White paper

How mature is your steel analysis?

As the demand grows for lighter-weight, more durable steel products, today's steel manufacturers are under pressure to create higher-value steel that includes the specific characteristics their customers require. Those that can meet this demand will command better prices for their products, while improving their competitive standing.

Yet producing premium steel requires next-generation tools that can produce high-quality data. Today, steel manufacturers typically turn to optical microscopes to identify the size and number of non-metallic inclusions, but these microscopes don't provide information about the chemical makeup. As a result, steel manufacturers lack the complete information they need to optimize their steel making process.

The Thermo Scientific™ Phenom™ ParticleX Steel Desktop Scanning Electron Microscope (SEM) addresses this issue, providing the fast, accurate, and complete information steel makers need to optimize their production process.

Challenges facing today's steel manufacturers

An infinitely recyclable and strong material, steel is a backbone of our modern economy. From the bridges and vehicles that form our transportation system to the windmills and power plants that provide our energy, steel is critical to the everyday lives of almost every country around the globe.

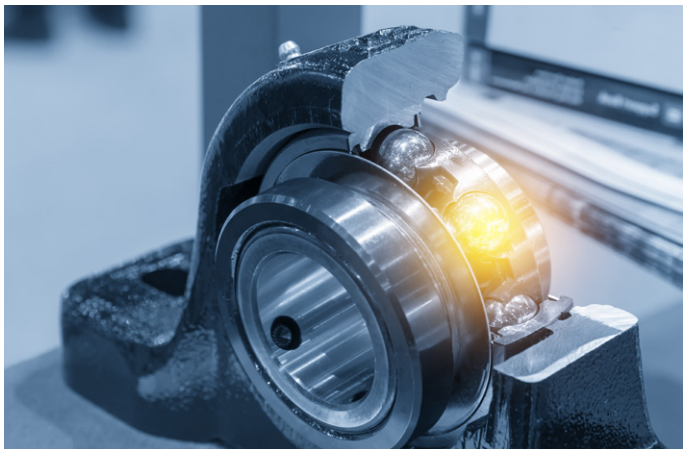
Steel makers that can meet the growing demand for high-quality steel will command the highest prices for their products and ultimately improve their competitive standing.

Demand is growing for higher-value steel

As manufacturers compete to create more durable, lighter weight products, the demand for high-strength steel is increasing. Today, roughly half of the 1,900 million tonnes of steel produced on an annual basis is needed for high strength applications.[1] Moreover, the market for advanced high strength steels and electrical steel is growing at a rapid rate as automakers are increasingly using such steels to meet new regulations and energy providers expand renewable energy sources.

Take the automotive industry, for example. To be competitive, today's auto manufacturers are under pressure to produce longer-lasting, lighter weight vehicles—and any component that misfunctions can undermine the manufacturer's competitiveness.

For example, every steel ball bearing that spins between the wheel and the axle needs to last at least 100,000 miles on every car the company produces, and an inclusion of just 50 microns can cause the bearing to begin to fail. In today's competitive market, steel makers that can meet automakers' demand for longer-lasting steel can command the highest prices for their product—and ultimately improve their market position.



The challenge of producing premium steel

Steel is not a single product and steel is not homogeneous. There are more than 3,500 varieties of steel,2 each with varying degrees of ductility, strength, and other properties. These properties are determined, in part, by the non-metallic inclusions that slip into the product during the manufacturing process. Left uncontrolled, these inclusions can damage the quality of the steel and even disrupt the production process, resulting in lost revenue and time.

Different steel applications require different degrees of cleanliness. For example, a 15-micron inclusion in a tire cord can be enough to break the component during manufacturing. Yet up to a 100-micron inclusion may be allowable in an automotive component such as structural tubing.

Manufacturing steel with the desired properties requires controlling the non-metallic inclusions. And to do that, manufacturers must obtain a quick and accurate understanding of the number, size, and chemistry of the inclusions both as the steel is manufactured and later as failures are identified by the manufacturer of the final component.

Historically, researchers have turned to optical microscopy to rate the size and number of inclusions, but this hasn't allowed them to identify what the inclusion is. In addition, they've been required to use two separate instruments—an optical microscope for inclusion analysis during the steel making process and a manual scanning electron microscope (SEM) for failure analysis of the manufactured components, adding to their costs and complexity.

