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(232) Development of an Inclusion Sensor for Molten Steel

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I. INTRODUCTION

The development and application of an inclusion sensor for molten steel will be described. The system, LiMCA (Liquid Metal Cleanliness Analysis) was originally developed for molten aluminum processing.[1] The method can provide a number density and size distribution of inclusion particles simultaneously. In the present study, the possible design and conditions of the inclusion sensor in molten steel systems are investigated.

II. METHOD AND APPARATUS FOR INCLUSION DETECTION

1. PRINCIPLE

The principle of particle detection is based on the E.S.Z. (Electric Sensing Zone) method[2], which is illustrated in Figure 1. Thus, when small particles pass through an electrically insulated orifice, the electrical resistance of a fluid electrolyte flowing through this orifice increases in direct proportion to a particle's volume. Voltage pulses generated in the presence of an electrical current can then be measured, and the number and size of particles counted.

The change in resistance caused by the introduction of a non-conductive particle into an electrically insulated orifice is given by[3] :

$$\Delta R = \frac{4\rho_e d^3}{\pi D^4} * [1-0.8(d/D)^3]^{-1} \quad \cdots\cdots\cdots (1)$$

where ΔR : change in resistance
ρ_e : fluid resistivity
d : particle diameter
D : orifice diameter

2. SYSTEM DESCRIPTION

The experimental set-up used to carry out the development of the inclusion sensor described in this study, is shown schematically in Figure 2. It consisted of an insulating sampling probe, an outside electrode, an electrical circuit including a power supply unit, a suction and blowing unit, and the E.S.Z. system. The E.S.Z. system consisted of a differential pre-amplifier, a logarithmic amplifier (a peak detector) and a pulse height analyzer (P.H.A.). The sampling probe contained a smooth measuring zone orifice. In this study, orifices with diameters ranging from 200μm to 400μm, were used.

III. RESULTS

A typical voltage pulse observed during the suction of molten steel is shown in Figure 3. The shape of pulse is smooth owing to the smooth orifice shape. A CRT display of the Pulse Height Analyzer is shown in Figure 4, providing the voltage pulse distribution obtained during a molten steel measurement.

IV. CONCLUSION

An on-line method for the detection and measurement of non-metallic inclusions in molten steel systems has been developed, employing a principle based on the E.S.Z. method. Voltage pulses due to the introduction of inclusion particles to the orifice were successfully monitored and counted.

REFERENCES

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2) W.H. Coulter : U.S. Patent No. 112819, Oct.20, 1953.
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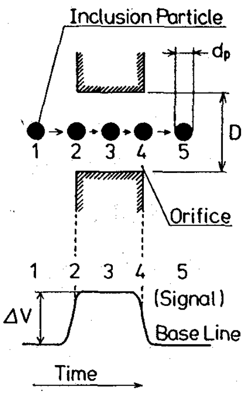

Fig.1 Principle of particle detection by the E.S.Z technique

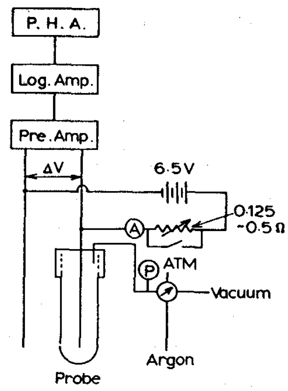

Fig.2 Schematic diagram of the LIMCA apparatus for molten steel systems

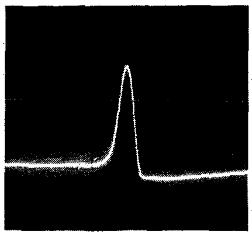

Fig.3 Voltage pulse obtained during the LiMCA measurements in a tundish for continuous billet casting

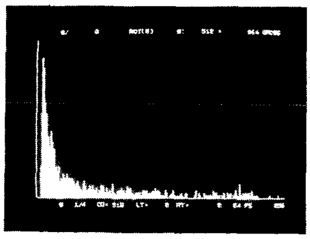

Fig.4 A CRT display of the P.H.A.