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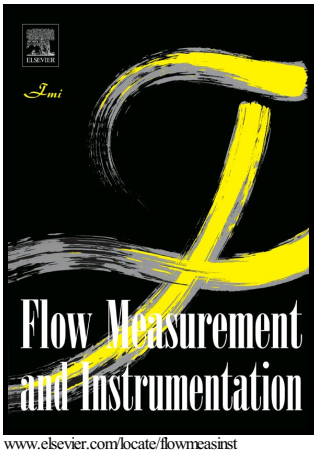

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Anti-slug control based on a virtual flow measurement

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Abstract

Feedback control is an effective and economic solution to prevent slugging flow regimes in offshore oil production. For this, the opening value of a choke valve at the topside platform is usually used as the control input to regulate the pressure or the flow rate in the pipeline. Designing such a control system based on topside measurements, without subsea sensing devices, is preferred from a practical point of view. Controlling the topside pressure alone is difficult and it is not robust in practice, but combining the topside pressure and the flow rate results in a robust control solution. However, measuring the flow rate of a multiphase stream is challenging and requires expensive instrumentation. In this paper, we propose an anti-slug control solution based on a virtual flow measurement. This virtual flow is estimated without neither density nor phase fraction involved, but it gives satisfactory results for the stabilizing control. In particular, applying a cascade structure results in a robust and recommended solution. The performance of the proposed controller is demonstrated by simulation using the realistic OLGA simulator and by experiments.

Keywords: Oil production, multiphase flow, flow control, unstable system, robust control

1. Introduction

In offshore oil production, a multi-phase mixture of oil, gas and water is transported from the producing oil wells at the seabed to the topside facilities through subsea pipelines and risers. Under certain inflow conditions (*i.e.* low inflow rates and low pressure), slugging flow regimes occur in the pipeline-riser systems. Such flow regimes are characterized by severe flow and pressure oscillations. These flow conditions cause numerous operational problems in oil production, *e.g.*, poor separation, overflow of inlet separators and unwanted gas flaring (Taitel, 1986).

The conventional solution to mitigate slugging flow is to reduce the opening of the topside choke valve (choking), but this increases the back-pressure on the producing oil wells and decreases the production rate. Therefore, a solution that guarantees stable flow together with the maximum possible production rate is desirable.

Feedback control has been shown to be an effective strategy to eliminate slugging (Courbot, 1996; Havre et al., 2000; Godhavn et al., 2005). Such a system is referred to as "anti-slug control" aiming to prevent severe slugging 1 (SS1), transient slugging (SS2, SS3) and other oscillatory (OSC) flow regimes. The feedback control stabilizes a stable (STB) flow regime for boundary conditions (inflow velocities and outlet pressure) that would lead to SS1, SS2, SS3 or OSC without control. The control solution is the same for all slugging and oscillatory flow regimes. However, PID parameters of the controller must be re-tuned for different inflow conditions.

The topside choke valve is usually used as the manipulated variable to regulate (control) subsea pressure at a given pressure setpoint. The subsea pressure sensor is usually installed at the pipeline inlet (P_{in}) or at the riser base (P_{rb}). Controlling the pressure measured from the riser