Continuous thermal monitoring to minimise slag carry-over in steel production
Continuous thermal mapping
for steel slag monitoring

When liquid steel is tapped from a basic oxygen or electric arc furnace, it is essential to minimise the quantity of slag carried over into the ladle.

In the past this has been done by visual observation of the tapping stream or by the use of electromagnetic induction coils mounted onto the furnace. However, neither of these methods has proved to be entirely reliable.

Main Problems of slag carry-over

- Slag layer hinders addition of alloys and conditioners
- High levels of FeO and MnO results in high oxygen content of steel leading to increased processing time and treatment costs
- High inclusion formation, steel cleanliness problems and increased risk of nozzle clogging in the caster
- Phosphorous reversion in the ladle
- Poor ladle desulphurization
- Ladle refractory wear

Key Benefits of the Slag Detection System

- Improved production yield
- Lower slag content improving steel quality
- Lower maintenance on BOF/ EAF vessel
- Reduced energy costs

Key Features of the Slag Detection System

- Alarms generated by the system directly stop the tap before the slag is carried over
- Fully automatic operation
- Enhanced data output for tap analysis
- Accurate detection independent of charge weight
- Reliable alarm independent of the operator
- Improved production yield
- Lower slag content improving copper quality
- Lower maintenance on BOF/ EAF vessel
- Reduced energy costs
The LAND SDS Solution

The Slag Detection System SDS has been developed using Land’s expert knowledge of the application and over 60 years of experience in the steel industry to monitor and aid control of slag carry-over from one process to another.

The SDS system is specially designed to withstand the harsh conditions of continuous operation in the steel plant, with minimum maintenance required. The industrial thermal imaging sensor is housed in a rugged water-cooled and air purged enclosure, continuously viewing the tapping area. As the tap commences, the dedicated LIPS SDS software automatically begins to record the tap as well as producing a data log and graph of the relevant steel/slag data.

When the level of the slag reaches the predetermined level an alarm is generated to stop the tap. The recording will end and the files saved by tap number. Full access of the tapping data is available to the operator for quality control purposes.

System Overview

Schematic diagram showing typical SDS system arrangement
Powerful detection system prevents slag carry-over

This comprehensive, fully featured software system has been developed to provide the steel plant engineers and managers with the tools to develop and improve the transfer of steel from one process to another.

SDS offers the steel plant a number of interconnectivity methods for on-line control and, more importantly, it automatically records the tap data in three forms for post analysis and future process improvement.

In addition to this, the image processing system has been pre-installed and configured to work straight out of the box – minimum set-up is required. Once the system hardware is installed onto the steel plant, the moment the system is turned on, the steel plant can immediately begin to reduce slag carryover. No other thermal slag detection system currently available offers these features.

Observe Critical Tap Information

Pre-installed on the powerful image processing system, the display allows users to observe critical tap information such as the live thermal image, steel and slag percentages, time versus percentage graph, alarm level and alarm status.

Secondary information such as tap number, sensor temperature, comms status, tap duration, steel / slag ratio and record status are less prominent so as to not distract the user during the tap.

View the Tap Information throughout the plant

Up to four users can also view remotely a condensed view of the live tap anywhere on the plant network by using the remote viewer software.

At the end of the tap the video, text data and graph are saved by tap number for later analysis and can be automatically deleted after a user defined number of days.

Inputs and outputs from the steel plant and slag detection system include: digital output, DDE, OLE, Ethernet and OPC.

How Slag carry-over is prevented

The following sequence of screens clearly illustrates how the SDS tracks the onset of slag, finally activating an alarm to stop the tapping process, preventing slag carry-over.

Screen 2
The Alarm is still showing green. Steel is at 91% (slag at 9%)

Screen 3
The Alarm is now showing red. The Steel content has fallen to 23% (slag at 77%). The alarm level (set at 35 % slag) was triggered, the tap is then stopped.

Screen 4
The SDS continues monitoring after the alarm has been triggered, showing the slag content rising to a maximum of 94%.
Full Screen Display (shown)

Allows users to observe the critical live tap information.

The three main display screens show the live thermal image, alarm level window and display graphs.

Also on screen are the location identifier, tap number, system status bar and an area for the plant logo.

Remote Viewer

Up to 4 remote connections allow viewing of live tap information to be viewed anywhere on the plant network.

