Analysis of Corrosion Rate of DHU Pressure (Dehydration Unit) on Gas Production CO2 Removal Process

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Abstract. In accordance with the development of an increasingly rapid and advanced era, especially in the field of oil and gas management, the dehydration process is a very important process in producing good quality oil or gas. The presence of hydrocarbons and water vapor, N2, CO2 and H2S will cause the formation of hydrates in the form of crystals and are corrosive that can cause malfunction in pressure vessels and other processes. Thus one process is needed to remove water vapor called the CO2 removal process. The purpose of this study was to determine the corrosion rate and remaining life time with the CO2 removal process. To make it easier to calculate the corrosion rate and remaining life time on this pressure vessel, we refer to ASME VIII and API 510 standards. By knowing the working pressure value of 4.9 bar or 72.52 Psi, we can know the lifetime the lowest pressure vessel is 8.54 years. Conclusions in this study determine that upon entering the separator the highest corrosion rate of 2.01 mm / year with the longest remaining service life is 37.12 years, which mis in position 3 and location A with the corrosion rate.

Keywords: Corrosion rate, CO2 removal, pressure vessel, remaining life time.

1. Introduction

Nowadays, pressure vessels have become a necessity in the chemical, oil, gas, electricity and public facilities industries and households in almost all countries in the world and will continue to increase their needs over time. Pressure vessel (Pressure Vessel) is a reservoir for a liquid in the form of liquid or gas with a pressure higher than atmospheric pressure. So that the pressure in the reactor is maintained, the primary system is equipped with a pressurizer.

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In oil or gas factories or companies, the dehydration process is one of the most important processes. The presence of hydrocarbon and water vapor control, N2, CO2 and H2S will cause the formation of hydrates in the form of crystals and are corrosive which can cause blockage of pipes and malfunction in pressure vessels and other processes. Because the carbon content of CO2 and water vapor is very large, so one of the reduction processes is carried out in order to minimize the carbon dioxide content of CO2 so that it is more balanced (balance) with N2 and H2S, it is needed a process to remove acid gas from the natural gas. One process to reduce CO2 levels in natural gas is to use a CO2 removal process facility.

2. Literature Review

2.1. Definition Of Pressure Vessel

Pressure vessel or term in engineering is a cylindrical closed tube, as a reservoir of both internal and external pressure. The components of a pressure vessel, consisting of several main parts such as; shell, head, manhole, nozzles, support and other accessories used as support, both internal and external components, as a means of the process of separation and storage, both for separating crude oil, water and gas or other fluid that will be separated in this pressure vessel will also settle gravity in the pressure vessel so that it separates by itself [3].

In designing pressure vessels, calculating corrosion rates and remaining service life can be calculated by hand (hand calculation) with formulas from the ASME (American Society of Mechanical Engineers) standard and computer analysis. The material or material used to make these pressure vessels is the steel plate that was planned in advance and calculated the thickness of the plates to be used and the material specifications to be planned in the manufacturing process of making these pressure vessels.

2.2. Classification of Pressure Vessel

Pressure vessel classification is divided according to the position or layout of the pressure vessel which consists of two kinds of positions namely: vertical position and horizontal position.

a. Vertical Pressure Vessel
   The vertical pressure vessel is where the pressure vessel is perpendicular to the neutral axis, where the pressure vessel (vessel) in this position is often used in the offshore oil refining process, which has limited space [3].

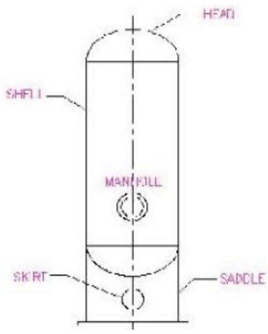

FIGURE 1. Verical pressure vessel

b. Horizontal Pressure Vessel
   Pressure vessels in the horizontal position are commonly found and used in onshore oil fields because they have a larger production capacity [3].

