



NESANS

TECHNICAL GUIDES

# Plant Start-Up Sequence: Proper Procedures to Protect Equipment and Production

Follow correct plant start-up and shutdown sequences. Protect crushing and screening equipment while maximizing production efficiency.

**Author:** Sivabalan  
Selvarajan

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Jaw crusher flywheel inspection is a critical safety activity that prevents catastrophic failures capable of causing serious injury or death. Flywheel cracks, often invisible to casual observation, can propagate under cyclic loading until sudden, explosive failure occurs. A systematic inspection program using proper techniques can detect developing cracks before they reach critical size, allowing safe planned replacement rather than emergency response to a dangerous failure.

## Understanding Flywheel Function and Failure Modes

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### Flywheel Function in Jaw Crushers

The flywheel serves critical functions in jaw crusher operation:

- **Energy storage:** Stores kinetic energy during non-crushing portion of cycle
- **Energy release:** Delivers stored energy during crushing stroke

- **Load leveling:** Smooths power draw from motor
- **Speed regulation:** Maintains consistent eccentric shaft speed

**Operating stresses:** Flywheels experience significant cyclic stresses from:

- Centrifugal force from rotation (tension in rim and spokes)
- Torque fluctuations from crushing cycle
- Belt tension from drive (asymmetric loading)
- Thermal cycling from operation

## Common Failure Modes

FAILURE MODE	LOCATION	CAUSE	DETECTABILITY
Rim cracking	Outer edge	Centrifugal stress, impact	Visual, UT
Spoke cracking	Spoke roots	Cyclic bending, casting defects	MT, PT, UT
Hub cracking	Around keyway, bore	Press fit stress, torque cycles	PT, UT
Keyway damage	Key seat	Impact loading, loose fit	Visual, PT

## Consequences of Flywheel Failure

Flywheel failure is among the most dangerous events in crushing operations:

- **Projectile hazard:** Fragments travel at high velocity (up to 200+ m/s)
- **No warning:** Failure occurs instantaneously without audible warning
- **Wide danger zone:** Fragments can travel 100+ meters
- **Secondary damage:** Structural damage to plant, equipment

## Visual Inspection Procedures

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### Preparation

Before visual inspection:

1. Lock out all energy sources (electrical, mechanical, hydraulic)

2. Verify crusher cannot rotate (blocking recommended)
3. Clean flywheel surface of dust, grease, debris
4. Ensure adequate lighting (1000+ lux recommended)
5. Have magnifying glass (10×) available for detailed examination

## Inspection Checklist

AREA	WHAT TO LOOK FOR	ACCEPT/REJECT CRITERIA
Rim outer surface	Cracks, chips, gouges	Any crack: Investigate. Chip >10mm: Evaluate
Rim inner surface	Cracks, corrosion	Any crack: Reject. Significant corrosion: Evaluate
Spoke surfaces	Cracks, especially at roots	Any crack: Reject
Hub bore	Cracks, fretting, wear	Any crack: Reject. Fretting: Evaluate
Keyway	Cracks, deformation, wear	Any crack: Reject. Deformation >0.5mm: Evaluate
Balance weights	Loose, missing, damaged	Any issue: Repair before operation

## High-Stress Areas

Pay particular attention to high-stress concentration areas:

- **Spoke roots:** Where spokes meet hub and rim
- **Keyway corners:** Sharp corners concentrate stress
- **Any machined features:** Holes, grooves, steps
- **Repair welds:** Heat-affected zones
- **Casting anomalies:** Porosity, inclusions, cold shuts

## Non-Destructive Testing Methods

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### Magnetic Particle Testing (MT)

Most effective for detecting surface and near-surface cracks in ferromagnetic materials:

**Application:**

- Best for spoke roots, keyway areas
- Can detect cracks as small as 0.1mm
- Requires cleaning but minimal surface preparation
- Provides immediate visual indication

**Procedure:**

1. Clean inspection area (remove oil, grease, paint)
2. Apply magnetizing current (yoke or prod method)
3. Apply magnetic particles (wet or dry method)
4. Examine under appropriate lighting (visible or UV)
5. Demagnetize after inspection

**Dye Penetrant Testing (PT)**

Effective for detecting surface-breaking cracks in any material:

**Application:**

- Useful for hub bore, machined surfaces
- Works on non-magnetic materials
- Can detect very fine cracks
- Requires thorough cleaning

**Procedure:**

1. Clean surface thoroughly (solvent cleaner)
2. Apply penetrant, allow dwell time (10-30 minutes)
3. Remove excess penetrant carefully
4. Apply developer, allow developing time
5. Examine under appropriate lighting

**Ultrasonic Testing (UT)**

Can detect internal defects not visible at surface:

