Journal of Engineering and Applied Sciences 13 (19): 8010-8015, 2018
ISSN: 1816-949X

Chemical Failure Analysis of Artificial Lift System in Petroleum Industry: A Review

[1]Jose Osorio Tovar, [2]Grimaldo Guerrero John William, [3]Pacheco Torres Pedro Jessid and [4]Chaparro Badillo Lizeth Paola
[1]Instituto Universitario Politecnico "Santiago Marino", Maracaibo, Estado Zulia
[2]Department of Energy, Universidad De La Costa, Calle 58 Nº 55-66, Barranquilla, Colombia
[3]Faculty of Engineering, Corporaccion Universitaria Reformada, Calle 38 No.74-179, 080002 Barranquilla, Colombia
[4]Department of Education, Universidad Del Atlantico, 7 km via. Puerto Colombia, Colombia

Abstract: In the following research described the chemical agents which affect the artificial lift functioning it was based on a bibliographical review of scientific articles and documents that they specialize in an artificial lift system. We describe the modification caused by the different agent in the equipment in order to offer to the reader a synthesis of the biggest causers of rod failure in the artificial lift systems.

Key words: Chemical agents, artificial lift systems, oil and gas, rod failure corrosion, chemical and described, system

INTRODUCTION

The energetic demand has presented substantial changes and a strong global growth, mainly in the demand of hydrocarbons which has been increasing (Guerrero *et al.*, 2017). In the oil industry it is important to increase the production recovery in the wells, during their useful life, these initially have the production by natural flow (as long as the oil field has the sufficient pressure). Nevertheless, due to the energetic loss of the oil field are used the Artificial Lift Systems (ALS) (Gil and Chamorro, 2009) to help the oil field and maintain its production of fluid, considering that all organic material represents a potential and important source of fuel because it can be converted into energy (De Souza and Schaeffer, 2015). Based on this, the companies in charge of the production have the aim to maintain and increase the production, to achieve this objective, they are doing investments in order to detect the causes that generate the production losses (Mills and Gaymard, 1996).

Based on the hydrocarbon transport system is complex and must meet a large number of technical requirements for optimum operation (Melendez-Pertuz, 2017). During the pumping cycle is losing energy constantly (Noonan, 2008) because the fluids exert damping force in the anular space, rod and pipeline, this effect is significant in deep wells with heavy crude oil with the previous consideration, to realize the well designs it is important consider these factors with the major possible precision, due they represent an additional load in the system that the surface and bottom equipment must support (Flatern 2015; Bucaram *et al.*, 1993).

Due all bottom-wells environments are corrosive even some degree. According to Denney (2004) the great majority wells in production are plagued with corrosion problems and any pump rod currently made can support alone the corrosion effects. Although, the corrosion cannot be eliminated but it is possible control the reaction (Nesic *et al.*, 2004). The inspection and verifications necessary of material and equipment before be used in operation and production process of each well, guaranteeing a reliable and lasting process to get the most benefit from the wells operability and productivity.

Due to the conditions which present the well geometry and the fluids conditions have external agents (chemicals and reactions) which one represent a great magnitude of problems to be solved in oil wells, especially, those that has a high quantity of H_2S like as the oil wells of Venezuela.

Venezuela has a biggest oil reserves in the world but they present a great number of chemical agents that cause alterations in the rods transmission to the pump. The chemical agents such as CO_2 and H_2S cause corrosion in

Crroesponding Author: Jose Osorio Tovar, Faculity of Engineering and Architecture, Universidad De Lima, Avenida Javier Prado Este No. 4600, Urbanization Fundo Monterrico Chico District of Santiago De Surco, Lima, Peru

the rods and in the production pipe as well as extension of the vulcanization of the elastomer which causes hardening and eventual rupture.

It is important emphasize the oil production it is based on the presence of an artificial lift system but these are given in accordance with the fluids, reservoirs conditions and other specific properties presents (Qiao *et al*., 2016). Nowadays the biggest oil quantity is weigh and extra weigh oil the mechanical pump and progressive cavities pump, execute the work with major efficiency due its design properties. Nevertheless its present limitations under conditions that can generate high charges in the pumping unit and in the rods where the external agents attack, causing problems like the rods failures that would cause the entire stop of the production and would affect greatly the industry because of the falls of production produced by the rupture.

