CHAPTER V
CORRELATION OF THE SERVICE LIFETIME OF PLASTIC CARDS

5.1 Abstract

The service lifetime data was analyzed by a result of tensile strength under outdoor exposure and QUV accelerated weather tester conditions using MATLAB application. This analysis allows to quantify the lifetime of plastic cards and makes exponential equations for predict about lifetime of plastic cards. The exponential equations between outdoor exposure and QUV accelerated weathering test were optimized the relationship between these conditions were related in 12 months of outdoor exposure and number of cycles of QUV accelerated weathering tester.

5.2 Introduction

Essence of applied mathematics and statistic is modeling, as the preceding sections have indicated. One assumes for determine the result certain general form for the model and then must somehow determine the various parameters in that form so that the model conforms to reality as well as it can.

Correlation of the result where substantial error is associated with data, polynomial interpolation is unsuitable and may yield unsatisfactory result when used to predict intermediate values. Experimental data is often for this type. A more appropriate strategy for case is to derive an approximating function that fit the shape or general trend of data without necessarily matching the individual point. This model can illustrates how straight line can be used to general characterize trend of the data without passing through any particular point. One way to do this is to derive a curve that minimize the discrepancy between the data point and the curve (Chapra, S. R., *et al.* 2006).

Exponential equations are often used when the rate of change of a quantity which is proportional to the initial amount of the quantity. If the coefficient associated with e is negative, y represents exponential decay. If the coefficient is positive, y represents exponential growth.

$$y = ae^{bx} \tag{5.1}$$

$$y = ae^{bx} + ce^{dx} \tag{5.2}$$

For example, a single radioactive decay mode of a nuclide is described by a one-term exponential as seen in eq. (5.1). a is interpreted as the initial number of nuclei, b is the decay constant, x is time, and y is the number of remaining nuclei after a specific amount of time passes. If two decay modes exist, must use the two-term exponential model, see eq. (5.2). For each additional decay mode, you add another exponential term to the model. Examples of exponential growth include contagious diseases for which a cure is unavailable, and biological populations whose growth is uninhibited by predation, environmental factors, and so on.

Furthermore, MATLAB is usually used for calculate and compute the correlation of the data that enables to perform computationally intensive tasks faster than with traditional programming languages such as C, C++, and Fortran. MATLAB integrates numerical analysis, matrix computation, signal processing and graphics in an easy-to-use environment where problems and solutions are expressed just as they are written mathematically.

The objectives of this study are to correlate the results of tensile strength after exposed in accelerated weathering exposure and outdoor exposure condition of the plastic card body (PVC, PC and PETG).

5.3 Experimental

Accelerated weathering test was measured by QUV accelerated weathering tester. QUV accelerated weathering tester was used with UV-B lamps irradiance at 0.48 W/m^2 340 nm. for 4 hours at 37°C and dark light under condensation for 4 hours at 37°C.

The outdoor exposure testing periods were set at 1, 2, 3, 4, 5 and 6 months. Samples were exposed in Bangkok's weather.

5.4 Results and Discussions

5.4.1 Total UV irradiance

Total UV irradiance data of outdoor exposure was receive from Thai Meteorological department at Bangkok station Lat. 13 40' N, Long. 100 37' E, Elev. 60m. The cumulative of UV and UV-B radiation were 170,988,180 Joule/m² (Table 5.1) and 4,843,121 Joule/m² (Table 5.2) respectively.

Total UV irradiance of QUV accelerated weathering tester per an hour was calculated from multiply of lamp's irradiance and conversion factor (specific value). In this experiment, total UV irradiance of QUV accelerated weathering tester per an hour and a cycle were 82,764 Joule/m² and 331,056 Joule/m² (Table 5.3).

