INTRODUCTION

Within the global steel- and metal industry there is a growing need for new sensor systems to measure and control the industrial process. New technologies for new sensors are continuously being developed for an ever growing market. The growth in the steel making industry is based on ore and Blast Furnaces therefore play an increasingly important role for the production of hot liquid iron and steel. We present a new interferometer micro wave system to make three dimensional topographic maps of the blast furnace burden surface. The Blast Furnace process is one of the oldest industrial processes. The furnace is tall and round. Layers of Coke and iron ore are successively laid, and air, pre-heated to 1200 °C, as fuel to the process. The coke and iron layers become semi-liquid and then liquid in the cohesive zone. The carbon from the coke reacts with the oxygen in the ore (which is Fe₂O₃ or Fe₃O₄) and form CO and CO₂ which goes off as off-gas. The iron, now mixed with some amount of carbon, is tapped in liquid form from the bottom. This is then taken to a converter, where oxygen is added to remove the carbon to form the final product of liquid steel.

TECHNOLOGY

It is important for the process that it remains symmetric. Therefore it is increasingly necessary to measure the burden topology and profile. Today single profile meters are used which include substantial mechanical and hydraulical arrangements. The topography is then modelled by assuming symmetry. Our novel approach has no moving parts and can be placed stationary at a single vantage point near the blast furnace top. By sending a series of microwave mono-chromatic waves from a single point and receive their reflection off the surface burden at a number of other points, it is possible to extract a three dimensional image of the blast furnace whole burden topography. The receiver is based on technology used in radio astronomy, applied to an industrial environment. The technology is described in our IEEE paper [1]. This technique makes it possible to see through dust and gas which obstruct ordinary optic monitoring and gives a sufficient high resolution. Our interferometer system is situated at the top of the plant, at the same level as the charging chute. The interferometer can be placed at an angle, as long as the view of the burden is unobstructed. The basic principles are as follows:

- A number of narrow frequency channels are successively transmitted towards the surface.
- The reflected channels are received at each interferometer element.
- The signal for each element is Fourier transformed from frequency space to delay space. The delay channels form concentric spheres of received signals.
- Every pair of elements are then combined for each delay channel (delay sphere).
- The set of pairs form the aperture plane and this is then Fourier transformed into an angular plane.

This procedure results in a spherical co-ordinate system, where the radius is the delay and the angular position is returned from the aperture plane transform. The only assumption made is that the surface is in the far-field of the interferometer, i.e. the phase centre of the reference for each element pair coincides with the optical axis of the interferometer system.

EXPERIMENTAL TESTS

We have performed a series of experimental tests of the technology. These have been more substantially described in a Licentiate thesis [2]. The point-spread function (beam) of the system was determined by first simulating a point source at 1.5 m distance and then observing a differential image with a hole made in a coke surface at a distance of 1.7 m. The simulation indicates a clear round beam, while the observed beam showed some side-lobe structures. Some of these erroneous structures are caused by that the experiment target is not a perfect point source. Other points, it is possible to extract a three dimensional image of the blast furnace whole burden topography. The receiver is based on technology used in radio astronomy, applied to an industrial environment. The technology is described in our IEEE paper [1]. This technique makes it possible to see through dust and gas which obstruct ordinary optic monitoring and gives a sufficient high resolution. Our interferometer system is situated at the top of the plant, at the same level as the charging chute. The interferometer can be placed at an angle, as long as the view of the burden is unobstructed. The basic principles are as follows:

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REFERENCES