METALLURGICAL ADVANTAGES OF NON-CONTACT MICROWAVE SENSING TECHNOLOGY OVER CONVENTIONAL METHODS AS APPLIED TO THE IRON & STEEL MAKING INDUSTRY[1]

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Abstract

This paper has the object to divulgate the Non-contact Microwave Sensors technology that has been gaining popularity, and rapidly replacing the outdated method of the past, offering relatively low cost, high performance, low maintenance and durable sensing solutions to many areas of the Iron and Steel Industry

Key-words: Non-contact microwave sensors; Iron and Steel industry.

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INTRODUCTION

When the application includes a lot of dust, steam, vapor, high temperatures, induced noise, or intense ambient light, reliably sensing the target is very difficult for other non-contact technologies such as laser and ultrasound, but quite simple using microwaves, as they are unaffected by such conditions.

In the past, microwaves sensors were plagued with false reflections, inaccuracy and misreading, rendering them a sub-standard solution to mechanical devices such as sounding, load cells and other simple contact devices.

There have, however, been considerable advances made in microwave sensor engineering over the last decade. As a pioneer in our field, this new technology has incorporated techniques, such as circular polarized microwaves, originally designed for aerospace/military use, and adapted them to microwave sensors for industry. The non-contact microwave sensors offer extremely reliable, maintenance free, comparatively low cost solutions for many applications which were previously thought impossible: effectively rendering contact/sounding/mechanical devices redundant.

GENERIC FEATURES/ADVANTAGES OF MICROWAVES

- Unaffected by temperature, flames, heavy vapor/dust,
- Low maintenance,
- Non-contact,
- Non-invasive,
- Solid state reliability/durability,
- 100% safe for personnel/operators,
- Comparatively low cost.

PROPRIETY FEATURES OF THE NON-CONTACT MICROWAVE SYSTEM

Generally, microwave sensors used in industry utilize *plane polarized microwaves*: the direction of oscillation of the electric field in an electromagnetic signal is called the polarization direction (or vector) and is perpendicular to the direction of propagation of the beam. That means the polarization vector is always fixed in one direction.

This often results in interference between single reflected (from the target) and double reflected (from target + other surfaces) microwaves as the sensor is unable to discriminate between the single reflected and multiple reflected microwaves.

If that direction were made to rotate, we have what is called circular polarized or rotary microwaves.

The basic advantage of rotary microwaves is simply explained. When a beam hits a strongly metallic target (eg. liquid metal) the direction of rotation completely reverses. When a beam hits a surface at a grazing angle a small phase rotation of the polarization vector occurs. If this is then reflected back into the antenna, the spurious signal is rejected by the controller as it is not tuned to receive this type of signal. As a result the probability of false detection has been reduced to a negligible level. The discriminator circuits in the sensors have been designed to accept or reject the reverse rotation depending on the type of sensor and its application.

The figure bellow shows how Rotary Microwaves are used in Radar Level Measurements to eliminate spurious reflections off walls and other objects within the beam path. Spurious reflections travel a greater distance that that of the direct reflection from the target and would cause interference if they were not eliminated.

