Application of the Cross-Correlation Method to Determine Solid and Liquid Velocities During Flow in a Vertical Pipeline

Leszek Petryka¹, Marcin Zych², Robert Hanus³, Jerzy Sobota⁴ and Pavel Vlasak⁵

¹AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland
²AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, Krakow, Poland
³Rzeszow University of Technology, Department of Metrology and Diagnostic Systems, Rzeszow, Poland
⁴Wroclaw University of Environmental and Life Sciences, Wroclaw, Poland
⁵Institute of Hydrodynamics AS CR, v. v. i., Prague, Czech Republic

ABSTRACT

The use of hydraulic transport during the extraction of nodules from the seabed will need constant monitoring of speed and concentration of solid grains in a vertical pipeline. In that case the most important is the measurement in the begin part of the pipeline exposed to high pressure and high flow nonstationarity. On the basis of this submission, the authors have built a prototype of a measuring device which tests on laboratory piping are the subject of the article. The presented research we conducted during transport of the nodules’ ceramic models in a vertical pipeline with an internal diameter of 150 mm, under conditions of non-stationary flow, expected during operation offshore, and the results we compared with radiotracer measurements and recorded the head losses at the measuring section of the pipeline.

KEY WORDS: Nodules hydrotransport, flow measurement, radioisotope gauge, hydrotransport control

INTRODUCTION

The planned mining of polymetallic nodules from the seabed provides, inter alia, the use of effective vertical hydraulic transport of solid phase. However, the reduction of energy losses during transporting of this type will need, on one hand low velocity of water, but on the other hand to prevent the clogging of the pipeline by grains fall out of the transported stream. In addition, during the operation nodules cannot be ruled out large fluctuations in the concentration and size of transported grains. These circumstances tend to control the performance of pumps based on the real state of the flow at the bottom of the pipe. However, while the velocity of the liquid phase can be measured, e.g. by means of ultrasonic or electromagnetic flow meters, the monitoring of the slowly moving grains of different sizes, in the oscillating pipe lowered to great depths, is a great challenge. This led the authors to reach the radioisotope method, to build a prototype two-phase flow control device and testing it in a laboratory hydraulic system. Description of progress of this work is the subject of the article.

RADIOISOTOPE METHOD

Nuclear devices are applied in Industry from many years. Several examples of that activity were collected by Johansen and Jackson (2004). In our case the gamma absorption set was applied. The constructed device recording the intensity of photons emitted by two closely fitted radioactive sources, collimated to a parallel beam in geometry resembling a knife. This radiation can pass through the center of the pipe cross-section as shown in Fig. 1.

Figure 1. Geometry of the gamma absorption set.