Understanding Tubing Movement and Its affects n Pressure and Temperature

ISSN (e) 2520-7393
ISSN (p) 2521-5027
Received on 15th Sept, 2018
Revised on 3rd Oct, 2018
www.estirj.com

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Abstract: In order to reduce the complication of producing wells it is essential to appropriately design the completion assembly prior to running in. Because, appropriate design of completion assembly saves the time and expenditures that might result in performing work over jobs and other operations on wells which may increase overall operation costs. The essential part of completion assembly design includes the tubing movement, stresses acting upon tubing string, compression, tension, ballooning, buckling and temperatures changes during injection and production. The prediction of tubing movement due to aforementioned forces acting on assembly is essential in the completion design of the producing or injection wells. The changes in length of tubing due to these forces are main cause of the completion problems. Therefore, this study deals with understanding all the factors that effect on tubing. Further, the compensation of tubing movement is also discussed with the factors.

Keywords: *Tubing movement, tubing length, tubing forces, tubing compensation, simulation*.

1. Introduction

Tubing movement is the study of how tubing strings are affected by pressure, temperature, and mechanical changes, this effect depends on well conditions, tubing to packer to casing configuration and tubing restraint. The contributing factors in the tubing movement can be broadly divided into two sections.

- Well conditions
- Tubing restrains (Tubing to packer to casing configuration)

1.1 Well conditions

Following factors come under well conditions:

Tubing properties

- Size, weight, material and length

Casing / Liner properties

- Internal Diameter

Fluid properties

- Weight, Pressures and Temperatures changes

1.2 Tubing restrains (Tubing to packer to casing configuration)

- Free movement: the tubing is free to move in any direction.
- Retrievable packers = Packer with no slips like the B Tandem or C-1 Tandem packers
- Permanent packer = Seal bore packer with floating seal nipples (no locator shoulder)
- Limited Movement: tubing movement is permitted only in one direction.
- Retrievable packers = Single grip packers like the AD-1, or packers with internal stroke like the Hornet
- Permanent packers = Seal bore packer with locator Seal Assembly.
- No Movement: tubing is not free to move in any direction
- Retrievable packers = Double grip packers like the FH or R-3
- Permanent packers = Seal bore packer with anchored seals

The prediction and calculations of tubing movement is essential part in the completion design of the producing or injection wells. The change in length of tubing due to forces is main cause of the completion problems [1].

The temperature and pressure are changes inside and outside the tubing due to the mode of a well (producer, injector, shut-in, or treating). There is equipment that is installed in tubing for adjunction the length of string. But the change in temperature effects on the length of tubing string and increase the force in the string which can potentially affect the packer and downhole tools [2].

2. Effect of Pressure and Temperature on Tubing

The change in temperature and pressure due to the mode of well effects on the movement of tubing. That change the amount of force required to set the tubing and increase the length of tubing which may potentially affect the down hole tools and packer.

2.1 Effects of Increase in Tubing Length and Force Changes

The increase in force and enlargement of length in string is possibly considered at the time of tubing landing and packer installation. There are different factors that impact on tubing string and packers depends on the

- Connectivity of the packer
- Packer types
- Setting procedure of Packer
- Compression and tension load on the packer

The enlargement in length and forces that are created at the time of installation affects and creates the stress on the string and at certain conditions it affects the performance of packers [3].

In resultant it damages the tubing, casing and reduces the performance of down hole tools. In the end, the enlargement in tubing length creates problem and increase the operational cost of various operations that will be conducted after installation of tubing, such as [4].

- Conducting squeeze cementing job after failure of primary cementing
- Performing acidizing and Fracturing job
- Performing work over jobs for various remedial operation

2.2 Length and Force Changes

The enlargement in length of tubing is mostly occurred at the time of packer setting. Therefore, it is necessary to understand the determination of seal that remained in seal bore packer and prevent the destruction of packer during seal installation and setting in seal bore extension [5, 6]. It is necessary to calculate the force that increases due to tubing length enlargement in order to prevent the following failures:

- Packer unseating
- Tubing and packer destruction
- Operating the SSD and SPM

The force and enlargement in length of tubing string is affected by four factors [7, 8].