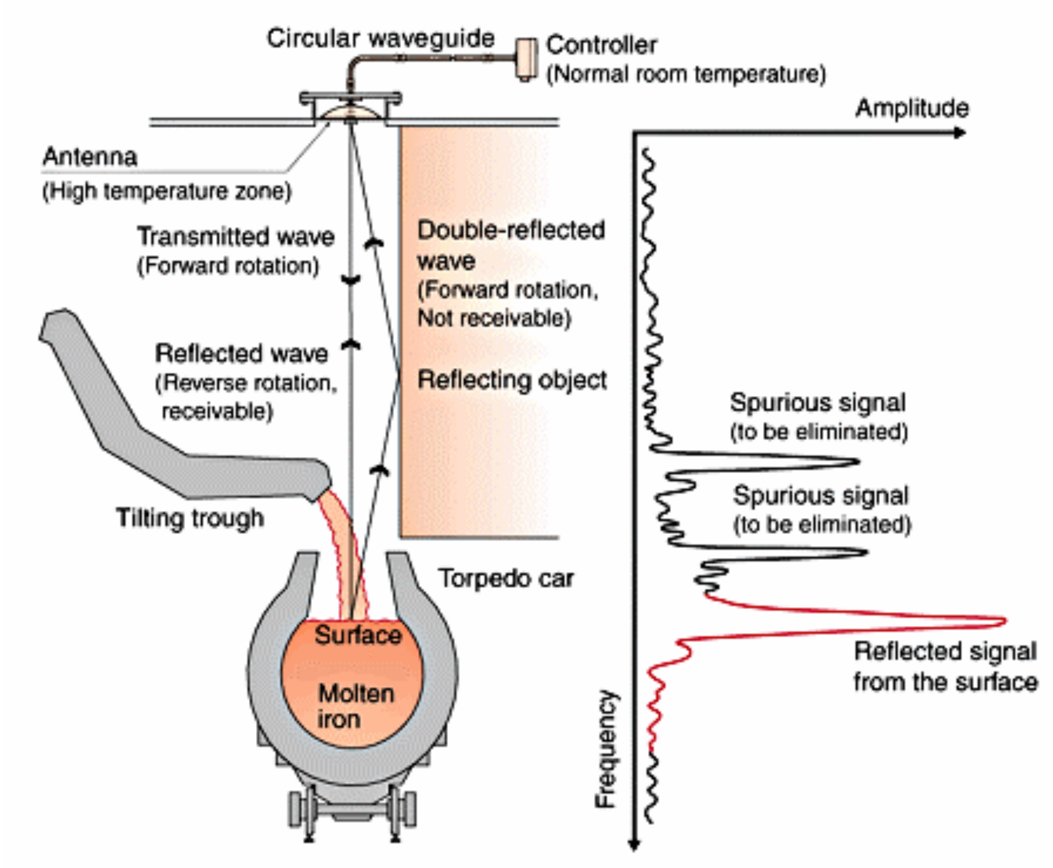

Figure 1. FMCW Radar using Rotary Microwaves.

The Figure 2 shows how Rotary Microwaves are used in Hot Product edge detection to prevent false actuation of the relay. Reflections from the edge of the strip cause chattering of the relay as the reflections move in and out of phase with the direct waves, however eliminating these reflections, through use of rotary microwaves, results in high stability and precision.

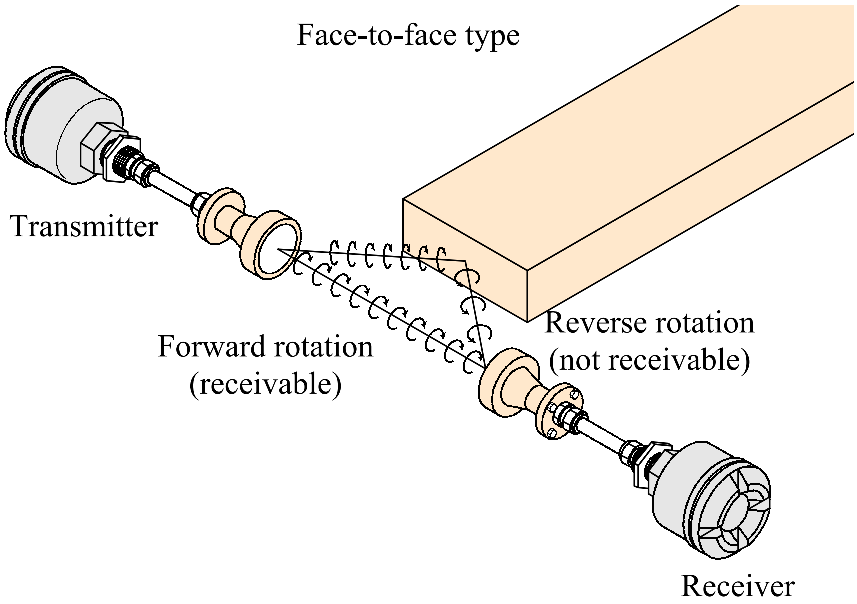

Figure 2. Microwave Edge Detector using Rotary Microwaves.

- Waveguide

  The Non-Contact Microwaves Sensors have been specially designed to use waveguides (bent and straight). This allows the antennas, which can withstand up to 600°C without any cooling (more so with heat shielding) , to be placed in the high temperature zones, whilst the sensitive electronics are located in a room temperature area some distance from the antennas.

Waveguides not only protect the electronics from the high temperatures, but they also allow installation of antennas in difficult to reach or confined spaces.

