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Cost of Corrosion of Metallic Products in Federal University of Agriculture, Abeokuta

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Abstract

The cost of corrosion has been increasing drastically due to the degradation of the metallic materials. This study was carried out to estimate the "Cost of Corrosion of Metallic Products in Federal University of Agriculture, Abeokuta (FUNAAB)". Questionnaires were administered and interviews were also conducted to gather necessary information. The cost of corrosion from 2013-2015 was estimated and analysed with the aid of engineering economy method and statistical analysis method. For the cost of corrosion prevention methods, cleaning gave the highest cost contribution (69%), followed by the use of oil (30%), use of grease (1%), and painting gave zero percent of the total cost. While on the cost of corrosion maintenance methods, repair gave the highest cost contributions (66%), and prevention gave (34%) of the total cost. The overall cost of corrosion from (2013-2015) gave an upward trend, but a downward trend in future value and the annualized value. While the forecast cost from (2013-2016) at (95%) confidence level and (5%) significance level gave an upward trend. The present value, future value, and annualized value from (2013-2016) increased by (66%, 43%, and 75%) respectively. The total cost and the total annualized value of corrosion from (2013-2015) were estimated to be ₦ 166,955,641 and ₦ 93,791,024, and with the forecast (2013-2016) were found to be ₦ 277,650,388 and ₦ 163,672,460 respectively. Under the corrosion prevention methods and corrosion maintenance methods, cleaning and repair gave highest cost contribution respectively. Corrosion prevention methods need to be added to bring down the repair cost of those facilities for saving cost.

Keywords: corrosion cost, present value, future value, annualized value, engineering economy method, statistical analysis method, corrosion prevention methods, trend, significance level, confidence level, forecast

INTRODUCTION

Corrosion is defined as the destruction or deterioration of materials because of the reaction with the environment by chemical or electrochemical. It is more of "extractive metallurgy", that is, the reverse process of metallurgy for metallic corrosion [5-6]. This is a natural phenomenon which occurrence cannot be prevented and difficult to be estimated if proper record is not kept, but it can be managed or controlled and failure to do so will cause catastrophe. Why metals corrode? In pure form, metals have tendency to corrode as a result of the difference in standard electrode potential, V^0 (v). In other words, pure metals have a high tendency to convert to their ores, because they are at higher energy state compare to the combined state which is at lower energy state [12-16].

Question may arise, why university is the case study for corrosion cost? University is an institution for learning and research with sub-division of units or local and international community. It's a general problem needs to be tackled academically and industrially, it's a pity that majority of institutions in Nigeria fail to produce records on corrosion cost update including academic environment. The usefulness of metallic facilities can be appreciated until spending to curb corrosion and for proper maintenance is specified. University's environment is a community on its own with metallic facilities, structures, and some domestic industries/factories need to be considered for proper study.

The total cost of other natural disasters in the world are less than the cost of damages caused by corrosion, or the cost of corrosion annually; and the cost of corrosion has been predicted of increasing drastically due to materials shortages, energy consumption, and climatic change [6].

The first attempt to estimate the cost of corrosion was made by Hadfield (1922) but was based on the annual rate of rusting of iron and steel in the world, followed by Uhlig (1950), Hoar (1966), NBS-BCL (1978), Dillon (1966), and Rajagopalan (1958) [3]. The recent survey on cost of metallic corrosion in United States with data collated from more than 130 economic sectors, was estimated to be $82 billion in 1975 which was 4.9 percent of its GNP then. It was found that 60 percent of that cost was unavoidable, and 40 percent was said to be avoidable [2]. In Nigeria, different papers have been developed on cost of corrosion of crude oil processing industry was calculated by engineering economy method and found to be 77 cent/barrel, and the corrosion cost in food and agro processing

industries was calculated by life cycle costing analysis and the total cost was found to be ₦22,350,600 [7-11]. This study was carried out to estimate the cost of corrosion of metallic products in Federal University of Agriculture, Abeokuta from 2013-2015 and to forecast the cost from 2013-2016, and to provide efficient corrosion measures.

MATERIALS AND METHODS

This study covered both the main campus and mini campus of the institution. It was very difficult to obtain complete parameters, since most of the public and private organisations in the country lack transparent or genuine databases for every operation being carryout. Questionnaire and interview proforma were used to collect data, but majority of the information gotten through interview preformed. The data collated were supplied by the respondents in the following units of the case study; works and services, physical planning, dufarm, bursary, and environmental management.

