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Preliminary Study of Aerodinamics Analysis of PTS Testing of Geothermal Well using Computational Solution

Jooned Hendrarsakti[1,2] and Victor Sukyono[1]
Faculty of Mechanical and Aerospace Engineering, Institut Teknologi Bandung
[2]Program of Study of Geothermal Technology, Institut Teknologi Bandung
Jalan Ganesha No.10, Bandung
Email :jooned@ftmd.itb.ac.id

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ABSTRACT

One of the survey conducted to acquire and evaluate condition of geothermal wells is PTS (Pressure Temperature Spinner) Survey. PTS Survey can be conducted when the wells either in well flowing or in injecting condition. The components of PTS equipment include rotating impeller and sensor to acquire the pressure and temperature condition.This current research discusses aerodynamics aspects: pressure, temperature, and velocity distribution of PTS tools in a geothermal well by using Computational or Numerical Solution. The well data is obtained from the actual data in "X" Geothermal Well.

Four configurations were studied such as vertical straight well, directional well with inclination 20°, directional well with inclination 50°, and well while there is contraction at the casing's diameter size. The study found that the results quite good and uniform among all the wells configuration. Pressure of steam increasing (850 kPa) at the inlet, while decreasing at the outlet area (800-825 kPa). The temperature is higher inside the PTS equipment (480 K) than the outside (475 K) due to the friction between impeller and steam. On the other hand contact between solid part of the PTS equipment and steam caused the velocity of the fluid inside the PTS equipment decreases (0-50 m/s) compared to the outer area (120 m/s).

INTRODUCTION

One type of down hole survey test is PTS (Pressure, Temperature, Spinner) test. PTS test is a part of the well test during the well flowing or at the injection condition. Main components consist of pressure and temperature sensors and spinner that rotates due to the fluid motion (1). Spinner is operated during up and down hole operation in the well and spinner frequency is recorded when the tools is at the surface to obtain the steam flow rate. Aerodynamics aspects of PTS tools such as drag force, lift force, and coefficient of pressure are vey important to ensure the tool stability and safety. These aspects depend on the ambient environment, well configuration, pressure, temperature, and steam velocity.

To reduce the failure risk occurring during the test, normally a preliminary survey is conducted by using a dummy PTS tools to simulate the actual process. This preliminary survey is necessary to predict the weight balance, and maximum well depth.

To reduce the cost of the down hole survey, it is important to ensure the safety of tools during operation. Current study is related to the safety factors by analyzing the steam velocity, pressure, and temperature distribution for a variey of well configuration

The objectives of the current study are to analyze the steam pressure, temperature, and velocity distribution near PTS tool for geothermal well for straight pipe, contraction pipe, and inclined pipe well using numerical method. The current study also investigated the effect of the fluid flow to the stability of the PTS tool.

PROCEDURES

The numerical study is started by collecting data of the PTS tools that is used as the model subject and data of actual geothermal well characteristics. The PTS tools data is then used to generate the necessary geometry. Using the numerical study, the steam flow characteristic is then generated using the actual well data, to obtain the flow pressure, temperature, and velocity distribution . The numerical method implements the mass, momentum, and energy equation in calculating the pressure, temperature, and velocity of the steam (2,3). The effect difference geometries or configuration of geothermal well are then investigated.

MODEL SIMULATION

The PTS tool used in this study has the weight range of 18-20 kg, outer diameter of 0.0445 m, and length of 1.68 m. This tool can survice under the well for about 4 hours at temperature of 350°C, and 6 hours at temperature of 300°C. The temperature and pressure sensitivity measurement is ±0,25°C and ±0,08 bar respectively. The rotation speed range is 300-20000 rpm (4).

