



LadleCheck

Thermal Imaging System for a Reliable Condition Monitoring of the Refractory Lining

- Increased Safety for Steel Production
- Prevention of Liquid Steel Breakouts
- Early Identification of Excessive Wear
- Maximization of the Refractory Lining Service Life
- Optimized Refractory Maintenance

Ladle Monitoring

The LadleCheck Refractory Monitoring System serves as a key solution to increase safety in steel making and to support the ladle maintenance schedules. It minimizes the risk of liquid steel breakouts while maximizing the lifetime of the refractory lining.

Increased Safety for Steel Plants

Liquid metal breakouts from a defective refractory lining of a ladle are a common danger in steel production. The well known consequences are damages of the surrounding equipment, high repair costs and loss of revenue due to production delays. Besides this economical impact there is always a high risk of personnel injuries or even the loss of lives.

The LadleCheck system is designed to effectively prevent hot breakouts. By continuously monitoring the ladles during production, areas with defects or depletions in the refractory lining are automatically detected long before they become critical.

Cost Reduction

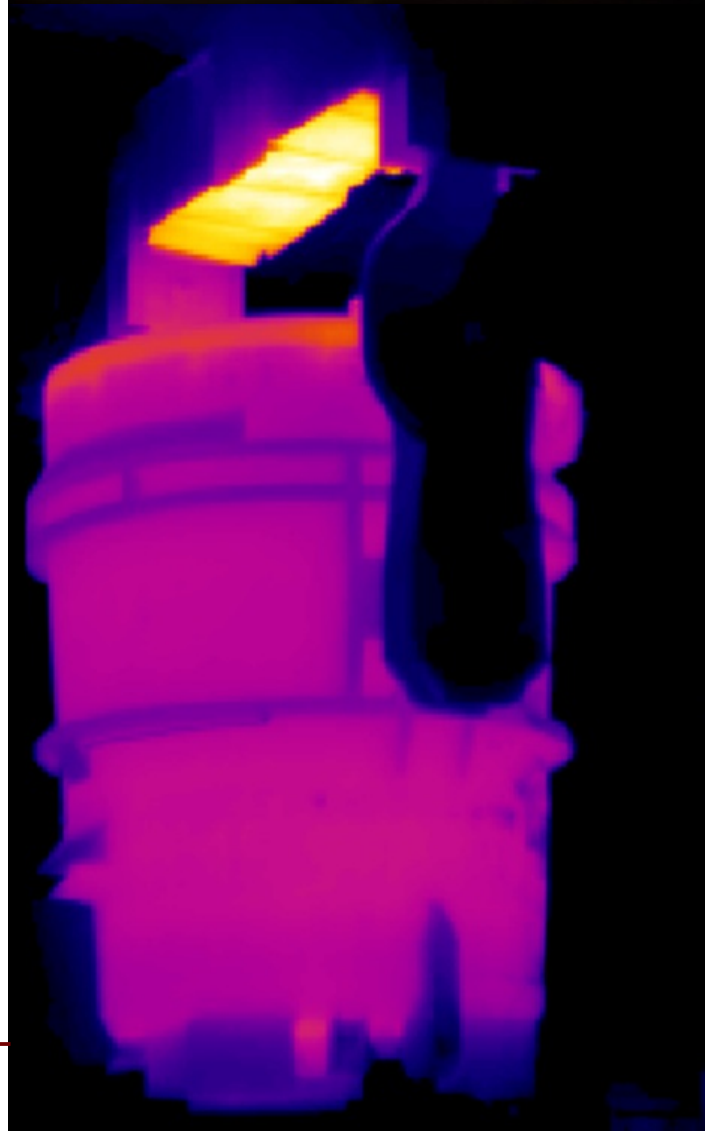
The system also helps to reduce the production costs by extending the service life of the ladle refractories. Each time the fireproof lining gets into contact with liquid metal its condition deteriorates until finally the ladle must be relined. Generally, the maintenance schedule for the refractory is determined based on experience. For safety reasons, the time intervals are commonly quite conservative.

LadleCheck allows a reliable assessment of the remaining lifetime of the refractory lining. The number of heats can thus be maximized without any safety issues and the re-lining can be scheduled more precisely. Considering the high costs for the refractory maintenance, the system can significantly contribute to a reduction of the production costs of steel.

