This process will provide a true “real world movie model” of all existing forces (maximums, etc.) which will then enable a Predictive Action Plan to optimize Gearbox life.

The creation of the model will illustrate the mill rigidity/flexibility, motor/drive characteristics, vibration signatures of bearings/gears as a function of time AND frequency. This is a very powerful Sentry solution benefit.

It also includes data collection parameters, an interim, final report on the drive train loading and condition assessment. Also included is an ODS model and final analysis report with specific Corrective Action Plans and recommendations.

Each processing Cycle will be sampled and stored to allow remote trending / alarming via the Sentry System. Collection of the signals simultaneously (i.e in real-time) will determine misalignment, mechanical ‘looseness’, metallurgical deformation and out-of-balance conditions of the mill drive train. We estimate an installation time of 4 hours using two personnel. Signals will be monitored, collected, analyzed, alarmed, and stored by the Sentry System.

1. Material/labor/deliverable overview:

1.1 Material Includes: Qty 1 - Sentry 16/8 Channel in NEMA 12 enclosure, up to 8 additional vibration sensors and cables (as required), an Ethernet link is included (assuming customer provides the ‘link’ to their network). The network can provide Speed, Motor Volts and Amps.

1.2 Installation Labor Includes: Connecting existing sensors using **temporary** wiring and magnets fixed to the equipment machinery for the eight additional sensors. Sensor cables are low voltage and will be routed using existing structure (e.g. cable trays) from the sensors to Sentry located near the controller. No conduit or penetrations are included as they will be customer provided. Two men on-site for four days is provided. This Installation effort includes initial set-up of Sentry software.

1.3 Monitored Signals: The following signals will be collected in real time simultaneously allowing for the capture of the inter-action (in both the time & frequency domain) between the various operating parameters i.e. motor voltage & current, vibration (axial thrusting & radial loading), etc. See sketch No. 1 for sensor location.

1.3.1 Vibration: Vibration data will be collected on 6 Accelerometers positioned on the foundation and motors and 10 additional existing accelerometers mounted to the gear box bearings. The accelerometers will be used to check the condition of the drive components including gear mesh backlash, and phase lag. In addition they will be mounted to each of the bearings to assess their condition.

1.3.2 Motor Current: The drive motor will require a single current output to the Sentry system. We assume that the current output will be supplied by or with customer assistance.

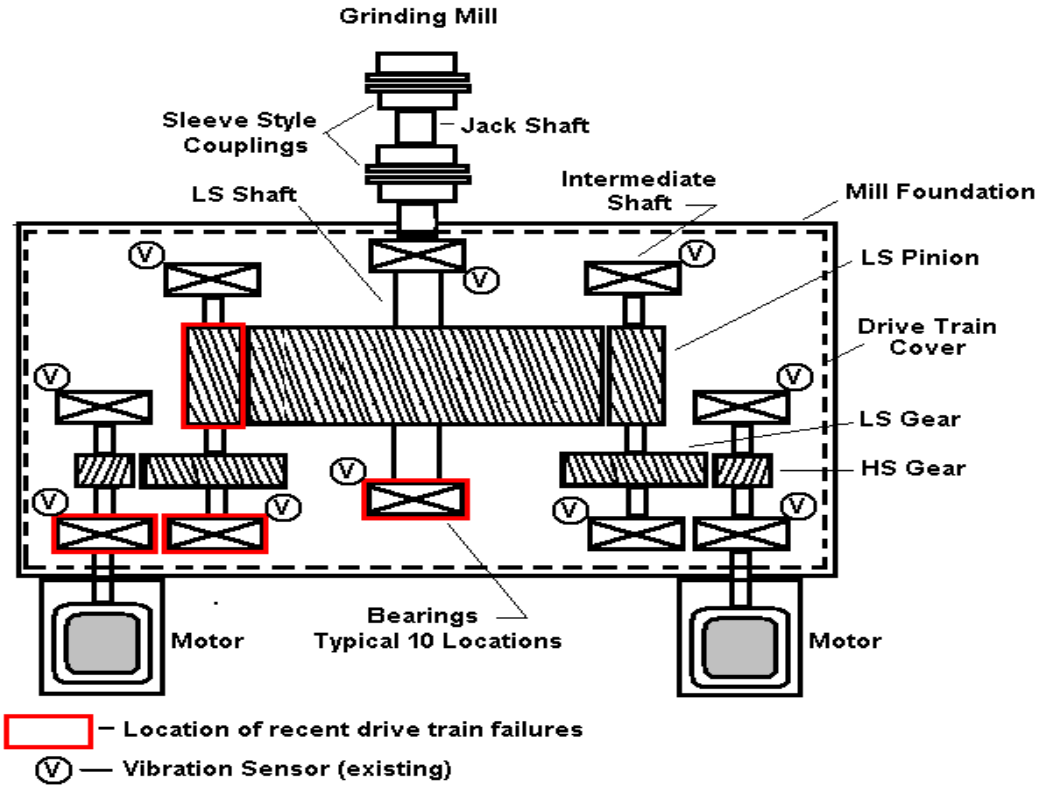
1.3.3 Speed Motor Shaft: Will be provided by H&S via an optical or proximity sensor. The output will be to the Sentry VSA. This speed sensor will require a short shut down (less than 10 minutes) to mount reflective tape to the motor output shafts.

