Sidewall Embedded Electromagnetic Measurement of Matte level in Pyrometallurgical Furnaces

HATCH

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CINDE
CANADIAN INSTITUTE FOR NON-DESTRUCTIVE EVALUATION
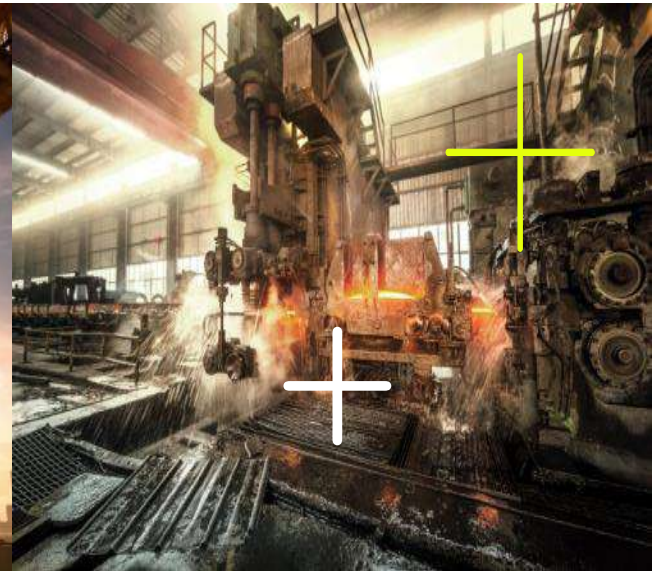
NDT in Canada
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Canada's NDT Conference

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Halifax Convention Centre
Halifax, Nova Scotia

Outline

▸ Overview
▸ Eddy current testing
▸ Materials and methodology
▸ Results
▸ Summary

HATCH

Introduction

Introduction

▸ Determine when to tap excess matte

▸ Better understanding of melt times

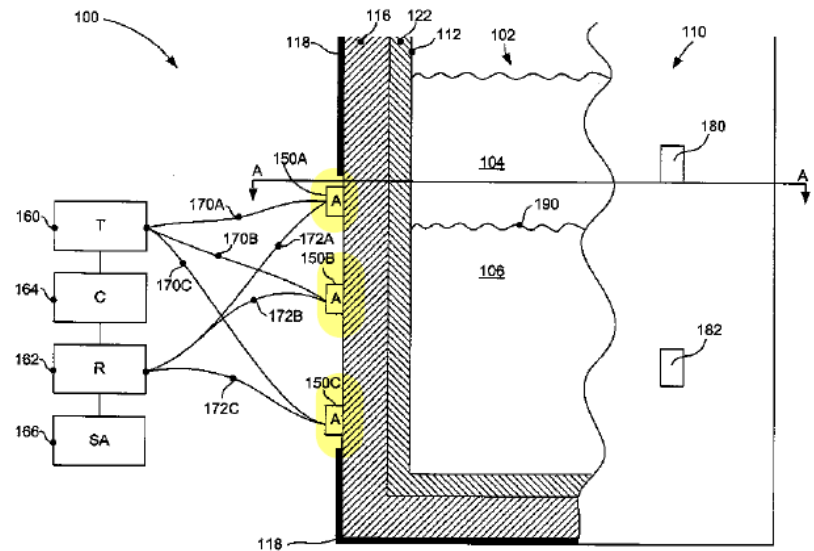▸ Monitor refractory wall condition

Figure: Hatch Patent

Common practice

▸ Sounding Bar
  ◦ Low accuracy
    • Human interpretation
  ◦ Not continuous
  ◦ Safety concerns

Figure: Sounding bar at Vale

Common practice

Figure: Sounding bar at NKS

Figure: Sounding bar measurement at PFK

Technologies Tested

▶ Hatch:
  ◦ Electrochemical oxygen
    • Lonmin, Anglo Platinum (2004)
  ◦ Electric potential (Stinger)
    • Lonmin (2016)

▶ Agellis Group AB:
  ◦ Eddy current probe
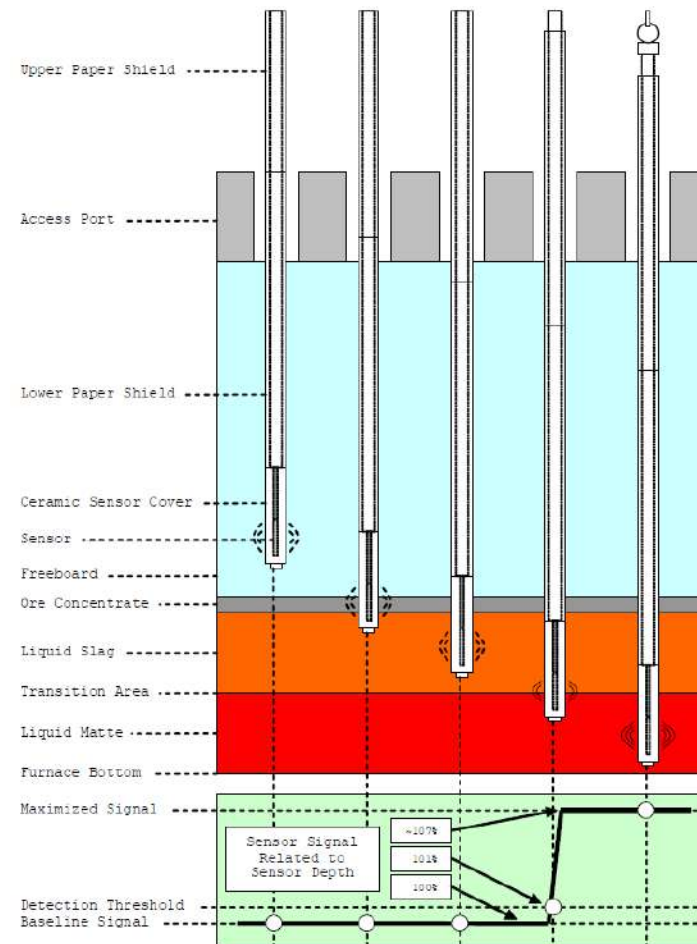   • Lonmin (2011)
    • Vale Sudbury, Onca Puma (2013)

