Flow Uncertainty Position

There are many parameters that determine the pressure and temperature distribution within the well. The pressure and temperature distribution will determine the density, and this determines the elevation head. The flow rates along with the density determine the flowing pressure drop. The frictional flow pressure drops in the various sections of the well geometry (away from the very top and the inlet) are small. There must be extra flowing pressure drops to result in the measured pressure below the BOP. It is well known that there is some pressure drop due to the extraction of fluids from a porous medium. This is often called the well draw down. There is also a pressure drop due to the flow entering the well, which is often referred to as skin. In our case we might assume that skin is large since an intact concrete plug is supposed to exist. However, since the well is flowing, we might assume that this plug has failed.

Two cases are often proposed to obtain a calculated match to the BOP pressure. These are the deep choke (well drawdown and skin) and the shallow choke (flow past a hanger near the top of the well). We have a single pressure measurement, so a variety of resistance pairs can yield the correct BOP pressure. It is conceded that the deep choke resistance cannot be zero, and one can estimate from the porosity measurements a minimum value for this parameter. Often it is assumed that the shallow choke is zero. This allows for a single value for the deep choke to match the BOP pressure.

The resistance at the top of the annulus flow past the hanger is unknown. It is stated that if the hanger has risen 6 inches, it will not provide much resistance. However, we do not know if it has risen at all.

The geometry of the flow is also unknown. Is it up the annulus, up the well bore, or both. The concrete plug was made in a single pour, and it was supposed to block flow from the reservoir to either path. It is possible that the plug never set up, and there is communication between both paths at the bottom of the well. Often the flow is considered to flow up one path or the other. The combined case just introduces too many more parameters required to determine the flow split.

Current observations have revealed that the drill pipe that was known to exist in the well has slipped from its last known position. We are told that it is at least 900 feet lower. This is not a definitive statement. It could extend down even farther.

We were previously told that the shears have operated and the result is a clean cut with little deformation of the ends allowing an easy exit from the drill pipe. Current observations of the plume out of the cut off riser reveal two distinct colors. This is consistent with the distinct colors out of the kink holes previously. This implies that there are two distinct flow paths through the BOP. Possibly the shears may have not completely sliced the drill pipe, and complete mixing of the drill pipe flow and the BOP annular flow has not occurred.

We have been told that diagnostic tests reveal that there is some flow through the BOP annulus. The visual observations of two color flow indicates that the two paths are nominally the same in magnitude. Again, the split in flow requires a model .

Reservoir depletion is another important factor. If enough oil has been extracted from the reservoir the reservoir pressure must decrease. We have been provided many estimates of this pressure reduction. They range from 550 to 2000 psi. The pressure at the BOP should reflect this reduction, but a reduction has not been observed.

Any model has to not only assume various flow paths and resistances; it has to account for potential erosion during the long flowing time. It is assumed that the kill operation where mud was forced through the various paths could have eroded the BOP. However, to this point no model has attempted to quantify this effect.

The model of the system will have a lot of parameters. Some of these are to approximate a complex process (the calculation of a two phase flow rate through an orifice, the difference between the gas and liquid velocities in a rising two phase flow, etc.). Some of these are to approximate the unknown geometry (the ratio of the deep and shallow flow resistances, the amount of flow flowing through the annulus of the BOP, etc.).

Once the model is complete, the model will calculate the BOP pressure during well shut in with and without a leak. The goal is to determine the if a leak exists by comparing the measured BOP pressure to the calculated values. Unfortunately, if this difference between the leak and no-leak BOP pressure is small compared to the accuracy of the prediction of the no-leak pressure, we will not be able to determine the integrity of the well.

At this point, no model has been able to predict why the kill operation. Many have predicted it would succeed. Ones that predict kill failure do not allow prediction of the steady flowing condition. Thus, one might conclude that the models have yet to be correct.

Let me pose a simple analogy. We are able to observe the rate of riders exiting the Metro at National Airport in Washington, DC. We know that the rate is sensitive to the operating condition of the red line (which does not go to National Airport). If the red line is not running, we know that the number of passengers exiting at National Airport will decrease. We can create the model, and determine a the effect of shutting down the red line. Even if our model reduction is accurate, if we do not know the baseline condition, we cannot determine if the red line is running or not. The only control we have is to reduce the number of exit styles. That still will not allow us to determine if the red line is running. This is why one cannot use an inaccurate model to determine if the well is sound. It is not that the sensitivity is low; it is that our uncertainties are high.

 