The facilities put into study were main gates, generators, toilet facilities, funaabot buses, university vehicles, tractors, and fuel filling station facilities, to obtain total expenditure in carrying out oiling, greasing, cleaning, painting, and repairing to control corrosion, and the data was from 2013-2015 covering three years, since the study was done in 2016, the current year was forecast. The gathering was made possible by knowing the frequent use or periods in rendering those services in preventing corrosion. The metallic corrosion cost was analysed by both descriptive statistics and engineering economy method for simplification. The procedures and some of the equations used were stated below:

1) Determine the statistical analysis of the respondents for accessing their performance.
2) Determine the market interest rate (I_f),

$$I_f = i + f + (i \times f) \quad (1)$$

3) Determine the future value (FV),

$$FV(2015) = PV(FV / P_v, I_f\%, n) = PV\left(1 + I_f\right)^n \quad (2)$$

4) Determine the annualized value (AV),

$$AV = PV\,(AV/PV, I_f\%, n) = PV\left(\frac{I_f e^{I_f n}}{e^{I_f n} - 1}\right) \text{(Akinyemi } et\ al.\text{, 2012)} \quad (3)$$

5) Finally, forecast the current year by least square method, and was compared with the previous years.

RESULTS AND DISCUSSION

The assessment of those responses according to the year of experience as shown in table 1, (M = 2, SD = 1.41) suggests that majority of the respondents fall within the group 6-10 years, according to knowledge and experience (M = 1.25, 0.75 and SD = 0.96, 0.96) indicates that group 6-10 years of experience conversant with the study, according to education and interest (M = 1.67, 1 and SD = 1.16, 1.73) indicates that respondents having high interest for the study were degree holders, and for professional body (M = 4, SD = 4.24) majority of the respondents belong to the professional bodies in their respective area of work.

Table 1: Descriptive statistical analysis of the respondents

S/N	Variable	N	Min	Max	Sum	Mean	SD
1.	Experience	4	1	4	8	2	1.41
2.	Knowledge and experience						
	Moderate High	4	0	2	5	1.25	0.96
		4	0	2	3	0.75	0.96
3.	Education and interest						
	Moderate High	3	1	3	5	1.67	1.16
		3	0	3	3	1	1.73
4.	Professional body	2	1	7	8	4	4.24

The total cost of prevention methods in all the facilities considered as shown in table 2 and fig. 1. Cleaning gave the highest cost contribution (69%) due to frequency of use, followed by the used of oil (30%) determined by the hour of operation, use of grease gave (1%) cost contribution, and painting zero percent cost contribution of the total cost

Table 2: Cost of corrosion prevention methods

Year	Oil	Grease	Cleaning	Painting	Total
2013	5,166,229	107,408	11,650,464	-	16,924,101
2014	5,554,538	115,293	12,604,506	6,820	18,281,157
2015	6,116,634	126,911	14,722,747	7,500	20,973,792
Total	16,837,401	349,612	38,977,717	14,320	56,179,050
	(29.97%)	**(0.62%)**	**(69.38%)**	**(0.025%)**	**(100%)**