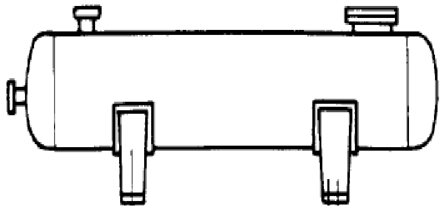

FIGURE 2. Horizontal pressure vessel

2.3 CO2 Removal Process

In the process of CO2 removal, the dehydration unit requires very large amounts of heat energy. The performance of the CO2 removal process in pressure vessels uses quite a lot of energy because it must operate at low temperatures. Energy is taken from heating and cooling acting on the system and energy from the product or energy recovery [2].

In the CO2 removal process aims to determine the severity of the rate of corrosion in pressure vessels that occur due to temperature changes, and the amount of excess hydrocarbons and H2S in the CO2 content so that CO2 removal technology is used in order to reduce acid content so that the levels of the hydrocarbons do not exceed 5% because the purification of gas that can be used in LPG is 5% [3].

2.4 Absorption CO2 Removal Process

Absorption is a process of separating the material or substance from a gas mixture by binding the substance to the surface of the liquid absorbem column followed by the solvent where the substance functions to neutralize or reduce the acid content of the substance. CO_2 removal is an example of a gas treating process by means of absorption, which is the process of absorption of CO_2 impurities from the desired compounds. The absorption process is strongly influenced by: Target desired gas purity, The concentration of impurities in the treated gas, Gas capacity to be treated, The type of solvent or absorbent used, and Amine concentration.

2.5 Corrosion and Corrosion Rate

Corrosion is one of the forced destruction of substances such as metal and mineral building materials surrounding media, which are usually liquid (corrosive agents). It usually starts on the surface and is caused by chemical and in the case of metal electrochemical reactions [6]. While the rate of corrosion is the speed of propagation or speed of decline in quality of material with respect to time. In calculating the corrosion rate, the unit commonly used is mm / th (international standard) or mill / year (mpy, British standard). The level of resistance of a material to corrosion generally has a corrosion rate between 1-200 mpy [6]. The long-term corrosion rate (LT) must be calculated from the following formula:

$$Corrosian\ Rate\ (LT) = \frac{tinitial - tactual}{time\ between\ tinitial\ and\ tactual\ (years)} \quad (1)$$

Short-term corrosion rate (ST) can be calculated by the following formula:

$$Corrosion\ Rate\ (ST) = \frac{tprevious - tactual}{time\ between\ tprevious\ and\ tactual\ (years)} \quad (2)$$

where :

tinitial = Value of the measurement of the thickness of the material when the pressure vessel starts to corrode (mm)

previous = The value of the measurement of material thickness when the pressure vessel is examined beforehand (mm)

tactual = Value of the measurement of material thickness at the time of the last inspection (mm)

2.6 Remaining Life (RL)

In the production process, an industry cannot be separated from the use of pressure vessel equipment, especially air receiver compressor tanks, such as the oil, chemical, food, power plant, etc. A pressure vessel must have a time of use until the pressure vessel cannot be reused. [9] During the use of a pressure vessel, failure is likely to occur if no periodic control and maintenance is performed. Some causes of failure occur due to material fatigue, corrosion and other external factors. One of the controls to anticipate the failure of the pressure vessel is to analyze the thickness of the material from time to time so that it can be seen how much material reduction occurs due to corrosion [9].

$$Remaining\ Life\ (RL) = \frac{tactual\ (ta) - trequired\ (tr)}{Corrotion\ Rate\ (CR)} \quad (3)$$

where :

tactual = The result of measuring material thickness at the time of last inspection (mm)

trequired = Minimum allowable thickness or design thickness (mm) for the top zone (mm)

The thickness required (trequirement) for the shell is calculated based on the longitudinal stress with the formula 4 and circumferential stress with the formula:

$$tr = \frac{P \times R}{SE - 0{,}6 \times P} \quad (4)$$

where :

tr = minimum shell thickness required, inches (mm)

P = internal design pressure, psi (kPa)

R = the radius in the shell, inches (mm)

S = maximum allowable voltage, psi (kPa)

E = welding joint efficiency

$$MAWP = \frac{(S \times ta) - (0{,}6 \times ta)}{R} \quad (5)$$

where ;

MAWP = Maximum Allowable Working Pressure (psi)

S = Maximum allowable stress, psi (kPa)

ta = Minimum actual thickness

R = The fingers in the shell, inches (mm)

