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PTS TOOL SAFETY ANALYSIS ON GEOTHERMAL PRODUCTION WELL USING FLUID FLOW MODELLING

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ABSTRACT

Well characteristics such as pressure, temperature, fluid flow, and productivity index are some of the basic information that needs to be obtained in order to maximize the utilization also monitoring of the reservoir. PTS survey is commonly used to obtain such information. The vertical movement of PTS tool along the wellbore is controlled by constant velocity wire while centralizer and additional weight are attached to the tool to maintain the position. Due to some of the failure cases of the survey occurred on the liner of the well-bore configuration due to the upward fluid-force was greater than the additional weight, safety tool subject is one of the main concerns.

A numerical study has been developed to understand this phenomenon. A fluid-flow model was built to simulate the behavior of the tool (with the additional weight that was calculated from the fluid properties of the well-bore casing of FSA-1 production well) in the liner using the ANSYS-FLUENT fluid-flow modeler. The PTS tool model is defined within a cylindrical well-bore liner with the boundary condition based on data obtained from the former PTS survey. Through this fluid-flow simulation, this study has found the safe additional weight that should be attached to eliminate the possibilities of tool failures.

INTRODUCTION

PTS survey was first implemented by Geophysical Research Corporation in oil wells on 1929 while on the geothermal industry on 1960[a]. PTS tool contains two main parts, the measuring parts (pressure-temperature and spinner tool), and supportive parts (sinker bar, centralizer).

Figure 1: Model of PTS survey tool

The implementation of the well-bore survey is divided on three basic well cases which are shut-in well, injected well, and well-flowing. Well-flowing can be described as a condition where the well is on flowing state while the down-hole survey is implemented. With the fluids are flowing on the upward direction, it is well-known that on this condition, the survey-failure is high, particularly on the liner part where the fluid velocity reaches its highest level. Most of the failures occurred due to the upward fluid force was greater than total weight of the tool. To reduce the percentage of the failures, some new technologies has been developed. CFM (Cable Force Modeling) was developed to analyze the tool safety along the well while drag coefficient calculation also being developed[b].

To strive with the upward fluid force, sinker bar has been attached to the tool configuration to add more weight. The main concern of this study is due to the buoyancy effect and turbulence flow, the upward force is unpredictable, which may cause a measuring (survey) failure.

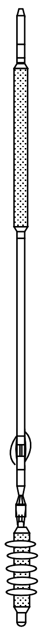
Fluid flow modeling has been developed to understand this phenomenon. With this model, the buoyancy force and turbulence flow inside the liner can be measured in such a way, so that the safety margin of the tool and also the number of weight that should be added can be calculated precisely.

METHODS OVERVIEW

Well and PTS tool geometry design

In order to perform a fluid-flow modeling, a figure of the liner of FSA-1 well and PTS tool must be designed.

PTS TOOL DIAGRAM



DESCRIPTION	LENGTH (m)	O.D. (m)	Weight (kg)
Cable Head	0.4	0.046	4.5
Sinker Bar, Tungsten	1.0	0.061	40
PTS tool	2.6	0.047	
			31
Centralizer (8 arms) ** uncompressed*		0.140	
Spinner		0.054	
Roller	0.7		10
TOTAL	***4.7***		***85.5***

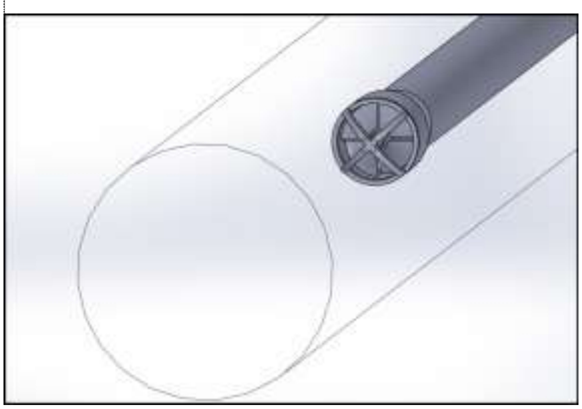


Figure 2: Illustration of liner and PTS tool model

Figure 2 (top) shows the tool configuration with total weight = 85.5 kg while the bottom picture shows the design of the PTS tool inside the liner (wireframe) which was made on the exact dimension. The tool design defined as two parts, the liner represents fluid flowing through the liner and PTS tool, while the PTS tool itself represents the wall that disturbs the fluid flow.