How it Works

While the ladles are transported by the overhead crane, several thermal imaging cameras automatically measure the temperature distribution on their external surface. The measurements are performed in full movement; there is no need to stop the crane. Due to the completely modular concept of the LadleCheck system, an inspection station can comprise a varying number of cameras. For covering the complete outer surface of the ladle including the bottom, generally 4 - 5 cameras are required.

Once a measurement is performed, the thermal data are analyzed and the status of the ladle is indicated to the crane operator. All thermal images, the temperature data and process related data are stored in a database enabling dedicated analyses of the refractory lining status.



Ladle Monitoring - Features

Temperature Trend Analysis

Based on stored data of previous measurements LadleCheck analyzes the temperature as a function of the ladle service time. A sudden increase in the temperature trend implies a potential breakdown of the refractory and will trigger an alarm. Moreover, the temperature trend also provides a clear information for the progression of refractory wear, allowing to schedule maintenance activities more precisely.

Alarm Colors

Areas on the ladle, where the temperatures indicate excessive wear or a defect are highlighted with alarm colors in the on-screen display. This way, the operator gets a clear impression about the location and severeness of a potential problem with the refractory.

Ladle status indication

Depending on the configuration of the LadleCheck system, the ladle status is displayed to the operators in multiple different ways:

- A signal light shows the condition information to the crane driver immediately after a measurement has been released.
- If the crane cabin is equipped with a computer, the Status page of the web application will give the crane driver all the additional details about the p measurement.
- Other personnel, like the operators in the control room or the ladle maintenance personnel may use the pages of the web application, either to display the data of the current measurement or to perform a dedicated analysis.

Various Interfaces

LadleCheck features various interfaces for connecting to your process control, data management and visualization. This comprises ODBC for connecting to a database as well as a data-telegram server for the exchange of process related data via LAN. With its COM/DCOM automation interface the system can be easily connected to a PLC, a process-visualization, or other computers.

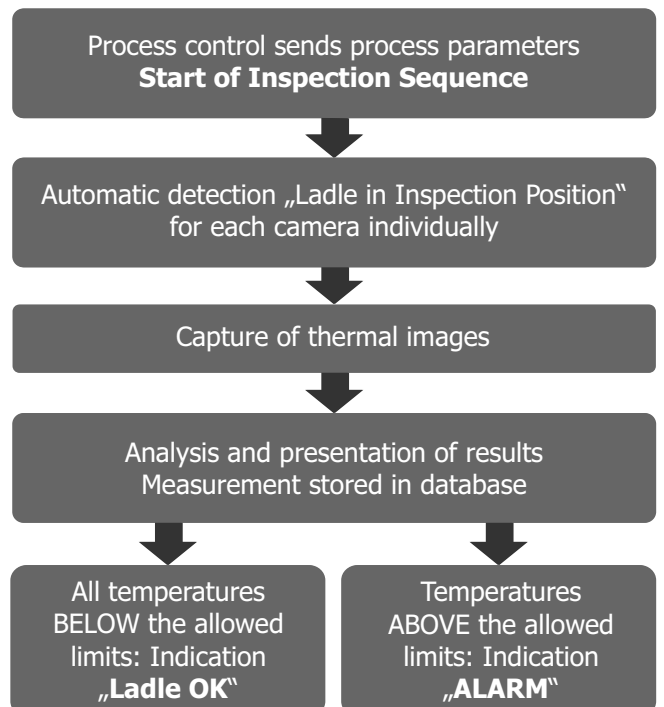
Designed for steel plants: Robust and Fail-Safe

The whole system is designed for reliable 7/24 operation in the harsh environment of a steel plant. Integrated self-diagnostic functions continuously monitor all components. Any possible functional impairment will be immediately detected and indicated. All system states are displayed and stored in a log file in the database which grants for a full traceability. With its intelligent reconfiguration-functions the system is able to eliminate most malfunctions without any user interaction.