3. Results and Analysis of Discussion

3.1. Calculation Data

Based on the resulys of fileld survey and the standart that must followed to analyzed the corrosion rate and residual life of the pressure vessel on the CO2 removal dehydration unit, the test were carried out using ultassonic test on the pressure vessel walls at 5 location, namerly location A,B,C,D, and E with clockwise 12,3,6 and 9. The picture above shows a measurement of the pressure vessel wall carried out in the field with measurements at 5 different locations with different clockwise directions. With measurements at each of these locations the thickness at each location of the wall in the pressure vessel. Measurements of each location in different clockwise directions were made to determine the actual thickness in order to analyze the corrosion rate and the remaining life of the pressure vessel.

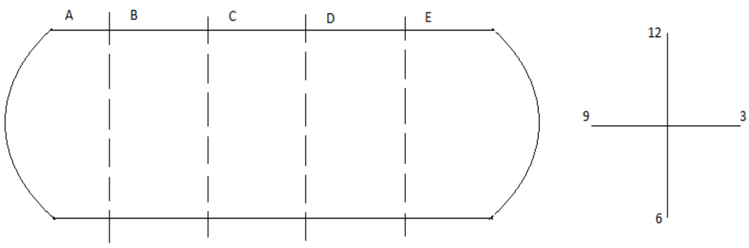

FIGURE 3. Point and location of pressure vessel measurement

3.2. Calculation of Corrosion Rate and Remaining life of pressure vessels

TABLE 1. Results of measurements of actual thickness and corrosion rate

POSITION	LOCATION									
	A		B		C		D		E	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
12	27,10	26,38	27,10	26,54	27,10	25,09	27,10	25,2	27,10	26,60
	Short	*Short*	*Short*	*Short*	*Short*	*Short*	*Short*	*Short*	*Short*	*Short*
Corrosion Rate	0,72		0,56		2,01		1,90		0,50	
Remaining Life	25,54		33,25		8,54		9,09		37,36	
MAWP	780,15		784,67		741,82		745,58		786,91	
3	27,00	26,50	27,10	26,53	27,12	25,30	27,10	25,09	27,10	25,40
	short		*short*		*short*		*short*		*short*	
Corrosion Rate	0,50		0,57		1,82		2,01		1,70	
Remaining Life	37,12		32,65		9,55		8,54		10,28	
MAWP	782,89		774,14		748,58		741,82		759,59	
6	27,10	26,40	27,10	26,50	27,10	26,50	27,00	25,30	27,10	25,40
	Short		*short*		*short*		*short*		*short*	
Corrosion Rate	0,70		0,60		0,60		1,62		0,98	
Remaining Life	36,49		30,96		30.96		10,72		19,96	
MAWP	780,9		791,52		771.88		748,58		773,45	
9	27,10	25,18	27,10	26,40	27,10	25,13	27,08	26,47	27,10	25,90
	short		*short*		*short*		*short*		*short*	
Corrosion Rate	1,92		0,60		1,97		0,61		1,20	
Remaining Life	8,99		31,80		8,73		30,83		15,15	
MAWP	744,82		783,56		744,82		790,67		773,45	

3.3. Calculation of Corrosion Rate and Remaining Life of Pressure Vessels

a. At Location A position 12:

1. Corrosion Rate

- $CR_I = \frac{ta1 - ta2}{time\ (years)\ between}$

  $= \frac{27{,}10 - 26{,}38}{1}$

  = 0,72 mm/years

2. *Remaining Life* (RL)

- $tr = \frac{P \times R}{S \times E - 0.6P}$

  $= \frac{145{,}038 \times 31}{23.300 \times 1 - 0{,}6 \times 145{,}038}$

  = 0,193 inch = 4,919 + 3 mm = 7,919 mm

- $RL = \frac{ta - tr}{CR}$

$= \frac{26,38 - 7.919}{0,72}$

= 25,64 years (the design life of a pressure vessel is 20 years, so the remaining life value that exceeds 20 years means the lifetime of the pressure vessel is 20 years.)