Mesh

The well-made geometry has to be meshed to smaller areas to obtain the best and real numerical value.

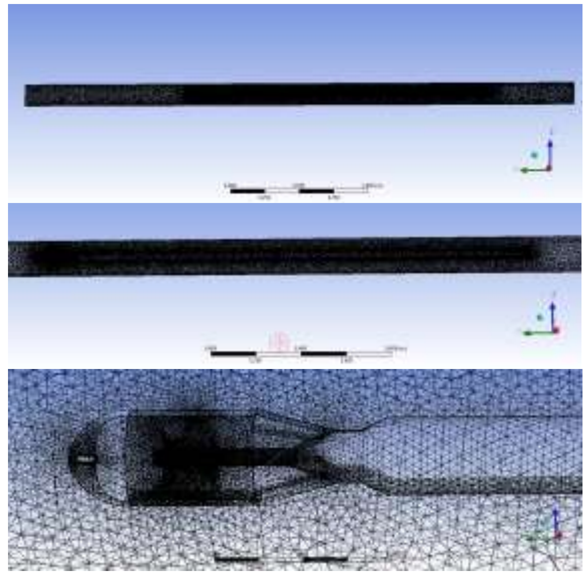


Figure 3: Illustration of meshing alongside liner

As Figure 3 shows, the meshing has been applied to the geometry with the following assumptions.

Assumption		Description
Geometry		Boolean-substract
Mesh method		Tetrahedron
Mesh Algorithm		Patch Conforming
Physics Presence		CFD
Slover Preference & Relevance		Fluent-64
Smoothing		High
Size	Min	4.5188e-4 m
	Max	9.0362e-3 m
Mesh elements		1133751 nodes

Table 1: Meshing assumption

In fluid-flow modeling, the meshing part is very essential to obtain the best iteration of the numerical method. As Table 1 shows, the mesh elements reached 1 million nodes in order to have the mesh skewness < 0.98.

Fluid-flow modeling

A fluid-flow model was built to simulate the behavior of the tool (with the additional weight that was calculated from the fluid properties of the well-bore casing of FSA-1 production well) in the liner using the ANSYS-FLUENT fluid-flow modeler. The PTS tool model is defined within a cylindrical well-bore liner with the boundary condition based on data obtained from the former PTS survey.

Method		Description
Solver		Pressure based- transient
Model		Multiphase volume of fluid
		Turbulence: realizable K-epsilon
Boundary condition	Inlet	Velocity magnitude = 81 m/s
		Pressure = 3439771 pascal
		Temperature = 515.68 K
	Spinner	Moving wall = rotational
	Outlet	Pressure = 3425652 pascal
		Temperature = 516 K
Number of iteration		200/ time step
Solution methods	Scheme	Coupled
	Spatial discretization	2nd order implicit

Table 2: Boundary condition and methods

Table 2 shows the methods and solver used for the iteration and also shows the boundary condition inside the liner. The calculation of the turbulence was based on the turbulence intensity and turbulent dissipation rate equations with the Reynolds Number = 2.73×10^{6}

$$I \equiv \frac{u'}{u_{avg}} = 0.16(Re_{D_H})^{-1/8}$$

The Turbulent Intensity, *I*, is defined as the ratio of the root-mean-square of the velocity fluctuations to the mean flow velocity which result is *I* = 2.7% while the turbulent dissipation rate can be solved by the following equation with Cμ is an empirical constant specified in the turbulence model.

