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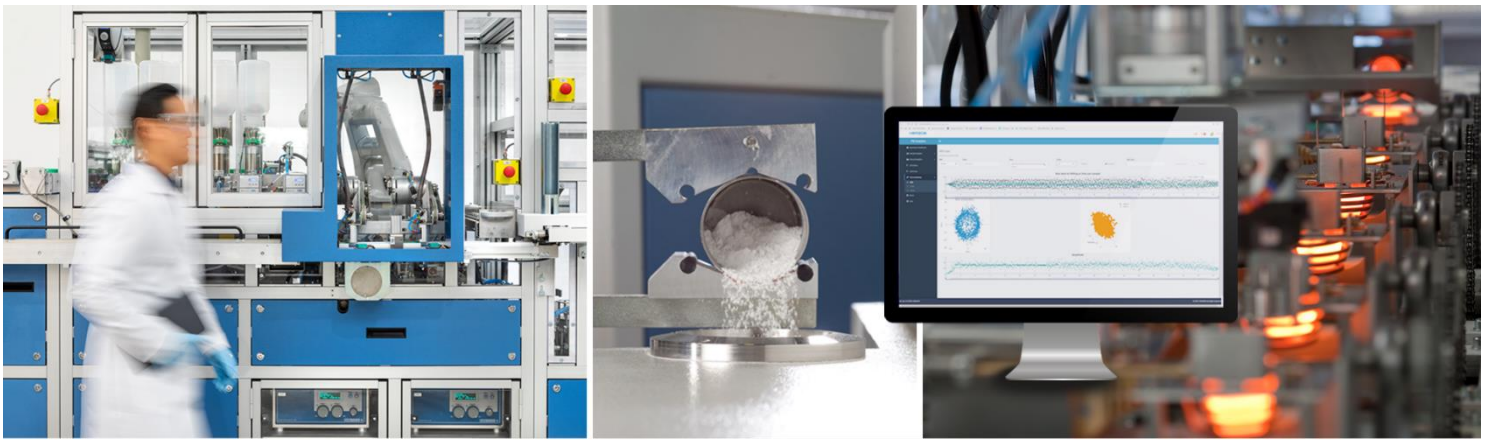

Acceleration-Based Tool Condition Monitoring in the HP-MCSA Mortar Crusher

Abstract

This application note demonstrates tool condition monitoring (TCM) for the HP-MCSA using a single 3D accelerometer and PrepMaster Analytics. Acceleration was captured during idle cycles with the sensor mounted near the mortar chamber. x–y acceleration plots form a characteristic ovoid “fingerprint” that is highly reproducible at the optimal 3 mm gap. Three deviation scenarios were imposed: a ~3 mm gap increase and two fixation loosenings. The widened gap produced a more uniform, lower-variance orbit that correlates with coarse product (>6 mm). Loosenings reduced amplitude and introduced directional asymmetry. PrepMaster Analytics analyses parameters and separates machine states in real time helping laboratories maintain particle-size compliance while reducing downtime and maintenance cost.

Key words

• Mortar crusher • Acceleration • Tool condition monitoring • PrepMaster Analytics • Gap shift

Introduction

High-throughput, representative sample preparation depends on stable machine behavior. The HP-MCSA is Herzog’s fully automatic crushing/splitting solution for laboratories processing large, heterogeneous materials such as ores. It combines a robust mortar crusher with a variable fully automated linear splitter in a closed, PLC-controlled workflow. We embed Tool Condition Monitoring (TCM) directly into the routine operation of the HP-MCSA.

Acceleration-based TCM is especially powerful in sample preparation equipment. Prior Herzog studies have shown that tri-axial accelerometers capture the dynamic “fingerprint” of mills and crushers, distinguishing normal motion from incipient faults. This note applies that approach to the HP-MCSA mortar crusher and demonstrates how a 3D accelerometer with PrepMaster Analytics provides a reproducible baseline and clear deviation signatures for gap changes and other issues.

Methods

A tri-axial accelerometer was mounted on a rigid point near the mortar chamber of the HP-MCSA (Figure 1) to maximize coupling to the crusher. Measurements were taken during idle cycles (no sample). Signals were acquired at high frequency and streamed to PrepMaster Analytics for processing and visualization.

Figure 1: Photographs of the inside of the HP-MCSA with upstream vibratory chute and mortar crusher.

The x- and y-components of acceleration were treated as a two-dimensional motion vector over time. Plotting x versus y yields a characteristic ovoid scatter cloud describing the orbital motion of the mortar. PrepMaster Analytics computed sector-wise statistics by dividing the orbit into angular segments (0–360°) and calculating mean vector magnitude and variability in each segment. Global features—major/minor axis ratio (eccentricity), x/y amplitude ratio, inner-void area, and principal-axis orientation—were also tracked for every run and compared with the baseline.