3. *Maximum allowable working pressure* (MAWP)

$MAWP = \frac{(S x ta) - (0,6 x ta)}{R}$

$= \frac{(23.300 x \frac{26,38}{25,4}) - (0.6 x \frac{26,38}{25,4})}{31}$

= 780,15 psi (With this MAWP value it can be concluded that the pressure vessel is feasible to operate because the MAWP is greater than the working pressure)

3.4. Analysis of Results of Discussion

After calculating the corrosion rate and the remaining service life on the pressure vessels ie on the seperator, the following discussion can be carried out:

1) By entering the data table Calculation of Corrosion Rate and Remaining Life position 12 at each location or inspection location, the following results are obtained:

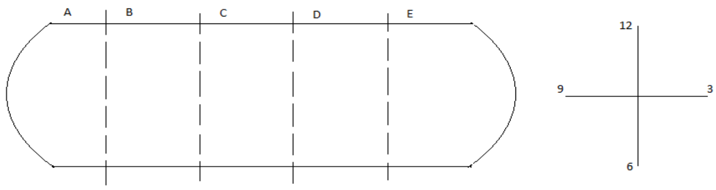

FIGURE 4. Point and location of pressure vessel measurement

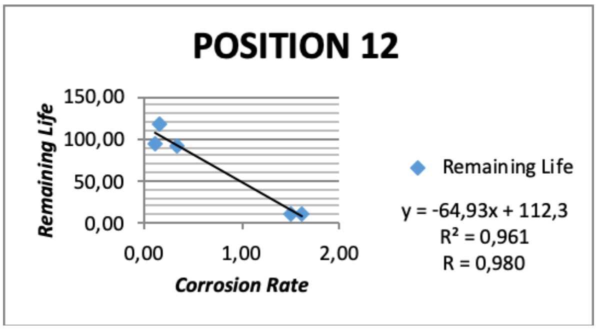

FIGURE 5. Comparison graph of corrosion rate and remaining service life on pressure vessels at location A

From the graph above in Figure 5 can be explained or show that the corrosion rate and the remaining service life of the separator at position A obtained a correlation value of R2 of 0.961. From these results, it was found that the pressure vessel or sepatpr experienced the largest corrosion rate at position A of 2.01 mm / year with a remaining service life of 8.54 years. If the corrosion rate that occurs in the pressure vessel is greater then it indicates the remaining life of the compressed vessel is getting smaller due to the erosion of the material.

By entering the data table Calculation of Corrosion Rate and Remaining Life position 3 at each location or inspection location, a graph of the results of the comparison of the corrosion rate and the remaining service life of the pressure vessel is obtained as follows:

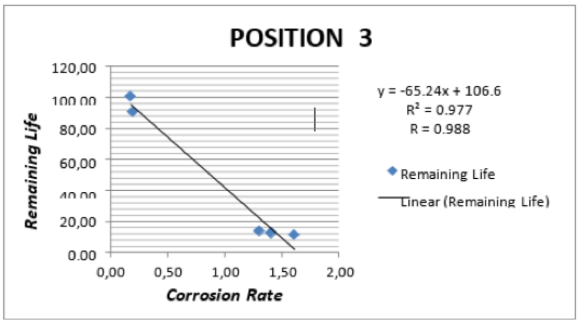

FIGURE 6. Comparison graph of corrosion rate and remaining service life on pressure vessel at location A position 3

From graph 6 above it can be explained that linearity shows that y = -65.24x + 106.6 where the value of sloope is -65.24x shows a decrease in the remaining life acceleration (remaining life) of -65.24 and constant (b) of 106, 6 which means the corrosion rate factor (CR) is not influenced by RL & CR of 106.6, which is caused by other influences such as material defects, lamination / segregation, welding defects and defects caused by third parties (sabotage). Then the remaining life models of the pressure vessel separator are as follows:

RL = -65.24 (CR) + 106.6

RL = Remaining Life (Years)
CR = Corrosion Rate (mm / year)

TABLE 2. Correlation value of CO2 in the separator

Position	Linearity	A (Slope)	B (Constanta)	R^2	R
12	y=-64,93x+ 112,3	-64,93x	112,3	0,961	0,980
3	y=-65,24x+ 106,6	-65,24x	106,6	0,977	0,988
6	y=-62,97x+ 89,41	62,97x	89,41	0,698	0,902
9	y= -27,1x + 56,64	-27,1x	56,64	0,259	0,508

From the above data it can be seen the R value of each inspection position and location. The highest R value has a correlation coefficient between the corrosion rate and the remaining service life of the pressure vessel close to 1 is 0.988. With these results explain that the highest percentage of remaining life (remaning life) when in the separator is 90%, this means it is influenced by the rate of corrosion rate of CO_2 removal dehydration caused by temperature, water content (H_2S).

