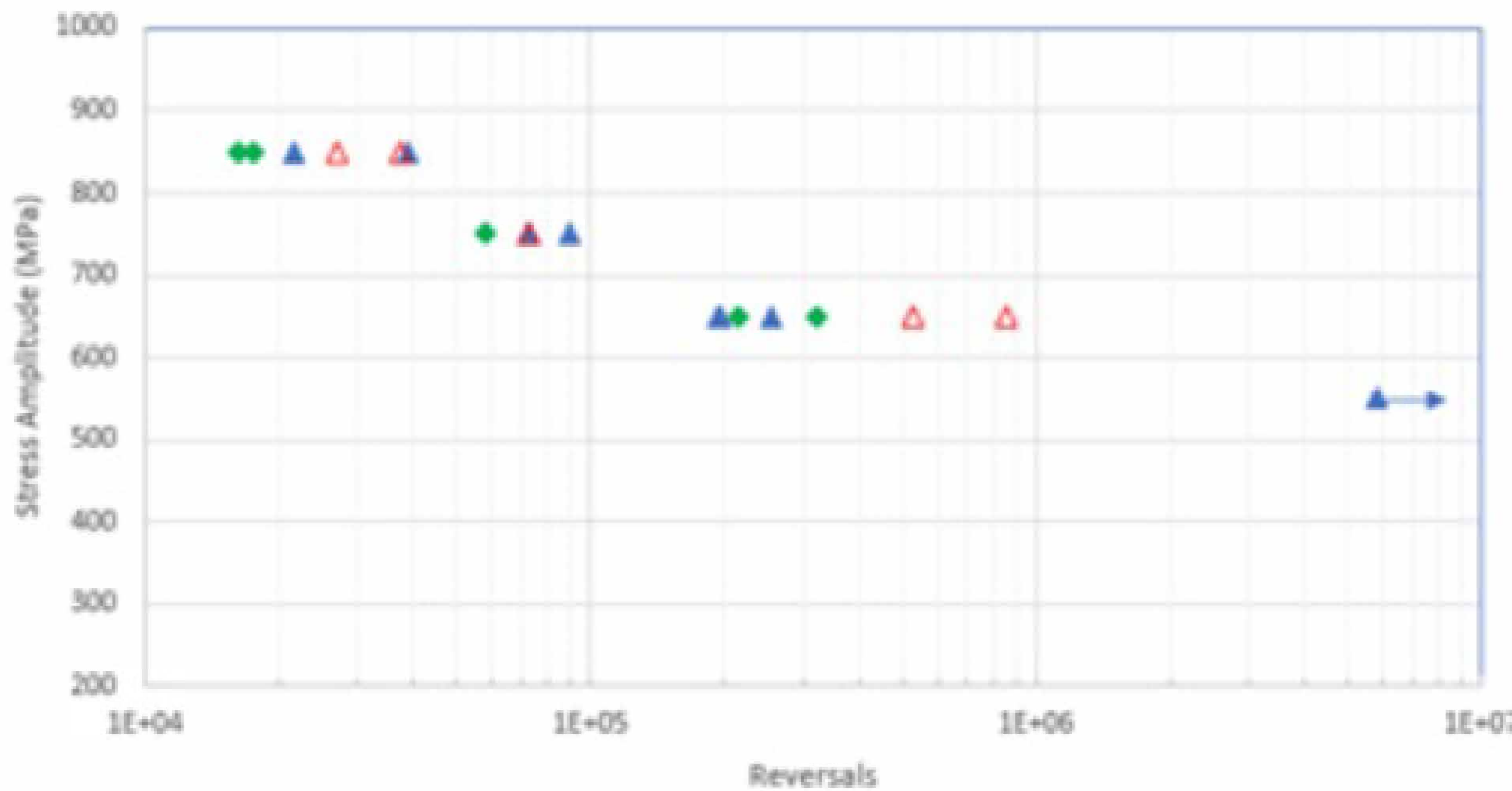


**Test Setup**

- Rotating-bending fatigue test
  - RBF200 system (System Integrators, LLC)
  - Cantilevered-type setup
  - Constant frequency for all tests

**Fatigue behavior of 17-4 PH SS**

Fatigue of PVD Specimens



Stress Amplitude (MPa) vs Reversals

- Specimens exhibited better fatigue strength under PVD coating for a duration of 2 hours.
- More than half an order of magnitude at higher stress amplitudes.
- Increase in fatigue resistance is not significant.
- The specimens subjected to a PVD coat of 1 hour showed no substantial improvement to fatigue resistance.
- A longer duration of the PVD coating process does show to have an effect on prolonging the life of the specimens.
- This is most likely due to the fact that cracks initiate at the surface in both wrought and PVD coated specimens.

**Conclusions**

- The experimental results revealed some influence of surface hardness on fatigue resistance for 17-4 PH SS in the PVD condition.
- Results are currently inconclusive, further work will be performed to investigate the effects of surface hardness on the fatigue behavior of PVD coated specimens.

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