Four controlled conditions were investigated:

Experiment 1—Baseline / reproducibility:

Crusher adjusted to the optimal gap for a 3 mm end fineness on iron ore. Ten independent idle runs were recorded; mean curves and confidence envelopes were calculated.

Experiment 2—Gap increased:

The crushing gap was widened by ~3 mm; subsequent material tests produced a coarser fraction (> 6 mm).

Experiment 3—Fixation loosened (front right):

The front-right fixation screw of the crusher module was deliberately loosened.

Experiment 4—Fixation loosened (rear right):

The rear-right fixation screw was loosened in the same manner.

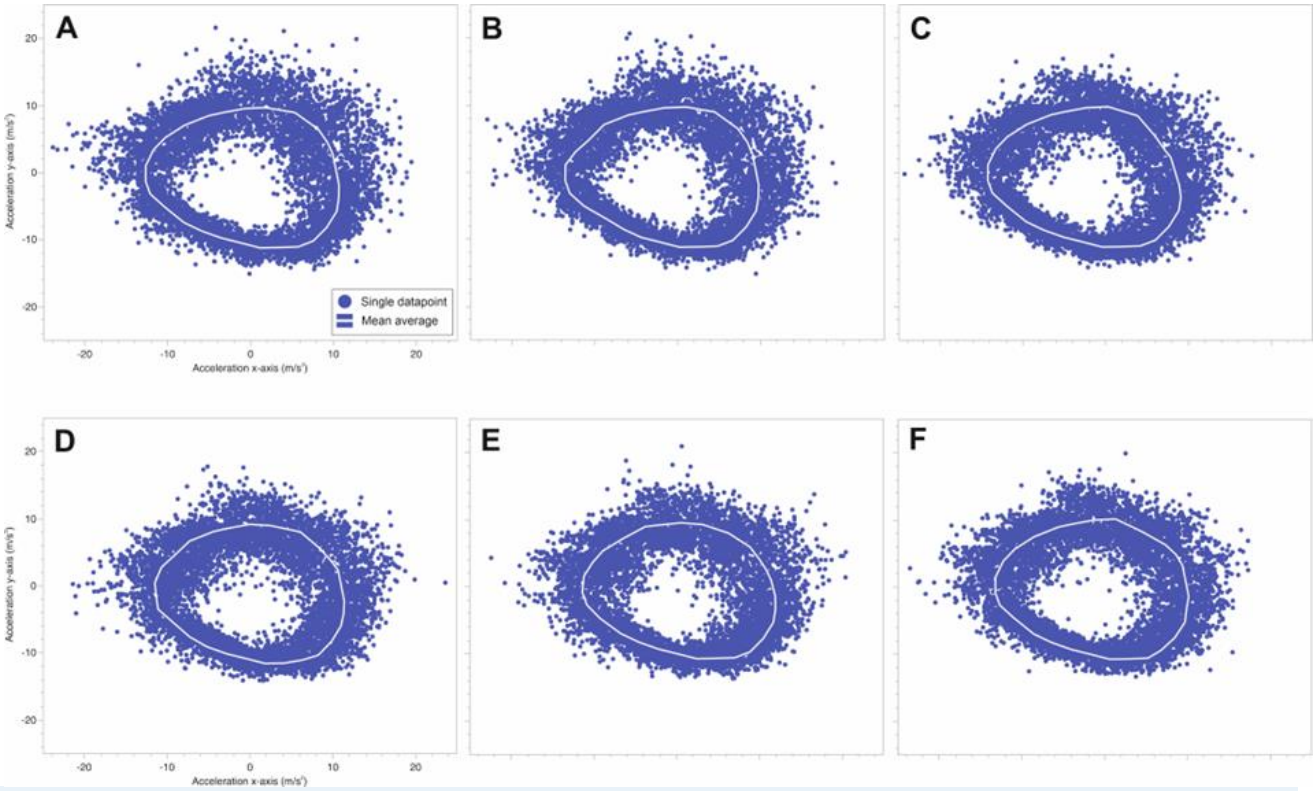

Figure 2: Baseline reproducibility—x–y acceleration from six idle runs at the optimal 3 mm gap (A–F).

Results

Baseline signature and reproducibility

With the optimal gap, the scatter assumes a pronounced ovoid ring. Variability is not uniform: the 270°–150° sector shows higher dispersion, consistent with the phase where the mortar approaches and contacts the chamber wall. Elsewhere the cloud tightens, reflecting unconstrained motion (Figure 2). Crucially, the pattern is highly reproducible. Overlays of ten mean curves almost superimpose with only small deviations across both axes (Figure 3). This stability establishes a robust "healthy-state fingerprint," enabling tight thresholds with minimal false alarms and providing a reliable reference for change detection.