1.3.4 Vibration Sensor Mounting: to be mounted using mounting magnets or mounting pads using adhesive.

1.4 Drive Train Analysis Includes: Multi-Variable display with data files of peak load during monitoring period, recorded variables include: vibration, torque, motor current & voltage, and speed. Condition based portion of analysis will include assessment of all gears, bearings, drive shafts, spindles, and motors using both time domain (waveform) and frequency domain (spectrum) analysis.

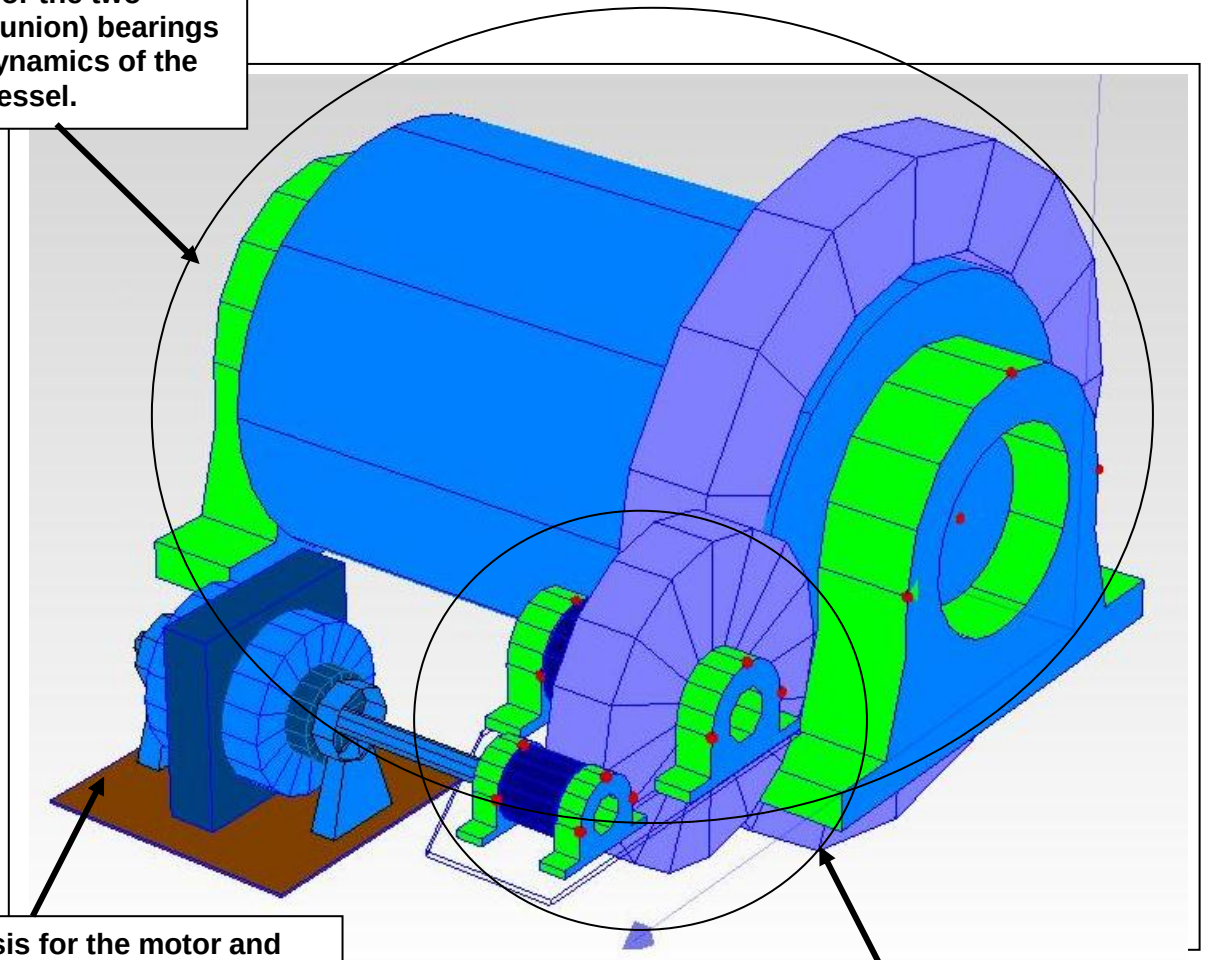
1.5 ODS Analysis Includes: Deflection shape analysis using vibration data. The 3-D Animation model will illustrate magnitude and direction of mechanical forces on the mill, gear box, shafts, housing bearings and gears.

Sketch No.1 shares scope of work which provides typical information on sensor quantity and location. All work and material will be provided based on Horsburgh & Scott standard terms and conditions.