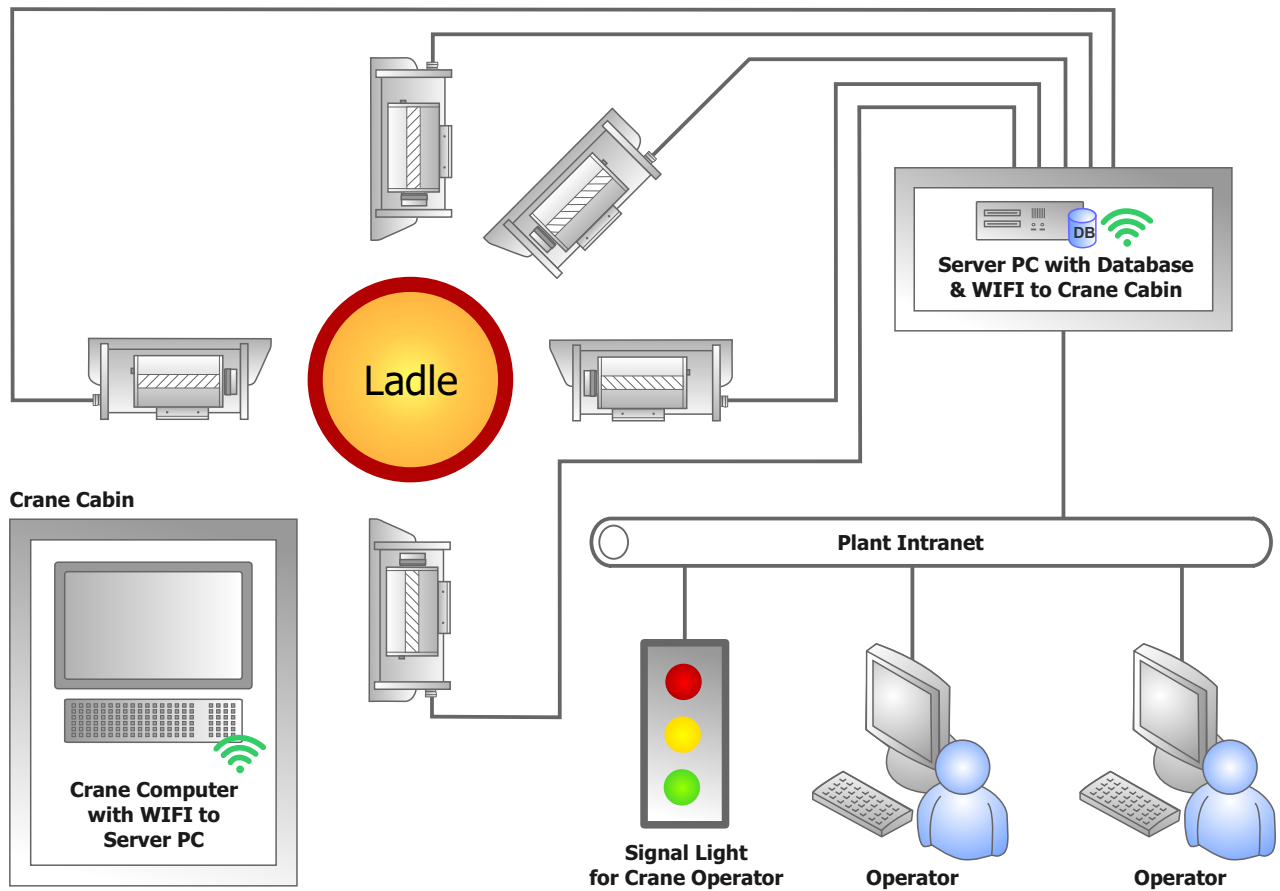


Alarm colors highlight potentially problematic areas in the thermal images

Inspection Sequence



System Setup



Typical Ladle Inspection Station:

- 5 thermal cameras in air-cooled enclosures for monitoring the complete outer surface of the ladles
- Server computer with database and web server
- Signal light for indicating the ladle status to the crane operator
- Computer in the crane cabin for the display of details about the current measurement

Key Advantages :

- Increased Safety for Steel Production
- Prevention of liquid steel breakouts
- Early identification of areas with increased wear
- Cost savings: Maximization of the refractory lining service life without safety risks
- Optimized refractory maintenance schedule and strategy
- Efficiency comparison of refractory linings

Key Features :

- Fully automated measurement sequence; no operator interaction required
- Modular and scaleable: 1 to 5 thermal cameras to cover the whole ladle surface
- 100% Traceability: Automatic storage of images, measured temperatures and process related data
- Advanced data management and analysis with database and web server
- Various interfaces for connecting to your process control, data management and visualization

Ladle Monitoring - Features

The LadleCheck system comprises the complete functionality for performing the inspections on all ladles of the steel plant, as well as for storing and analyzing the data.