$$\epsilon = C_{\mu}^{3/4} \frac{k^{3/2}}{\ell}$$

RESULTS AND DISCUSSION

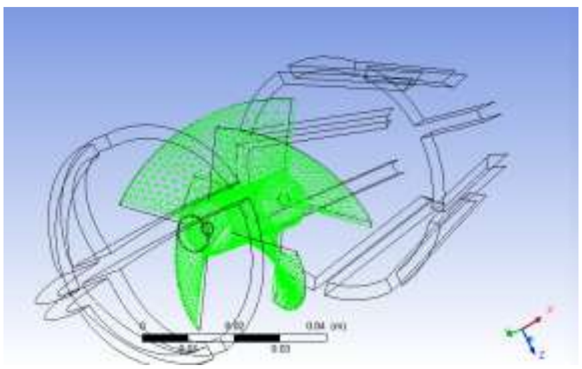


Figure 4: Wireframe mesh view of result

Figure 4 shows the wireframe and mesh of the PTS tool which the result will be shown below

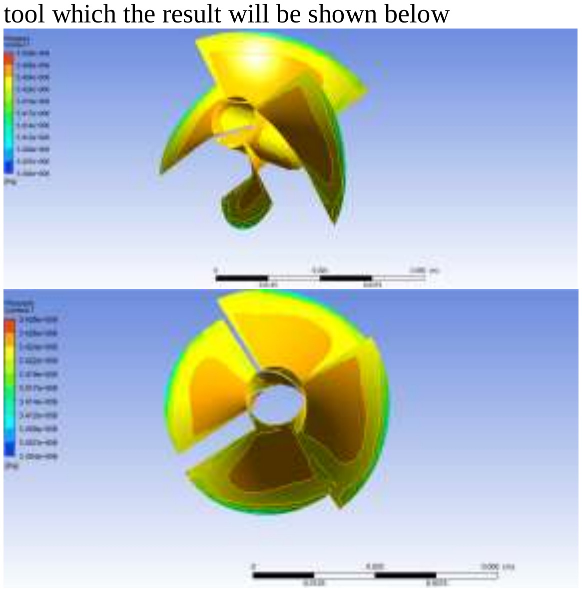


Figure 5: Pressure profile on the PTS tool

From Figure 5, the pressure profile is spread between 3.414 MPa to 3.426 MPa. This data range is mainly caused by the turbulence occurred during the well testing as shown in Figure 6.

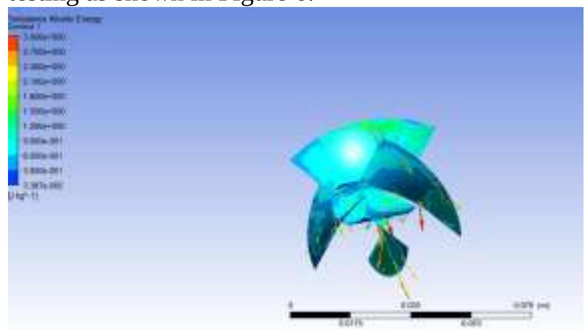


Figure 6: Turbulence Kinetic Energy profile

With the pressure profile known, the upward fluid-force can be determined and with basic mass balance equation, the analytical tool failure can also be determined.

Description		Value
Fluid Force	Min	885.76 N
	Max	888.87 N
Tool Force		838.755 N

Table 3: Mass balance calculation

Table 3 shows that the upward fluid force is greater than the tool force. This condition will result in tool failure. The tool will be forced to move in the upward direction which may cause the cable tool bundled to each other (fishing) and also if the well configuration is directional well, it may also cause the tool stuck in the casing. The best solution that can be given is to add more sinker bar (20 kg for each 0.5 meter) which will result as below.

Description		Value
Fluid Force	Min	885.76 N
	Max	888.87 N
Tool Force		1034.95 N

Table 4: Mass balance added weight calculation

As shown in Table 4, the tool force will be much greater than the fluid force even if the turbulence happens excessively. This will provide the guarantee that the tool will not be forced back by the fluid flow.

CONCLUSION

By combining data and through fluid flow simulation, insights have been gained into the nature of upward fluid force in the liner part of well configuration. The upward force with turbulence can be predicted with purpose of adding the safe weight into the tool configuration.

The numerical fluid flow model accurately estimates the fluid force encountered when running survey with the PTS tool. Accurate prediction of fluid force depends on how accurate knowledge of operating parameters such as fluid density, fluid temperature, tool and well geometry, friction factor, and fluid pressure. Although friction factor are usually not known with major certainty, the numerical fluid flow modeling can be used for sensitivity analysis to reduce the possibility of measurement failure.

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