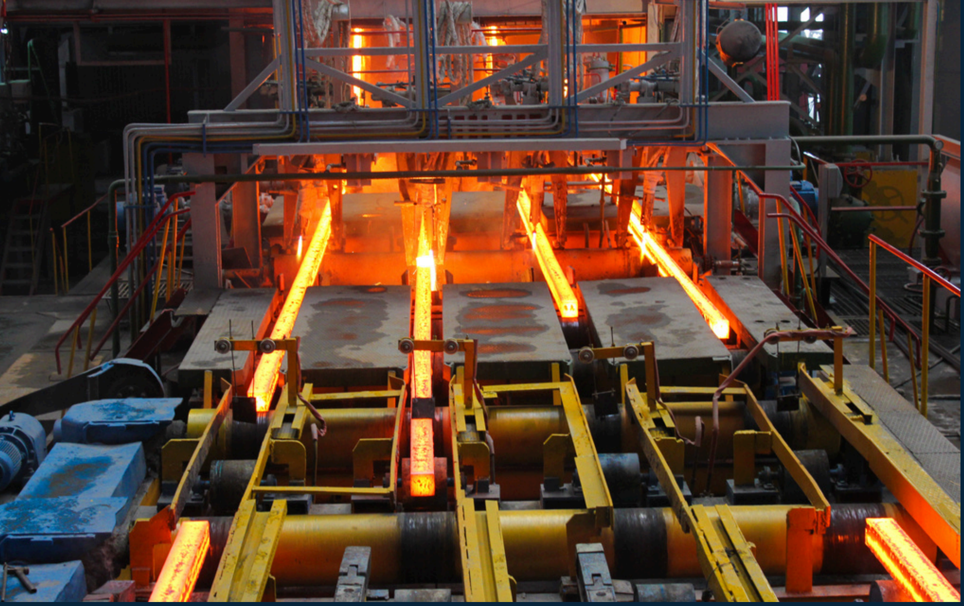

DIAGNOSE ROOT CAUSE OF CONTINUOUS CASTER BREAKOUTS IN MINUTES

Breakouts in continuous casting are among the most disruptive and costly challenges steelmakers face. These incidents occur when the partially solidified shell of a cast billet ruptures, releasing molten steel and forcing unplanned downtime, equipment damage, and production delays. For metallurgists and Melt Shop managers, understanding and preventing breakouts has traditionally been as much art as science – until now. AI-powered tools like Fero Labs are transforming how steelmakers diagnose and fix these costly disruptions.

In the high-stakes world of steel manufacturing, few production issues strike as much fear into the hearts of Meltshop managers as the dreaded breakout. These catastrophic events not only disrupt production but can also pose serious safety risks, damage equipment, and significantly impact a steel plant's bottom line.

Given the severe economic impact of breakouts, swift and accurate root cause analysis is paramount. Timely identification of the underlying factors contributing to a breakout is crucial for several reasons:

- **Prevention of Recurrence:** By pinpointing the exact cause, steelmakers can implement targeted corrective measures to mitigate the risk of similar incidents in the future.
- **Process Optimization:** Root cause analysis often reveals opportunities for overall process improvements, enhancing the efficiency and stability of the casting operation.
- **Cost Reduction:** Addressing the fundamental issues leading to breakouts can significantly reduce both direct costs (repairs, lost production) and indirect costs (quality control, customer satisfaction).
- **Safety Enhancement:** Understanding the mechanisms behind breakouts allows for the development of more robust safety protocols and early warning systems.

The current standard for investigating the root cause of steel breakouts often involves using statistical analysis tools such as Minitab.

While Minitab is a powerful platform for analyzing data, the process of conducting root cause analysis in such tools is labor-intensive, time-consuming, and prone to inefficiencies. The complexity stems from the highly interconnected and dynamic nature of steelmaking operations, which require data from multiple sources to be merged, visualized, and analyzed cohesively.

Many well proven advanced analytical approaches can be used depending on the breakout and the time-sensitivity involved in implementing a fix. These can include a rigorous **Six Sigma** project involving multiple cross-functional teams across a **3-6 month period**.

Beyond Six Sigma, steel plants often employ additional methodologies such as **Statistical Process Control (SPC)** for manually monitoring process stability each day by specialized domain experts, this only allows for a focus on limited variables (typically 10-20 key parameters).

