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Attenuating severe slug flow at large valve opening for increased oil production without feedback control signal

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A B S T R A C T

In the co-current flow of gas-liquid mixtures through pipeline-riser system, severe slugging is frequently encountered and manifests in significant fluctuation of flow and pressure. This can pose serious threat to production facilities. The most common method for its mitigation is by choking which unfortunately could negatively affect production. The objective of this study therefore is to develop a technique that can help stabilise the system and maximise production simultaneously.

In this paper, a new general method for multiphase flow system stability analysis was proposed based on a new passive attenuation method – the intermittent absorber. A series of experiments were carried out in a 4″ pipeline-riser system which is 55 m long with horizontal pipe inclined at −2° connected to 10.5 m high catenary riser followed by 3 m horizontal topside section. Air and water were used as experimental fluids. Numerical studies were also conducted on a 4″ pipeline-riser system to proof the concept.

The results showed that the intermittent absorber possess potential for stabilising severe slug flow at larger valve opening and lower pressure. For the case studied, up to 9% reduction in the riser base pressure was reported which practically implies increased oil production.

1. Introduction

In the co-current flow of gas-liquid mixtures through pipeline-riser system, severe slugging is frequently encountered for wide range of pipe inclinations and flow rates. Severe slugging is a flow regime which can be described as a four stage transient cyclic phenomenon. At low flow rate, the liquid accumulates at the riser base blocking the gas flow while the riser column gets filled with liquid (slug formation stage), the gas is compressed in the upstream pipeline causing a pressure build-up which later becomes sufficient to overcome the hydrostatic head in the riser thereby forcing the liquid slug out of the riser (slug production stage). This is followed by a gas surge (gas blow out) and the remaining liquid in the riser fall back to the riser base (liquid fall back stage) which again starts the cycle (Taitel, 1986). Severe slugging usually manifests in significant fluctuation of flow and pressure. This instability is as a result of the upward multiphase flow in the riser and compressibility of gas. Due to these two factors, any increment of gas flow can cause two opposite effects on the riser base pressure, positive and negative. The negative effect can make the system unstable if it is dominant. The threat of severe slugging to production facilities has been known since the 70's. This undesirable flow phenomenon continues to attract the attention of researchers and operators alike. The problem of controlling slugging has attracted much interest in the past decades (Cao et al., 2013; Havre and Dalsmo, 2001; Havre et al., 2000; Jansen and Shoham, 1991; Jansen et al., 1996; Kovalev et al., 2004, 2003; Sarica and Tengesdal, 2000; Yocum, 1973).

The most common method of mitigating severe slugging is by choking the valve at the exit of the riser which unfortunately could negatively affect production. The use of controller however, has been reported to be able to help alleviate this problem by stabilising the system at larger valve opening (Ogazi, 2011). To achieve this, bifurcation maps are developed to ascertain the bifurcation point, and controllers which are able to stabilise the system in an unstable region are then designed (Di Meglio et al., 2012; Ogazi et al., 2010, 2011; Ogazi, 2011; Storkaas and Skogestad, 2003; Storkaas, 2005). This method usually requires measurements from the riser base for the feedback control and these might not be

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