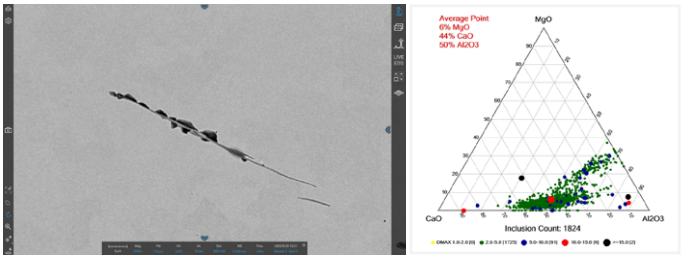
Without the right tools to control their inclusions, it can be cumbersome, and even impossible, to meet customer demands for steel with the desired properties for each specific application. To manufacture the next-generation high-strength steel, metallurgists require fast access to higher-quality data. They also need a versatile instrument that can accurately evaluate inclusions at various stages of the production cycle.

Introducing Phenom ParticleX Steel Desktop SEM

The Phenom ParticleX Steel Desktop SEM is designed to give steel manufacturers the quick, accurate, and complete information they need to develop higher-quality steel. One of three products in the ParticleX family, the Phenom ParticleX Steel Desktop SEM is specifically designed to help steel manufacturers rapidly assess steel cleanliness based on the quantity, morphology, and chemical composition of non-metallic inclusions.

Integrated EDS analysis

The Phenom ParticleX Steel Desktop SEM directly integrates advanced energy dispersive X-ray (EDS) analysis into the microscope. Reliable, high-quality SEM images can be obtained in less than one minute. What's more, researchers can quickly analyze the size and location of each inclusion down to 0.5 microns, while also obtaining the elemental composition of each particle. Knowing the size, number, and chemistry of inclusions, steel makers can optimize their steel making process for specific applications and customer demands.



The Phenom ParticleX Steel Desktop SEM can be used for flexible SEM-EDS failure analysis during the day (left), while being set up for automatic and unattended inclusion analysis at night and on weekends (right).

Dual uses

A key benefit of the Phenom ParticleX Steel Desktop SEM is that it can be used for the dual purposes of inclusion analysis during the steel making process and failure analysis after the component has been manufactured. During the day, researchers can manually use the instrument to pinpoint the root cause of failures identified by the customer after the final product has been manufactured. Overnight and on weekends, the SEM can be set up for automated routine inclusion analyses as part of the steel manufacturing process. Together, these capabilities give manufacturers the complete information they need to accelerate the development of higher-quality steels.

Automation and ease-of-use

The Phenom ParticleX Steel Desktop SEM fully automates inclusion analysis of steel processing samples, allowing users of all experience levels to see the chemistry, size, and shape of inclusions within seconds. Built-in templates and automated recipes enable researchers to quickly get started and then tailor these recipes to their specific needs as they become more familiar with the microscope.

Moreover, with a streamlined user interface, foolproof sample loading, and industry specific software, anyone can get quality results from the instrument almost immediately, extending failure analysis to a broader number of users.

Small form factor

The highly versatile microscope fits on a desktop, freeing up valuable laboratory space. The small instrument footprint makes the Phenom ParticleX Steel Desktop SEM easy to add to any analytical lab without the need to adjust the facility infrastructure—including crowded, centralized labs and smaller steel mills that previously outsourced their quality control efforts.

The Phenom ParticleX Steel Desktop SEM is small enough to fit on a desktop, making it versatile to use in almost any lab without the need for expensive renovations.

CeB_6 source

The Phenom ParticleX Steel Desktop SEM is the only cerium hexaboride (CeB_6)-source instrument on the market that is specifically made for inclusion analysis. The high-brightness CeB_6 source allows characterization of inclusions down to the sub-micron level. It also provides at least double the service life of Tungsten sources found in most SEMs. And unlike a Tungsten source, which can fail suddenly and contaminate the column, a CeB_6 source slowly degrades over time, allowing users to predict its failure and replace it between operating sessions.

Zenith Steel optimizes its steel making process

Founded in 2001 in the Jiangsu province of China, Zenith Steel produces steel components used in commercial vehicles and engineering machinery. These industries have different requirements for the steel they use, requiring Zenith to strictly control its steel making processes.