Considering some factors as the bacteria presence which one generate operative problems such as the production of hydrogen sulfide which one cause changes of the normal behavior of the materials giving as consequence the corrosion (Crolet, 1983). Nevertheless, in operative level, generates an increase in the maintenance, reflected in the increase of the production costs, also, increase the labor risk on the part of the generation of H_2S.

Based on what I have said, to know the chemical properties of the crude oil it realized a heavy oils characterization, based on division, dividing a sample of heavy oil into smaller quantities or fractions, so that, each one fraction had a different composition. The division based on the solubility of the hydrocarbons components in various solvents used in this test (Denney, 2001).

Each fraction consists of a solubility class that contains a status of different molecular weight species. In this method, the crude oil is divided into four classes of solubility, called collectively "SARA": saturated, aromatic, resins and asphalt (Greaves *et al*., 2004). The saturated are in general iso and cycle paraffin while the aromatic, the resins and the asphalt generate continuous molecules with molecular weight, aromatic property and heteroatoms content increasing. The asphalt also can contain metals as nickel and vanadium. Sometimes, this method is an analysis of deposition of asphalt/wax/ hydrate. In this way, we can know how the chemical composition of crude oil also can affect the normal functioning (Curtis *et al*., 2003).

Firstly, all the problems in Artificial Lift Systems (ALS) caused by external agents are reflected in the corrosion, showing the corrosion process in Fig. 1 which one is the destructive result of an electrochemistry reaction of the operative ambience in which the subsoil

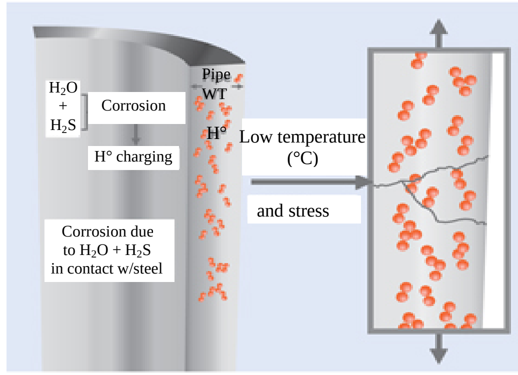

Fig. 1: Corrosion process, effect of H_2S and CO_2 in pipeline

system is submitted (Dunn *et al*., 1995). The corrosion is the way as nature converts a material done by the human in the state of major energy (steel) back to its elementary state (native mineral) as it is in nature. The elementary iron into the steel gets combine with the moisture or acids to form other compounds like sulfides, carbonates, iron oxide among others. Some form and concentration of the water present in the wells are considered as corrosive, for example, the acidic gases, like as the Carbonic acid (CO_2) and the Hydrogen Sulfide (H_2S), common in the mold of the oilfield. They are extremely soluble in water and dissolve quickly in the same one what tends to low the pH, all the waters with low values of pH it is considered corrosive, for example, the steel.

Nevertheless, the entire environment well below are corrosive for the presence of several compounds which are in the crude oil and in the refined currents. The most important are organic sulfides of nitrogen and oxygen. In addition, there are touches of metallic compounds that can be a cause of problems in some catalytic processes.

As far as it goes, generally we can say that a high-water percentage being the fluid produced in the watery phase with drops of oil will be able to happen "Stung" with metal loss. That is why it will present tin he following study clear definitions how the external agents affect the functioning of the ALS.

MATERIALS AND METHODS

The methodology study was framed in the descriptive type and documentary investigation with a not experimental design of descriptive type. The information compilation was carried out by a bibliographical review and as instrument used the structured review focused to study about the artificial lift

