

Enhancing XRF Reliability through Automated Vision-Based Pellet Inspection

Abstract

The mechanical integrity of pressed pellets is a critical factor for reliable XRF and XRD analysis and safe instrument operation. Defective samples can release particles during handling or measurement, leading to contamination of the analytical instrument and unplanned downtime. This application note presents an automated vision-based inspection system implemented in PrepMaster Vision, which evaluates pellets immediately after pressing and prior to analysis. By combining darkfield illumination with adaptive image processing, the system enables robust detection of surface defects and missing material, even under challenging conditions such as slag samples and varying geometries. The solution provides a reliable quality control step that improves process stability, reduces operator dependency, and protects analytical equipment in routine laboratory environments.

Key words

• Pressed Pellets • Machine Vision • Image Processing • Laboratory Automation • XRF • XRD

Introduction

Reliable XRF analysis depends fundamentally on the mechanical integrity of pressed pellets. Even minor defects such as cracks, edge breakouts, or insufficient material can lead to particle release during transport or measurement. This not only compromises analytical accuracy but also introduces a significant risk of contamination inside the analyzer, often resulting in unplanned downtime for cleaning and recovery.

In modern automated laboratories, where high throughput and minimal operator intervention are key objectives, such risks become even

more critical. Manual inspection is often inconsistent, operator-dependent, and difficult to integrate into fully automated workflows. As a result, undetected defective samples can pass into the analytical stage, where their impact is significantly more costly.

To address this challenge, PrepMaster Vision introduces an automated inspection step immediately after pellet pressing, for example in combination with the HP-MP, and prior to transfer to the analyzer. The system evaluates each pellet in real time using advanced imaging and classification methods and ensures that

only mechanically stable samples proceed to analysis. By integrating this inspection directly into the automated workflow, a reliable and reproducible quality gate is established, improving both process stability and overall laboratory efficiency.

Methods

The inspection system combines a tailored optical setup with advanced image analysis to ensure reliable detection under realistic laboratory conditions. Darkfield illumination is used to enhance surface irregularities, making defects such as cracks, fractures, or chipping clearly visible even on difficult materials like slag (Figure 1). At the same time, the inspection task is complicated by the geometry of the pellet-ring assembly. The front side of the pellet appears nearly flush with the ring, while the opposite rear side is recessed, resulting in significantly different visual characteristics and local shadowing effects.

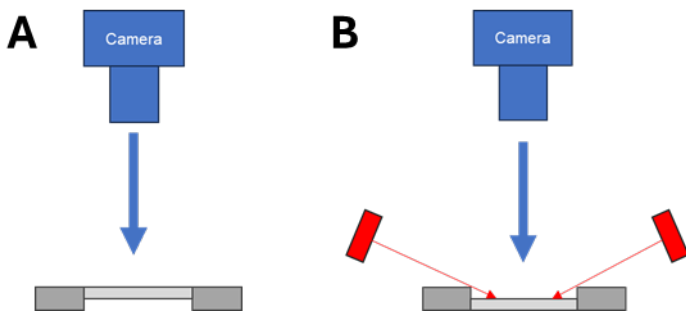


Figure 1: Visual inspection of the (A) front side and the (B) rear side of a pressed pellet.

To overcome these challenges, the system applies adaptive thresholding techniques that evaluate local image regions rather than relying on global intensity thresholds. This enables robust segmentation of the pellet surface despite non-uniform illumination, geometric shadowing, and natural variations in surface texture (Figure 2).

In addition to detection of defects, the software determines whether a valid sample is present inside the ring at all. The final classification is

based on the proportion of the surface identified as intact. If this proportion falls below a configurable threshold, the pellet is rejected. This concept provides a transparent and application-oriented decision criterion that can be easily adapted to specific quality requirements.

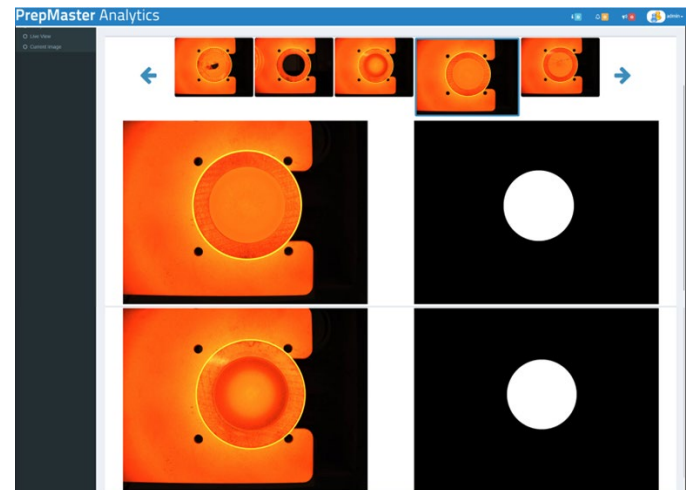


Figure 2: PrepMaster Vision interface showing pellet images and corresponding segmentation results.

Results

The system demonstrates stable and reliable performance across a wide range of real-world conditions. Damaged pellets are consistently identified due to the pronounced surface irregularities that indicate a risk of particle detachment (Figure 3 A, B). The system also detects samples that have been ground inefficiently and still contain particles of large particle sizes. Accordingly, the image exhibits a highly heterogeneous, fragmented pattern with dense, irregularly distributed high-contrast regions (Figure 3 C). At the same time, intact samples are correctly classified even when their appearance varies significantly between the two sides of the pellet.