Sketch No.1: Drive Train at Autogenous Mill. Note: Depending on availability, both motor current and motor speed could be added to the vibration data collection.

Analysis for the two journal (trunion) bearings and the dynamics of the rotating vessel.

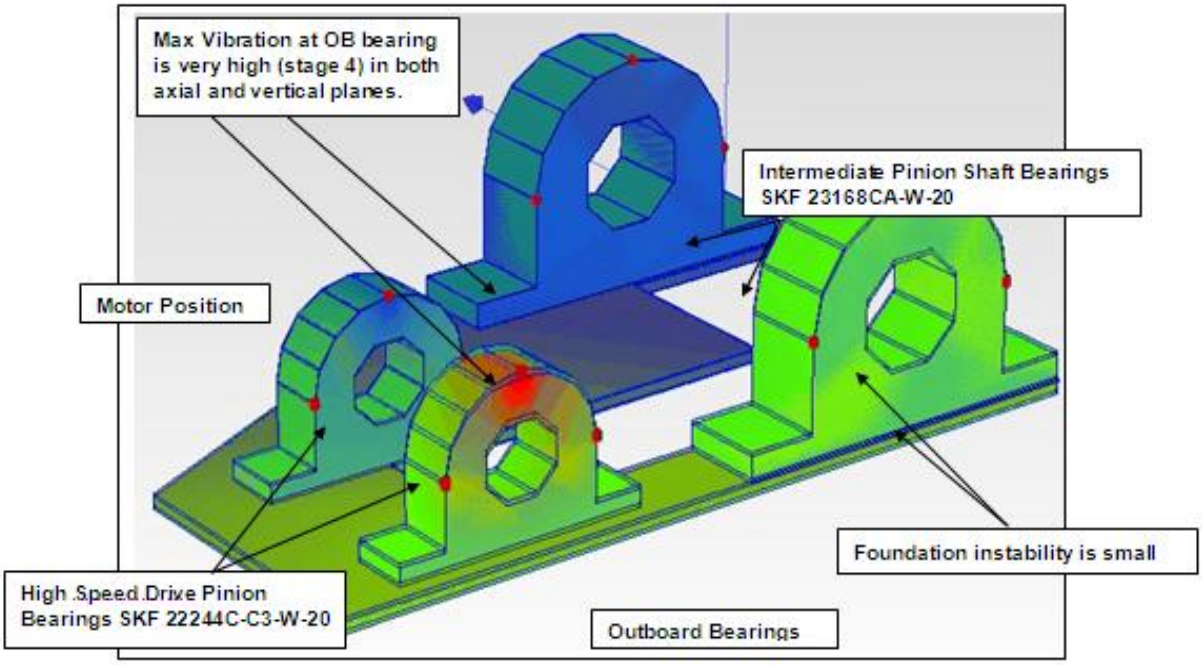


Analysis for the motor and structural support assembly.

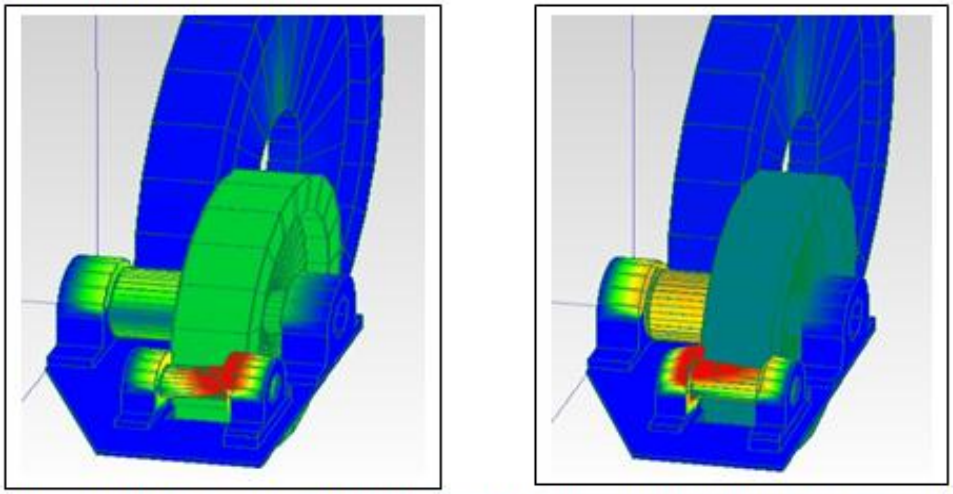
Analysis for sole plate, four roll style bearing (mounted to the plate).

Typical Mill Monitoring & Analysis approach, areas of stress/failures.

Section No. 3 - Phase No.1 & 2 Analysis Sole Plate & Roller Style Bearings:



ODS Diagram No.4 Autogenous Mill No. 6 Sole Plate with high speed pinion & intermediate gear roller bearings. As the colors move from blue to red they represent increased motion (vibration).



ODS Diagram No.5a & 5b Consecutive Data sets illustrating thrusting on HS bearings.

“Snap shots” from ODS 3-D animation which illustrate how heavy loading results in tooth slippage and thrusting.