PART A / *BAHAGIAN A*

(1). (a). (i). Suppose the following information on the failure modes in circuit packs is obtained: insufficient solder – 52; failed component – 126; incorrect component - 208; missing component – 131; excess solder – 88; others – 23; incorrect position - 150. Sketch a Pareto chart.

Maklumat berikut adalah pelbagai mod kegagalan pembungkusan litar yang diperolehi: kekurangan pateri – 52; kegagalan komponen – 126; kesilapan komponen - 208; kehilangan komponen – 131; kelebihan pateri – 88; lain-lain – 23; kesilapan kedudukan - 150. Lakarkan sebuah carta Pareto.

(10 marks/*markah*)

(ii). As a process engineer, select three failure modes based on the Pareto chart to work on in order to improve the production yield. Justify your selection.

Sebagai jurutera proses, pilih tiga jenis mod kegagalan berdasarkan carta Pareto tersebut untuk diperbaiki agar dapat meningkatkan hasil pengeluaran. Justifikasikan pilihan anda.

(5 marks/*markah*)

(b). Discuss two approaches that we can use to judge if a set of data is taken from a normal distribution.

Bincangkan dua pendekatan yang boleh digunakan untuk menjustifikasi sama ada satu set data tersebut adalah diambil daripada taburan normal.

(5 marks/*markah*)

…3/-

(c). Lifetime of batteries produced by company AXY are normally distributed with mean 55 hours and standard deviation of 5 hours. Find the probability that a randomly chosen battery lasts between 43 to 52 hours.

Tempoh hayat bateri yang dihasilkan oleh syarikat AXY biasanya bertaburan secara normal dengan purata 55 jam dan sisihan piawai 5 jam. Cari kebarangkalian bagi bateri yang dipilih secara rawak dan mempunyai tempoh hayat antara 43 ke 52 jam.

(5 marks/*markah*)

(2). (a). What is the difference between population and sample?
Apakah perbezaan antara populasi dan sampel?

(5 marks/*markah*)

(b). Table 2.1 shows the breaking load (kg/25 mm width) for various fabrics in both unabraded condition and abraded condition. Construct a confident interval for the population mean difference between unabraded condition and abraded condition using confident level of 95%.

Jadual 2.1 menunjukkan beban pemecah (kg/ 25 mm lebar) bagi pelbagai fabrik yang tidak tersekar dan tersekar. Binakan selang keyakinan bagi perbezaan populasi purata antara fabrik yang tidak tersekar dan tersekar pada aras keyakinan 95%.

Table 2.1 Breaking load of different types of fabrics

Jadual 2.1 Beban pemecah bagi pelbagai jenis fabrik

Type of fabric/Jenis fabrik	1	2	3	4	5	6	7	8
Unabraded/ Tidak tersekar	36.4	55.0	51.5	38.7	43.2	48.8	25.6	49.8
Abraded/ Tersekar	28.5	20.0	46.0	34.5	36.5	52.5	26.5	46.5

(12 marks/*markah*)

(c). A manufacturer of sprinkler system used for fire protection in office buildings claims that the true average system-activation temperature is 54.00^{o}C. A sample of n = 9 systems, when tested, yields a sample average activation temperature of 54.57^{o}C. If the distribution of activation temperature is normal with standard deviation (population) of 0.85^{o}C, does the data contradict the manufacturer's claim at significant level α = 0.01?

Sebuah pengilang menghasil sistem pemercik untuk perlindungan api dalam bangunan pejabat menuntut bahawa purata suhu pengaktifan sistem adalah 54.00^{o}C. Suatu sampel sebanyak 9 sistem, bila diuji, mendapat purata sampel suhu pengaktifan adalah sebanyak 54.57^{o}C. Jika taburan suhu pengaktifan adalah normal dengan sisihan piawai (populasi) 0.85^{o}C, adakah data tersebut bercanggah dengan tuntutan pengilang tersebut pada paras bererti α = 0.01?

(8 marks/*markah*)

(3). Table 3.1 shows the effects of cyclic loading frequency and environment conditions on fatigue crack growth rate at a constant 22 MPa stress for material A.