Table 5.1 Monthly integral UV radiation at Bangkok (Lat. 13 40' N, Long. 100 37' E, Elev.60m)

Month	Monthly Integral UV Radiation, Joule/m²		
	Sum	Average	Cumulative
Aug, 2010	26,973,342	870,108	26,973,342
Sep, 2010	26,966,139	898,871	53,939,481
Oct, 2010	23,729,039	765,453	77,668,520
Nov, 2010	23,634,581	762,406	101,303,101
Dec, 2010	22,927,374	739,593	124,230,475
Jan, 2011	24,730,876	797,770	148,961,351
Feb, 2011	22,026,829	815,808	170,988,180

Table 5.2 Monthly integral UV-B radiation at Bangkok (Lat. 13 40' N, Long. 100 37' E, Elev.60m)

Month	Monthly Integral UV-B Radiation, Joule/m²		
	Sum	Average	Cumulative
Aug, 2010	853,965	27,547	853,965
Sep, 2010	835,011	27,834	1,688,976
Oct, 2010	663,286	21,396	2,352,262
Nov, 2010	637,268	21,242	2,989,530
Dec, 2010	590,674	19,054	3,580,205
Jan, 2011	629,963	20,321	4,210,168
Feb, 2011	632,954	22,605	4,843,121

Table 5.3 QUV integral UV-B radiation, Joule/m2

Cycles	QUV Integral UV-B Radiation, Joule/m²	
	Number of hours	Total UV iradiance
-	1	82,764
1	4	331,056
3	12	993,168
6	24	1,986,336
9	36	2,979,504
12	48	3,972,672
15	60	4,965,840

5.4.2 Correlation of the results

The correlation in tensile strength of outdoor exposure and QUV accelerated weathering test were analyzed by MATLAB application in exponential equation form; $y = ae^{bx} + c$ Where y is the tensile strength (GPa) independent of x,

both *a* and *b* are coefficients that are estimated by the fit. Coefficients *a* and *b* are slope of the equation. Moreover the mathematics mark of *b* is trend of the graph. For example if *b* is -0.536, trend of the graph will decrease. Coefficient *c* is error term; the least value of *y* when the period approach to infinity. Each coefficient was analyzed by tensile strength data that were shown in table 5.4 and the exponential equations were shown in figure 5.1-5.6. When the exponential equations between outdoor exposure and QUV accelerated weathering test were optimized the relationship between these conditions were related in 12 months of outdoor exposure and number of cycles in QUV accelerated weathering tester were shown in table 5.5.

Table 5.4 correlation coefficients

Materials	**Weathering tester**					
	Outdoor Exposure			**QUV**		
	a	b	c	a	b	c
PC	4.29	-0.536	65.26	0.1579	0.1967	63.36
PVC	31.37	-0.2412	21.78	50.24	-0.003	0
PETG	35.39	-2.2225	18.12	-149.5	-0.002312	200

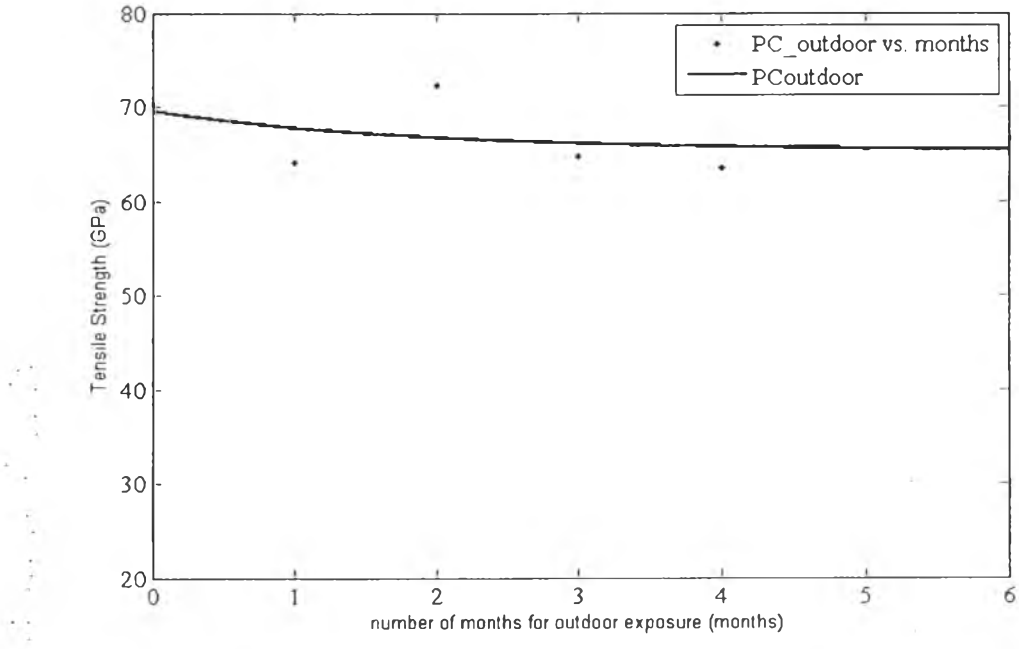

Figure 5.1 Curve fitting of the results of tensile strength of PC cards after outdoor exposure.

