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AIR FLOW THROUGH AN EJECTOR WITH ANNULAR SUPERSONIC NOZZLE

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Abstract. During development of the continuous production of copper dried concentrate and fluxes were injected through the top-blowing lance into the molten bath. The properties of the equipment designed were determined by both classical measurements and modern flow visualization methods. The results of the classical measurements of the air flow parameters through an ejector with annular supersonic nozzle were confirmed by the Shleer and the shade methods of flow visualization.

Keywords: Ejector, annular nozzle, supersonic flow, copper.

1. Introduction

During development of the continuous production of copper dried concentrate and fluxes were injected through the top-blowing lance by preheated, compressed and

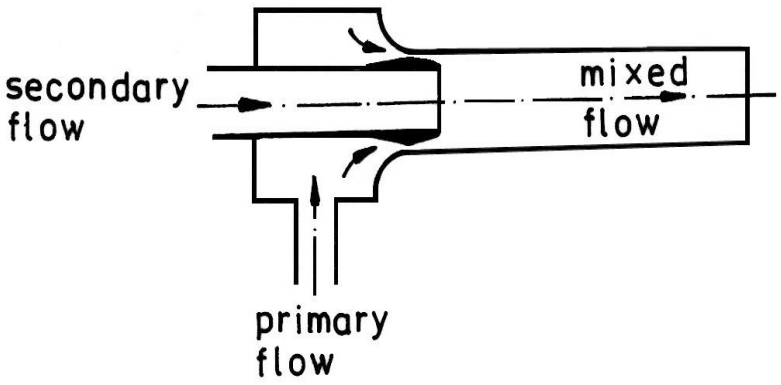

Figure 1. Schematically illustrated lance with annular supersonic nozzle ejector

oxygen enriched air into the molten bath in the copper production zone [1-3]. Using an ejector with an annular supersonic nozzle for the top-blowing lance, the experimental

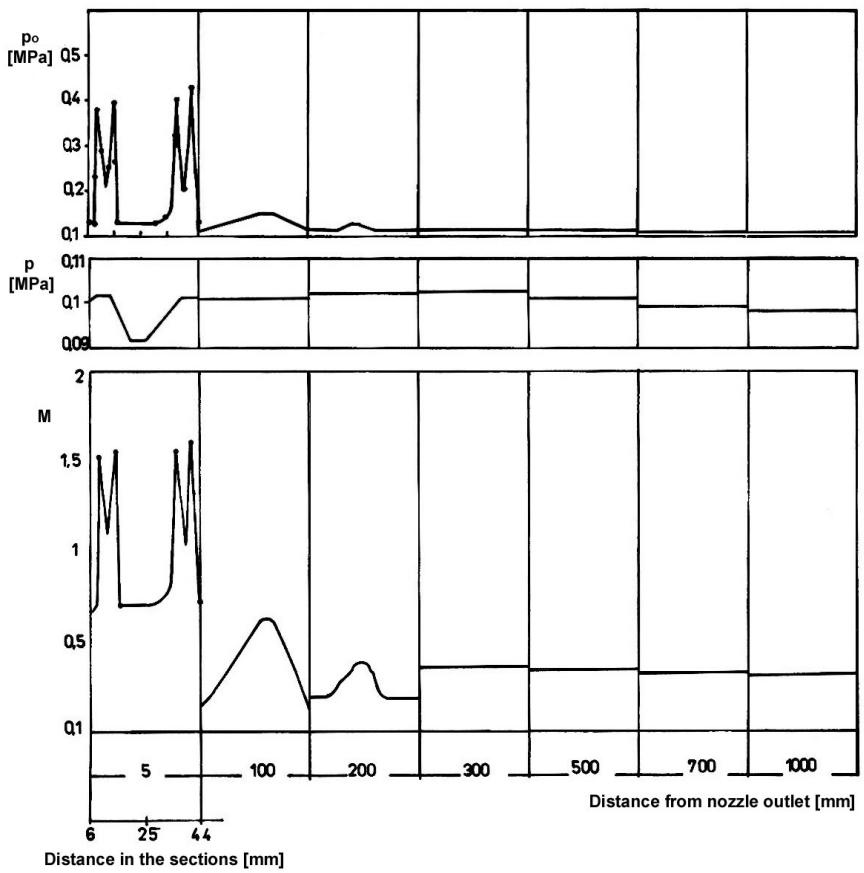

Figure 2. Graphical illustration of measured and calculated aerodynamic characteristics for the lance with annular supersonic nozzle ejector.

study of the air flow parameters was performed.