Jadual 3.1 menunjukkan kesan frekuansi pembebanan berkitar dan suasana persekitaran pada kadar pertumbuhan retakan lesu pada tegasan malar 22 MPa bagi bahan A.

Table 3.1 Effects of cyclic loading frequency and environment conditions on fatigue crack growth rate

Jadual 3.1 Kesan frekuansi pembebanan berkitar dan suasana persekitaran pada kadar pertumbuhan retakan lesu

Fatigue growth rate (mm/cycle)

	Environment		
Frequency	Air	H_2O	Salt H_2O
10	2.29	2.06	1.93
10	2.47	2.05	1.96
10	2.48	2.23	1.78
10	2.12	2.01	2.06
1	2.65	3.2	9.98
1	2.68	3.18	10.01
1	2.06	3.98	10.03
1	2.38	3.66	9.36
0.1	2.22	11.01	9.97
0.1	2.65	10.95	10.03
0.1	2.71	9.76	9.38
0.1	2.12	11.2	10.33

(a). How many factor, levels, and replicate in this experiment?
Berapakah faktor, paras dan ulangan dalam eksperimen ini?
(3 marks/*markah*)

(b). State the null hypothesis and alternate hypothesis of this experiment.

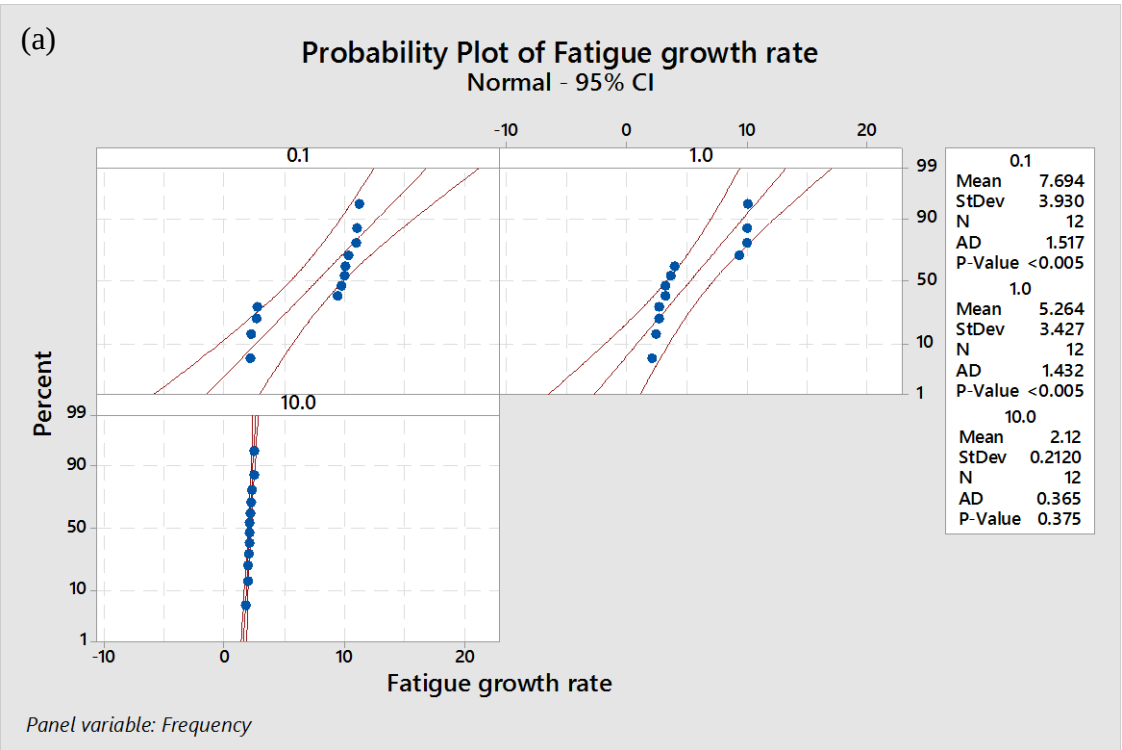
Nyatakan hipotesis sifar dan hipotesis alternatif bagi eksperimen ini.

