Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Tool Weight Analysis – An Engineering Approach to Optimize Pressure Temperature and Spinner Data Acquisition

Hidayatus Syufyan, M. Ramos Suryanta, Peter and Cedric Cease

Chevron Geothermal Indonesia, Ltd

Sentral Senayan II, 26th Floor, Jl. Asia Afrika No. 8, Jakarta 10270, Indonesia

hidayatus@chevron.com; ramos.suryanta@chevron.com; peter.chemeng@chevron.com; cedriccease@chevron.com

Keywords: PT-Spinner production, fluid flow modeling, cable and tool forces, friction force, drag force, tension prediction.

ABSTRACT

Pressure Temperature Spinner survey (PTS) is one of the key logging tools that is very important for reservoir characterization and surveillance. PTS data are useful for prediction of reservoir productivity zones and their contributions.

This tool requires ideal conditions during the survey, meaning that the condition during the logging survey should be similar or as close as possible with the normal well operating condition particularly the production rate.

Operating the well during the survey at high flow rates to enable reliable data acquisition and accurate interpretation is not as easy as it appears. Logging the well particularly at such conditions always come with the risk of losing the tool in the wellbore from excessive "bumping" due to flow turbulence, or in rare cases, tool and cable being cut and going up out the wellbore into the production lines. Consequences of the presence of fish and cable in the wellbore or production line will potentially impact profitability. For example, the PTS tool cost about $ 100,000-150,000. and cost of fishing tool and cable cost a minimum of $20,000. Data acquisition alone costs about $ 10,000 and excessive "bumping" of the tool degrades the quality from the spinner.

Estimating the proper weight of the tool given the conditions in a well is traditionally done by trial and error. An initial estimate of the flow parameters (usually with the assumption of a homogeneous fluid) in the production casing (above the production liner) is used to calculate the required tool weight. The tool is then run in the well and if "bumping" occurs as observed in the cable tension, the well production rate is then reduced. If the production rate during the test is deemed too low, the tool is then pulled out of the hole for weight to be added to the tool assembly or the configuration changed. This poses significant risk and delays to the survey.

The actual fluid flow characteristics, particularly for 2 phase wells, are quite complex even in the production casing with brine flashing to steam. Inside the production liner (within the reservoir) multiple fluid entries with varying fluid enthalpies compounded by varying wellbore diameters (as in the case of telescoping wells) further increases this complexity

Tool Weight Analysis (TWA) is an engineering approach that integrates modeling of the fluid flow in the well and its impact on the logging tool and cable. It is basically a calculation of forces between the tool/cable components and flowing wellbore fluid.

1. INTRODUCTION

TWA is a macro-excel based spreadsheet integrated with GeoFlow (Inhouse Chevron Geothermal Wellbore Simulator). TWA was initially developed in 2007 and implemented for Salak Geothermal Field. This tool is then undergoing continuous modification in order to be able to produce a better simulation to match cable tension data from well surveys, both shut-in and flowing.

The ultimate goal of this tool is to be able to predict the proper tool weight to enable the PTS flowing survey to be executed in a condition which is as close as possible to the normal operating well condition. This is very important because by this approach we can reduce the risks, minimize the non-productive time of the well, and more importantly can confidently give recommendations to the well test team to adjust the well accordingly prior to the survey.

2. GUIDING THEORY

The first step to be able to predict the optimum wellbore condition to do the log is to understand the forces acting upon the tool during different type of survey. Generally, there are three condition of doing the survey, namely

1. Shut-in survey at bleed conditions:
   Most likely no fluid force acting to the tool besides buoyant force
2. Injection survey:
   Fluid force on the tool from top to bottom (from injection fluid on the tool), most likely safe at all operating conditions
3. Flowing/Production survey
   Fluid forces on tool from bottom to top, this will be safe only at certain wellbore conditions, especially for high rate producers.

This paper will then discuss about the flowing/Production PTS survey as it is the survey with the highest risk.

2.1 Weight Force

Weight force is a function of mass of the tools and cable and gravity acceleration. This is the only force that counteracts all the forces acting upon the tool. It is simply formulated as

$$F_{wt} = m\ g \quad (1)$$

where F_{wt}, m, g are weight force, mass of the tools and cable, and gravity acceleration.

2.2 Buoyancy Force

Buoyancy force is the force exerted by static fluids on floating or immersed bodies by integrating the vertical component of the pressure force over the entire surface of the body.