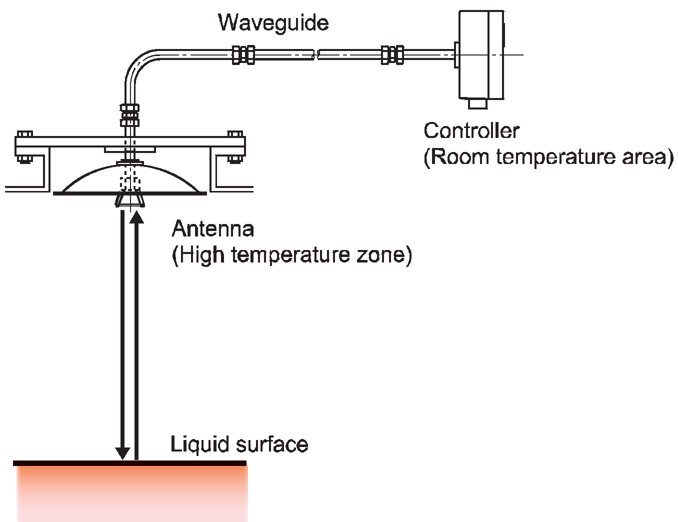

Figure 3. FMCW Radar using Waveguides.

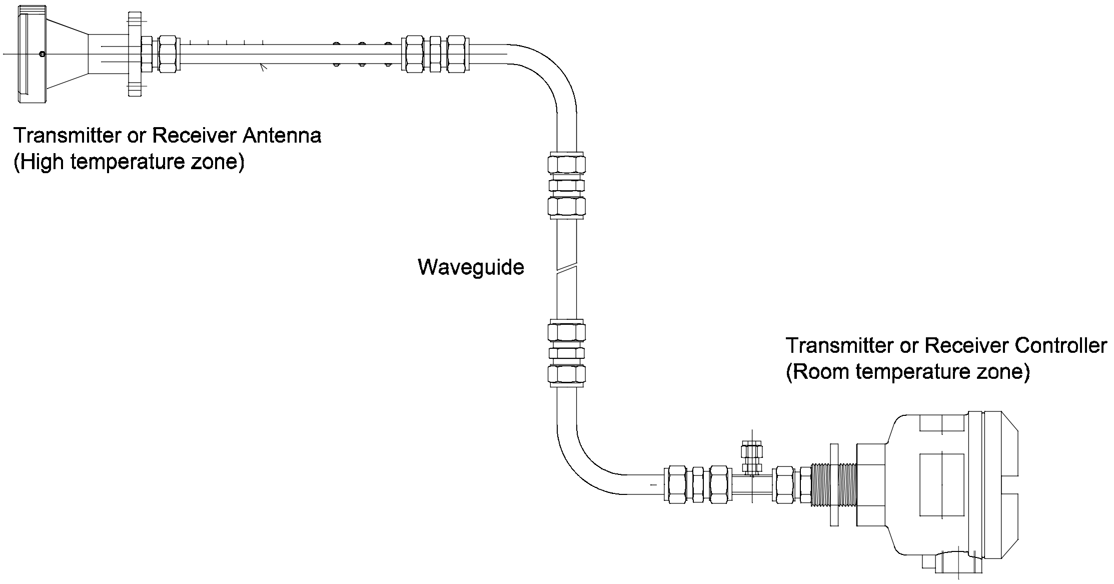

Figure 4. Microwave Edge Detector using Waveguides.

APPLICATIONS IN INDUSTRY AND METALLURGICAL BENEFITS

It was developed two microwave based sensors specifically for the Iron & Steel industry:

- High performance FMCW Radar
- Product tracking sensor "microwave barrier", for replacing laser, gamma ray sensors.

➢ *APPLICATIONS FOR FMCW RADAR IN IRON & STEEL*

- **Torpedo Car Level Measurement**

General:

Real time level measurement in the torpedo car whilst tapping from the blast furnace for full tapping automation[3].

Metallurgical Benefits:

Allows cars to be filled to maximum capacity. Increasing production, reducing heat energy loss and eliminating accidents caused by overfilling.

Figure 5. Level Measurement System in the Torpedo car

- **BOF Bath Level Measurement**

General:

Bath level measurement in the Basic Oxygen Furnace (BOF) before oxygen blow[4&5].

Metallurgical Benefits:
Allows the position of the oxygen lance to be optimized, thus maximizing efficiency of blow resulting in energy savings through shorter blow times. Improved end point chemistry and temperature

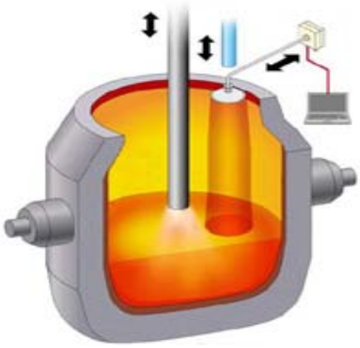

Figure 6. Level Measurement System in the BOF

- **Blast Furnace Burden Level Measurement**

General:
Real time burden level measurement within the Blast Furnace.