- Variation in temperature,
- Effect of Piston due to change in pressure
- Effect of ballooning due to variation in average pressure within tubing and surrounding the tubing.
- Buckling effect due to the difference in internal tubing pressure and annular pressure.

The major effect of shortening the tubing string is buckling. On the other side the other parameters also affect and may tend to increase or decrease the length of string and mainly depend on the application of these factors. During movement of tubing in the packer bore, the ballooning affect and temperature only have an impact on changing of length of tubing. If the free movement of tuning at the packer is restricted, then it would create a force in the string.

At initial stage when the string of the tubing has been landed on the packer, it will remain at neutral condition until any compression load or mechanical strain functional by the rig operator. After completion job, any change in pressure and temperature of tubing causes of change in tubing length.

There are different methods that were presented for determination the length and force changes. Most methods determine their effects due to buckling and ballooning [9, 10].

3. Effect of Piston

The change in pressure between packer and the annulus effect on the piston at different parts (Figure 1.1) that increases the required force and length to the piston. Therefore, it is necessary to calculate the parameters of length and force changes are given below [18].

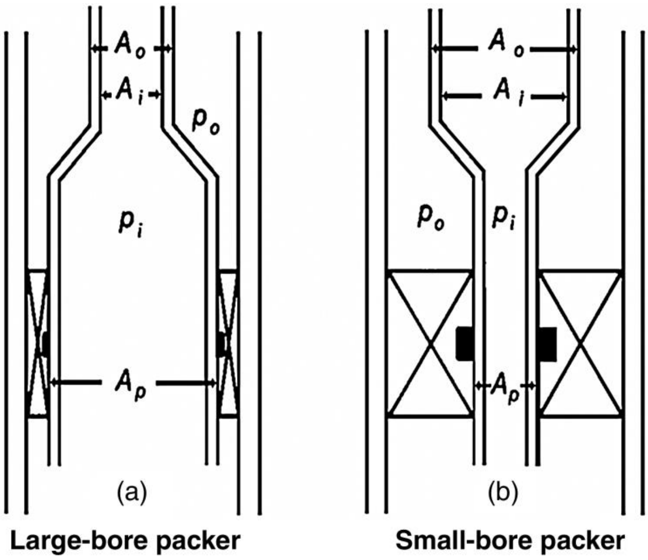

Figure. 1. Areas acted upon by pressure in the tubing and the annulus.

$$\Delta L_1 = \frac{-L}{EA_s}\left[\left(A_p - A_i\right)\Delta p_i - \left(A_p - A_o\right)\Delta p_o\right]$$

And

$$F_1 = \left(A_p - A_i\right)\Delta p_i - \left(A_p - A_o\right)\Delta p_o.$$

Where:

- ΔL_1 = Length change effect on piston
- F_1 = Change in force due to effect of piston
- L = Length of tubing,

- E = Elasticity modulus
- As = Tubing wall cross-sectional area
- Ap = packer bore area,
- Ai = Tubing ID area,
- Ao = Tubing OD area,
- Δpi = Tubing pressure change at the packer,
- Δpo = Annular pressure change at the packer.

ΔL_1 the length change is the combination of L/EAs and piston force F_1. Where the piston force is the combine effect of two pressures acting at different parts.The one for the annulus and second for tubing. The area where the pressure change affect in the tubing is the area between the packer bore and tubing ID (Ap –Ai). In the same way the area where the pressure change in the annulus is the area between the packers bore and the tubing OD (Ap –Ao).