Upper Paper Shield
Access Port
Lower Paper Shield
Ceramic Sensor Cover
Sensor
Freeboard
Ore Concentrate
Liquid Slag
Transition Area
Liquid Matte
Furnace Bottom
Maximized Signal
Sensor Signal Related to Sensor Depth
Detection Threshold
Baseline Signal

Figure: Agellis Probe

Eddy current NDT

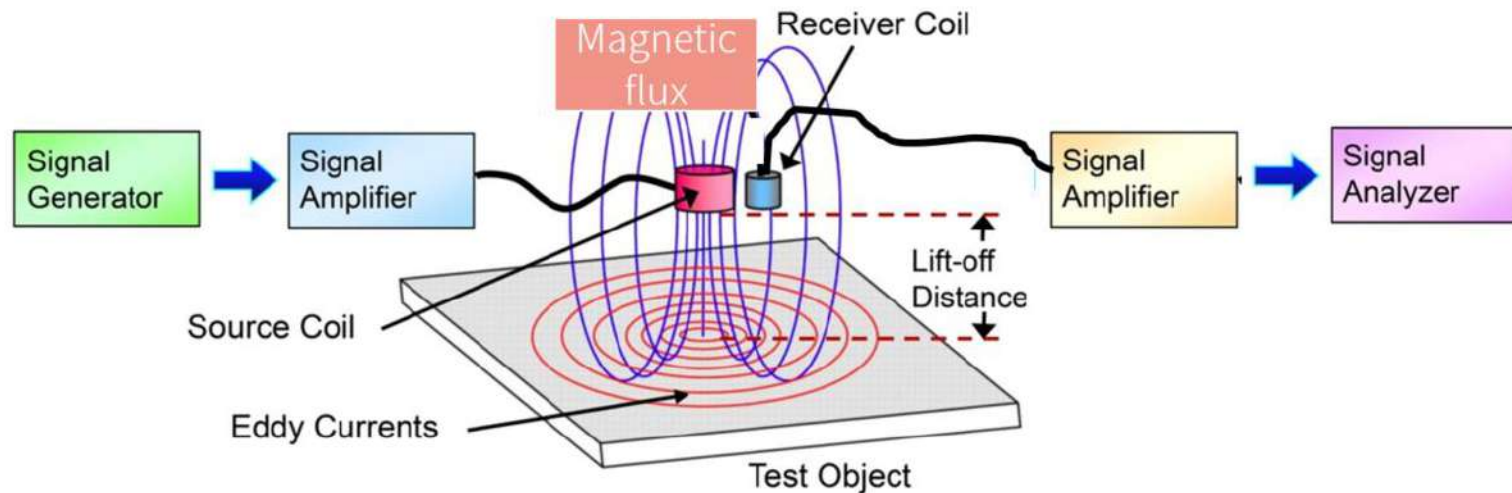▸ Matte/slag = conductive/non-conductive interface

Figure: Eddy Current System

Eddy current NDT

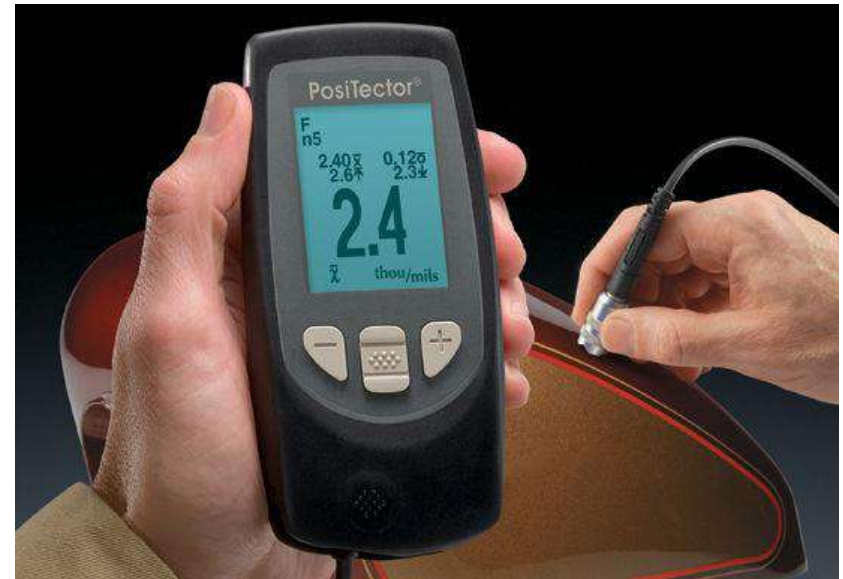
Figure: RMC eddy current application

Figure: Eddy current coating thickness testing

Challenges

- Sensor location
- Refractory erosion
- High temperature
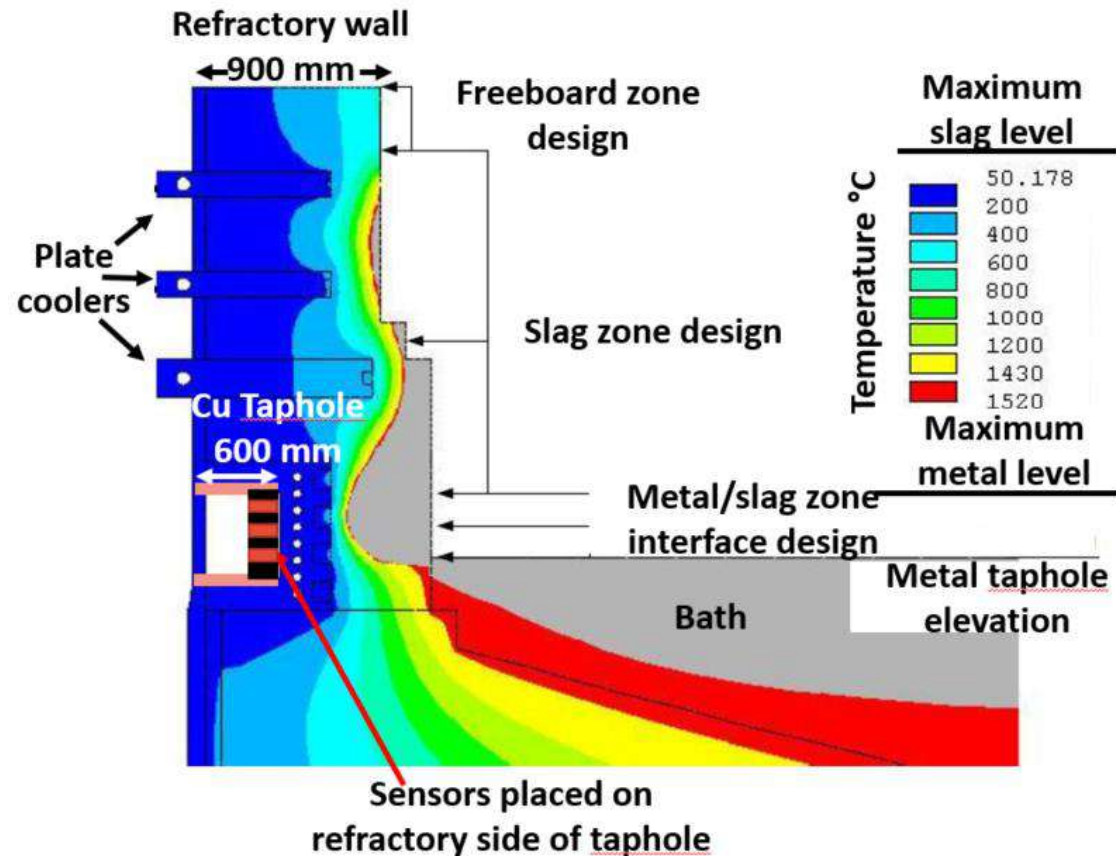- Remote detection
- Metal shielding
- Background noise