A simple illustration of this force in the wellbore can be observed in subsequent figure:

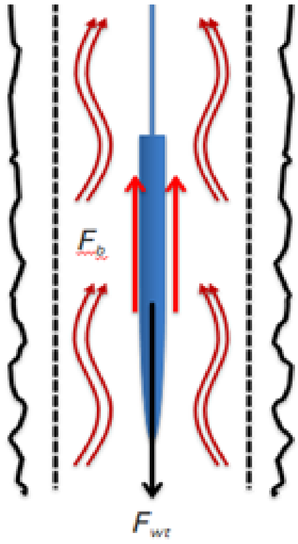

Figure 1: Weight Force and Buoyancy Force

This illustration shows the tool immersed inside a wellbore and being affected by the fluid in the wellbore. It is simply formulated as

$$F_b = \rho\ g\ V \quad (2)$$

where F_b, ρ, V are buoyancy force, fluid density, gravity acceleration and volume of the tools and cable.

2.3 Friction Force

Friction force is a force created when two surfaces are trying to move across each other (Tipler and Paul 1990). It is simply formulated as

$$F_r = \mu k\ N \quad (3)$$

Where μk, N are kinetic friction coefficient-dependent on the texture of both surfaces (tools/cable and casing) and normal force-force perpendicular to the contact surface.

During the logging survey, this force affects tool and cable in the deviated sections of the well where they sit on one side of the wellbore wall. A simple illustration of friction force in the wellbore can be observed in figure 2.

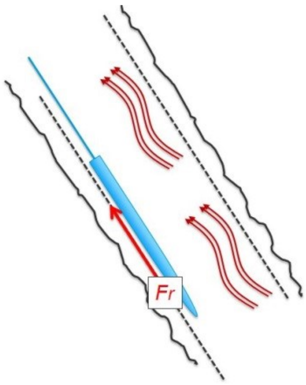

Figure 2: Friction Force

2.4 Drag Force

Drag Force is the force experienced by an object due to movement through a fully enclosing fluid. The formula is accurate only under certain conditions: the objects must have a blunt form factor and the fluid must have a large enough Reynolds number to produce turbulence behind the object.

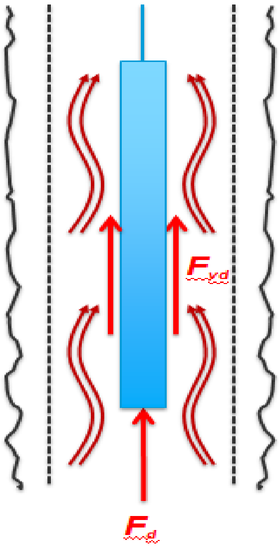

Figure 3: Drag Force

For the case of a flowing PTS survey, there is a drag force at the front of the tool because of fluid flow and there is a viscous drag force on the tool and cable because of fluid flowing around the tool and cable and illustrated in figure 3.

These two types of drag forces are computed using the following formulae:

1. Frontal Drag

$$F_d = 0.5 \,.\, \rho \,.\, v^2 . A \,.\, C_d \tag{4}$$

2. Viscous Drag

$$F_{vd} = 0.5 \,.\, \rho \,.\, v^2 . A \,.\, C_f \tag{5}$$

where p, v, A, C_d, C_f are fluid density, speed of the object relative to the fluid, frontal cross-section surface area of tool, drag coefficient (for cylindrical shaped object = 0.47) and viscous drag coefficient (depends on Reynold's number).

3. APPLICATION

The flowcharts to use the TWA are as follows:

1. Input data preparation consists of well geometry, feed zone location, calibrated production indices, reservoir pressure and enthalpy.
2. Run wellbore model using GeoFlow at specified well head pressure (WHP) to calculate flowing fluid velocity, density and viscosity.
3. Calculate the forces acting on the tool and cable to determine the net cable tension.
4. Evaluate the result, if the fluid forces on the tool (F_{fl}) are greater than the tool weight, add weight and/or increase the WHP to reduce fluid flow velocity.
5. Reiterate until safe and optimum operational conditions to perform the well test is achieved.

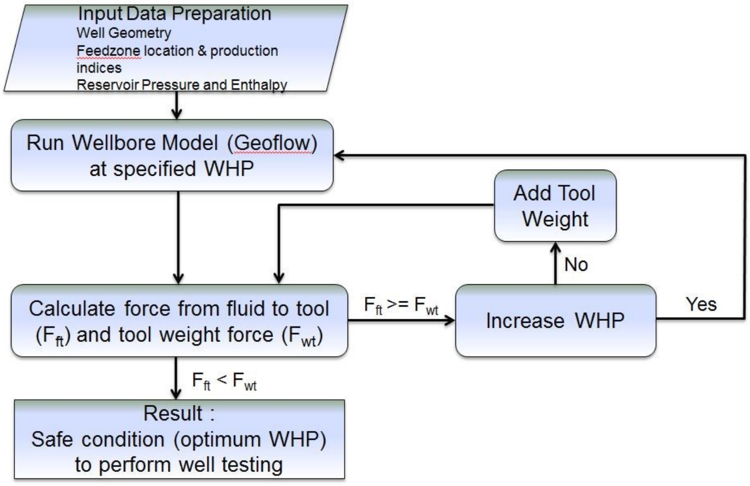

Figure 4: TWA Flowchart

4. SIMULATION RESULT

An example of TWA process is given using a well in Darajat Geothermal field Indonesia, As mentioned earlier, the equation to calculate the net tension is described as:

$$F_n = F_{wt} - Sum(F_r) - Sum\ (F_d) - F_b \quad (5)$$

where F_n, F_{wt}, Sum(F_r), Sum(F_d), F_b are net cable tension, weight of tool and cable, summation of friction forces acting on the tool and cable, summation of fluid drag forces acting on the tool and cable, and buoyancy force.

Following are examples showing how TWA matches the cable tension data in well surveys.

4.1 Shut in Condition in Deviated Well

In this example the forces acting on the tool and cable are only the buoyancy force and friction force. DRJ-X is a dry steam well and therefore the buoyancy force imparted by the steam in the well bore on the tool and cable is very small. The fluid drag forces are also small since the relative velocity of the tool and cable is small. The kinetic friction coefficient (μ_k) is determined by matching the Net Force calculated to the actual cable tension data. It is found that the μ_k value for DRJ-X is 0.96.

The simulation results for net tension are as follows:

- Log Down tension data for shut-in well

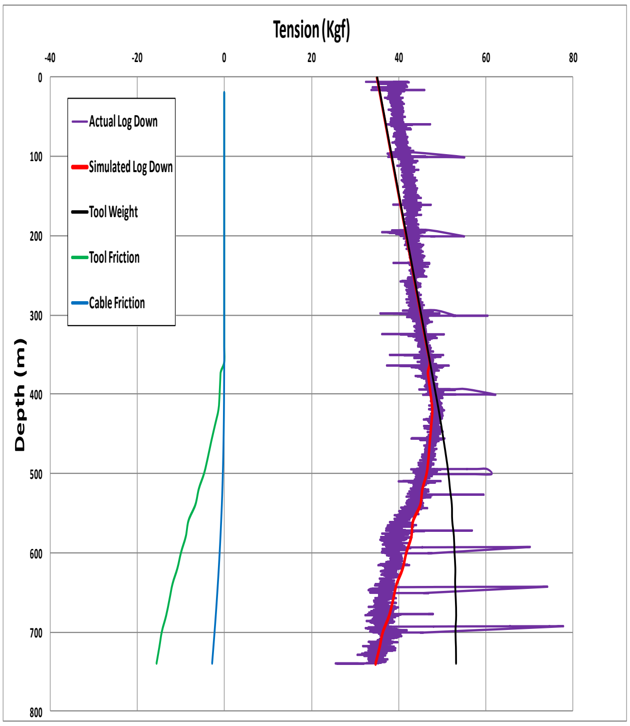

Figure 5: Simulated Log Down Tension in Shut-in and Deviated Well

- Log Up tension data for shut-in

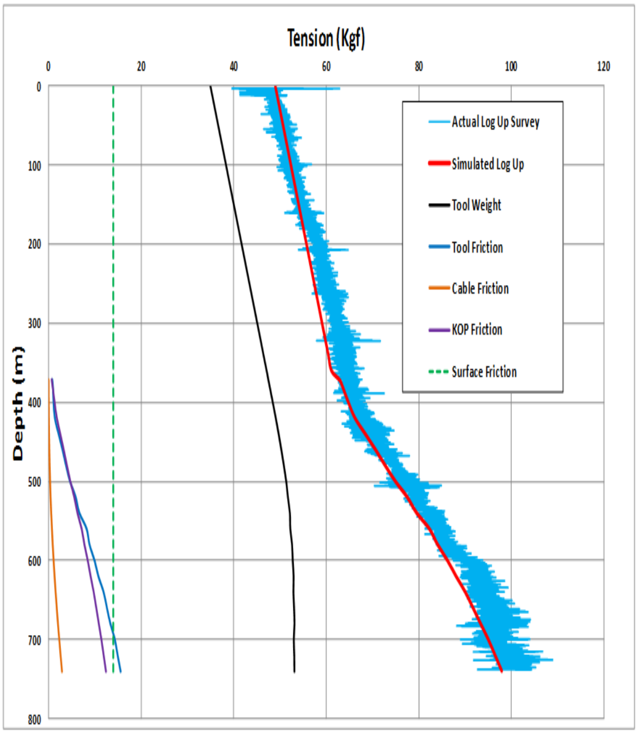

Figure 6: Simulated Log Up Tension in Shut-in and Deviated Well

4.1 Flowing Condition in Vertical Well

From eq.5, for vertical well in flowing condition, the friction forces are non-existent since it is assumed that the cable and tool is always in the center of the well bore and not constantly touching the walls of the casing and liner. The forces to be considered are the fluid drag forces and buoyancy.