Thermo Fisher Scientific's advanced SEM instruments have enabled Zenith Steel to more quickly and accurately identify the root cause of failures that occur as its customers build the finished product. For example, the steel tire cord can break as auto manufacturers draw the steel to create a wire. And when that happens, the steel is sent back to Zenith, whose engineers analyze the inclusions that caused the fracture, including the composition, size, and position.

The company also uses Thermo Scientific instruments to conduct thousands of quantitative analyses on liquid process samples so it can improve the quality of the steel it produces.

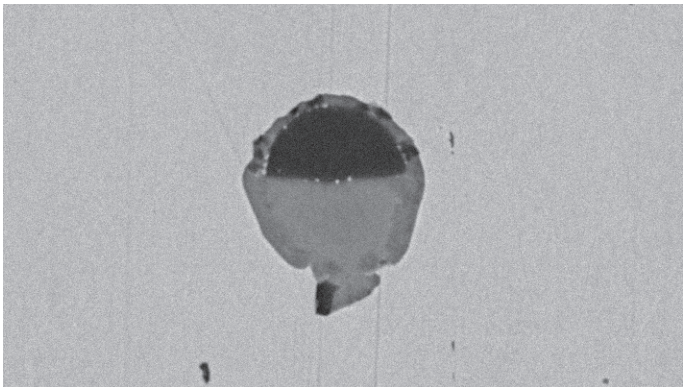
"I think the biggest value of this equipment ... [lies] in the fact that we can make full use of its features to facilitate the optimization of our steel making process," says Wang Kunpeng, Deputy Chief Engineer at Zenith Steel.

One tool, dual uses

The Phenom ParticleX Steel Desktop SEM combines two modes of operation: an easy-to-use system for manual SEM-EDS failure analysis of manufactured steel components and a fully-automated, recipe-driven SEM-EDS system for the analysis of inclusions during the steel making process.

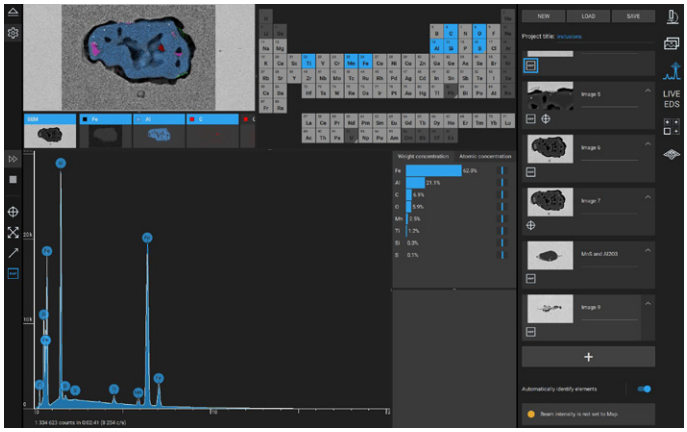
Fast and accurate failure analysis

The instrument's easy-to-use user interface allows users to quickly and accurately identify the root cause of component failures. A full-screen SEM image is captured within less than one minute after loading the sample. Users can then quickly zoom in to examine areas of interest at high magnification without losing where they are on the sample.



The Phenom ParticleX Steel Desktop SEM enables users to quickly zoom in to determine the root cause of component failures. Here the user zoomed in an 8.8 micrometer sized inclusion for further analysis.

Take a small particle that's stuck to the grid of a component. As you zoom in, you can collect EDS information about the particle, seeing both its size and morphology along with its chemical makeup using the integrated EDS detector and elemental mapping. Within just a few clicks, you can see the particle, capture the EDS spectrum, and generate a customized report summarizing your results.



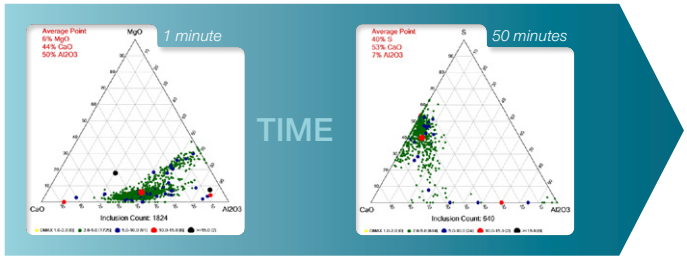
Using the Phenom ParticleX Steel Desktop SEM, users can zoom into an inclusion at high resolution, quickly identifying the particle's size, morphology, and chemical makeup. Here the user analyzed the chemical makeup of a 23 micrometer sized inclusion.