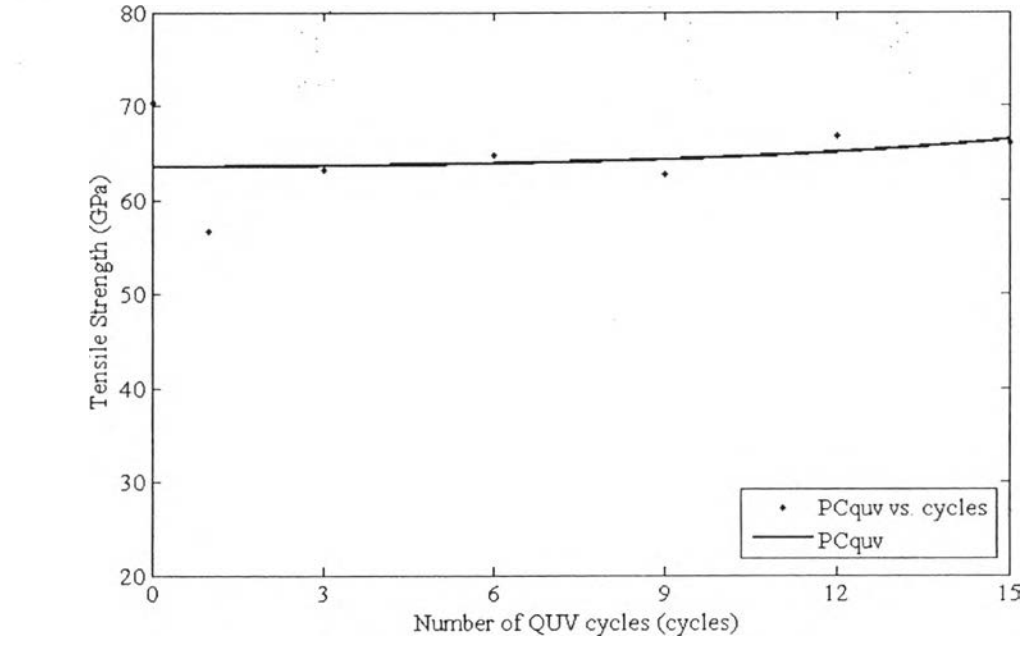

Figure 5.2 Curve fitting of the results of tensile strength of PC cards after exposure in QUV accelerated weathering tester.

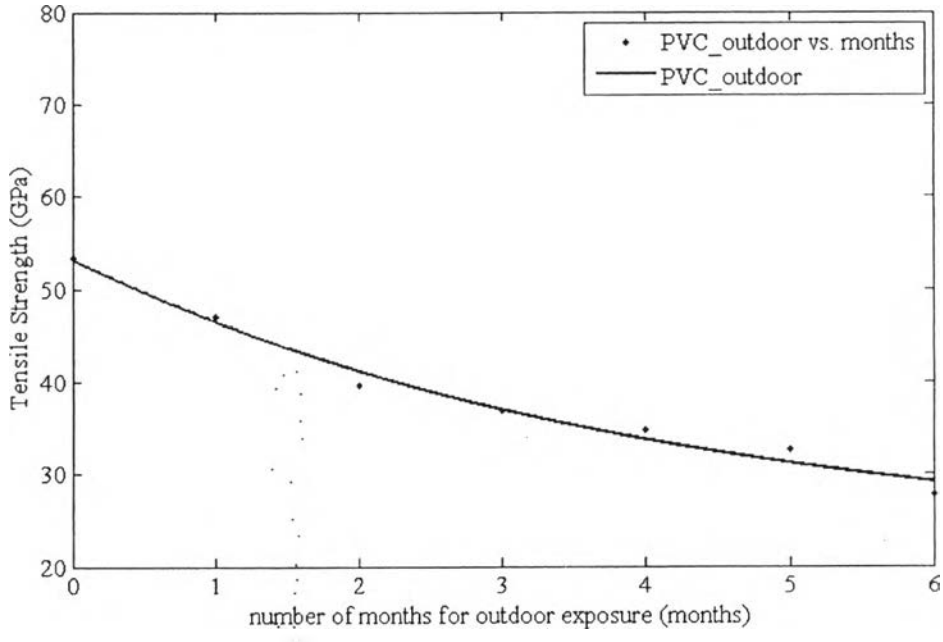

Figure 5.3 Curve fitting of the results of tensile strength of PVC cards after outdoor exposure.

