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Robust Control of Unexpected Gas Influx During Drilling

In Managed Pressure Drilling (MPD) the use of a rotating control device (RCD) and a controlled choke at the wellhead allows for the dynamic application of surface backpressure while drilling. This MPD equipment enables a well control procedure, known as dynamic kick handling, that entails continuing circulation while increasing surface backpressure as the initial response to a detected influx. Dynamic kick handling reduces influx volume, increases operational safety, and significantly reduces NPT compared to conventional well control.

In this procure, the bottom hole pressure is controlled to a new set point, above reservoir pressure, and then kept constant while the kick is circulated out. This can be achieved with an automatic backpressure choke controller, however design of such a controller is complicated due to

- The complexity of the PDE describing the distributed two-phase flow dynamics
- The actuation nonlinearity appearing through the choke flow equation
- The large changes in plant time constants when gas enters the well

In this work a first-order approximation to the infinite-dimensional system is identified, which captures the dominating mode of the pressure dynamics in the frequency range of interest. The discarded high-frequency pressure dynamics are then represented by a multiplicative uncertainty. This approximation is modified to accommodate the changes to the dynamics introduced by the two-phase flow.

The linearized plant has an open-loop time constant which varies between 2 and 600 seconds depending on operating point and gas distribution in the well. Robust controller design is then performed using Linear Matrix Inequalities (LMIs) via a polytopic norm-bounded description of both the high-frequency multiplicative, and the low-frequency parametric uncertainty. It is shown that, in order to achieve acceptable performance over such a large range of open loop time constants, a time-varying controller gain is required. The main contribution is to achieve this control objective systematically by formulating the control design problem as an LMI optimization problem.

Biography:

Ulf Jakob F. Aarsnes is a PostDoc at the International Research Institute of Stavanger (IRIS), Norway. He holds a MSc and PhD in Engineering Cybernetics from the Norwegian University of Science and Technology. His PhD thesis was entitled 'Modeling of Two-Phase Flow for Estimation and Control of Drilling Operations'. His research interests include modelling, analysis and control of distributed parameter systems and their application to drilling. Aarsnes has authored and/or coauthored more than 15 technical papers in this field

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