System Status Bar

Displaying communication status, imager temperature status, tap duration and Ethernet connections.

Alarm Level Window

- Steel and slag percentages
- Alarm level
- Alarm status
- Steel, slag alarm percentage, steel/slag alarm status, available via OPC and Ethernet connection. Values can be transferred to SDS from the steel plant via OPC or Ethernet.

User Defined Variables

Any five user defined variables can be chosen with corresponding values altering as determined by the steel plant.

This information is included in the auto record data for each tap.

Display Graphs

A bar or line graph displays the steel and slag percentage versus time. A pie chart illustrates the total steel slag pixels during each tap, this is extremely useful when comparing taps. This screen also shows alarm condition status.

This information, along with the thermal video and all text data, is automatically recorded as soon as the tap commences.

Language

All text displayed on the full screen can be user configured to suit the required language.
Sensor - Protective Enclosure dimensions

BASE VIEW

210/8.27 crs

dia. 6.5/0.26

210/8.27 crs

FRONT VIEW

270/10.63

371.8/14.64

250/9.84

SIDES VIEW

483.5/19.04

250/9.84

210/8.27 crs

270/10.63

655/25.79

630/24.80

600/23.62

380/14.96

322/12.68

380/14.96

322/12.68

REAR VIEW

236/9.29

169.7/6.68

70.2.76

All dimensions mm/inch

To fit 10.4/0.41 i.d. water hose

To fit 38/1.5 i.d. air hose

Mounting holes (4 off) dia.10/0.39

Sensor - Supply Unit dimensions

All dimensions mm/inch

LAND
Typical System

- Pre-configured image processing system
- Serial communications and video cable set pre-wired and labelled to suit plant
- Power, communications and video connection service panel mounted up to 10m from the sensor enclosure
- Pre-wired 10m cable and conduit supporting serial communications, video and power connections
- Rugged water-cooled enclosure with an integral air purge and adjustable bracket
- High-resolution FPA thermal imaging sensor and integrated telephoto lens
- Optional air purge blower unit and hose mounted up to 30m from the sensor enclosure

Outline Specifications

### Image Processing System

<table>
<thead>
<tr>
<th>Slag detection:</th>
<th>Alarm activation when a preset percentage of either slag or steel detected within defined window</th>
</tr>
</thead>
<tbody>
<tr>
<td>User display:</td>
<td>Front page information display, plant logo and location identifier</td>
</tr>
<tr>
<td>Frame rate:</td>
<td>25 frames/sec</td>
</tr>
<tr>
<td>Automatic functions:</td>
<td>Auto tap detection, steel/slag ratio, video file, log file of all data, steel/slag percentage graph, all saved as tap number.</td>
</tr>
<tr>
<td>Language:</td>
<td>User defined</td>
</tr>
<tr>
<td>Outputs:</td>
<td>Digital output card, DDE, OLE, Ethernet and OPC Options</td>
</tr>
</tbody>
</table>

### Sensor Supply Unit

<table>
<thead>
<tr>
<th>Functions:</th>
<th>Local connection interface between imaging sensor and image processing system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cables:</td>
<td>30/150/300m pre-wired and labeled, greater distances to 1km are available</td>
</tr>
</tbody>
</table>

### Enclosure

<table>
<thead>
<tr>
<th>Service:</th>
<th>Water, air, power input, communications, video, located to the rear of the enclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added Protection:</td>
<td>Sacrificial plate protects the main enclosure from direct impact</td>
</tr>
<tr>
<td>Sighting tube:</td>
<td>Design significantly reduces the risk of direct impact of liquid steel against the field replaceable sapphire window</td>
</tr>
<tr>
<td>Air bleed:</td>
<td>Provides positive pressure within the enclosure</td>
</tr>
<tr>
<td>Environmental rating:</td>
<td>IP65</td>
</tr>
</tbody>
</table>

### Thermal Imaging Sensor

| Temperature measurement range: | 600 to 2000 °C |
| Thermal image resolution:      | 320 x 240 pixels |
| Detector:                      | Microbolometer, focal plane array                                                               |
| Wavelength:                    | 3.9 µm                                                                                           |
| Field of view:                 | 6° x 4.5°                                                                                       |
| Motorised focusing range:      | 3 m to infinity                                                                                  |

### Options

- Blower unit, setup monitor, sensor carry case