Root Cause Analysis (RCA) and **8D** can be employed using a variation of tools for structured problem-solving methodologies, commonly deployed after breakouts occur. These investigations can require **2-4 weeks** to complete using the resources of **5-10 domain specialists**, but still with limited ability to analyze complex interactions.

Another powerful process for testing breakout prevention hypotheses, **Design of Experiments (DOE)** faces significant time (**months**), costs ("test to failure" scenarios), and difficulty isolating variables in production environments.

Fero Diagnostics revolutionizes the traditional process of root cause analysis for steel breakouts by dramatically reducing the time to actionable insights. Unlike traditional methods that require extensive manual data preparation and hypothesis testing, **Fero Diagnostics** provides a streamlined, automated approach that enables engineers to focus on solutions rather than data wrangling.

The **entire workflow** can be contained and performed within the Fero platform **within a few short minutes**.

In this report we will investigate the causes of caster breakouts and how Fero Diagnostics makes short work of diagnosing, fixing, and ultimately preventing breakouts.

UNDERSTANDING COSTLY BREAKOUTS

A breakout occurs when molten steel penetrates through the solidified shell and the mold during the continuous casting process. This results in molten metal escaping from its intended containment, potentially causing:

- Equipment damage requiring extensive repairs
- Production downtime lasting days or even weeks
- Significant safety hazards for personnel
- Material losses and quality issues
- Environmental concerns

The financial impact can be staggering.

A single serious breakout can cost millions in repairs, lost production time, and wasted material.

For an average-sized steel plant producing 3 million tons annually, just one major breakout can reduce annual production by 0.5-1%, directly impacting the bottom line.

JUST ONE MAJOR BREAKOUT CAN REDUCE ANNUAL PRODUCTION BY 0.5-1%

ROOT CAUSES OF CASTER BREAKOUTS

Metallurgical Factors

- **Steel Chemistry:** Improper carbon content, phosphorus, or sulfur levels can affect solidification patterns.
- **Inclusion Content:** Non-metallic inclusions can disrupt the shell formation.
- **Superheat:** Excessive superheat can delay solidification and thin the shell.

Operational Factors

- **Casting Speed:** Inappropriate casting speeds may not allow sufficient shell formation.
- **Mold Level Fluctuations:** Unstable mold levels disrupt uniform solidification.
- **Cooling Water Flow:** Irregular cooling water distribution creates thermal stresses.
- **Mold Oscillation:** Issues with stroke, frequency, or lubrication can lead to shell sticking.
- **Mold Taper:** Incorrect mold geometry fails to accommodate shell shrinkage.

Mechanical Factors

- **Misaligned Equipment:** Misaligned segments, rolls, or molds create stress points.
- **Worn Components:** Degraded mold plates or rolls can cause irregular cooling.
- **Clogged Nozzles:** Blocked cooling nozzles create hot spots vulnerable to breakout.

TRADITIONAL APPROACHES TO BREAKOUT PREVENTION

Steel domain experts have historically relied on several approaches to diagnose, prevent, and manage breakouts:

Post-Mortem Analysis

When a breakout occurs, metallurgists typically conduct thorough investigations:

- Analyzing shell fragments
- Reviewing operational data leading up to the incident
- Examining equipment condition
- Testing material samples

While valuable, this reactive approach only helps prevent future occurrences after damage is already done.

Preventive Maintenance

Regular inspection and maintenance of critical components:

- Scheduled replacement of mold plates
- Regular cleaning of cooling systems
- Inspection of alignment and mechanical systems

These practices reduce risks but cannot eliminate them entirely and often result in excessive downtime during critical production periods.

Real-Time Monitoring Systems

Many steel plants employ:

- Thermocouples to detect temperature anomalies
- Mold level monitoring systems
- Sticker detection systems
- Early breakout detection (EBD) systems

Expert Knowledge and Experience

Perhaps most importantly, steel plants rely heavily on the expertise of veteran metallurgists and operators who:

- Recognize patterns in operational data
- Make adjustments based on intuition and experience
- Maintain "tribal knowledge" of plant-specific behaviors

This expertise, while invaluable, faces challenges with retirement trends, knowledge transfer issues, and limits of human pattern recognition across hundreds of variables.

TRADITIONAL ANALYTICAL METHODS: SIX SIGMA AND OTHER APPROACHES

The steel industry has long embraced structured analytical methodologies to tackle persistent quality and process challenges like breakouts. However, traditional approaches come with constraints, and are resource and time intensive. Six Sigma, in particular, has been widely adopted for its rigorous, data-driven approach to problem-solving.