(4 marks/*markah*)

(c). The normal probability plot and test for equal variance are shown in Figure 3.1 and Figure 3.2, respectively. Do the assumptions for the model hold? Justify your answer.

Plot keberangkalian normal dan plot ujian sesama varian adalah ditunjukkan di Rajah 3.1 dan Rajah 3.2. Adakah andaian bagi model ini adalah tepat? Justifikasikan jawapan anda.

(a)



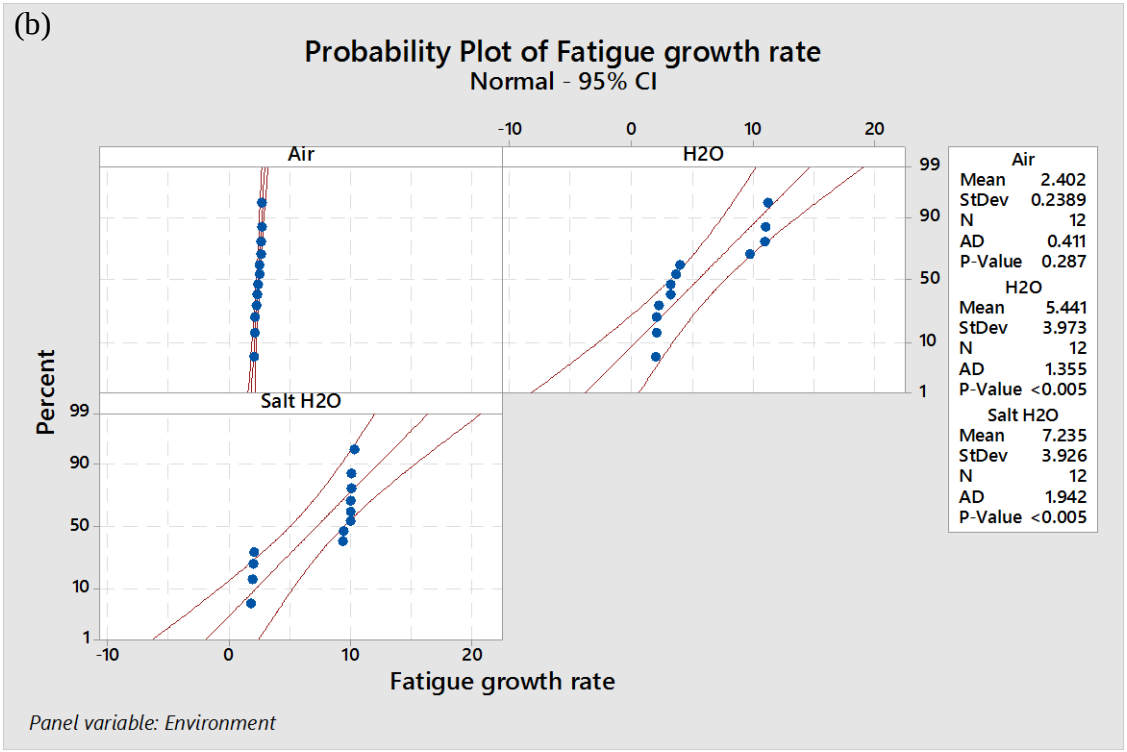
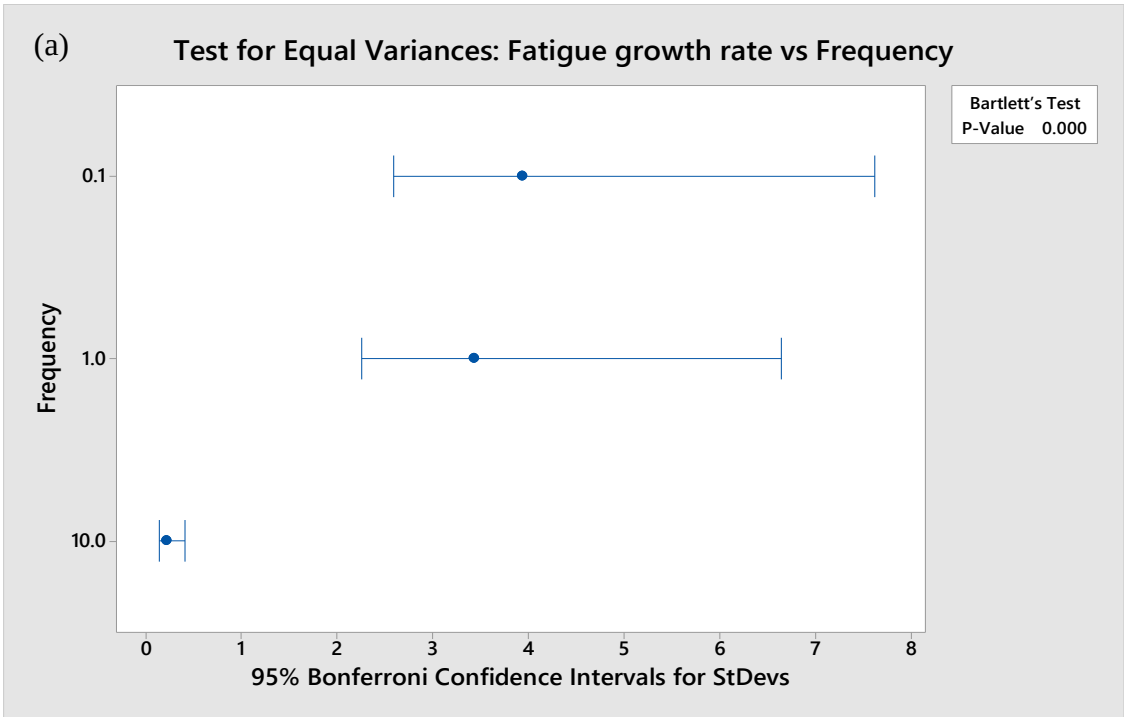