Refractory wall

← 900 mm →

Freeboard zone design

Plate coolers

Cu Taphole

600 mm

Slag zone design

Maximum slag level

Temperature °C

	50.178
	200
	400
	600
	800
	1000
	1200
	1430
	1520

Maximum metal level

Metal/slag zone interface design

Bath

Metal taphole elevation

Sensors placed on refractory side of taphole

Figure: EAF Thermal Profile

Approach

Model and design system for:
1. No cooling elements
   ◦ Impregnated refractory
2. Plate coolers
3. Waffle coolers
   ◦ Taphole

Proposed System: Plate Coolers
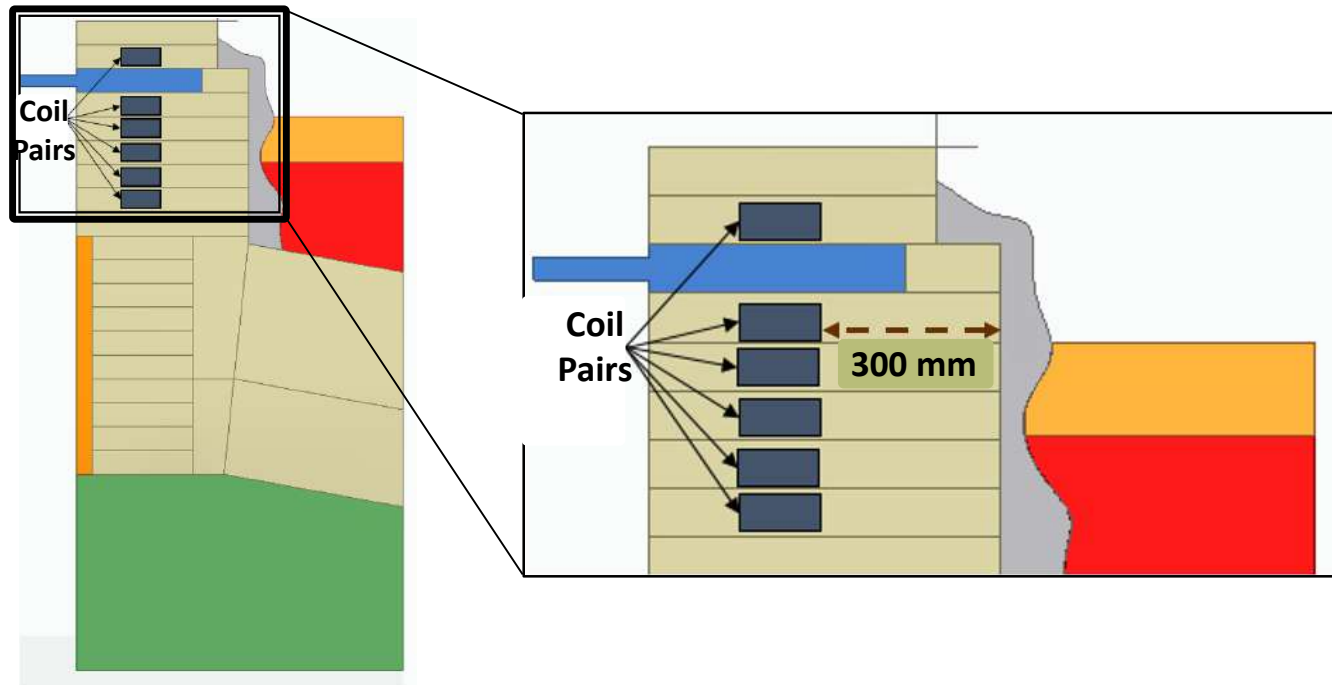
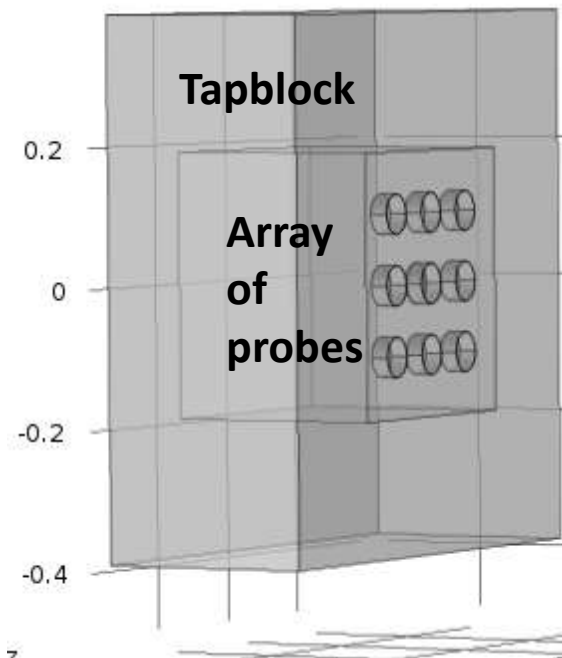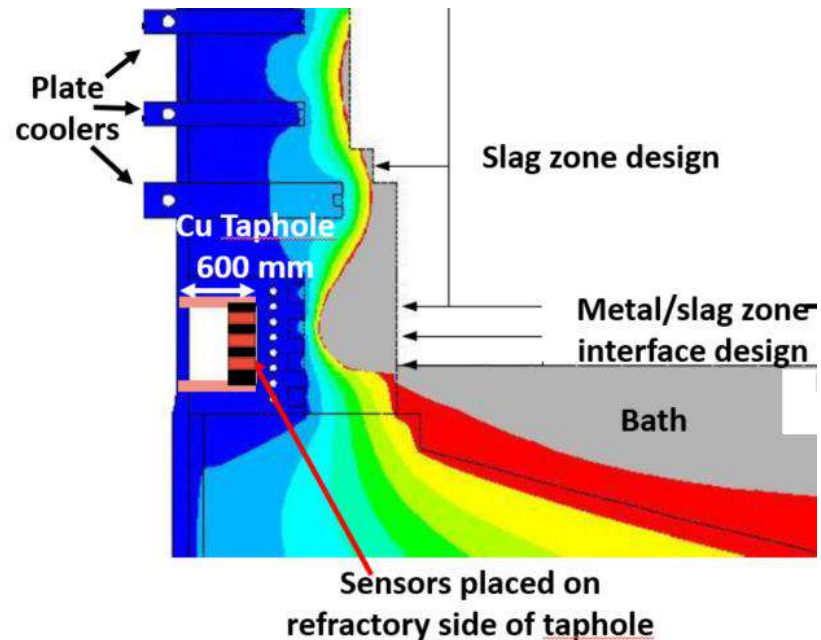Figure: Proposed Plate Cooler Setup