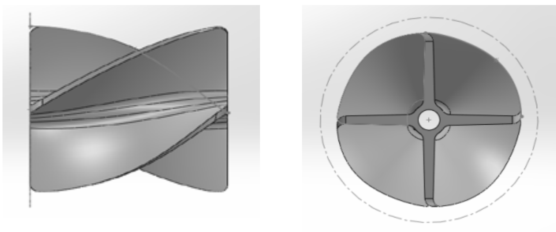


Figure 1. Impellar Model (a) Side view (b) Cross Section view

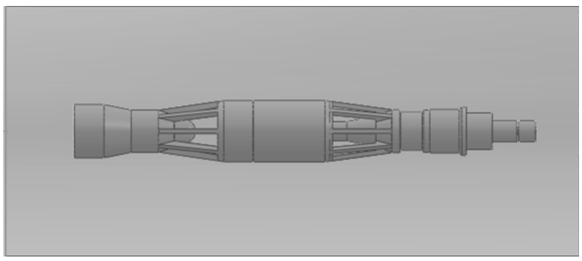


Figure 2. PTS model

Flow rate measurement is conducted by setting the tool down the well with constant speed, and then the tool undergoes up-down hole process with different velocity to target depth at the feedzone. From this depth, the tool is pulled to the surface a constant velocity. This concept is called continuous spinner survey. The data resulted from the spinner is the frequency data that would be converted into the fluid velocity data. This data can be accessed at the surface using SRO (Surface Read Out)

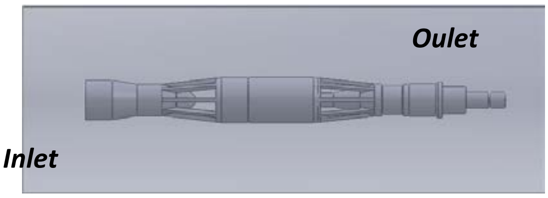
The geothermal well used for the current study has the depth of 10,500 feet or about 3500 m. The casings used are production line 1 and production 2 with diameters of 10.75 and 8.625 inch respectively. The production lines 1 and 2 have the depth of 5000-8700 ft and 8700-10500 ft respective (5).

Both casings are located the deepest area of the the geothermal well. The deepest area of a geothermal well has the critical thermodynamics characteristics of highest pressure and temperature. The temperature can reach as high as 450°F and pressure of 9 bar. The type of impeller has four blades and angle formed is 90° as described in Figs. 1 and 2.

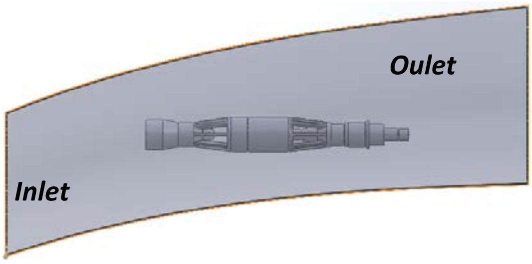
Data inputs and boundary conditions used for the numerical simulation are:

a. Flow types are laminar and turbulence
b. Working fluid is steam in condition of superheated regime.
c. Inlet temperature is 400°F, pressures inlet and outlet are 8.618 and 8.218 bar respectively.

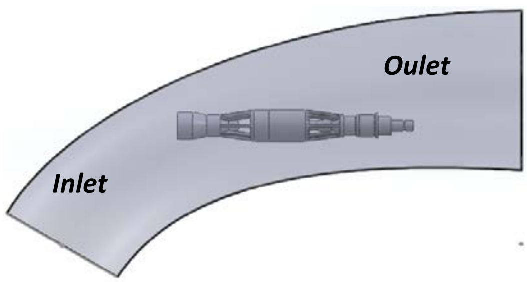
The four well configurations studied are the vertical straight with 0 inclination angle, the directional well with approximate angles of 20 and 50, and contraction area between production casing liner 1 and 2. Model configurations are shown in Figs. 3-6.



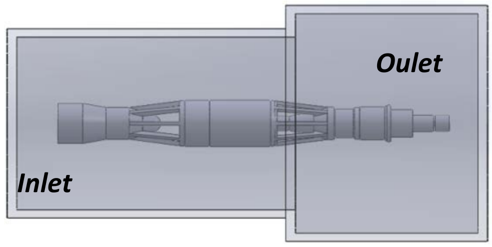
Gambar 3. Model at the vertical straight pipe



Gambar 4. Model at the straight pipe with inclination angle of 20°



Gambar 5. Model at the straight pipe with inclination angle of 50^0



Gambar 6. Model at the straight pipe with contraction (size reduction.