Figure 3.1: Normal probability plot of fatigue growth rate (a) loading frequency and (b) Environment.

Rajah 3.1: Plot keberangkalian normal pertumbuhan retakan lesu bagi (a) frekuansi pembebanan berkitar dan (b) suasana persekitaran



…8/-

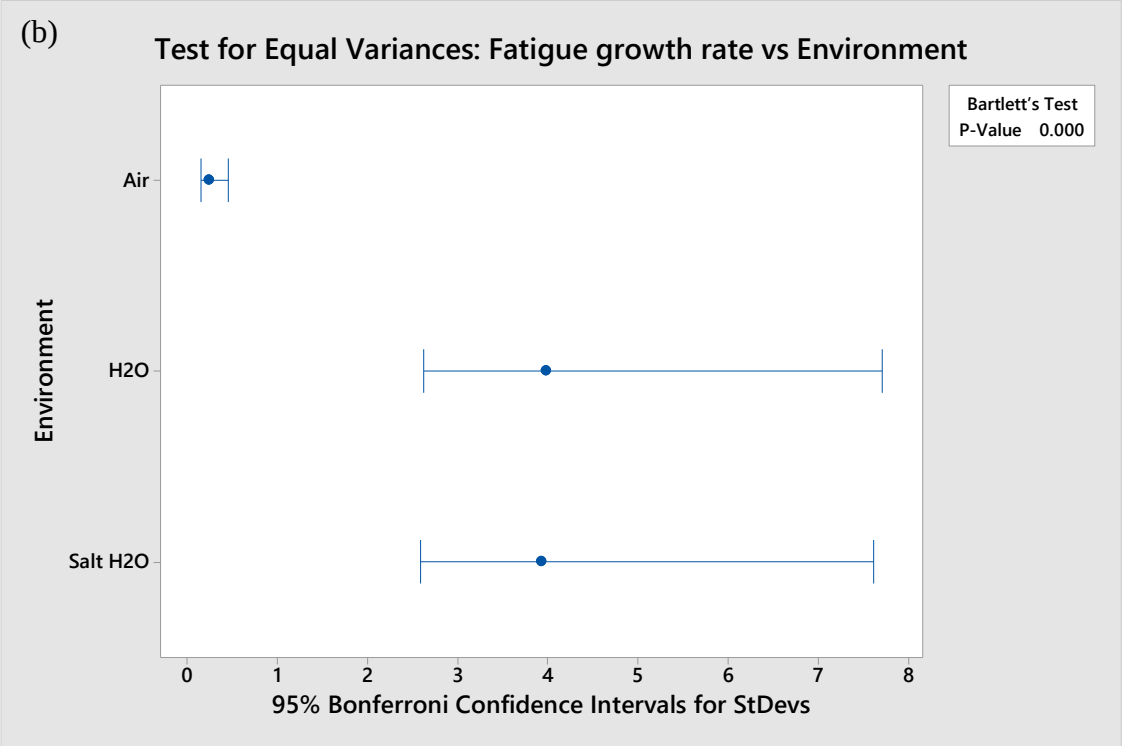


Figure 3.2 Test for equal variance of fatigue growth rate (a) loading frequency and (b) Environment.

Rajah 3.2 Ujian sesama varian pertumbuhan retakan lesu bagi (a) frekuansi pembebanan berkitar dan (b) suasana persekitaran pada kadar.

(8 marks/*markah*)