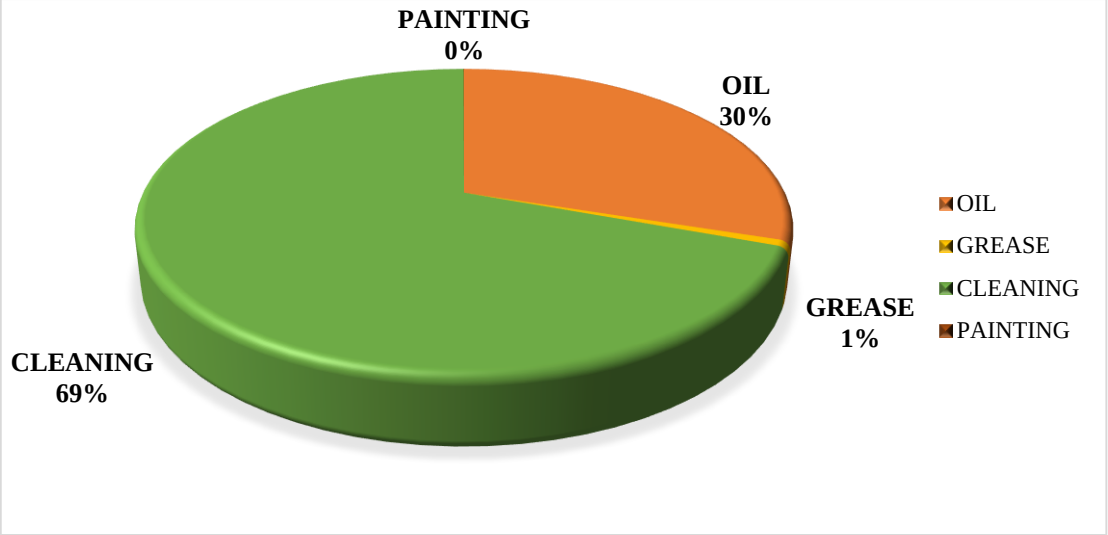

Figure 1: Percentage cost of corrosion prevention methods

Table 3: Cost of corrosion maintenance methods

S/N	Year	Prevention	Repair	Total
1.	2013	16,924,101	33,316,876	50,240,977
2.	2014	18,281,157	35,866,466	54,147,623
3.	2015	20,973,792	41,593,249	62,567,041
	Total	56,179,050	110,776,591	166,955,641
		(33.65%)	**(66.35%)**	**(100%)**

The cost of corrosion maintenance methods as shown in table 3 and fig. 2. Prevention is the addition of the cost of (oiling, greasing, cleaning, and painting). Repair is the cost of element of facility, cost in overhauling, and scheduled maintenance when the facility can no longer be maintained by routine maintenance. From the result, repair gave highest cost contribution (66%), and prevention gave (34%) of the total cost of corrosion. Repair consumes large amount of money or the case study loses huge amount of money to repair, was as a result of unproductive, non-effective, and low awareness on corrosion prevention methods, but with proper corrosion control measure like; oiling, greasing, cleaning, and painting will reduce the loses.

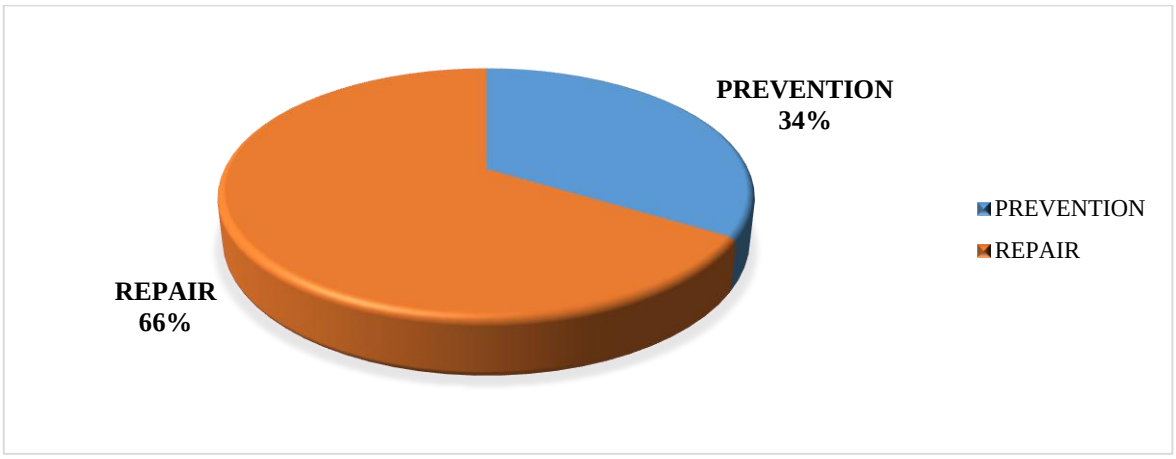

Figure 2: Percentage cost of corrosion maintenance methods

Table 4: Summary of annual cost of corrosion

S/N	Year	PV	FV(2015) = PV(FV/PV, I_f%, n)	AV = PV(AV/PV, 23.85%, 3)
1.	2013	50,240,977	71,805,422	33,748,548
2.	2014	54,147,623	65,182,909	30,635,967
3.	2015	62,567,041	62,567,041	29,406,509
	Total	**166,955,641**	**199,555,372**	**93,791,024**