### Application:

- Rim thickness measurement and defect detection
- Detection of subsurface cracks
- Assessment of casting soundness
- Requires trained technician

### Key measurements:

- Rim thickness at multiple points (detect wear or corrosion)
- Scan spoke sections for internal defects
- Hub bore area for cracks

## Inspection Frequency and Scheduling

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### Recommended Inspection Intervals

INSPECTION TYPE	FREQUENCY	PERFORMED BY
Visual walk-around	Daily	Operator
Detailed visual	Monthly	Maintenance technician
MT/PT critical areas	Quarterly	NDT technician
Comprehensive NDT	Annually	Certified NDT inspector
After incidents	As needed	NDT technician

### Factors Requiring Increased Frequency

- Flywheel age approaching design life
- Previous repairs or crack indications
- Severe operating conditions (impact loading, overloads)
- Visible damage or wear
- After tramp iron events

# Crack Assessment and Decision Making

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## When Cracks Are Found

1. **Immediately:** Stop the crusher, do not operate
2. **Document:** Photograph, measure, record location
3. **Assess:** Determine crack type, size, orientation
4. **Consult:** Contact OEM or qualified engineer
5. **Decide:** Repair (if permissible) or replace

## General Guidelines (Consult Engineer for Specific Cases)

FINDING	TYPICAL ACTION
Any crack in spoke	Replace flywheel
Crack at keyway	Replace flywheel
Crack in hub	Replace flywheel
Small rim chip (<10mm, no crack)	Blend, monitor
Large rim chip (>10mm)	Engineering evaluation required
Surface porosity (casting defect)	Engineering evaluation required

## Repair Considerations

Flywheel repair is generally NOT recommended due to:

- High consequence of failure
- Difficulty achieving original material properties
- Residual stress from welding
- Risk of hidden defects

If repair is considered (only with OEM approval):

- Must be performed by qualified welder with approved procedure
- Requires post-weld heat treatment

- Comprehensive NDT required after repair
- Reduced inspection intervals afterward
- Document everything for liability purposes

## Flywheel Replacement Criteria

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### Mandatory Replacement Triggers

- Any crack (except as specifically evaluated and approved)
- Keyway damage beyond limits
- Bore wear exceeding tolerance
- Rim thickness below minimum
- Significant imbalance that cannot be corrected
- Age exceeding manufacturer's recommended service life

### Service Life Considerations

Flywheel service life depends on:

- **Material:** Typically ductile iron or cast steel
- **Design:** Safety factors in original design
- **Operating conditions:** Loading severity, speed
- **Maintenance:** Balance, alignment, lubrication

Typical service life guidance: 15-25 years or 100,000-150,000 operating hours for well-maintained flywheels without defect indications. However, always follow OEM guidance for specific equipment.

## Guard Inspection

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### Flywheel Guard Requirements

Guards provide the last line of defense against flywheel fragment hazards:

## Guard construction requirements:

- Steel plate construction (typically 6-12mm minimum)
- Designed to contain fragments at maximum operating speed
- Secure mounting that withstands impact
- Complete enclosure of rotating mass

## Guard Inspection Checklist

ITEM	CHECK	ACTION IF FAILED
Guard integrity	No cracks, holes, severe corrosion	Repair or replace guard
Mounting security	All fasteners present and tight	Replace missing, tighten loose
Clearance	No contact with rotating parts	Adjust guard position
Coverage	Complete enclosure of flywheel	Add sections if incomplete
Access doors	Interlocked, secure when closed	Repair interlock, adjust door

## Documentation and Records

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### Inspection Records

Maintain comprehensive records including:

- Date and time of inspection
- Inspector name and qualifications
- Inspection methods used
- Areas inspected
- Findings (including "no defects found")
- Measurements (rim thickness, bore diameter)
- Photographs
- Actions taken or recommended

## Equipment History File

Maintain a complete history file for each flywheel including:

- Original specifications and certificates
- Installation date and operating hours at installation
- All inspection reports
- Any repairs performed (if applicable)
- Operating conditions and any incidents
- Balance records

## Conclusion

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Flywheel inspection is a non-negotiable safety requirement for jaw crusher operations. The consequences of flywheel failure—potential fatalities and catastrophic damage—make thorough inspection essential. Implement daily visual checks, monthly detailed inspections, quarterly NDT on critical areas, and annual comprehensive NDT by certified inspectors. Any crack finding requires immediate shutdown and engineering evaluation. Never operate a crusher with a cracked flywheel. Maintain guards in proper condition as the last line of defense. Document all inspections thoroughly. The cost of inspection and planned replacement is insignificant compared to the potential consequences of failure.

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**Topics:**

#Plant Operations

#Safety

#Start-Up Procedure