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Inverted Venturi: Optimizing Recovery Through Flow Measurement

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Abstract

The advent of high crude oil prices and mature fields has seen a rush for efficient recovery methods. This has spurred the development of “monitor-feedback-control” systems through intelligent well system (IWS) and interventional processes. Traditionally, downhole permanent flow measurement is performed using differential pressure meters; e.g. venturi. The intrusive nature of these flowmeters prevents easy access for interventional processes and creates a loss in well lift.

The main aim of an inverted venturi design is to allow full bore access whilst maintaining the downhole measurement accuracy requirements. The flowmeter has a reverse mechanical design compared to a restrictive venturi. Instead of a constricted section in the tubing, the inverted venturi has an expanded section. The theoretical principles are still based around simple energy and momentum conservation. Due to these facts, the operation of the tool requires the use of a pair of high resolution pressure gauge. The main breakthrough came from the development of a high resolution pressure transducer.

Surface testing of the flowmeter has demonstrated flow measurement uncertainty better than 8% for instantaneous flow rate measurement and better than 1.5% in bulk flow rate measurement. These flowmeters have also been deployed successfully in the field. Installation of these flowmeters in the Gulf of Mexico (GOM) region has shown a similar level of accuracies and has provided immense value to production. Apart from providing full bore access, the flowmeter is more robust as it is able to withstand higher gas volume presence in production rather than that of restrictive venturi. Due to the sensitivity of the pressure transducer, the flowmeter is also able to detect the presence of gas in production which adds value to the recovery process.

Installations are planned in the near future in IWS applications. These will include applications for multi-zone allocation flowmeters, injection flowmeters for both gas and water applications and commingled flow production meters. The application for the inverted venturi is limitless as it is not constrained by the typically issues surrounding restrictive venturi such as the loss of wellbore access and well lift.

Introduction

Over the years, the oil and gas community has had its share of scare mongering concerning declining reserves. This has triggered a hunt for more efficient technologies both in the drilling and exploration as well as completion and production. The development of more complex recovery technologies is aimed at prolonging the recovery period from mature and brown fields. These improvements include the introduction of intelligent or smart well technology [1].

Intelligent technology aims to utilise the feedback loops system (figure 1), whereby production is monitored and the information is fed back to aid in decision making for interventional processes to take place. Using downhole control tools, production can be adjusted to modify the rates, fluid types and fluid composition. Other interventional processes include more invasive procedures, e.g. re-perforation.

There are two feedback loops used in production optimisation; the fast loop and the slow loop as described in the paper by Going *et al.* [2] and Vachon *et al.* [3]. The fast loop is a production optimization loop whilst the slow loop is also known as a reservoir optimization loop – intended to prolong production from a particular well or field. The monitoring component of the loop is achieved through the usage of permanent downhole monitoring tools.

Permanent downhole monitoring equipment is defined as the tools that are placed downhole for the lifetime of the well with little or no need for intervention (e.g. servicing). These tools include pressure and temperature gauges, flow meters, fluid fraction meters, fluid composition meters, seismic and microseismic tools and any auxiliary equipment required to communicate data to surface.

Pressure and temperature measurement has always been the main information that is sought by operators even though the production of hydrocarbon is essentially a flow of fluid from downhole to surface. Over the last decade, there has