Proposed System: Tapblock

Tapblock

Array of probes

0.2

0

-0.2

-0.4

Figure: Modelled Taphole Setup

Plate coolers

Cu Taphole
600 mm

Slag zone design

Metal/slag zone interface design

Bath

Sensors placed on refractory side of taphole

Figure: Proposed Taphole Setup

Tapblock design

Cu block (Tapblock)

x
y
z

Ti Sheet Metal height, x
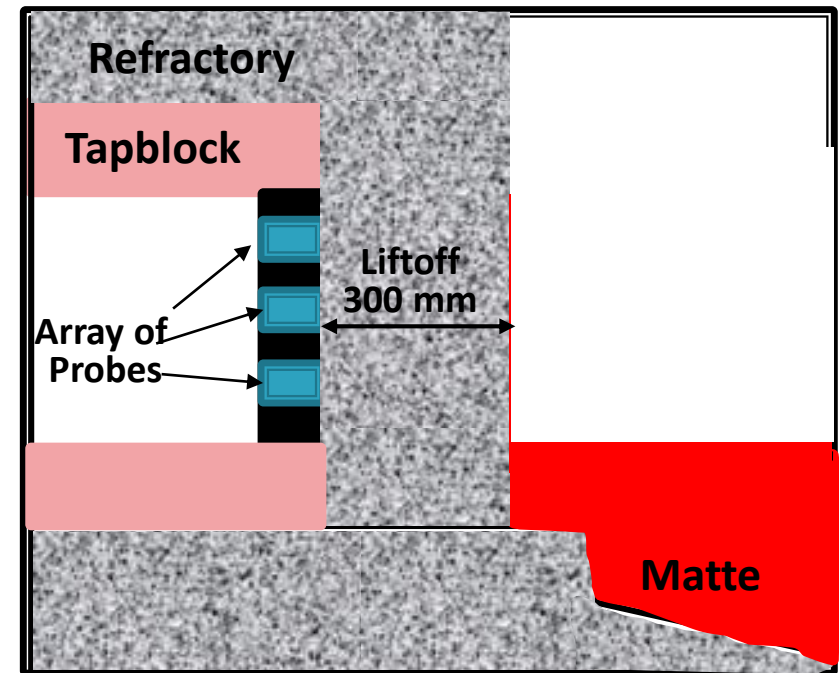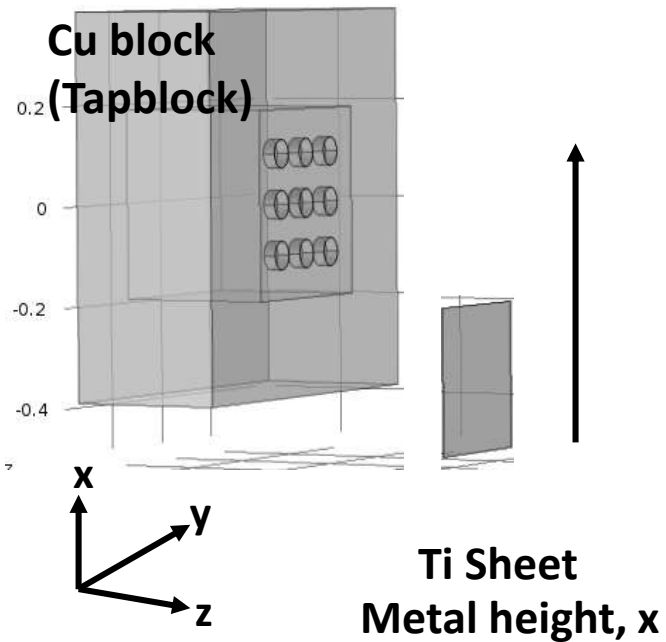
Figure: Modelled taphole geometry