Notably, the inspection remains robust despite shadowing effects introduced by the darkfield illumination and the ring geometry. Even in challenging cases, such as highly inhomogeneous slag surfaces, the adaptive image analysis ensures consistent classification results. This robustness is particularly important

in routine laboratory environments, where variations in sample composition and surface structure are unavoidable.

Furthermore, severe pressing failures, where no valid pellet is present, are reliably detected and handled by the system. The classification results are stable over verification, indicating a high degree of reproducibility. Overall, the system achieves a dependable separation between acceptable and defective samples, providing a solid basis for automated downstream processing without additional manual verification.

A key strength of the solution lies not only in its detection performance but also in its usability. The software is designed for practical operation in routine environments, offering intuitive configuration, flexible parameter adjustment, and the ability to evaluate stored images for optimization purposes. A live view function further supports efficient setup and maintenance by simplifying camera alignment and system adjustments.

Overall, PrepMaster Vision establishes a robust and user-friendly quality control step that enhances process stability, improves instrument availability, and supports consistent analytical performance in automated laboratories.

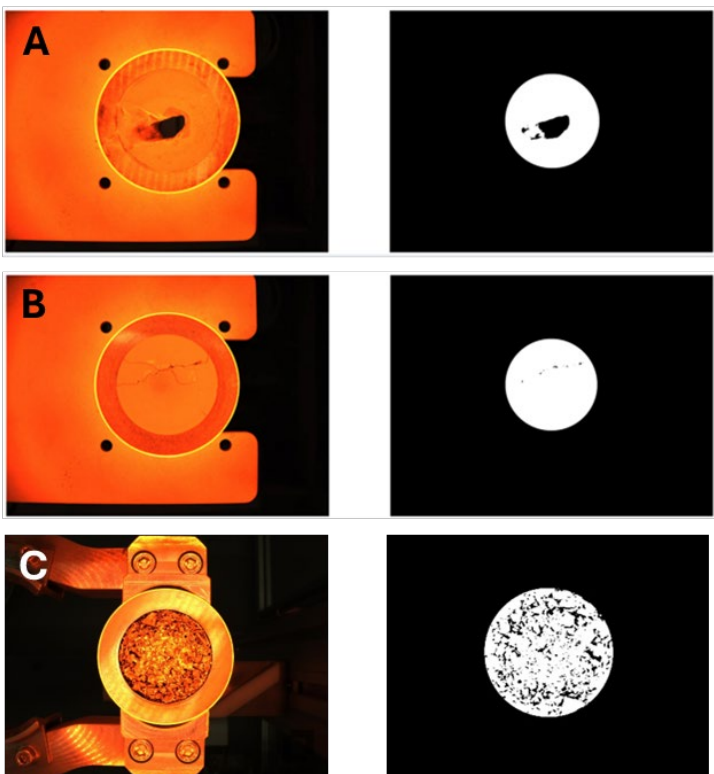


Figure 3: Representative inspection results of pressed pellets using PrepMaster Vision. (A) Severely damaged pellet with a large breakout. (B) Pellet with a fine crack; minor localized defects are detected. (C) Highly heterogeneous slag sample because of insufficient grinding; the segmented image shows a dense distribution of irregular structures.

Discussion

By integrating automated visual inspection into the sample preparation workflow, PrepMaster Vision substantially increases the reliability of XRF operations. The system prevents defective samples from reaching the analyzer, thereby reducing contamination risks and avoiding costly downtime. At the same time, it replaces subjective manual inspection with an objective and reproducible evaluation method.

HERZOG



Germany

HERZOG Maschinenfabrik
GmbH & Co. KG

Auf dem Gehren 1
49086 Osnabrück
Germany

+49 541 9332-0
+49 541 9332-33
info@herzog-maschinenfabrik.de

Subsidiaries

USA	Japan	China	India	France
<p>HERZOG Automation Corp.</p> <p>8245 Dow Circle Strongsville, OH, 44136 USA</p> <p>+1 440 891 9777 info@herzogautomation.com www.hertzogautomation.com</p>	<p>HERZOG Japan Co., Ltd.</p> <p>3-7, Komagome 2- chome Toshima-ku Tokio 170-0003 Japan</p> <p>+81 3 5907 1771 +81 3 5907 1770 info@herzog.co.jp www.hertzog.co.jp</p>	<p>HERZOG (Shanghai) Automation Equipment Co., Ltd.</p> <p>No.473, West Fute 1st Road, Waigaoqiao F.T.Z, Shanghai, 200131, P.R. China</p> <p>+86 21 50375915 +86 21 50375713 MP: +86 15 80 07 50 53 3 xc.zeng@herzog- automation.com.cn www.hertzog-automation.com.cn</p>	<p>HERZOG Automation India Office No 416, 4th Floor, Westport, Baner Gaon Pune, Pune City, Maharashtra, 411045 Indien</p> <p>+49 541 9332 40 info@herzog-automation.in www.hertzog-automation.in</p>	<p>HERZOG FRANCE 8 bis, Rue Gabriel Voisin, 51100 REIMS France</p> <p>+33 (0)6 81 72 41 65 nolan.lopez-at-herzog- automation.fr www.hertzog-automation.fr</p>