(d). Assume that the data are taken from a normal distribution and have equal variance, analyze the residuals from Figure 3.3. Are the ANOVA assumptions satisfied?

Anggapkan data adalah diambil dari taburan normal dan mempunyai sesama varian, buat analisis sisa daripada Rajah 3.3. Adakah andaian ANOVA dipenuhi?

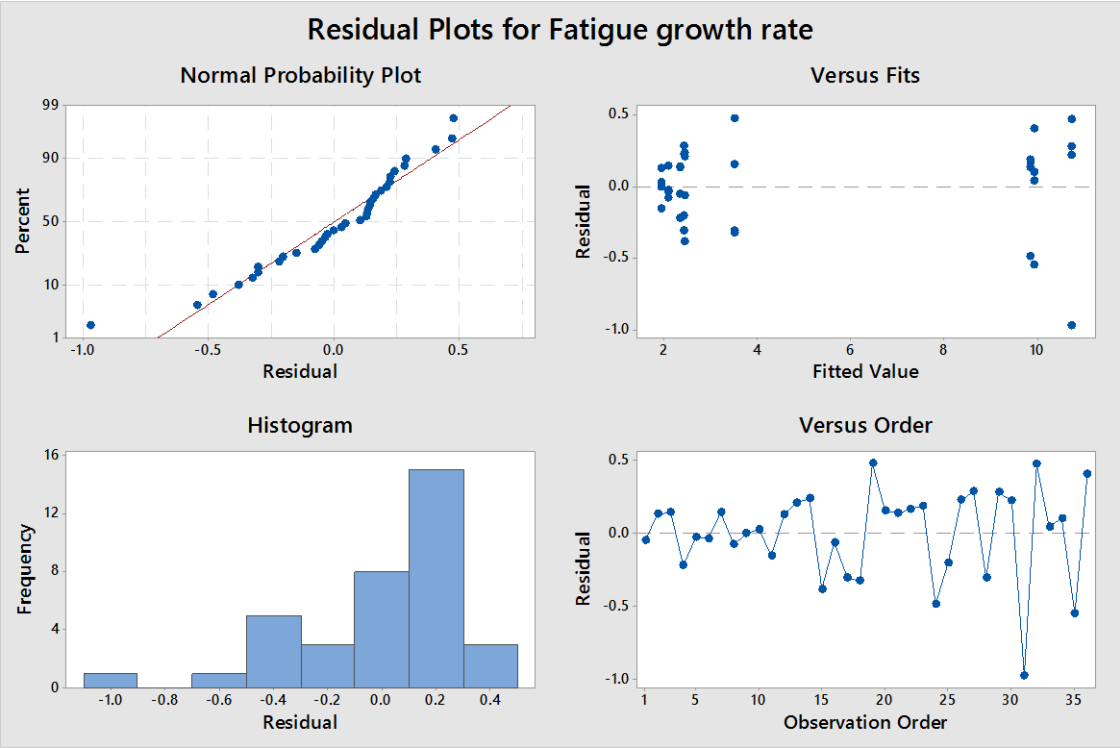


Figure 3.3 Residual plots

Rajah 3.3 Plot sisa-sisa

(5 marks/*markah*)

(e). Assume that the residual analysis is valid, does the cyclic loading frequency and environment conditions affect the fatigue crack growth rate based on the ANOVA table in Table 3.1? (α = 0.05).