Refractory

Tapblock

Array of Probes

Liftoff 300 mm

Matte

Figure: Rising matte level in a furnace
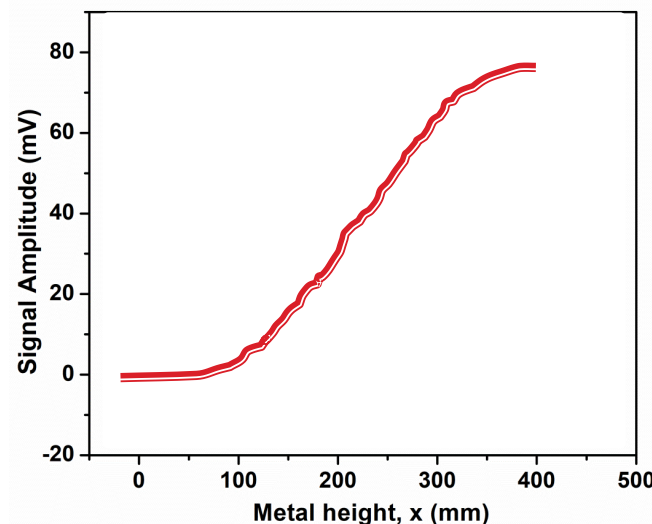
Figure: Output signal

Tapblock design
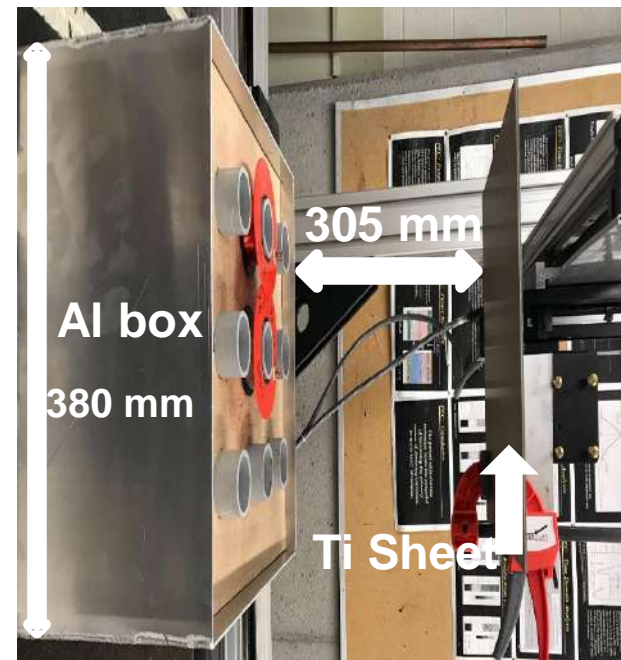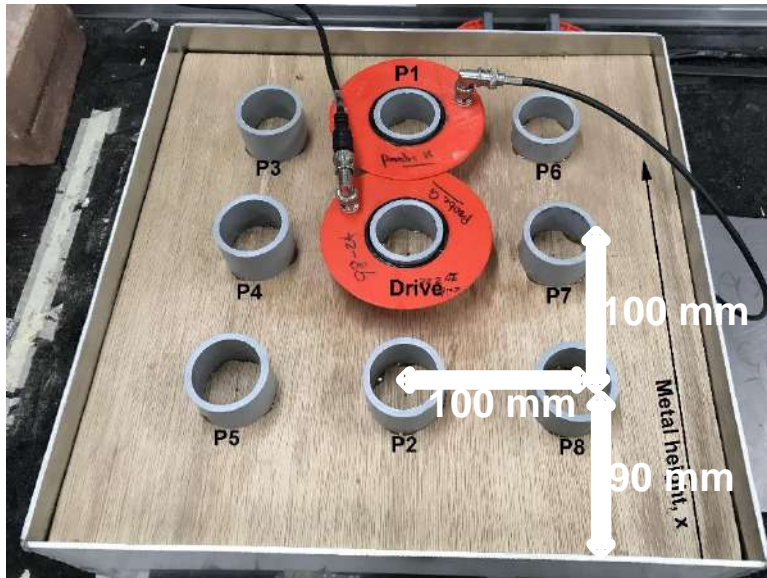
Results - Tapblock