RESULTS AND DISCUSSION

Simulation results are presented as pressure, temperature, and velocity distribution for four different well configurations.

Vertical Straight PipeWell

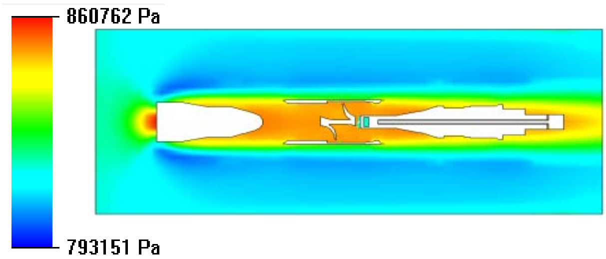
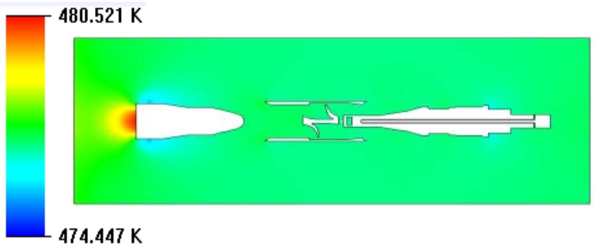


Figure 7. Pressure distribution at vertical straight pipe well.

Figure 7 shows the pressure distribution is uniform crossing the inlet due the fact that the inlet is the location where the steam temperature of 205°C and pressure of 860 kPa. At the inlet, the pressure increases from 840 to 860 kPa. As the flow moves to the outlet, the pressure decreases to 825 kPa.

Figure 8. Temperature distribution at vertical straight pipe well



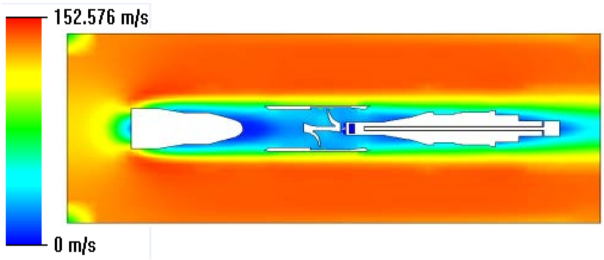


Figure 9. Velocity distribution at vertical straight pipe well

Figure 8 shows the temperature at inner the vertical well has the highest temperature of 480.5 K since the fluid particles collides with surface walls and the friction increases.the surrounding temperature within the impellar..

Figure 9 shows the highest velocity occurs at the outer part of PTS at 152.5 m/s, while the lowest velocity is near the impellar at 10-30 m/s. This is due the blades of impellar would breakdown the fluid concentration moving toward it and cause the fluid velocity decreases. Some of fluid energy are transferred as the kinetic energy of impellar

. Figures 7 and 9 show that in vertical straight pipe, the PTS tool should have no problem in penetrating the well when the tool is set at exactly at the center of the pipe. Ambient pressure and velocity of steam would not affect significantly the tool motion due the uniform pressure and velocity results. Figure 8 show that the steam temperature would not get affected by the tool except at the nose location where some of the heats get accumulated.

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Well with 20° Inclination Angle

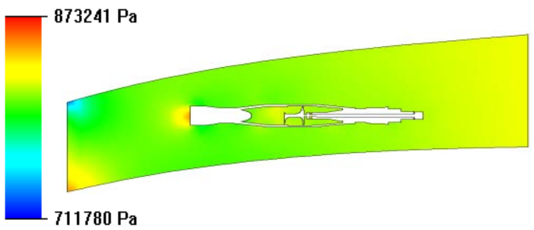


Figure 10. Pressure distribution at pipe well with 20° inclination angle.