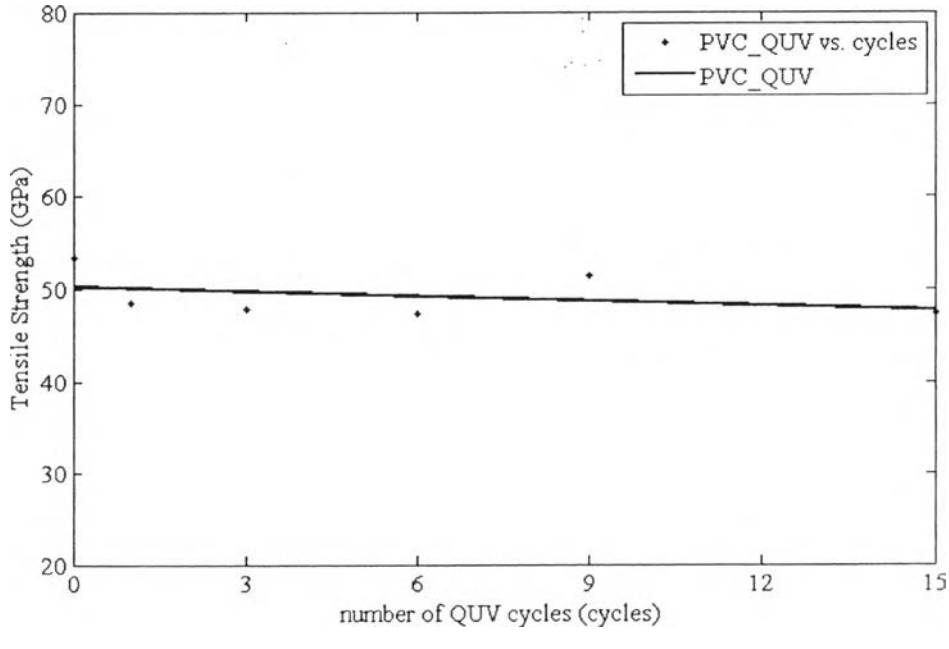

Figure 5.4 Curve fitting of the results of tensile strength of PVC cards after exposure in QUV accelerated weathering tester.

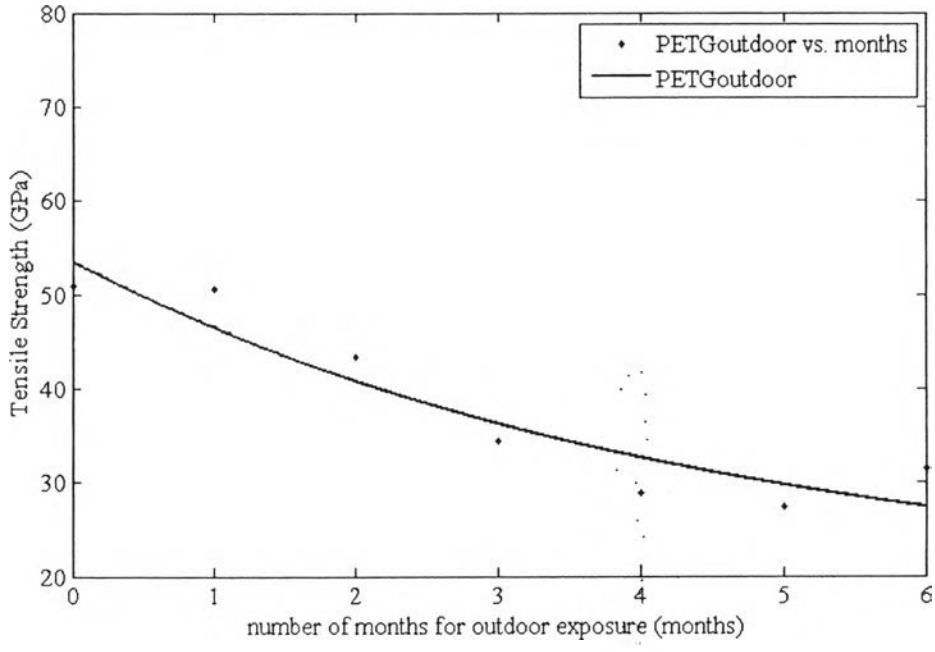

Figure 5.5 Curve fitting of the results of tensile strength of PETG cards after outdoor exposure.