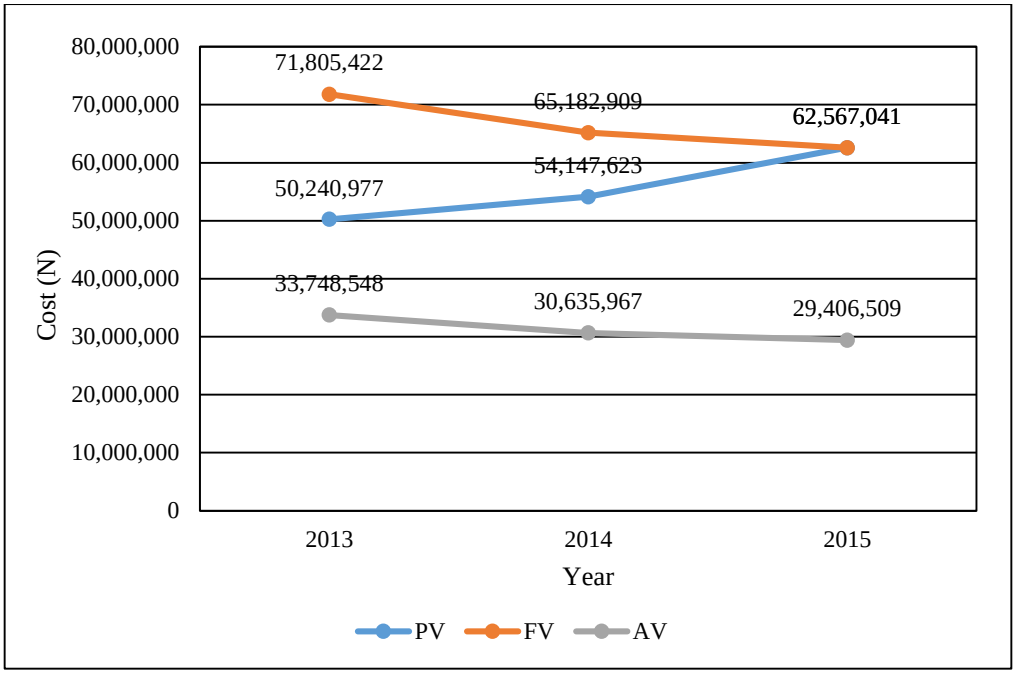

Figure 3: Overall cost of corrosion from (2013-2015)

Table 5: Forecast summary of annual cost of corrosion (2013-2016)

S/N	Year	PV	FV(2016) = PV(FV/PV, I_f%, n)	AV = PV(AV/PV, 35.10%, 4)
1.	2013	50,240,977	85,843,382	40,346,390
2.	2014	54,147,623	78,467,185	36,879,577
3.	2015	62,567,041	77,489,280	36,419,962
4.	2016	110,694,747	110,694,747	50,026,531
	Total	**277,650,388**	**352,494,594**	**163,672,460**

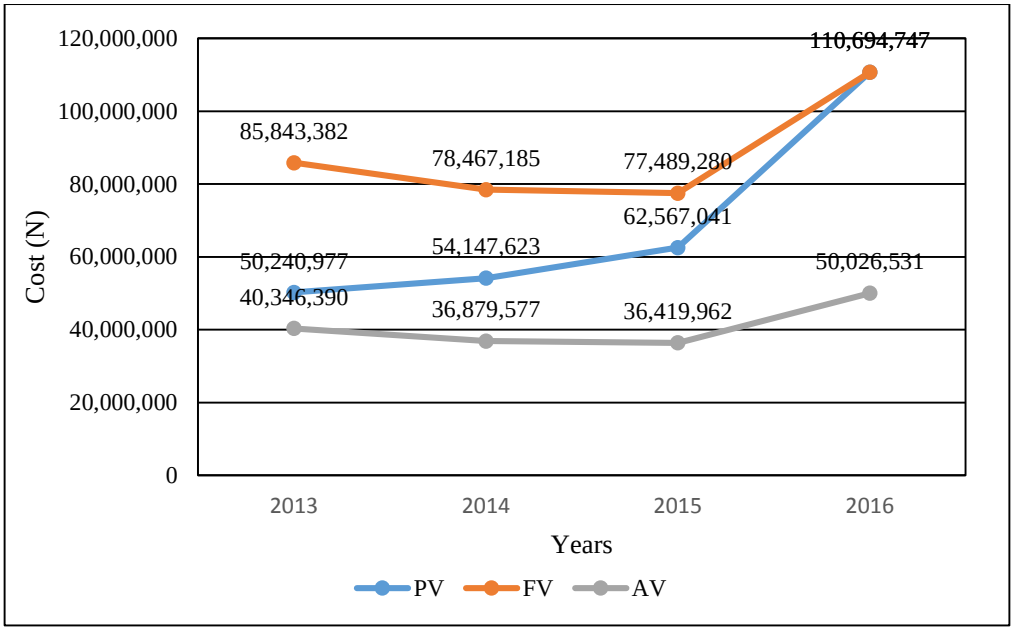

Figure 4: Overall forecast cost of corrosion from (2013-2016)

Table 6: Overall cost of corrosion between (2013-2015) and (2013-2016)

S/N	YEAR	TPV	TFV	TAV
1.	2015	166,955,641	199,555,372	93,791,024
2.	2016	277,650,388	352,494,594	163,672,460

The summary of the overall cost of corrosion from (2013-2015) was given in table 4 and shown in fig. 3. The future value was discounted in 2015, and the annualized value was discounted to 2015, and estimated with the aid of real interest rate, inflation rate, and market interest rate given in the appendix i table 7.