The tubing string that has smaller OD and ID than the packer bore has large bore packer as shown in fig.1 (a). In this situation the downward force is applied due to annular pressure and upward force is applied due to tubing pressure. This position is reversed for small bore packer as shown in fig. 1 (b). The resulting direction of action has been determined through magnitude force. The schematic diagram of packer and tubing should be made to determine force, areas, and the action of force direction.

3.1 Effect of Buckling

The increase of tubing internal pressure Pi than the annular pressure Po causes of buckling that further reduces the tubing length but the actual force applied is insignificant. The reduction in length is also depending on the shape of tubing. The tubing string is being in a spiral shape rather than straight therefore it will also decrease the length. The change in length of tubing is calculated from the following given formula [18]:

$$\Delta L_2 = \frac{-r^2 A_p^2 (\Delta p_i - \Delta p_o)^2}{8EI(W_s + W_i - W_o)}$$

Where;

- ΔL2 = Change in length due to buckling problem
- r = Radius between casing ID and tubing OD, [(IDC – ODt)/2]
- Ap = Packer bore area
- Ai = Tubing ID area
- Ao = Tubing OD area
- Δpi = Change in tubing pressure at the packer
- Δpo = Change in annulus pressure at the packer
- E = Elasticity Modulus
- I = Tubing inertia movement to its diameter [I = π/64 (D4 – d4)]; where D is the tubing OD and d is the tubing ID
- Ws = Tubing weight per inch
- Wi = Tubing fluid weight per inch
- Wo = Displaced fluid weight per inch.

3.2 Ballooning and Reverse Ballooning

The pressure changes outside or inside the tubing string causes the ballooning effect. The length of tubing is shortening and decrease due to the internal pressure swells. In the same way the tubing is elongate due to the squeeze of annular pressure and called reverse ballooning. The change in length and force due to ballooning and reverse ballooning are given by [18].

$$\Delta L_3 = \frac{-2L\gamma}{E} \frac{\Delta p_{ia} - R^2 \Delta p_{oa}}{(R^2 - 1)}$$

And

$$F_3 = -0.6(\Delta p_{ia} A_i - \Delta p_{oa} A_o).$$

Where;

- ΔL3 = Change in length due to ballooning/reverse ballooning
- F3 = Change in force due to ballooning effect/reverse ballooning
- L = tubing length
- γ = Poisson's ratio
- E = Elasticity Modulus
- Δpia = Tubing pressure change,
- Δpoa = Annulus pressure Change,
- Ai= Tubing ID area,
- Ao = Tubing OD area,
- R = Tubing OD to ID ratio

3.3 Effect of Temperature

The major length change in the tubing is due to the Thermal expansion or contraction. The cooled metal contact and the heated metal expands. The contraction or elongation can be considerable in tubing string with change in temperature over the full length. The producing, injecting and treating are the three operational modes that are affected by the change in temperature.

The tubing length change due to temperature is calculated from given formula [18].

$$\Delta L_4 = L\beta\Delta t.$$

Where;

- ΔL4 = Tubing length change,
- L = Length of tubing,

- β = Thermal expansion coefficient (0.0000069 for steel),
- Δt = Average temperature change.

The change in temperature also affects the force that is created by the movement of tubing and calculated from given formula [18].

$$F_4 = 207 A_S \Delta t$$

Where;

- F4 = Force in pounds
- AS = Tubing wall area
- Δt = average tubing temperature change

3.4 Combined Effects (Net Results)

The change in length of tubing is affected by different parameter. Therefore, the overall change in length is the sum of change in length due to temperature, ballooning and piston effect. It is necessary to consider the direction of change in length due to this effect. The length and force changes due to ballooning and buckling can be determined graphically [17]. But the graphical method is useful particularly in development wells that have same casing, tubing and packers size. It is necessary to consider the pressure and temperature effect during planning the sequential of completion and work over job. On the other hand it is also necessary to determine and use pressure effect during selection of packer and use of annular pressure foe offsetting the length.