The simulation results for net tension are as follows:

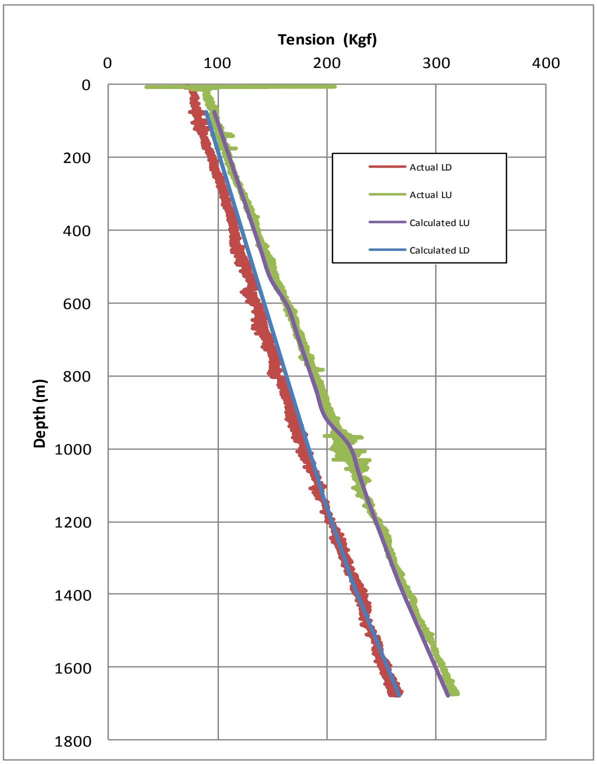

Figure 7: Simulated Log Up and Log Down Tension in Shut-in and Vertical Well

4.1 Flowing Condition in Deviated Well

From eq.5, for deviated well in flowing condition, all forces are accounted: friction force, fluid drag force and buoyancy force.

The simulation results for net tension are as follows:

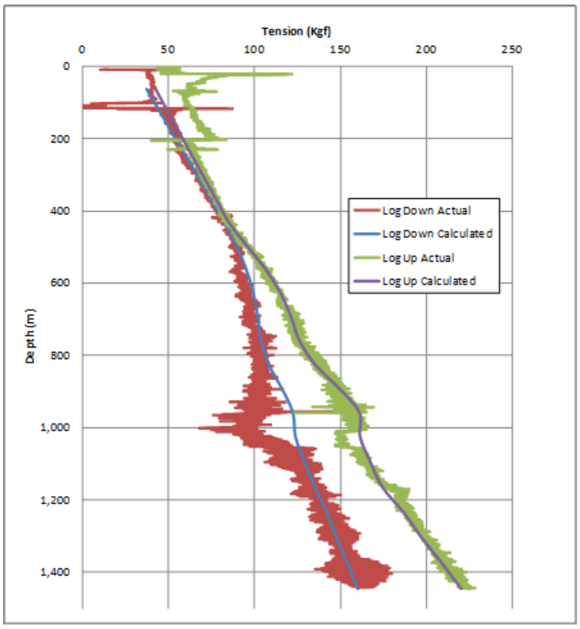

Figure 8: Simulated Log Up and Log Down Tension in Shut-in and Vertical Well

5. CONCLUSION

1. Tool Weight Analysis is an engineering approach that combines wellbore simulation (GeoFlow) and force calculation on the logging tool and cable.
2. There are some forces acting upon the PTS tools during the survey that will affect the cable tension: friction force, drag force, weight force of the tool and cable and buoyancy force.
3. The tension prediction that results from this modeling can be interpreted as a leading indicator to detect possible scaling because of deviation of actual data from the theoretical forces (friction and drag forces) calculated.
4. By utilizing the TWA spreadsheet, the tension can be predicted such that the PTS survey can be done safely at the required well operating conditions.

REFERENCES

Tipler, Paul A., and Mosca, Gene P.: Physics For Scientist And Engineers, W.H. Freeman & Company, (1990).

Hidayaturrobi, A. Dawud: Shut in Go Devil DRJ-11 Report, Chevron Internal Report, 2011.

Martiadi, Krisnendar: DRJ-11 Flowing Pressure-Temperature-Spinner Report, Chevron Internal Report, 2006.

Hadi, D. Katriya: DRJ-17 Flowing Pressure-Temperature-Spinner Report, Chevron Internal Report, 2010.