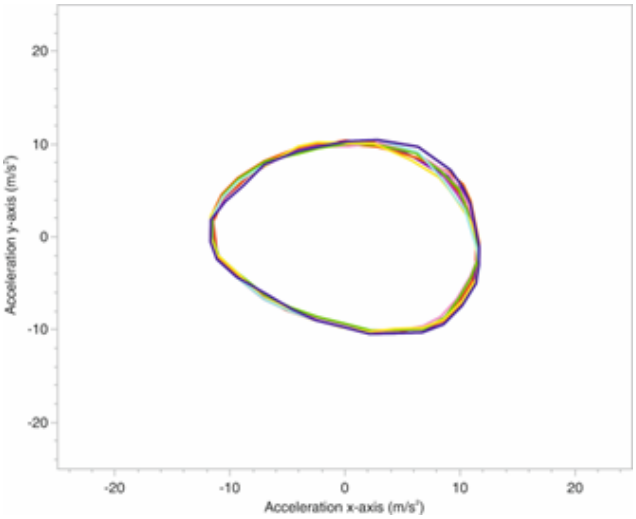

Figure 3: Baseline overlay—mean x–y curves of ten runs at the optimal gap show minimal deviation.

Gap widened by ~3 mm

Increasing the gap preserved the ovoid but made the ring more uniform and less variable—particularly in the 270°–150° sector. The inner void enlarged slightly and ring thickness evened around the orbit. Sector standard deviations decreased across the cycle (figure 4, B). Mechanistically, the change reflects reduced contact between the mortar and the wall, which aligns with the observed failure to reach the 3 mm target fineness (coarser particles > 6 mm).

Fixation loosened

Loosening fixation screws reduced overall vibration amplitude and introduced asymmetry relative to baseline. In Experiment 3 (front-right), the y-component diminished compared with x, and the cloud flattened (Figure 4 C). In Experiment 4 (rear-right), similar attenuation occurred with a different angular distribution of variability (Figure 4D).

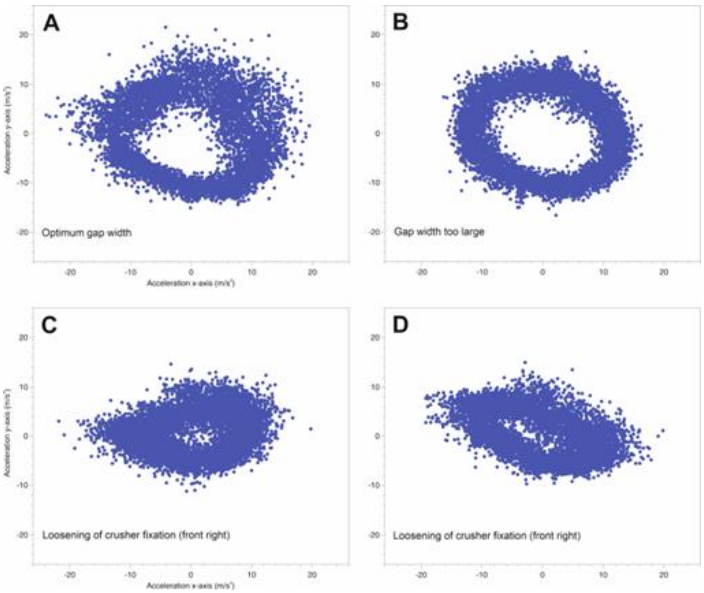

Figure 4: Deviation states—A optimal; B gap +3 mm; C front-right loosened; D rear-right loosened.

Discussion

This study shows that a 3D accelerometer mounted within the HP-MCSA mortar crusher is sufficient to generate a clear, repeatable baseline and to differentiate between two common deviation classes: (i) a widened crushing gap that yields oversized material and (ii) mechanical faults due to insufficient fixation. These disturbances lead to a significant change in the acceleration curve and can be easily distinguished from the baseline curve of the normal state.

From an operational perspective, this TCM supports the following two business-critical outcomes: (i) Consistent product quality**:** Early detection of a widened gap prevents off-spec particle size and rework. (ii) Lower downtime and cost: Identifying mechanical defects before they propagate avoids secondary damage and enables planned maintenance.

PrepMaster Analytics operationalizes these practices by storing reference signatures, computing sectorized statistics, trending deviations, and integrating alarms with the SCADA. These indicators translate directly into higher uptime, lower costs, and consistently compliant particle size in demanding production laboratories.

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