Figure 10 shows the uniform contour of pressure around 820 kPa. Some parts of inlet have increasing pressure as noted of reddish yellow contour.

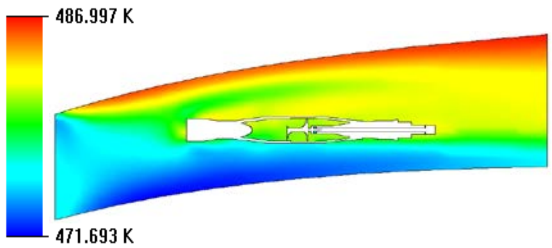


Figure 11. Temperature distribution at pipe well with 20° inclination angle.

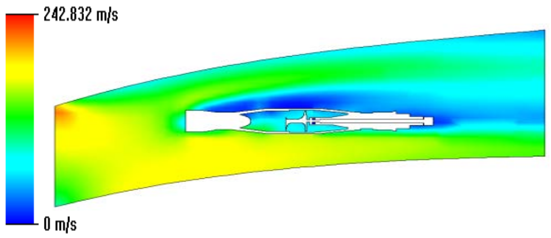
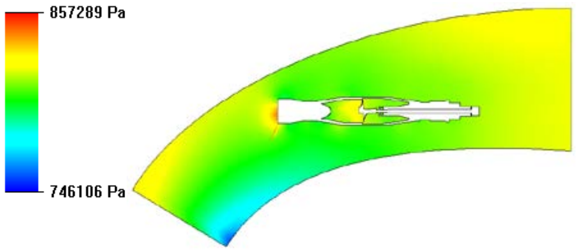


Figure 12. Velocity distribution at pipe well with 20° inclination angle.

Figure 11 shows that the steam might slightly affected by the presence of the tool. The area near the inlet has lower temperature as some heats are transferred to the tool. Figure 12 shows the fluid velocity increases at the outer part of PTS tools, since the fluid can move freely with no collision and friction. This is shown by yellowish green of 120-180 m/s, At inner part of tool, there contour are with dark blue and lighter blue (lower velocity of 0-60 m/s). Compared to the velocity between inlet and outlet, inlet velocity is higher than the outlet velocity. The imbalance velocity can cause the tool changing the direction and then losing its stability.



Well with 50° Inclination Angle

Figure 13. Pressure distribution at pipe well with 50° inclination angle.

Figure 13 shows relatively uniform pressure distribution surrounding the PTS tools with around 800 KPa. Near the impellar, the pressure increases to around 830 kPa as the impellar converts the kinetic energy produced from the rotation to the pressure energy.

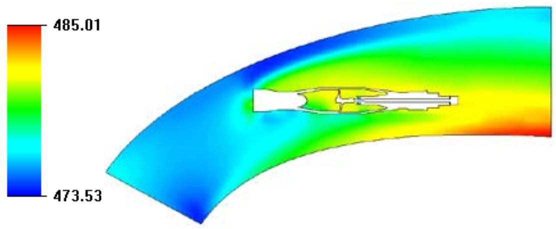


Figure 14. Temperature distribution at pipe well with 50° inclination angle.

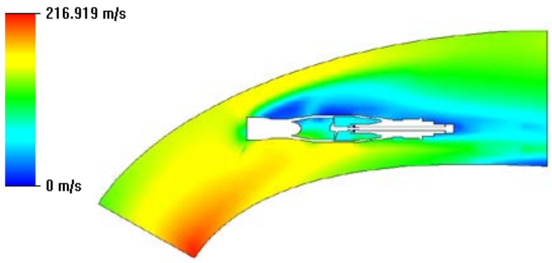


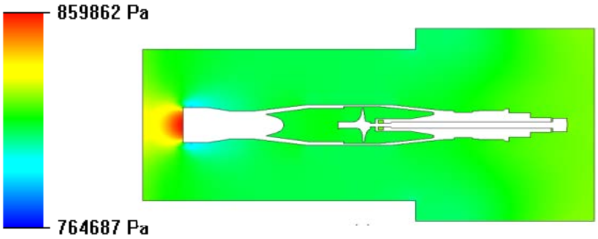
Figure 15. Velocity distribution at pipe well with 50° inclination angle.