Six Sigma in Steel Production

Six Sigma's DMAIC methodology (Define, Measure, Analyze, Improve, Control) provides a structured framework for addressing breakout issues:

- **Define:** Identifying the specific type and characteristics of breakouts
- **Measure:** Gathering data on affected heats, conditions, and impact
- **Analyze:** Using statistical tools to identify potential causes
- **Improve:** Implementing process changes based on findings
- **Control:** Monitoring results and standardizing successful interventions

While proven effective, implementing Six Sigma for breakout analysis presents significant challenges:

Time and Resource Investment

A typical Six Sigma project investigating breakouts requires:

- **3-6 months** to complete the full DMAIC cycle
- **Cross-functional teams** pulling experts away from daily operations
- **100-200 personnel hours** just for data collection and preparation
- **Black Belt or Master Black Belt expertise,** which is often in short supply
- **Multiple iterations** as hypotheses are tested and refined

Data Integration Hurdles

Six Sigma analyses are only as good as their data inputs, and therein lies a major challenge:

- **Manual data extraction** from multiple systems (Level 1, Level 2, MES, LIMS, maintenance systems)
- **Hours spent reconciling timestamps** across different data sources
- **Data quality issues** requiring extensive cleaning and validation
- **Spreadsheet limitations** when handling millions of data points
- **Difficulty incorporating unstructured data** like operator notes or maintenance logs

Analysis Limitations

Traditional statistical methods face limitations when applied to the complexity of breakout situations:

- **Linear analysis tools** may miss non-linear relationships between variables
- **Sample size constraints** when dealing with rare or emerging breakout types
- **Difficulty modeling time-lagged effects** where causes precede effects by variable intervals
- **Inability to analyze hundreds of variables simultaneously**
- **Challenges in quantifying interaction effects** between multiple factors

OTHER TRADITIONAL ANALYTICAL APPROACHES

Beyond Six Sigma, steel plants often employ additional methodologies:

Statistical Process Control (SPC)

While valuable for monitoring process stability, SPC for breakout prevention typically requires:

- Daily chart updates and reviews (1-2 hours per day)
- Regular limit recalculations as processes change
- Specialized training for correct interpretation
- Focus on limited variables (typically 10-20 key parameters)

Root Cause Analysis (RCA) and 8D

These structured problem-solving methodologies are commonly deployed *after* breakouts occur:

- Each investigation requires **2-4 weeks to complete**
- Teams of **5-10 specialists** must be assembled
- Extensive documentation and verification steps
- Limited ability to analyze **complex interactions**

Design of Experiments (DOE)

While powerful for testing hypotheses, DOE approaches to breakout prevention face significant hurdles:

- **Production constraints** limit experimental possibilities
- **High costs** associated with "test to failure" scenarios
- **Months required** to design, run, and analyze experiments
- **Difficulty isolating variables** in production environments

THE HIDDEN COSTS OF TRADITIONAL ANALYTICS

Beyond the direct resource investments, traditional analytical approaches carry substantial hidden costs:

- Opportunity cost of skilled personnel diverted from other optimization efforts
- Delayed implementation of solutions while analysis continues
- Incomplete utilization of available data (typically only 15-30% of collected data is analyzed)
- Knowledge continuity risk as analysis expertise often resides with a small number of individuals
- Inconsistent application across different shifts, teams, and plant locations

Traditional analytical methods, while valuable, simply cannot keep pace with the complexity and speed of modern steel production.

THE TIME AND EFFORT GAP

The reality for many steel producers is stark: traditional analytical methods, while valuable, simply cannot keep pace with the complexity and speed of modern steel production:

- A thorough Six Sigma analysis of breakout causes might take 3-6 months to complete
- By that time, production conditions, materials, or equipment may have changed
- Recommendations may arrive too late to prevent significant financial losses
- The analysis itself represents a substantial investment of scarce expert time

CHALLENGES WITH TRADITIONAL APPROACHES

Fragmented Data Sources

Steel plants generate vast amounts of data across various systems, including mold temperature sensors, casting speed monitors, liquid level controllers, and mold powder usage logs. Modern steel plants generate massive amounts of data across hundreds of sensors – more than humans can effectively monitor. These datasets are often siloed in separate databases or systems that lack seamless integration. Analysts must manually extract and consolidate data from these disparate sources, a process that is both error-prone and tedious.