Completely automated Inspection Procedure

Inspections are performed fully automatically in the background without any operator actions. The software utilizes highly accurate shape recognition functions and object tracking routines which determine for each camera individually, if the ladle is in the optimum position for performing a measurement. The measurement is then released automatically. With these features the crane driver can focus on his job in the usual way; neither there is a need to drive the ladle to a defined measurement position nor to perform any operating steps for releasing the measurement.

Customizable Inspection

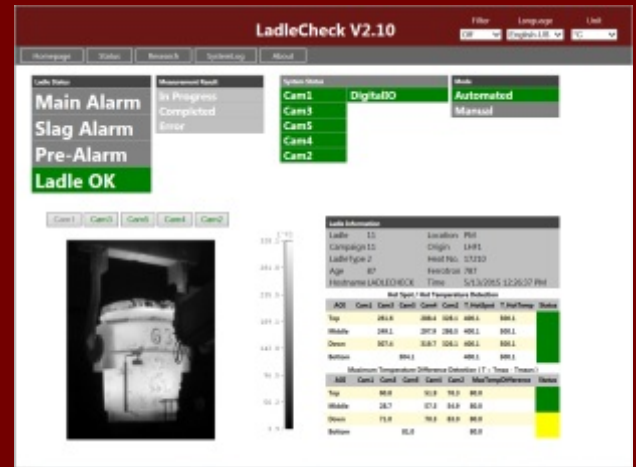
All settings for temperature measurement and evaluation are completely adjustable with an easy-to-use fully graphical operator interface. This allows an optimum adaptation to the ladles and production conditions of the steel plant. Temperatures are evaluated in individual areas which can be freely placed within the infrared image of the ladle. With LadleCheck you can use an unlimited number of these so called Regions of Interest, to get an arbitrarily fine subdivision for the temperature evaluations on the ladle surface. During an inspection the measured temperature data are compared with preset alarm thresholds. Temperature data outside the Regions of Interest will not be considered for the evaluation, thus effectively preventing false alerts due to other hot objects in the image.

Advanced Data Management

LadleCheck includes a powerful database for automatically storing the temperature data, the thermal images and the process parameters (ladle ID, heat number, campaign, ladle type, measurement location etc...). This allows a long-term analysis for all ladles. The database may also be connected to the intranet of the plant in order to allow data exchange and to pass the data to other data processing systems.

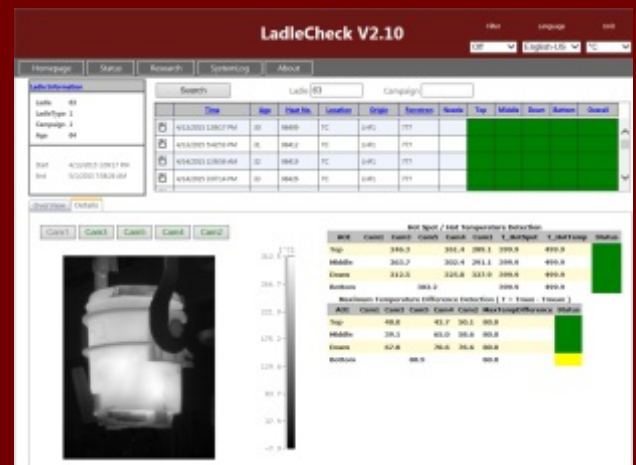
Web Application for Data Display and Data Mining

A configurable web-application serves for displaying the inspection results and for performing extensive analyzes. With this concept an unlimited number of users can get simultaneous access by just using a standard web-browser. The web-application includes several pages: A Status page gives a complete overview of the currently performed inspection, showing all temperature data, thresholds, thermal images and process-related data. With the Research page the user can perform detailed analyzes for all ladles, based on the content in the database. The SystemLog page lists all status messages, ensuring a complete traceability of all system functions.



