A PRACTICAL STRATEGY FOR CONTROLLING FLOW OSCILLATIONS IN SURGE TANKS

G.C. NUNES†, A.A. RODRIGUES COELHO†, R. RODRIGUES SUMAR‡ and R.I. GOYTIA MEJÍA‡

† Research Center of PETROBRAS – CENPES
22411.001 – Rio de Janeiro – RJ – Brazil
E-mail: giovani@cenpes.petrobras.com.br

‡ Department of Automation and Systems, Federal University of Santa Catarina
Box 476 – 88040.900 – Florianópolis – SC – Brazil
E-mail: {aarc,sumar,rodrigog}@das.ufsc.br

Abstract—The use of accumulation vessels – production separators, electrostatic treaters, etc– as filters of feed oscillations has been proposed to optimize the offshore treatment of crude oils. This change in philosophy of control suggests letting the level to oscillate within certain limits –called band– for which existing algorithms require the measurement of the flow rate. An alternative algorithm is presented in this paper that requires only the measurement of the level. The basic concepts of the proposal are presented. It is demonstrated that besides being simpler, this algorithm has a good performance when compared to the traditional PI controller for surge tanks conception in surge tanks.

Keywords—Level control, load regulation, outflow, stabilization, PI controllers, surge tank.

I. INTRODUCTION

First of a series of separation equipment in petroleum production plants, gravity separators are used for two and three phase separation of gas, oil and water. It feeds dedicated treatment systems designed to specify each of these streams for exportation. In offshore units the inflow of separators is oscillatory, frequently characterized by slugs of liquid and gas coming from the wells, a flow regime generically named slug flow (Shinskey, 1996; Skogestad, 2003). Proportional and Integral, PI, controllers are used for level and pressure control. Precise load regulation is adopted to avoid upsets such as liquid carry over, gas carry under, etc. As the integral mode guarantees offset free response for the controlled variables - level and pressure - flow perturbations are not filtered and oscillations are passed to the downstream treatment systems. In general oscillations are minor and this is no cause of concern (Luyben, 1990).

However, flow conditions in platforms, offshore Brazil, are becoming more stringent and higher amplitude slugs have achieved frequencies that result in significant degradation of performance of such plants. Furthermore, in a move to reduce dimensions of offshore platforms, very compact equipment are increasingly more used for water and oil treatment. Their reduced volume makes them especially sensitive to oscillations (Nunes, 2004; Junior, 1997).

Thus, an algorithm that is able to dampen the oscillatory feed of gravity separators is desirable. The aim is to keep the manipulated flow as constant as possible, while maintaining the level (or pressure) within bounds. A variety of such proposals is found in the literature: non-linear control, feedforward, proportional control, etc, which are presented under many different names: surge control, level averaging control, etc. However, from an operational point of view most of these applications have serious drawbacks: some require extra measurements (i.e., flow rate), others are hard to tune, and some allow excessive volume change (Cheung and Luyben, 1979; McDonald and McAvoy, 1986).

With that in mind, an algorithm named Band control has been developed by Petrobras. Its conception is simple and no extra measurement is required beyond that of the controlled variable. The concept applies to any accumulating vessel.

II. TRADITIONAL PI LEVEL CONTROL

Consider the material balance of liquids in separators. For a vessel with length $C$ and diameter $D$ with equivalent dimensions, and assuming a linear relationship between the height $h$ and the volume, in which case volume is $V=Ah=CDh$, then

$$A \frac{dh(t)}{dt} = Q_{in}(t) - Q_{out}(t),$$

where $Q_{in}(t)$ is the inflow volumetric flow rate, $Q_{out}(t)$ is the outflow volumetric flow rate and the character "o“ represents the deviation around the nominal operating point. The piping and instrumentation diagram (P&ID) of a gravity surge tank separator is shown in Fig. 1.

The output flow is not significantly induced by the liquid level since the pressure $P_1$ is higher than the liquid pressure, which means $P_2=\rho gh \approx P_1$. For simplicity the openness dynamic of the control valve is considered fast, that is,