- Resistivity of Ti = 50 µΩ.cm , Cu = 1.72 µΩ.cm
- Resistivity of slag = ~ 4 µΩ.cm × 10^6 µΩ.cm
- 16 % signal increase with Cu/Al sheet, compared to Ti sheet
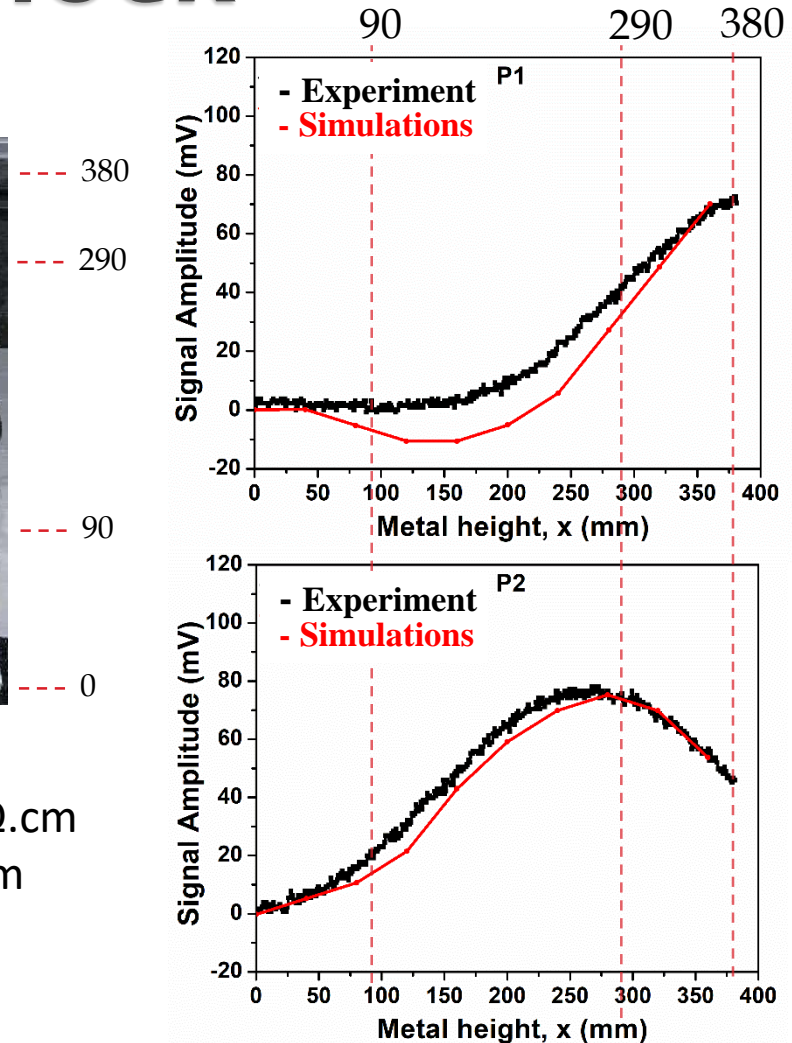
Projection to Latent Structures (PLS) model
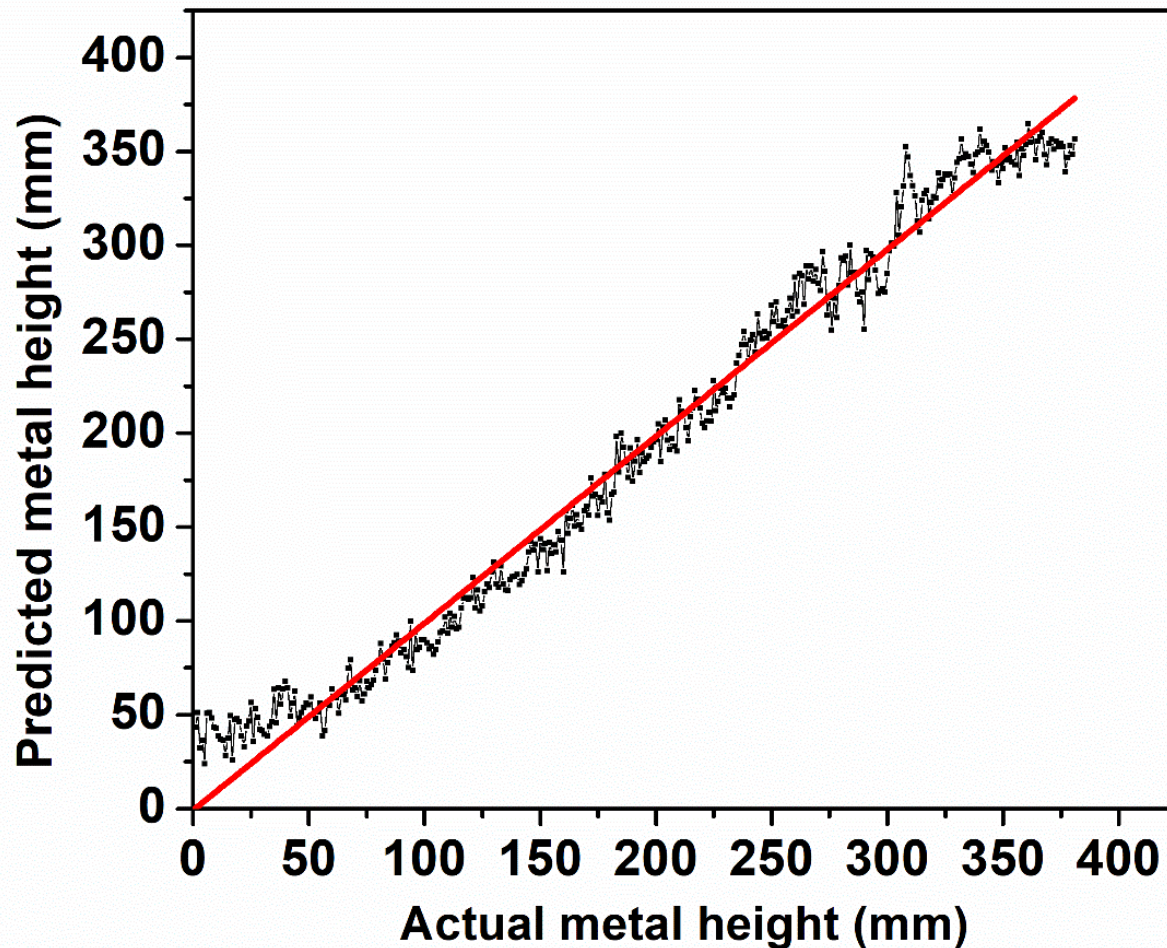
Effect of Liftoff

Tapblock depth

254 mm

Al "Tapblock"