4. Conclusions

From the above calculation, the conclusions can be drawn are as follows:

1) The thickness measurement data above shows the lowest thickness is 25.09 which is located at position 12 location C. And the results of the calculation of the corrosion rate above shows the largest value of corrosion rate is 2.01 mm / year which is located at location C at 12 o'clock position This greatest corrosion occurs due to the possibility of erosion / erosion on the left wall of the pressure vessel.
2) By knowing its working pressure value of 4.9 bar or 72.52 psi, it can be seen that the lowest lifetime of a pressure vessel is 10.66 years which is located at C location in the 12 o'clock position with the largest corrosion rate which is 2 , 01 mm / year .. Where is the lowest Remaining Life (RL) value of 8.54 years with an MAWP value of 741.82 Psi which means the pressure vessel is still feasible to operate because MAWP is greater than working pressure. And the remaining life of the longest pressure vessel is 37.12 years which is in position 3 and location A with a corrosion rate of 0.50 mm / year.

References

1. P. Teknologi, R. Nuklir, A. Tegangan, T. Pada, D. Bejana, And T. Reaktor, "Analisis Tegangan Termal Pada Dinding Bejana Tekan Reaktor Pwr Elfrida Saragi , Roziq Himawan," Vol. 21, No. 1, Pp. 40–47.
2. R. Adikharisma, "Analisis Kinerja Proses Co 2 Removal Pada Kolom Absorber Di Pabrik Amoniak Unit 1 Pt. Petrokimia Gresik Performance Analysis Of Co 2 Removal Process In Absorber Column At Unit 1 Ammonia Plant Pt . Petrokimia Gresik," Institut Teknologi Seuluh Nopember, Surabaya, 2014.
3. A. Aziz, A. Hamid, And I. Hidayat, "Perancangan Bejana Tekan (Pressure Vessel) Untuk Separasi 3 Fasa," Sinergi, Vol. 18, Pp. 31–38, 2014.
4. J. P. Vol, A. Gas, G. Co, A. Hysys, And K. Kunci, "Jurnal Integrasi Proses Website : Http://Jurnal.Untirta.Ac.Id/Index.Php/Jip Simulasi Absorpsi Gas Co 2 Dengan Pelarut Dietanolamina (Dea) Menggunakan Simulator Aspen Hysys 1 Program Studi Teknik Kimia , Fakultas Teknologi Industri , Universitas Katolik," Vol. 6, No. 3, Pp. 100–103, 2017.
5. I. Fuqoha, "Perancangan Dan Estimasi Biaya Unit Pemisahan Gas Asam Dengan Kandungan CO2 Dan H2S Tinggi," Universitas Indonesia, 2012.
6. Y. K. Afandi, I. S. Arief, And Amiadji, "Analisis Laju Korosi Pada Pelat Baja Karbon Dengan Variasi Ketebalan Coating," J. Tek. Its, Vol. 4, No. 1, Pp. 1–5, 2015.
7. A. P. Institute, "API 510, Pressure Vessel Inspection Code : In-Service Inspection , Rating , Repair , And Alteration," No. June,Edition, Ninth, 2014.
8. U. Test, "Analisis Sisa Umur Pemakaian (Remaining Life Assesment) Air Receiver Compressor Tank Menggunakan Metode Ultrasonic Test Fuad Khoirul 1 , Muh Amin 2, Muhammad Subri 3 Abstrak," Traksi, Vol. 17, No. 1, Pp. 10–20.
9. Sholihin M. Yudi, Sistem Pemipaan Produksi Minyak Dan Gas Menggunakan Metode Rbi, Series 1. Indonesia: Universitas Indonesia, 2003.