Metallurgical Benefits:
Optimization of raw material usage, real time data allows monitoring of furnace operation.
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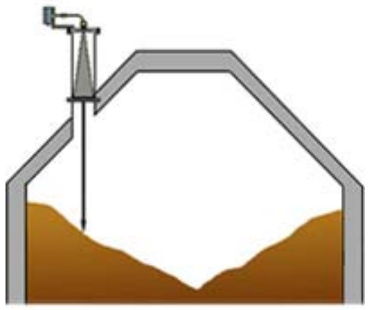

Figure 7. Level Measurement System at the Blast Furnace application

- **Freeboard Measurement in Ladle**

General:
Freeboard measurement in the Ladle at the Desulphurization facility or other secondary steel making processes.

Metallurgical Benefits:
Allows the position of the Inert Gas Stirring lance to be optimized: thus maximizing efficiency of blow. Minimizing error in flux/alloy additions

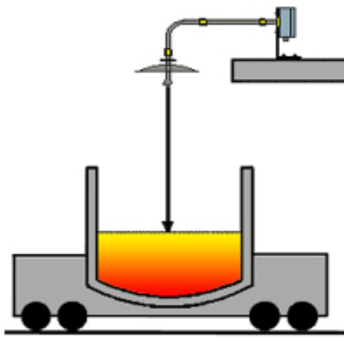

Figure 8. Level Measurement System at the the Ladle's Free Board application

- **Crash Avoidance on Quenching Cars**

General:
Sensors are equipped on the quenching cars in order to detect the distance between cars, allowing for crewless operation.

Metallurgical Benefits:
Increased operating efficiency by synchronization of the cars activity. Collision avoidance.

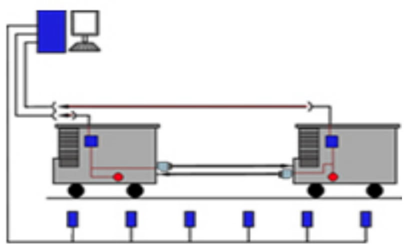

Figure 9. Sensors on the queching cars

➢ *APPLICATIONS FOR MICROWAVE BARRIERS IN STEEL MILLS*

- **Detection/positioning of slab on Continuous Casting lines**

General:
When the microwave beam between the transmitter and receiver is broken by the slab the sensor detects.

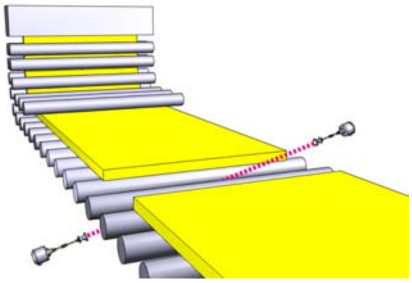

Figure 10. Positioning Detector

Metallurgical Benefits:
Detection of slab position is essential for controlling other process. Unaffected by heavy vapor or extreme temperatures, microwave barriers offer increased reliability under harsh environments.

- **Positioning of slab on entrance/exit to reheat furnace.**

General:
When the microwave beam between the transmitter and receiver is broken by the slab the sensor detects.

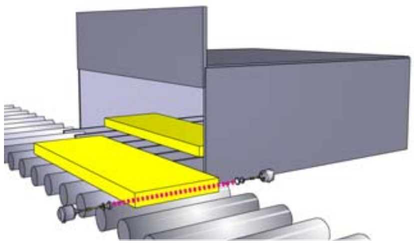

Figure 11. Positioning Detector on entrance to reheat furace

Metallurgical Benefits:
Detection of slab position is essential for controlling other process. Unaffected by heavy vapor or extreme temperatures, microwave barriers offer increased reliability under harsh environments.

Other applications include:
- Positioning/detection of hot/cold slab/strip/coils
- Tracking of hot product in Section Mills
- Tracking of hot strip in Plate/Hot Strip mills.

CONCLUSION

Tried and proven by some of the largest Iron and Steel makers in the world, Non-Contact Microwave Sensors are rapidly growing in popularity as the inherent features of microwave technology have many advantages to offer to Iron and Steel makers.

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TECNOLOGIA SEM CONTATO PARA MEDIÇÃO DE NÍVEL

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Resumo

Este trabalho tem como objetivo divulgar a tecnologia de Sensores com base em microondas que tem ganhado popularidade e rapidamente substituindo métodos antigos, oferencendo baixo custo, alta performance, baixo custo com manutenção e soluções duráveis para várias áreas da Idústria Siderúrgica.

Palavras-chave: Sensores baseados em Microondas; Indústria siderurgica.

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