4. Tubing Movement Compensation

Two methods are generally used

- Landing the tubing in tension/compression: This method is limited by material strength. Landing and spacing procedure is critical and often difficult achieve.
- Allowing free movement of subsurface seals: Locator tubing seal assemblies and seal receptacles can compensate for length changes. Ensure that the sealing elements do not leave the polished bore or mandrel. Landing and spacing is less critical.

5. Conclusion

The tubing movement during running completion is an essential part of the completion design. The main tubing movement factors that effects the completions design are buckling, tension or compression, ballooning and temperature. Preliminary analysis of tubing forces is beneficial for the project and helps to avoid remedial operation such as work over and well intervention.

References

[1]Miller, Mark A. "A Stochastic Approach to Shale Well Completion Design." Unconventional Resources Technology Conference (URTEC), 2014.

[2] Denney, Dennis. "Integrated Completion Design for Horizontal Wells in Unconventional Reservoirs." Journal of Petroleum Technology 64.11 (2012): 118-121.

[3] Pogoson, Oje James, and Andres H. Cardona. "Flow Analysis: A Critical Step in Completion Design and Optimization: A Case Study of Multizone Completion Designs." SPE Annual Technical Conference and Exhibition.Society of Petroleum Engineers, 2013.

[4] Nagel, N., et al. "Stress Shadow Evaluations for Completion Design in Unconventional Plays." SPE Unconventional Resources Conference Canada.Society of Petroleum Engineers, 2013.

[5] Chavez, E., et al. "Lower Tertiary-A Comprehensive Well Completion Design Methodology to Overcome Reservoir Challenges." SPE Annual Technical Conference and Exhibition.Society of Petroleum Engineers, 2013.

[6]Packer Calculations Handbook. 1992. Baker Oil Tools Div.

[7] Lubinski, A., Althouse, W.S., and Logan, J.L. 1962. Helical Buckling of Tubing Sealed in Packers. J. Pet Tech 14 (6): 655-670. SPE-178-PA. http://dx.doi.org/10.2118/178-PA.

[8] Moseley, N.F. 1973. Graphic Solutions to Tubing Movement in Deep Wells. Petroleum Engineering Intl: 59.

[9] Durham, Kenneth S. "Tubing movement, forces, and stresses in dual-flow assembly installations." Society of Petroleum Engineers Journal 22, no. 06 (1982): 866-874.

[10] Hammerlindl, D. J. "Movement, forces, and stresses associated with combination tubing strings sealed in packers." Journal of Petroleum Technology 29, no. 1 (1977): 195-208.

[11] Hammerlindl, D.J. 1980. Basic Fluid and Pressure Forces on OilwellTubulars. J. Pet Tech 32 (1): 153–159. SPE-7594-PA

[12] Hammerlindl, D.J. 1980. Packer-to-Tubing Forces for Intermediate Packers. SPE J. 32 (3): 515-527. SPE-7552-PA.

[13] E. Kuru, A. Martinez, S. Miska, and W. Qiu, “The buckling behavior of pipes and its influence on the axial force transfer in directional wells”, Journal of Energy Resources Technology, vol. 122, pp. 129-135, 2000

[14] X. Du, H. Wang, S. Wang, and J. Liu, “Mechanics analysis of down hole string used for deep well fracturing and its application”, Oil Field Equipment, vol. 37, no. 8, pp. 28-33, 2008.

[15] Z. Wang, W. Li, and Y. Xu, “Analysis on stress distribution of fracturing string with finite element method in deep gas well”, Science Technology and Engineering, vol. 9, no. 2, pp. 409-412, 2009.

[16] Z. Li, J. Dai, and Z. Yu, “Mechanical analysis of downhole strings for two-layer fracturing and its application”, Oil Drilling & Production Technology, vol. 31, no. 1, pp. 81-84, 2009.

[17] Moseley, N.F. 1973. Graphic Solutions to Tubing Movement in Deep Wells. Petroleum Engineering Intl: 59.