Figure 14 shows the temperature distribution at the inlet (with blue contour) has lower temperature of 474 K compared to the outlet (with greenish yellow contour) of 482 K. Similar to the case of 20^0, there is no significant affect of the tool to the steam temperature distribution inside the pipe.

Figure 15 shows the higher velocity at the inlet (green contour) at the velocity of 110m/s compared to theoutlet velocity (blueish contour) at velocity of 50 m/s. This occurs as continuity law states that as the fluid flow velocity gets smaller, the cross section area get larger. Similar to case at 20^0 angle, the velocity difference at the inlet of pipe and the area near tool might affect the stability of the tool.

Well with Size Reduction or Contraction

The number of size reduction of casing depends on the well characteristic and design. Current study uses an actual



data of the geothermal well with the reduction of diameter size of *casing production liner* 1 (10,75 in) to *casing production liner* 2 (8,625 in).

Figure 16. Pressure distribution at contraction pipe

Figure 16 shows the relatively uniform pressure distribution with average pressure of 810 kPa. Near the inlet, the pressure increases (with reddish yellow) to 850 kPa. Inlet area has larger pressure due to the fact that the inlet is in the feedzone area whose high temperature and pressure of superheated steam. The pressure accumulation at this inlet or nose of the tool is expected to have minimal effect since the pressure difference is not significant and is uniform in radial direction.

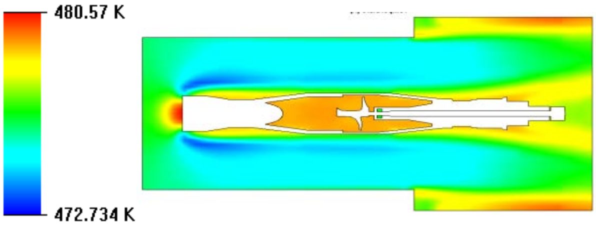


Figure 17. Temperature distribution at contraction pipe

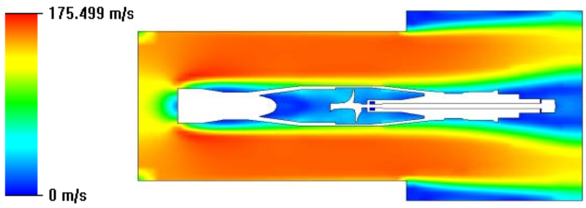


Figure 18. Velocity distribution at contraction pipe

Figure 17 shows the temperature distribution at the contraction pipe. There is no significant affect of the tool to the steam temperature as the temperature range is very close.

Figure 18 show the inlet velocity is larger than the outlet velocity as indicated in red and blue contours. This is affected by the diameter size which is smaller at the inlet compared at the outlet. This might be caused also by the presence of impellar and solid part of PTS tool that makes the steam flow cannot move free and makes smaller velocity. At this case, the stability of the tool should have no problem as long as the tool is set exactly at the center of the pipe. While the turbulence might occur near the contraction, this should have minimal effect due to the uniform velocity distribution in radial direction.

CONCLUSIONS

From the current study, it can be concluded that in general:

- Pressure distributions for four configurations well have the similar results forsurrounding the PTS tool. The pressure increases to 825 kPa at the inlet and decreases toward the outlet to 800-825 kPa.
- The simulation for the temperature distribution shows the area surrounding the PTS tools tend to have higher temperature of 480 K compared to at the ambient fluid of 475 K due to the friction between the fluid and the impeller blades.
- Simulation of the velocity distribution shows the area at inner tools has lower velocity of 0-50 m/s compared the ambient fluid that have velocity of 120 m/s due to the geometry of the tools causing the collision and friction between solid walls and the fluid.
- It is necessary to have the tool set at exactly the center of the pipe to ensure the tool stability.

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