Experimental and Computational Investigation of Turbulent Pulsatile Flow through a Flexible Hose

N.R. Ramesh, K. Thirumurugan, S. Rajesh, C.R. Deepak, M.A. Atmanand
National Institute of Ocean Technology
Pallikaranai, Chennai, India

ABSTRACT

An underwater mining system which is a crawler based system consisting of a mining machine moving on the sea bed collecting polymetallic nodules, crushing and pumping the crushed nodules through a flexible riser to the mother ship by a slurry pump has been developed. The slurry pump is a single stage positive displacement type driven by an independent hydraulic system that pumps nodules. Pressure drop studies for clear water and slurry flow with solids through flexible hoses of varied bend angles and various bend radii were conducted using the solids pump in an experimental test setup. The studies were conducted for the most likely occurring bend angle of 70°, 20° and 60° with a bend radius of 5 times the hose diameter for various flow rates. The results of 20° bend angle were compared with the steady state pressure drop values obtained using Computational Fluid Dynamics using FLUENT™ software. The results from the tests were useful in conducting subsea tests on underwater mining machine at 1032 m depth.

KEY WORDS: flexible riser, Oil hydraulics, hydro-transport manganese nodules, pressure drop studies, solid-liquid flows.

NOMENCLATURE

ω  angular frequency (rad/s)
 T  total time in sec
 n  number of data

INTRODUCTION

The present study aims to estimate the pressure drop in bends of hoses for pulsating flows while conveying water and solids to generate experimental data that could be useful for sizing the positive displacement pump for deep-sea mining applications. An experimental set up has been developed to carry out investigations to obtain data on pressure drop and understanding situations causing plugging in the flexible riser system.

HOSE LAYOUT CONFIGURATION

Many investigators have studied the problem of pressure drop in pipeline bends for both Newtonian and Non Newtonian fluids and developed correlations for estimation of pressure drop. However, the work done on the same for hoses and pulsating flows is very limited. Some investigators have studied pressure drop in conveyance of solids in straight hoses. A few investigators have worked on hose bends conveying fine solids in steady flows.

Yoon and Kwon [2001] have conducted an experimental study on the flow characteristics of solid-liquid two-phase mixture in a flexible hose for steady flows conveying alumina particles of sizes 2 mm size in hose of 50 mm diameter. The results show that for solid-liquid flows with mixture velocity more than 1.5 m/s, the pressure drop increases with the increase in curvature of the bend. Chung and Lee [2001] have conducted experiments in two phase vertically upward hydraulic transport of silica sand particles and show that the pressure gradient of 100 mesh fine sand particles increased over the measured Re range, as compared to the larger 8-10 and 30-40 mesh sands. Boczariski and Ivanov [2001] proposed correlations of slip velocity, hydraulic gradient and relevant measurements of hydraulic conveying of large particles in vertical pipes. Experimental data were presented for the slip velocity of 10mm particles in a 150mm pipe.