Automated inclusion analysis

The Phenom ParticleX Steel Desktop SEM can also be used for automatic, unattended inclusion analysis, helping metallurgists to quickly determine the quality of manufactured steel by providing insight into the quantity and chemistry of inclusions that emerge during the steel making process. The instrument analyzes a selected area, taking SEM images and EDS spectra from all the inclusions that are present and displaying the data as ternary diagrams.

Understanding nozzle clogging

Different variables can be studied at any point during the steel making process. For example, one issue steel makers face is the costly blockage of the caster nozzle due to the changing composition of inclusions during the casting process. When pouring steel from the ladle into the tundish, calcium sulfide inclusions can mix with oxygen to become calcium aluminate and magnesium aluminate. Using SEM analysis to understand these chemical changes over time gives steel makers the direction they need to decrease the re-oxidation in the tundish.

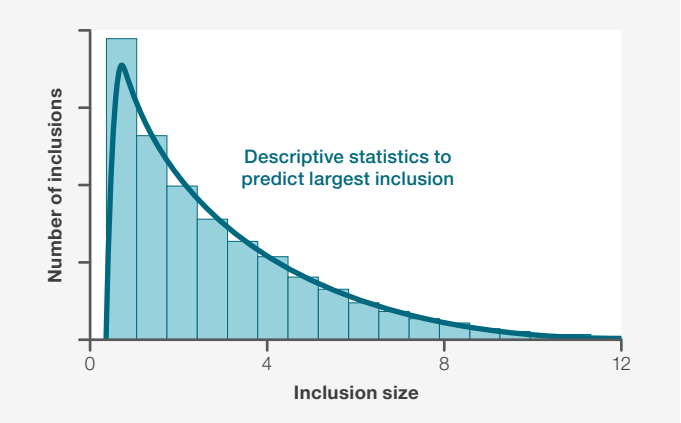


Using the Phenom ParticleX Steel Desktop SEM, steel makers can observe re-oxidation phenomena over time to better understand the nozzle clogging process.

With the results displayed in ternary diagrams, metallurgists can identify the inclusions present at different points in time, observing the re-oxidation phenomena to better understand nozzle clogging and optimize the steel making process.

Predicting the largest inclusions

Another challenge steel makers face is predicting the failure rate of finished steel. With the large quantity of steel most manufacturers produce each day, it would be impossible to measure every inclusion. Yet with the Phenom ParticleX Steel Desktop SEM, metallurgists can measure the inclusions in specific areas and then use a statistical model to predict the overall failure rate.



Combining the Phenom ParticleX Steel Desktop SEM with a statistical model, steel makers can predict the largest inclusions that are present according to ASTM E2283 standard practice for extreme value analysis.

Using the Phenom ParticleX Steel Desktop SEM to measure the size, morphology, and chemistry of inclusions in a sufficiently large area and then entering this data into a statistical model, metallurgists can predict the largest inclusions that are present as described in the ASTM E2283 standard practice for extreme value analysis of non-metallic inclusions in steel. And since the largest inclusions are typically where failures occur, steel makers have the information they need to optimize the steel making process, while accurately certifying the quality of their steel products.

Accelerate the development of premium steel

Do you have the easily obtainable, high-quality data you need to manufacture premium steel? The easy-to-use Phenom ParticleX Steel Desktop SEM extends quality control to a broader range of users, helping manufacturers to reduce the failure of steel manufactured components and improve the quality of their steel. With the fast, accurate, and complete information you need to analyze non-metallic inclusions, you can meet the demand for higher-value steel—ultimately strengthening your profits and your competitiveness.

Notes

1. "1,900 million tonnes of steel produced on annual basis"Source: https://www.worldsteel.org/about-steel.html
2. "More than 3,500 varieties of steel" Source: https://www.worldsteel.org/about-steel/steel-facts.html

Watch the webinar

Phenom ParticleX Steel workflow introduction

Duration 6:23

Learn more at **thermofisher.com/phenom-particle-x-steel**