Anggapkan analisis sisa-sisa adalah sah, adakah frekuensi pembebanan berkitar dan suasana persekitaran mempengaruhi kadar pertumbuhan retakan lesu berdasarkan Jadual ANOVA yang ditunjukkan pada Jadual 3.1? (α = 0.05).

…10/-

Table 3.1 ANOVA table

Jadual 3.1 Jadual ANOVA

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Frequency	2	187.448	93.7240	791.14	0.000
Environment	2	143.214	71.6071	604.45	0.000
Frequency*Environment	4	153.159	38.2897	323.21	0.000
Error	27	3.199	0.1185		
Total	35	487.020			

(5 marks/*markah*)

PART B / *BAHAGIAN B*

(4). (a). The problem of this research was to investigate the ultimate tensile strength (MPa) of the single-layer vascular grafts in the radial direction. The two inputs of interest are polymer type (1,2) and rotational speed (5000 min^{-1} and 15000 min^{-1}). A 2^2 factorial design was adopted to investigate the effect of the two factors mentioned on the ultimate tensile strength (MPa) values as in Table 4.1.

Masalah penyelidikan ini adalah untuk menyiasat kekuatan tegangan muktamad (MPa) cantuman vaskular satu lapisan dalam arah jejari. Dua input yang diminati ialah jenis polimer (1,2) dan kelajuan putaran (5000 min^{-1} and 15000 min^{-1}). Reka bentuk faktorial 2^2 telah diguna pakai untuk menyiasat kesan dua faktor yang disebut ke atas nilai kekuatan tegangan muktamad (MPa) adalah seperti dalam Jadual 4.1.

Table 4.1: Ultimate Tensile Strength Value (MPa)

Jadual 4.1 : Nilai Kekuatan Tegangan Muktamad (MPa)

Polymer type *Jenis polimer*	Rotational speed (min^{-1}) *Kelajuan putaran* (min^{-1})		
	5000	15000	
1 (PCL)	3.74	5.90	$Y_{1..}$ = 28.82
	2.81	7.50	
	2.11	6.76	
2 (PLC)	2.69	3.35	$Y_{2..}$ = 18.05
	2.71	3.20	
	2.70	3.40	
	$Y_{.1.}$ = 16.76	$Y_{.2.}$ = 30.11	$Y_{...}$ = 46.87

…12/-

Table 4.2: ANOVA Table For Ultimate Tensile Strength Value (MPa).

Jadual 4.2 Jadual ANOVA Untuk Nilai Kekuatan Tegangan Muktamad (MPa).

Source / *Sumber*	Degree of freedom (d.f)./ *Darjah kebebasan*	Sum of Squares (SS)/ *Jumlah persegi*	Mean of Squares (MS)/ *Minpersegi*	F-Test/ *Ujian-F*	F-Statistic Table/ *Jadual Statistik-* ***F(0.05)***
Polymer Type */Jenis Polimer*					
Rotational Speed */ Kelajuan putaran*					
Polymer Type* Rotational Speed *Jenis Polimer* Kelajuan putaran*					
Error/ *Ralat*		2.642		NA	NA
Total/*Jumlah*	11	34.92	NA	NA	NA
S = 0. 5746	**R-Sq = A**		**R-Sq(adj) = B**		R-sq(pred) = 82.98%

(Hints/ *Petua*::

Total/*Jumlah*: $SS_T = \sum_{i=1}^{2}\sum_{j=1}^{2}\sum_{k=1}^{3} y_{ijk}^2 - \frac{y_{...}^2}{abn}$

$= [3.74^2 + 2.81^2 + 2.11^2 + \ldots. + 3.40^2] - \frac{46.87^2}{2(2)(3)}$

$= 217.9861 – 183.0664$

$= 34.92$

Error/ *Ralat* : $SS_E = SS_T - SS_P - SS_R - SS_{PR} = 2.642$)

Assume the significance level is α = 0.05. Answer the following questions:

Andaikan aras signifikan adalah α = 0.05. Jawab soalan- soalan berikut:

(i). Develop the model of ultimate tensile strength value (MPa) experiment in the Table 4.1.