Ti sheet

"Cold face" 3 2 1 "Hot face"
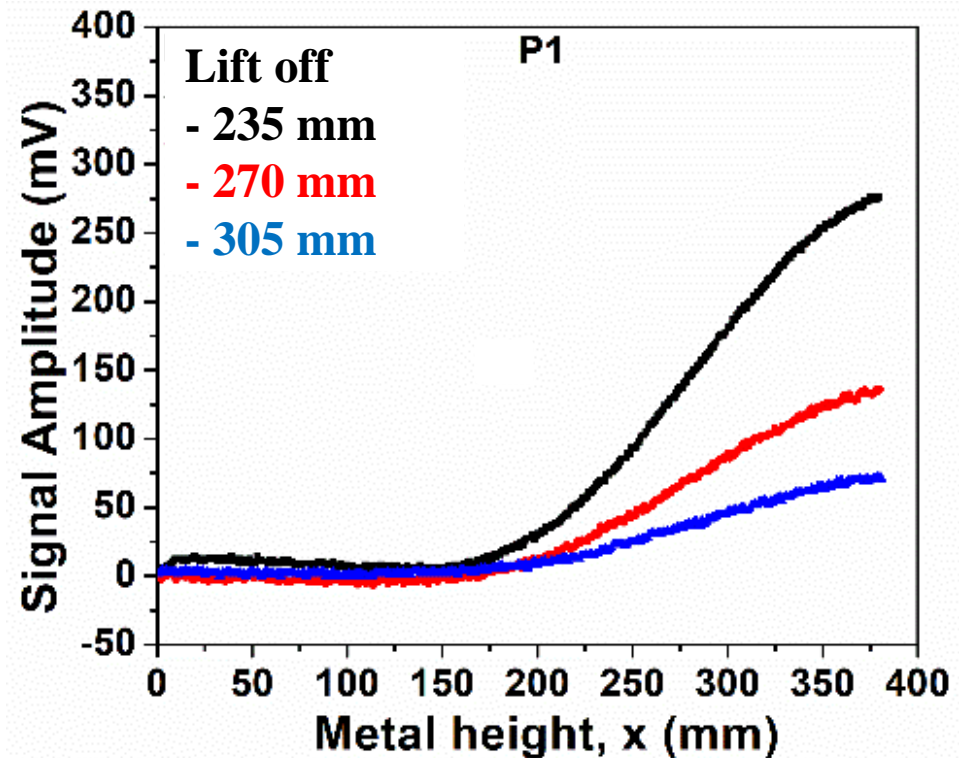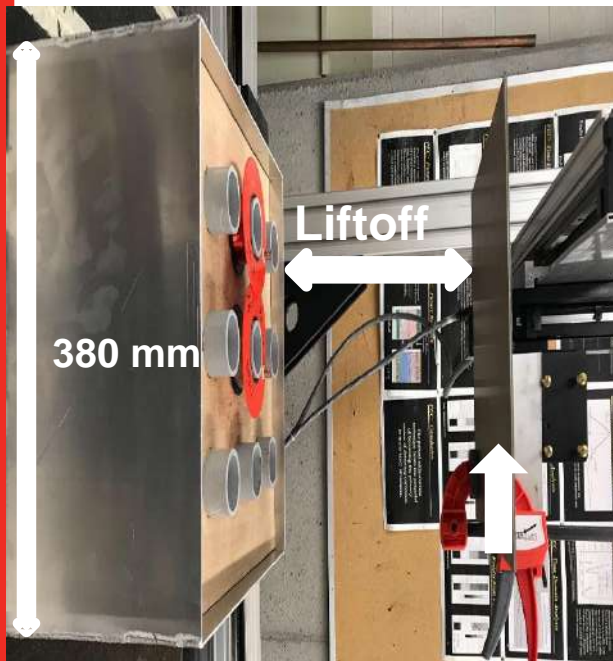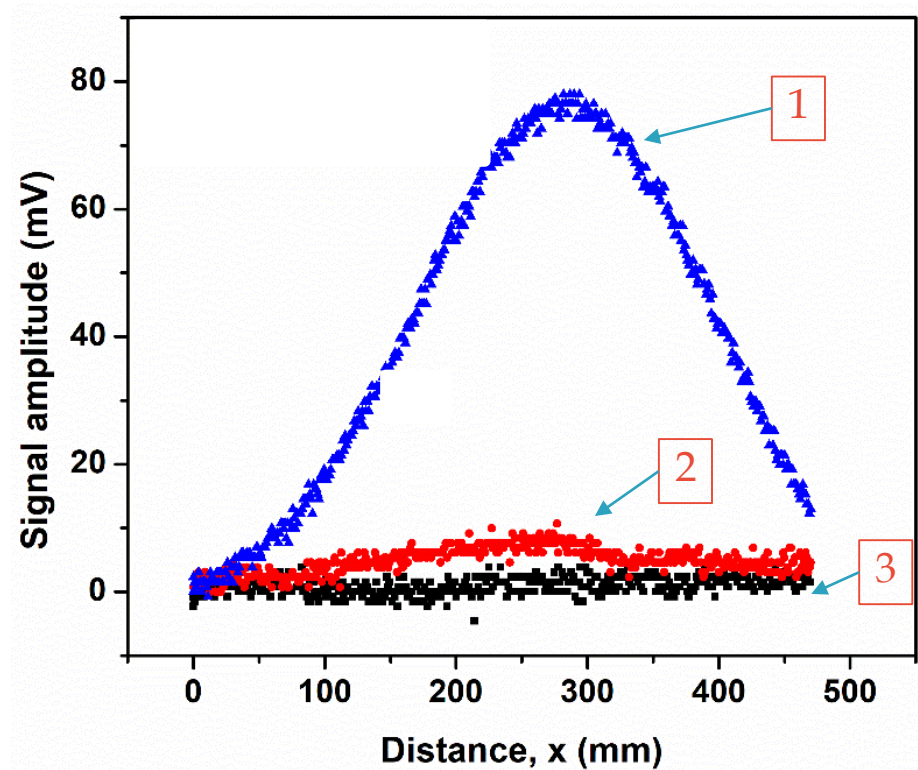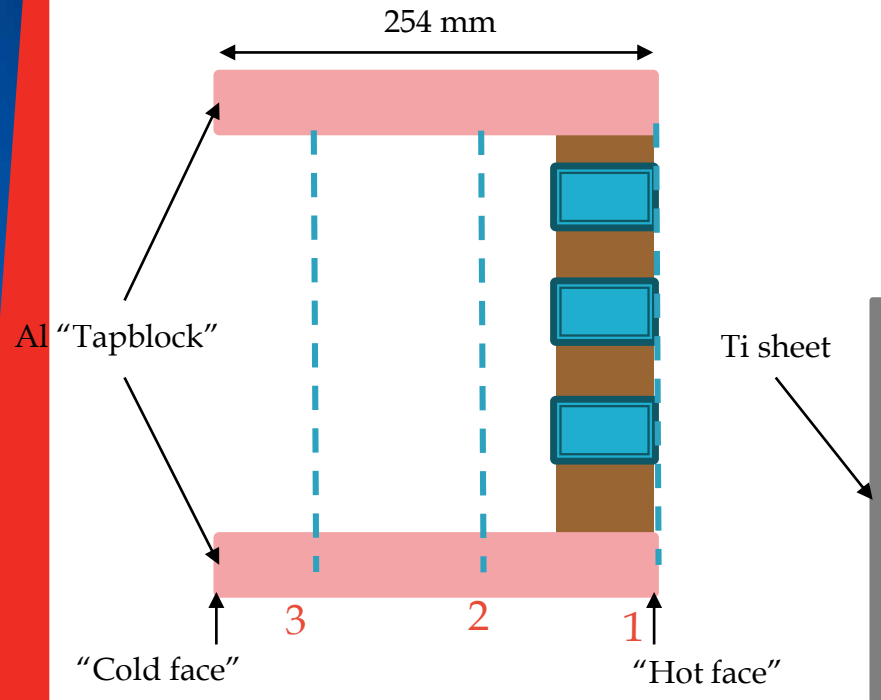
Brick Impregnation