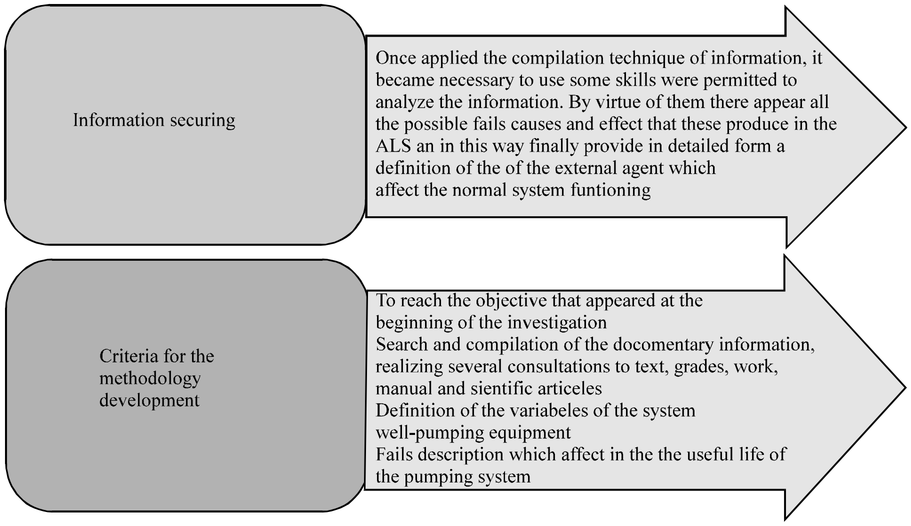

Fig. 2: Methodology description, process to achieve the paper

systems. The results obtained determined that the probable causes that they bear to operational failure in the lift systems are a shortcomings product in the integrity of the surface and subsoil system, also were established own properties in order to optimize the operational functioning of the same ones as method of artificial raising of crude oil. To develop the investigation there were established two phases to be known (Fig. 2).

RESULTS AND DISCUSSION

External agents (Chemical)

Corrosion H_2S: Pitting by H_2S is rounded in base, deep with directional pipelines and beveled edges. It is usually small, random and scattered over the entire surface of the rod. A second corroding mechanism generated by H_2S is iron sulfide scale. The surfaces of the pumping rod and the pit will be covered with black scale as Fig. 3 show that is tightly adhered.

Iron sulfide scale is highly insoluble and cathodic to steel which tends to accelerate corrosion penetration rates. A third corrosive agent is hydrogen cracking which causes the fracture surface have a brittle or granular appearance. A crack initiation point may or may not be visible and a fatigue portion may or may not be present on the fracture surface. The shear tear of a hydrogen cracking failure is immediate during fracture due to the absorption of hydrogen and the loss of ductility in the steel. Although, a relatively weak acid, any measurable trace amount of H_2S acid gas is considered justification for chemical inhibition programs when any measurable trace amount of water is also present (McNaughton, 1989).

Fig. 3: Iron sulfide and underdeposite corrosion

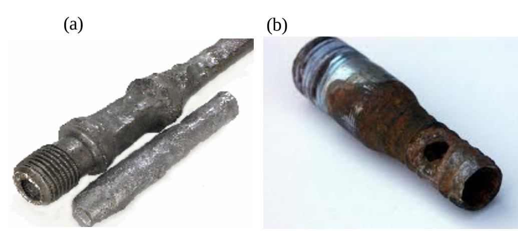

Fig. 4: Oxygen corrosion

Oxygen-enhanced corrosion: Oxygen-enhanced corrosion will be most prevalent on couplings with a few instances found on rod upsets it can see in Fig. 4. Oxygen corrosion is rarely seen on the rod body. In fact, aggressive oxygen-enhanced corrosion can erode couplings without harming the sucker rods on either side. The rate of corrosion is directly proportional to the dissolved Oxygen (O_2) concentration, chloride content of

Fig. 5: Iron sulfide scale formation

the produced water and/or presence of other acid gases. Dissolved O_2 can cause severe corrosion at extremely low concentrations and erode large amounts of metal (McNaughton, 1989).

Pitting is usually shallow, flat-bottomed and broad-based with the tendency of one pit to combine with another (Fuentes, 2007). Pit shape characteristics may include sharp edges and steep sides if accompanied by CO_2 or broad, smooth craters with beveled pit-edges if accompanied by H_2S. Corrosion rates increase with increased concentrations of dissolved O_2.

The following figures are examples of oxygen enhanced corrosion. The figure on the left is an example of the effects of oxygen-enhanced CO_2 acid gas corrosion. The figure in the middle is an example of H_2S corrosion and the figure on the right is an example of chloride corrosion. Whereas the samples of the dowels in Fig. 4 exhibit the effects of corrosion for CO_2 increased by oxygen near the bounce (left) and the corrosion for CO_2 in the rod body of the (right).