Bangunkan model untuk nilai kekuatan tegangan muktamad (MPa) dalam eksperimen di Jadual 4.1.

(2 marks/*markah*)

…13/-

(ii). Based on the above given ultimate tensile strength value (MPa) data, construct the details of table and complete the empty cells in Table 4.2.

Berdasarkan data nilai kekuatan tegangan muktamad (MPa) yang diberikan di atas, bina butiran jadual dan lengkapkan ruang kosong dalam Jadual 4.2.

(8 marks/*markah*)

(iii). Explain the difference between R-Squared (R-Sq or R^2) and Adjusted R-square (R-Sq(adj))

Terangkan perbezaan antara R-Squared (R-Sq atau R^2) dan Laras R-squared (R-Sq(adj))

(2 marks/markah)

(iv). Find the values of R-Squared (R-Sq or R^2) and Adjusted R-square (R-Sq(adj)) from ANOVA Table 4.2.

Cari nilai R-Squared (R-Sq atau R^2) dan Laras R-square (R-Sq(adj)) daripada ANOVA Jadual 4.2 .

(3 marks/*markah*)

(b). Using the data from Table 4.1, Main effect plot and Interaction plot of Ultimate tensile strength value (MPa) were plotted.

Menggunakan data daripada Jadual 4.1, Plot kesan utama dan Plot Interaksi nilai kekuatan tegangan muktamad (MPa) telah diplotkan.

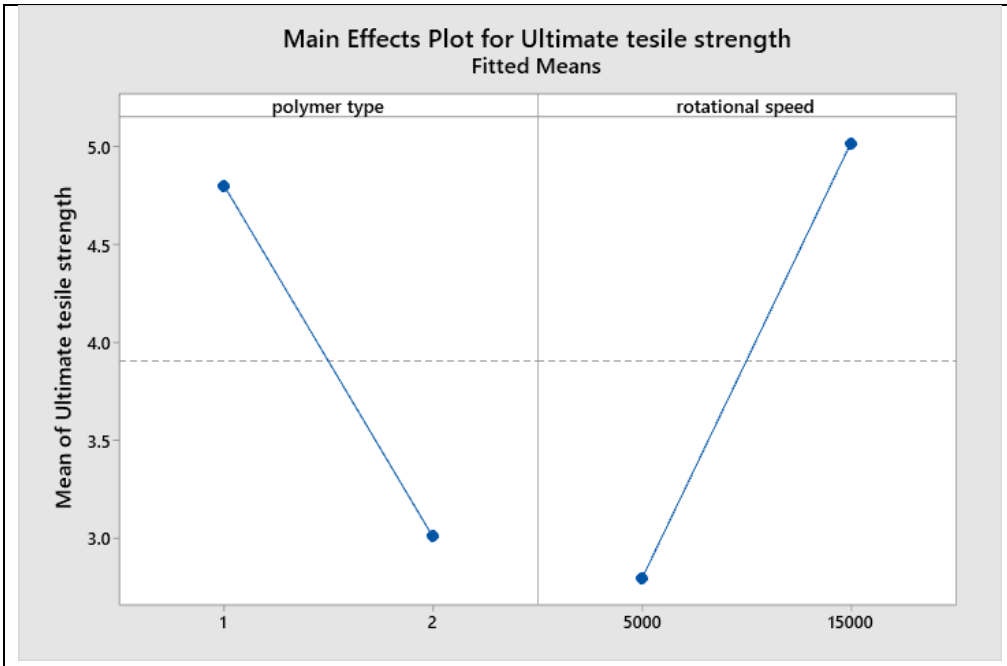


Figure 4.1: Main effect plot of ultimate tensile strength value (MPa)
Rajah 4.1: Plot kesan utama bagi nilai kekuatan tegangan muktamad (MPa)