▸ Impregnated brick between sensor and metal
  ◦ Skew brick from Vale FF2

Plate cooler design

Side Cu plate

Without Cu
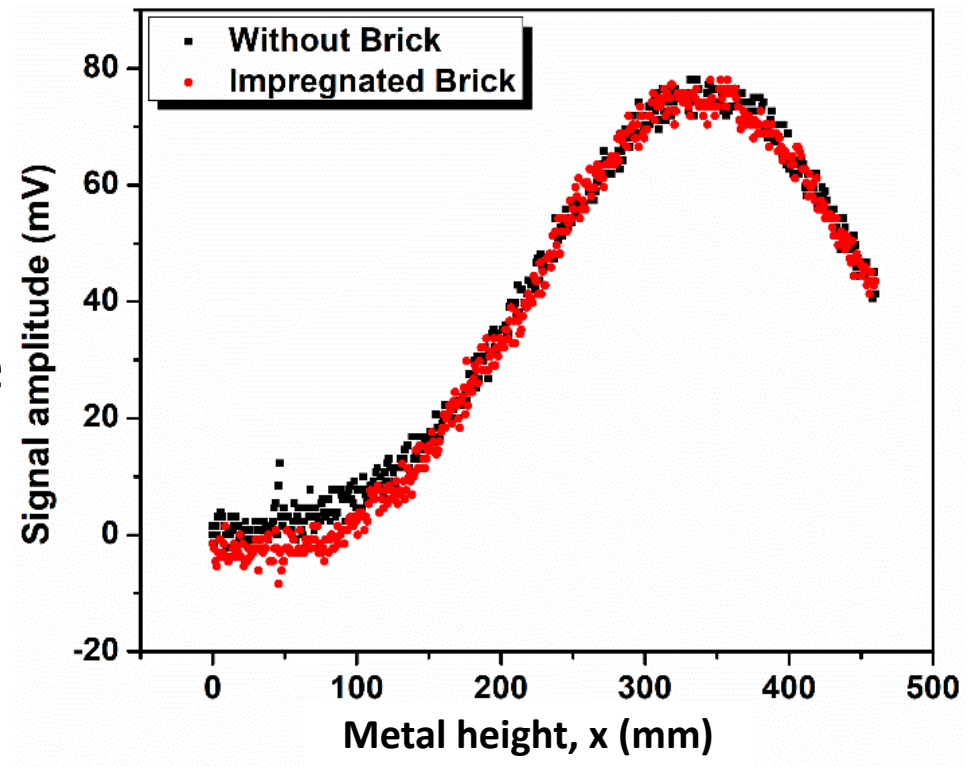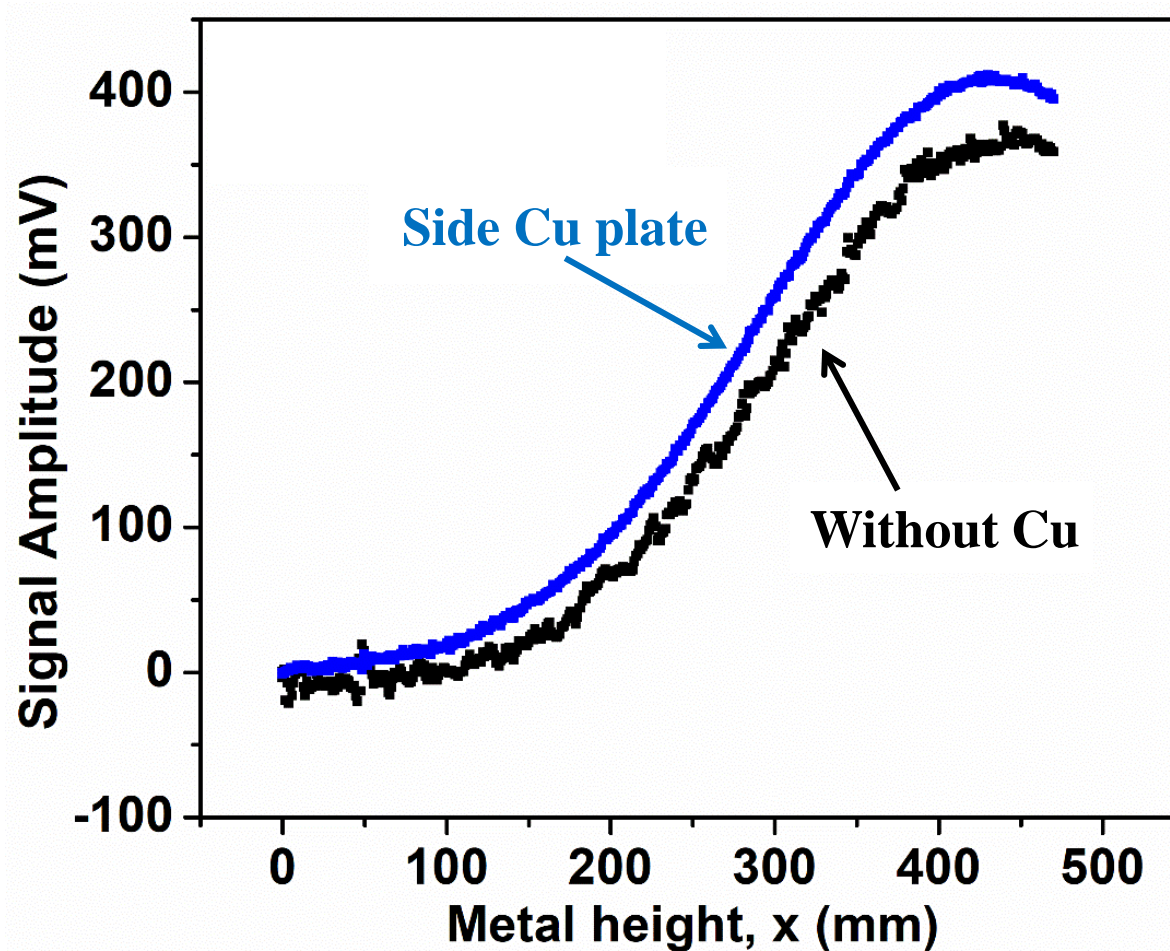
Summary

- Matte level determined at ~300 mm liftoff
  - High resolution (~5 mm)

- Signal decreases exponentially with liftoff

- Impregnated bricks have negligible effect

- Copper plates do not change the signal significantly

Summary

▸ Matte level sensitivity demonstrated in lab for:

1. No cooling elements
2. Plate coolers
3. Waffle coolers – at tapblock hot face

Acknowledgements

Thank you