Manual Data Cleaning & Preparation

Once data is collected, it typically requires extensive preprocessing to make it usable for analysis. This includes tasks such as:

- Aligning timestamps across datasets and joining based on primary keys
- Filling in missing data points
- Filtering out irrelevant or noisy data

These steps demand significant time and expertise, delaying the investigation process.

Time-consuming Visualization-Based Study

Minitab relies heavily on manual input to create visualizations such as scatter plots, control charts, or histograms. Analysts must painstakingly select variables to plot, adjust parameters, and interpret results iteratively. Exploring multiple hypotheses or relationships between variables can quickly become overwhelming when dozens of potential factors are at play.

Difficulty Identifying Patterns

Steel breakouts are complex phenomena influenced by a combination of operational parameters, material properties, and environmental conditions. Identifying patterns or correlations in such multi-dimensional datasets using traditional tools requires significant domain expertise and trial-and-error experimentation. Without advanced automation or machine learning capabilities, subtle but critical insights may go unnoticed.

Lack of Real-Time Feedback

Minitab is primarily designed for post-event analysis rather than real-time monitoring or predictive analytics. This means that by the time an investigation is completed, valuable time has already been lost, leaving the plant vulnerable to additional breakouts before corrective actions can be implemented.

Collaboration Bottlenecks

Root cause analysis often involves multiple stakeholders -process engineers, metallurgists, operators, and quality control teams- each contributing their expertise to the investigation. However, Minitab's static reports and charts make collaborative problem-solving cumbersome, requiring frequent back-and-forth communication and manual sharing of top line findings.

FERO: THE AI SOLUTION ENGINEERS RECOMMEND TO EACH OTHER

By automating labor-intensive tasks like data preparation, hypothesis testing, and visualization, Fero Diagnostics enables engineers to identify root causes in minutes rather than days. This dramatic reduction in investigation time not only minimizes downtime but also empowers teams to implement corrective actions faster, preventing future breakouts and improving overall plant performance.

KEY ADVANTAGES OF FERO DIAGNOSTICS

1. **Pre-Cleaned and Integrated Data:** One of the most time-consuming aspects of traditional root cause analysis is merging and cleaning data from disparate sources throughout the production process from ladle treatment through continuous casting. Fero Diagnostics eliminates this bottleneck by providing pre-cleaned, aggregated data that is immediately ready for analysis. This seamless integration ensures that engineers can begin investigating issues without delays caused by data preparation.
2. **Automated Hypothesis Testing:** Fero Diagnostics leverages advanced AI to automatically test multiple hypotheses about potential causes of a breakout. This capability removes the need for manual trial-and-error exploration, allowing engineers to quickly identify correlations and causative factors. For instance, it can analyze patterns in casting speed, mold temperatures, or liquid steel levels to pinpoint anomalies that contributed to the incident.
3. **Incident Comparison with Historical Data:** Using its "Find Similar" tool, Fero Diagnostics enables engineers to instantly compare the current breakout incident with historical occurrences. By identifying similarities and differences between incidents, the tool provides deeper insights into recurring issues or unique factors that may have led to the breakout. This historical context is invaluable for saving time and developing targeted preventive measures.
4. **Interactive and Explainable Visualizations:** The platform generates interactive visualizations that make complex data easy to interpret. Engineers can explore trends, outliers, and relationships between variables in real-time, gaining a clear understanding of the problem without needing advanced statistical expertise.
5. **Identify Complex Patterns:** Using advanced machine learning algorithms, Fero’s system identifies subtle correlations between variables that human analysts might miss, such as the combined effect of slight chemistry deviations and minor cooling anomalies, or sequential patterns that develop over time, or multi-factor interactions that traditional threshold-based systems cannot detect.
6. **Collaboration and Knowledge Sharing:** Fero Diagnostics facilitates teamwork by allowing findings to be easily shared across departments. Engineers can generate reports that they can share with colleagues, ensuring that everyone, from operators to senior management, has access to the same actionable insights. This collaborative functionality reduces communication bottlenecks and accelerates data-driven decision-making.
7. **Learn and Improve:** Unlike static systems, Fero's platform continuously learns from new operational data, outcomes of implemented recommendations, or changing plant conditions and equipment states.