Gas flow in the ejector with annular supersonic nozzle can be characterized as an anisotropic discontinuous flow of viscous gas. The flow discontinuity is the result of the energy losses due to the friction of air on the ejector walls and due to the shock waves in supersonic flow [4-6].

2. Experiments

The experimental study of air flow through the ejector with annular supersonic nozzle was realized on the lance schematically illustrated in Figure 1. The measurements of the air flow parameters in the ejector mixing chamber with the simultaneous mea-

surements of the pressures of primary, secondary and mixed flow were carried out for the total air pressures of 0.4, 0.5, 0.595 and 0.69 MPa.

The results of the measurements for the primary flow with total pressure $p_o = 0.69$ MPa in the mixing chamber of the ejector are given in Figure 2.

It was difficult to carry out the measurements to determine the shock waves in the air flow, so the Shleer and shade methods were applied. These optical methods make the air flow visible. The visualized free flows under the total air pressure p_o= 0.69 MPa are shown in Figures 3 and 4.

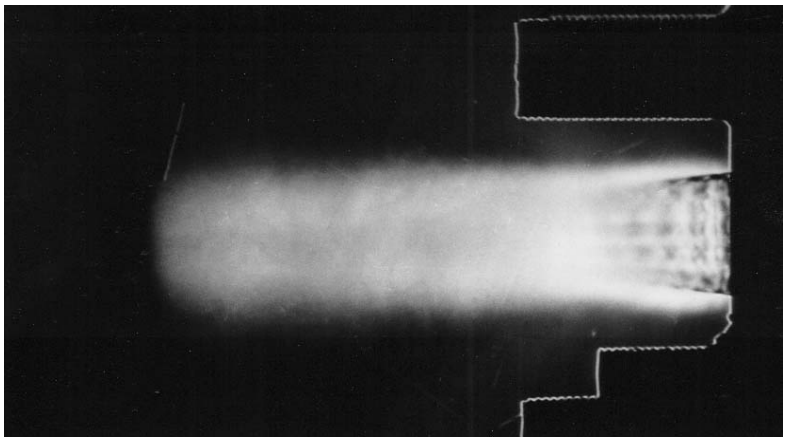

Figure 3. Photograph of the free flow of the air from the lance with annular supersonic nozzle ejector visualized by the Shleer method

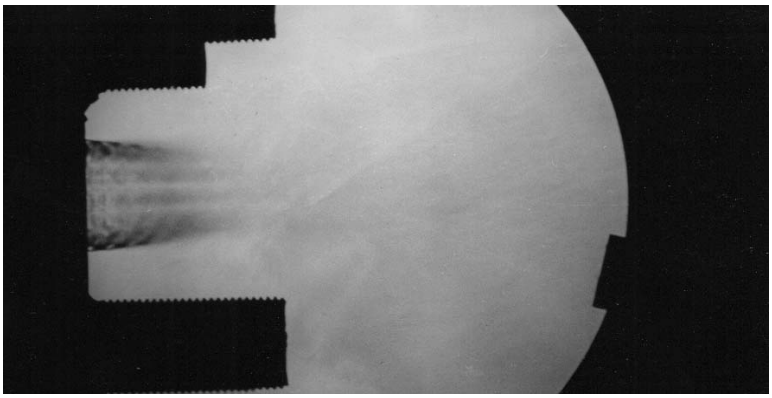

Figure 4. Photograph of the free flow of the air from the lance with annular supersonic nozzle ejector visualized by the shade method

3. Discussion

The visualization of the free flow from the ejector with annular supersonic nozzle showed shock waves of similar character to those in the flow originating from the Laval nozzle. The air flow from supersonic annular nozzle slows down in the boundary layer due to the contact of the flow with the surrounding air as well as due to the reciprocal effect of the shock waves in the annular section of the air flow. Further influencing factors are the energy losses and the flow deformation. Measurements confirm that an ejector with supersonic annular nozzle has lower efficiency than the Laval nozzle.

4. Conclusion

This investigation of the air flow in an ejector with a supersonic annular nozzle showed that the flow was similar in character to the flow from the Laval nozzle but the efficiency of the former device is lower.

The investigated basic aerodynamic data of the air flow in the ejector with supersonic annular nozzle have been used for the construction of a top-blowing lance for a continuous copper reactor.

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