Scale corrosion: Scale forming as Fig. 5 shows such as barium sulphate, calcium carbonate, calcium sulphate, iron carbonate, iron oxide (rust), iron sulphate and strontium sulphate must be prevented in the sucker rod. Although, scales in a sucker rod delay the corrosion penetration rate, they also, reduce the chemical suppressants efficiency. The strict located corrosion in pitting form ensues at any time when the scale is cracked by a flexion movement or when it is removed by abrasion.

Failures by abrasive wear: Abrasive wear implies a progressive loss of weight of the rod body that results from the contact in constant movement, between hard particles and the surface of the rod. In this particular case, this wear is caused by the direct contact between tubing string and rod string. The reduction of the cross-section of the rod produces resistance loss and it produces the cracking that entails the failure (McNaughton 1989).

Fig. 6: Stray current corrosion

Morphology: Loss of roundness of the rod associated with the loss of mass, they can present flat zones along the rod body. The abrasive wear usually can be observed as diversions of the original rod geometry. The bosses of angular abrasive wear indicate rod strings that are entering in contact aggressively with the pipeline in a determined angle as result of cycles of impact associated with the pumping process.

Failures by erosive wear: These failures are produced because of liquid or gaseous fluids that contain hard particles and because the flow rate is enough to remove the superficial matter of the rod (Oglesby *et al*., 2003).

Morphology: Loss of roundness of the rod associated with the loss of mass, the zones of damage present parallel ruts associated with the type of particles in touch with the surface, if the damage is in advanced condition flat zones will be able to be observed along the rod body. The form and the size of the fingerprints formed by erosive wear depend among other aspects, on the speed, the size and the angle of impact of the particles, thus, if the particles are made of diverse characteristics, the fingerprints that are formed will cause heterogeneity in the rod surface, altering its geometry in great way.

Stray current corrosion: Rarely seen in most wells, stray current corrosion refers to the induced or stray, electrical currents that flow to or from the rod string. Stray current corrosion, show in Fig. 6 can be caused by grounding electrical equipment to the well head, casing or from nearby cathodic protection systems. Arcs originating from the rod string leave a deep, irregular shaped pit with smooth sides, sharp pit-edges and a small cone in the base of the pit. Arcs originating from the tubing leave deep pits with smooth sides and sharp edges that are random in dimension and irregular in shape. Stray current corrosion pits are usually singular and isolated in a row down one side of the sucker rod near the upsets.

CONCLUSION

Mainly the oil wells have acids particles which affect directly the perforation equipment, casing and in this case the production equipment, especially, the artificial lift system. It is clear to say that the problems of corrosion will be a difficulty in the oil production which one will be a constant evolution.

Nevertheless, in the oil industry the principal difficulty will be essentially the moment to know exactly as far as the corrosion by CO_2, H_2S or any other corrosive acid will allow the equipment stability. Generally, the corrosions by H_2S have a roll aspect formed by hydrogen or caustic attack (fissures). To prevent this failure, there are several steel products which one are commercially allowed and they have been used on specific situations, in order to maintain a stable production. However, the problems are present when there are acids reactions which prevent a technical, develop to stop the corrosion produced by these ones.

Despite the operative applications are not yet specific and there is not a general rule to stop an eventual corrosion by acids. Wherefore, this study shows a characteristic series how technically are the failure which one will permit relate the corrosion generated in the equipment because the acids presences in the hydrocarbons production and offer a theorist support to the near development in laboratory proofs, field proof into installations under acids effects, high pressures and high temperature.

Taking side of the information showed, the failures presents a wide range of properties that must be corrected to solve them as the energy demands demand the use of new technologies to avoid the long time stop due the rods failure ,especially which come from normally uncontrolled source and could substantially increase the economic and operational problems for this reason it is imperative to know that technically the failure could be handled properly from the economy or environmental point of view.