TRANSFORMATIONAL TIME AND EFFORT ADVANTAGES

The contrast between traditional analytics and Fero's AI approach is striking:

Aspect	Six Sigma	Fero Labs AI Solution
Initial implementation	3-6 months	Minutes to hours*
Data Collection	80-120 hours manually gathering from multiple systems	Automated integration with existing data sources, access to live production data
Data Preparation	40-60 hours of formatting and cleaning	Automated data harmonization and validation, guided tagging where needed
Analysis Time	Weeks of expert analysis	Real-time continuous analysis
Number of Variables Analyzed	Typically 15-30 key variables	Hundreds of variables simultaneously
Update Frequency	Project-based, often quarterly or annually	Continuous learning and rapid adaptation
Personnel Requirements	Cross-functional team of 5-10 specialists	1 engineer, minimal oversight, no additional staffing or expertise
Time to Insights	Months	Seconds to minutes
Time to Value	6-12 months	Minutes to hours

**Assumes customer is using Fero Live Production*

UNPRECEDENTED SPEED, ACCURACY, & IMPACT

Steel producers implementing Fero's AI solution have experienced dramatic improvements:

- **Real-time analysis**: Continuous monitoring without delays
- **Immediate recommendations**: Actionable insights delivered instantly to operators
- **90% reduction in false alarms** compared to traditional threshold-based systems
- **95% detection rate** for conditions that would lead to breakouts
- **Specific variable identification** pinpointing exact causes and remedial actions
- Early prediction: Potential breakouts identified 15-30 minutes before traditional detection systems

A BREAKOUT WORKFLOW USING FERO

Unlike traditional methods that require extensive manual data preparation and manual hypothesis testing, **Fero** provides a streamlined, automated approach where engineers can focus on solutions rather than data wrangling.

Where most process workflows begin with a failure, a typical workflow in Fero starts with a real-time **alert** to help highlight issues before they impact production. **Fero Alerts** can be customized to track whatever is most important to you, whether it's predicting quality metrics, tracking production changes, identifying a defect, and more.

Upon receiving an alert, Fero users would typically run a diagnostics workflow for Breakouts in **Fero Diagnostics** to diagnose the issues leading up to the breakout, and would run an instant batch comparison analysis using **Fero's Production Zone Identifier (PZI)** to compare a heat with a breakout to a heat without casting issues.

Together, these tools swiftly reduce the time to actionable insights to have your operations running efficiently in a fraction of time.

We recently collaborated with a new customer whose quality engineer had just spent an ***entire day*** analyzing the source of a breakout. Using **Fero Diagnostics** the engineer identified the same root cause in less than 15 minutes.

WHO BENEFITS FROM FERO'S AI SOLUTION?

Fero's platform creates value across the steel production team:

Metallurgists

- Gain deeper insights into complex variable interactions
- Test theories against comprehensive historical data
- Focus expertise on improvement rather than firefighting
- Document and preserve metallurgical knowledge systematically

Process Engineers

- Receive specific, actionable recommendations
- Understand process limits with greater precision
- Identify opportunities for process optimization
- Implement changes with confidence backed by data

Meltshop Managers

- Reduce costly breakout incidents
- Improve overall equipment effectiveness
- Decrease unplanned downtime
- Enhance safety for personnel
- Meet production targets more consistently

Plant Leadership

- Improve profitability through reduced waste and downtime
- Decrease capital expenditures for emergency repairs
- Retain institutional knowledge despite workforce changes
- Demonstrate commitment to technological advancement
- Executive reporting of revenue savings and emissions reductions

BEYOND BREAKOUTS: ONE PLATFORM FOR ALL YOUR NEEDS

While breakout prevention alone justifies implementing Fero's AI solution, it's just the beginning. The same platform can address:

- Quality optimization: Reduce defects and improve grade consistency
- Yield improvement: Reduce material losses throughout production
- Slag optimization: Production efficiency and environmental impact
- Energy efficiency: Minimize energy consumption while maintaining quality
- Reclassification from Live Production: From root cause analysis to backtesting changes

THE FUTURE OF STEEL PRODUCTION

The steel industry has always adapted to new technologies – from basic oxygen furnaces to continuous casting. AI represents the next frontier in this evolution.

Fero Labs' solution doesn't replace the expertise of metallurgists, engineers, and operators – it enhances it. By handling the massive data analysis that exceeds human capacity, AI frees experts to apply their knowledge more effectively and strategically.

The results speak for themselves: fewer breakouts, reduced downtime, high quality products, and better bottom-line results.

TAKE THE NEXT STEP

Stop wasting time with old tools and techniques. Contact a Fero expert today to see for yourself how Fero streamlines breakout diagnostics.

BOOK A BREAKOUT DIAGNOSTICS DEMO

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