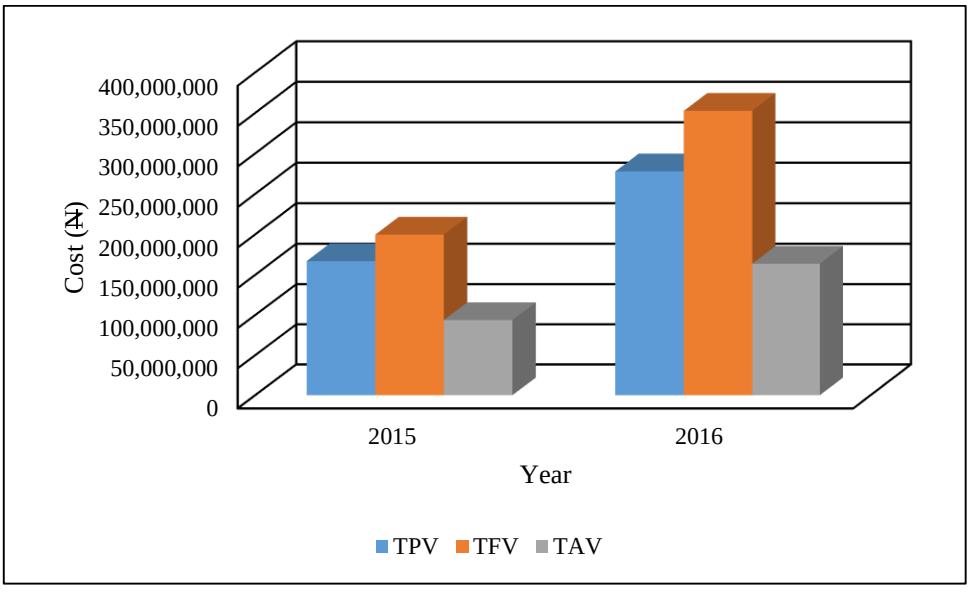

Figure 5: Overall cost of corrosion between (2013-2015) and (2013-2016)

Only the present value of the cost gave an upward trend, but the future value and the annualized value of the cost gave a downward trend.

The forecast summary of the overall cost of corrosion from (2013-2016) with (95%) confidence level and the (5%) significance level as shown in table 5 and fig. 4, and was obtained by regression (least square method) shown on appendix ii table 8. The present value, future value, and annualized value gave an upward trend caused by double increment in market interest rate and improper corrosion control measure. The correlation between the overall cost of corrosion from (2013-2015) and from (2013-2016) as shown in table 6 and fig. 5. There was upward trend in the costs in 2016.

The annualized value of the cost of corrosion obtained in this study was estimated to be ₦ 93,791,024, was of high value than the average total cost estimated to be ₦ 22,350,600 by (Jekayinfa *et al.*, 2005) on a period of five years, and was lower than the previous study carried out by (Akinyemi *et al.*, 2012) on a period of five years was estimated to be $ 1,216,236. Thus, with effective prevention methods can bring down loses by repair cost. The other cost of corrosion to have been included are the labour cost, cost in controlling pollution, downtime cost, and conversion/disposal cost, but the data on all these costs were not given.

CONCLUSIONS

The overall cost of corrosion of metallic products in FUNAAB from (2013-2015), considered the prevention methods cost and the maintenance cost, and the forecast cost from (2013-2016) was estimated and analysed by engineering economy method and least square method, and the following conclusions were deduced from the study:

1) From the total cost of corrosion prevention methods of all the facilities, cleaning gave the highest cost contribution (69%), followed by oiling (30%), greasing with (1%), and painting with zero percent cost contribution.

2) The total cost of corrosion of all the facilities was estimated to be ₦ 166,955,641, with repair cost gave (66%), and prevention cost (34%) of the total cost.

3) The total annualized value over the three (3) years when compounded continuously was estimated to be ₦ 93,791,024, which was discounted to 2015.

4) The overall cost of corrosion from (2013-2015) gave an upward trend, but a downward trend in future value and the annualized value. While the forecast cost from (2013-2016) gave an upward trend in all the parameters, was as result of improper corrosion control practices and double market interest rate.

5) The repair cost is higher than the prevention cost, treating corrosion prevention methods effectively will bring down the repair cost to minimum, and save the institution huge amount of money and extend the facilities useful life.

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