NOMENCLATURE

- ALS = Artificial Lift System
- H_2S = Hydrogen sulfide
- CO_2 = Carbon dioxide
- SARA = Saturated, Aromatic, Resins and Asphalt
- O_2 = Oxygen

REFERENCES

Bucaram, S.M., J.D. Clegg and N.W. Hein Jr., 1993. Recommendations and comparisons for selecting artificial-lift methods. J. Pet. Technol., 45: 1-128.

Crolet, J.L., 1983. Acid corrosion in wells (CO_2, H_2S): Metallurgical aspects. J. Pet. Technol., Vol. 35,

Curtis, C., R. Kopper, E. Decoster, A. Guzman-Garcia and C. Huggins *et al*., 2003. [Deposits of heavy oil]. Oilfield Rev., 23: 32-55.

De Souza, J. and L. Schaeffer, 2015. Biogas plants construction: Bioreactors dimensioning. Spaces, Vol. 36,

Denney, D., 2001. Hollow-rod technology for PCP systems. J. Pet. Technol., 53: 45-46.

Denney, D., 2004. Integrated CO_2-corrosion and multiphase-flow model. J. Pet. Technol., Vol. 56,

Dunn, L.J., C.M. Matthews and T.A. Zahacy, 1995. Progressing cavity pumping system applications in heavy oil production. Proceedings of the SPE International Symposium on Heavy Oil, June 19-21, 1995, Society of Petroleum Engineers, Calgary, Alberta, Canada, pp: 1-10.

Flatern, R.V., 2015. Defining Artificial Lift. Schlumberger, Houston, Texas, USA.,.

Fuentes, C., 2007. Prediction of corrosion by CO_2+H_2S in steel pipes at carbon. Scientia Technica, 1: 881-886.

Gil, E. and A. Chamorro, 2009. [Recommended techniques for increasing production in mature fields]. OilProduction. Net., IHS Inc., Spanish. (In Spanish) http://www.oilproduction.net/files/Aumento%20de%20produccion%20en%20campos%20maduros.pdf

Greaves, M., S. Ayatollahi, M. Moshfeghian, H. Alboudwarej and H.W. Yarranton, 2004. Estimation of SARA fraction properties with the SRK EOS. J. Can. Pet. Technol., 43: 1-9.

Guerrero, J.W.G., M.A.M. Becerra and W.P.R. Calle, 2017. Forecast electricity demand model using predicted values of Sectorial gross domestic product: Case of Colombia. Spaces Mag., 38: 1-12.

McNaughton, K.J., 1989. [Pumps: Use and Maintenance Selection]. McGraw-Hill Education, New York, USA., ISBN: 9789684220362, Pages: 373 (In Spanish).

Melendez-Pertuz, F., 2017. Structural integrity of pipelines for hydrocarbons transportation: Current scenario. Spaces Mag., 38: 1-10.

Mills, R.A.R. and R. Gaymard, 1996. New applications for wellbore progressing cavity pumps. Proceedings of the International Conference on Petroleum and Exhibition of Mexico, March 5-7, 1996, Society of Petroleum Engineers, Villahermosa, Mexico, pp: 1-8.

Nesic, S., S. Wang, J. Cai and Y. Xiao, 2004. Integrated CO_2 corrosion-multiphase flow model. Proceedings of the SPE International Symposium on Oilfield Corrosion, May 28, 2004, Society of Petroleum Engineers, Aberdeen, UK., pp: 48-49.

Noonan, S.G., 2008. The progressing cavity pump operating envelope: You cannot expand what you don't understand. Proceedings of the International Symposium on Thermal Operations and Heavy Oil, October 20-23, 2008, Society of Petroleum Engineers, Calgary, Alberta, Canada, pp: 398-404.

Oglesby, K.D., J.L. Arellano and G. Scheer, 2003. Fourteen years of progressing cavity pumps in a Southern Oklahoma waterflood. Proceedings of the SPE Symposium on Production and Operations, March 23-26, 2003, Society of Petroleum Engineers, Oklahoma, USA., pp: 439-447.

Qiao, Q., G. Cheng, W. Wu, Y. Li and H. Huang *et al*., 2016. Failure analysis of corrosion at an inhomogeneous welded joint in a natural gas gathering pipeline considering the combined action of multiple factors. Eng. Failure Anal., 64: 126-143.