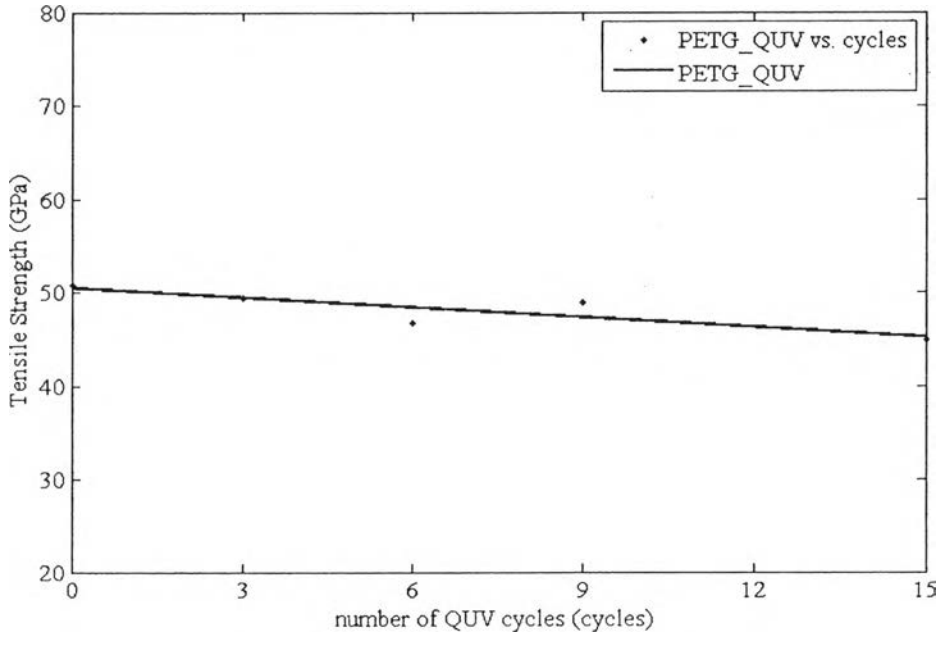

Figure 5.6 Curve fitting of the results of tensile strength of PETG cards after exposure in QUV accelerated weathering tester.

Table 5.5 correlation of period between outdoor exposure and QUV accelerated weathering tester

Materials	Correlation of period	
	Outdoor exposure (Months)	**QUV accelerated weathering tester (cycles)**
PC	12	12.64
PVC	12	251.47
PETG	12	78.93

In calculation, x in exponential equation of outdoor exposure instead by 12 and replace a, b and c from table 5.4 in each equation for determine y or tensile strength. Take y value and instead a, b and c from table 5.4 in each exponential equation of QUV accelerated weathering test for determine number of cycles. For example, In PVC calculation the number of cycles of QUV accelerated weathering tester for 12 months of outdoor exposure is

$$y_{outdoor} = ae^{bx} + c$$
$$y_{outdoor} = 31.37e^{-0.24x} + 21.78$$
$$y_{outdoor} = 23.54$$

Take y value and instead a, b and c from table 5.4 in exponential equation of PVC (QUV accelerated weathering test) for determine number of cycles, which is

$$y = ae^{bx} + c$$
$$23.54 = ae^{bx} + c$$
$$23.54 = 50.24e^{-0.003x}$$
$$x = 251.47$$

The correlation of period in PVC which is high number of QUV accelerated weathering test because the tensile strength results was increase when increase cycles of accelerated weathering tester.

5.5 Conclusions

For 12 months of lifetime in outdoor exposure of PC, PVC, and PETG amount 12.64, 251.47 and 78.93 cycles of QUV accelerated weathering test respectively. Coefficient *b* of correlation equation shows the greatest number indicating the higher degradation of plastic.

5.6 Acknowledgements

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5.7 References

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