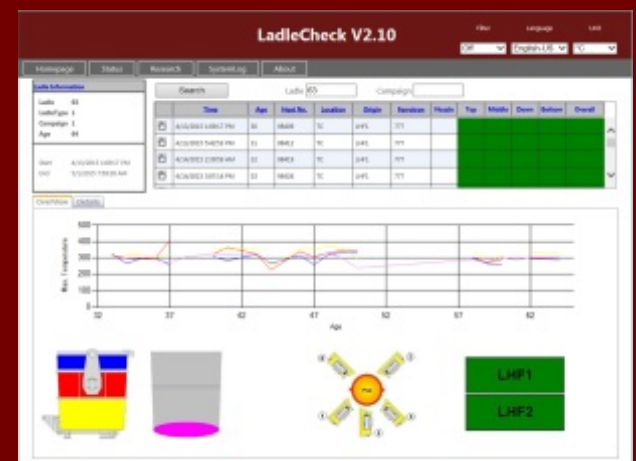
Status Page of the Web Application

Display of detailed information about the current measurement



Research Page of the Web Application

Details about previous measurements on the ladle



Research Page of the Web Application

Temperature trend for selectable Areas of Interest on the ladle

Ladle Monitoring - Technical Data

Thermal Cameras

Maintenance-free thermal cameras with un-cooled detector (5 pcs. for capturing the complete outer surface of the ladle). The cameras are consistently designed for industrial applications, featuring intelligent processing functions and a Standard-GigE-Interface for data exchange. They are calibrated with an extended measurement range of up to 600°C for measuring absolute temperatures with high accuracy.

Type	IRSX-I Industrial Infrared Camera	
Temperature Measurement Range	-40°C to +600°C	
Temperature Measurement Accuracy	± 2°C or ± 2% of reading	
Thermal Resolution	0.1°C	
Image Pixels	336 x 256	640 x 512
Field of View	25° x 19°	45° x 35°
	other lenses available on request	
Frame Rate	9 Hz or 60 Hz	
Detector	Uncooled Microbolometer	
Interface	Gigabit Ethernet	
Ambient Temperature Range	-40°C to +60°C	
Weight	310 g	
Dimensions	55mm x 55mm x 87mm	
Protection Class	IP67	

Camera Enclosures

Double-chamber protective enclosure, manufactured from stainless steel. An air barrier installed at the front side effectively prevents dust formations at the durable Germanium window. All connection cables are guided through one cable gland with a high-temperature-resistant hose at the rear of the enclosure. Equipped with a wall mount with manually adjustable joint, the enclosures can be easily installed in any required position.

Type	IRCamSafe AIW 168
Enclosure Material	Stainless Steel
Coolant	Air or water
Germanium Window	Ø70mm x 3mm, DLC coated
Air Barrier	Adjustable air flow, supply pressure 1 - 3 bar
Cable Protection	Heat resistant hose, configurable length. Resistance to thermal load: up to +1640°C
Ambient Temperature Range	-40°C to +350°C
Weight	10.5 kg
Dimensions	Ø168mm x 505mm
Protection Class	IP67
Mounting Bracket	Heavy duty bracket with joint, made from stainless steel. Load rating 45 kg.

Other Components

Server Computer	Industry standard server computer, 19"metal case for rack installation. The server computer hosts the LadleCheck measurement software, the database and the web-server
IRCamSafe Controller	Integrated inside the camera enclosure. The board gives a significantly reduced installation effort, allowing a direct connection to mains power and Ethernet without any additional connection cabinet. It features various sensors to continuously monitor the ambient conditions in the enclosure, thus ensuring a safe operation of the camera. <ul style="list-style-type: none"> ■ 4 Port Switch with 2x LWL-LC 100Base-FX or 2x RJ45(10/100) Up-Links ■ 2 internal sensors for temperature; sensors for pressure and humidity ■ Supports a ring structure of the network for lower cabling complexity ■ Switchable camera power and heater via Modbus-TCP/IP (controlled by the monitoring software)

Interfaces

Web-Server	Ethernet Link
ODBC	OPC
Modbus-TCP	SQL Database
Digital I/O, 24V Input/Output, Potential-Free (Fieldbus Module)	

Data Link of Cameras and Computer

Gigabit Ethernet
Up to 90m with Industrial Ethernet Cable
Up to 500m with Multi-Mode Glass Fiber Cable
Up to several km with Single Mode Glass Fiber Cable



Temperature Monitoring for Continuous Casting



EAF Transformer Monitoring



Slag Detection



Torpedocar Monitoring



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