Requirements for an Underbalanced Training Simulator

Introduction

Currently, there is a need to develop an effective training simulator for underbalanced drilling operations. To date, industry has relied on the experience of personnel who have previously used underbalanced drilling methods to supervise UBD applications. As the application of UBD is expanding, the availability of sufficiently trained personnel is being strained. Oil and gas operators on critical projects are using more systematic training on a case-by-case, but this is proving to be expensive and labor intensive.

The IADC Underbalanced Drilling Committee has targeted training as one of the major issues that must be addressed. Presently, the IADC is proposing a course curriculum for training of supervisors, engineers and rig personnel. The proposal calls for both classroom and simulator training for all levels of training. If adopted, this guideline would apply to worldwide operations, creating a training requirement for a significant number of personnel.

The availability of a transient simulator is essential for proper UBD training. Although the absolute accuracy of the model is not critical, the directional response to changes within the system is very important. This is necessary because the transient pressure response during UBD operations is radically different than well control responses during conventional drilling. The ability to accurately analyze and correctly respond to changes in surface pressures is critical for successful implementation of a UBD project.

Functional Capabilities

To adequately represent the UBD system, a comprehensive two phase flow hydraulics model that couples the drill string, well bore, surface equipment (choke), and a simple reservoir flow should be used.

The simulator must be able to address the following scenarios:

1. Bringing in a well with gas starting from an initially overbalanced condition.
2. Drilling with a stable system in an underbalanced condition.
3. Able to model the dynamic response (drill pipe, bottom hole and choke pressures) that occurs after changes in the controlled variables (opening or closing the choke, varying the pump rate, varying the density of the pumped fluid). This must include a direct link to the reservoir inflow and a delayed response at the various observation points.
4. Able to model various problem situations such as:
    a. a wash out (leak in the drill pipe)
    b. a plugged nozzle at the bit
    c. packing off in the annulus
    d. opening part of the reservoir with higher pressure or flow potential
    e. lost circulation or cross flow into the formation

    f. a washout or restriction in the surface choke

5. The simulator must be able to model the pressure response associated with making a connection. Specifically:
    a. If the well is shut-in during a connection, gravity separation of the fluids in the annulus and the resulting pressure slugs
    b. Conversely, if the well is allowed to flow during a connection, increased flow from the formation and unloading of fluid from the annulus
6. Killing a well from the dynamic well inflow to a static condition.
7. Simulator must be able to handle the following well geometries and set-up information:
    - Vertical and directional well profiles (including inclinations > 90°)
    - Ability to inject gas into annulus using parasite or concentric casing strings
    - Fully generalized string and casing geometries – no presumption of 'traditional' drill pipe/HWDP/drill collars configuration.
    - Variable pore pressure, fracture pressure and formation PI's as a function of measured depth.
    - Temperature profile for all injection paths (string, parasite string, concentric-casing annulus) and annulus (T as a function of MD). Alternatively, and without significant additional computational burden, simulator could compute steady-state temperature profiles for injection and return streams

<u>Controlled variables:</u>

1. Pump rate gas
2. Pump rate fluid
3. Pumped fluid density
4. Surface choke position (percent opening size of adjustable choke)
5. Rate of penetration (amount of cuttings entering the well stream)

<u>Uncontrolled variables:</u>

1. Reservoir inflow
2. Produced fluid density
3. Reservoir fracture gradient
4. Integrity of the drill string
5. Obstruction in the drill string
6. Obstruction in the annulus or surface choke

<u>Simulator outputs:</u>

1. Surface drill pipe pressure
2. Bottom hole annular pressure
3. Surface pressure at the choke

4. Return flow rates, gas and fluid

As this is a training simulator, the number of cases being analyzed can be fixed. What cannot be fixed is the response of the person being trained to the various scenarios. As an example, he may open the choke slightly. Later he may open the choke more or change the ratio of gas to liquid at any point. As the reservoir inflow will change with any change in the controlled variables, the fluid system will rarely be stable or homogeneous.