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Non-Uniformity of Gas/Liquid Flow in a Riser and Impact of Operation and Pipe Configuration on Slugging Characteristics

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Abstract

A pipeline-riser system is a typical complex pipe configuration in which the non-uniformity of gas/liquid flow is observed to be significant under certain flow rates. This article interprets slugging flow, the most common flow regime in a pipeline-riser system, in the context of a pipeline-riser system, which differs from the approaches used to characterise slugging cycles in previous studies. By comparing data collected by several transmitters positioned locally on the riser and comparing flow in a simple vertical pipe, both the temporal and spatial non-uniformity of the gas/liquid distribution in the riser is presented and interpreted; the relationship between them is also illustrated. The non-uniformity of the flow provides an effective means to quantitatively evaluate the severity of slugging in a pipeline-riser system under different operating conditions. In addition to flow uniformity, specific flow characteristics can be affected by operating conditions as well as pipe configuration. Several factors closely related to the design of experimental facilities and procedures are investigated by a case study of three experimental loops with different layouts and dimensions, and several general findings are summarised. The results may contribute to a better and more specific understanding of gas/liquid flow mechanisms in a pipeline-riser system in addition to serving as a means to evaluate the features of laboratory pipeline-riser systems and the applicability of laboratory results in industrial cases.

Keywords: pipeline-riser system; temporal and spatial non-uniformity; differential pressure; pipe configuration; flow boundary condition; active flow control

Nomenclature

Variables or symbols		Abbreviations (also subscripts)	
C	choke coefficient, $\text{Pa}\cdot\text{s}^2\cdot\text{m}^{-2}$	DI	downward inclined
DP	differential pressure transmitter	DV	downward vertical
Δp	pressure drop, kPa	H	horizontal
P	pressure transmitter	IR	Irregular regime, described in Section 2
p	pressure, kPa, MPa	OSC	Oscillation regime, defined in Section 2
Q	mass flow rate, $\text{kg}\cdot\text{min}^{-1}$	R	Riser
u	velocity, $\text{m}\cdot\text{s}^{-1}$	SS	Severe slugging regime
		SS1	Type 1 of Severe slugging regime, defined in Section 2
Subscripts		SS2	Type 2 of Severe slugging regime, defined in Section 2
a	air	SS3	Type 3 of Severe slugging regime, defined in Section 2
in	inlet	ST	Stable regime, defined in Section 2
s	superficial (at 0°C, 101.325 kPa)	UST	Unstable regime, defined in Section 2
sep	separator		
w	water		

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