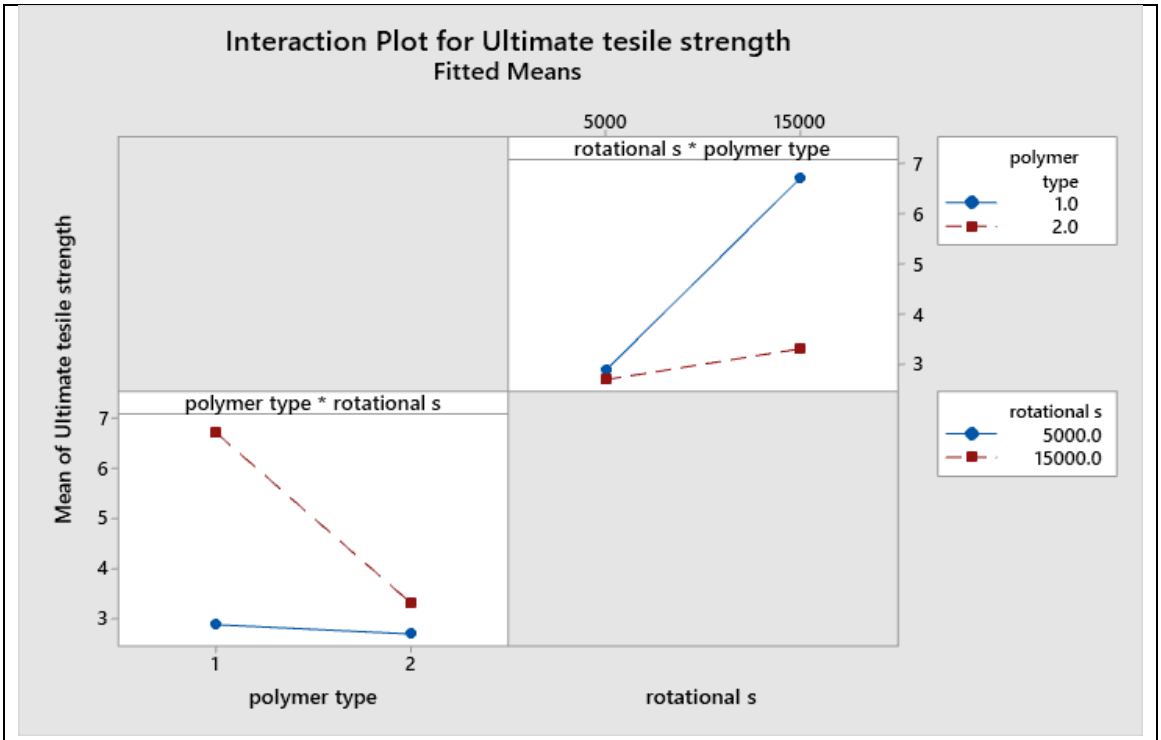


Figure 4.2 Interaction plot of ultimate tensile strength value (MPa)
Rajah 4.2: Plot interaksi nilai kekuatan tegangan muktamad (MPa)

…15/-

(i). Using the Main effect plot and Interaction plot Figure 4.1 and Figure 4.2 perform an analysis on interaction or relationship between the two factors?

Menggunakan plot kesan utama dan plot Interaksi Rajah 4.1 dan Rajah 4.2 melakukan analisis terhadap interaksi atau hubungan antara dua faktor?

(4 marks/*markah)*

(ii). Using the values of R-Squared (R-Sq or R^2), Adjusted R-square (R-Sq(adj) and R-square prediction (R-sq(pred)), conclude the ANOVA analysis results?

Dengan menggunakan nilai R-Squared (R-Sq atau R^2), R-square terlaras (R-Sq(adj) dan ramalan R-square (R-sq(pred)), simpulkan keputusan analisis ANOVA?

(6 marks/*markah)*

(5). (a). "Bread Maker" factory decided to investigate the possible way to increase the yield of cookies for the two factors Temp and Water in the production line as in Table 5.1. Using the yield of cookies for the two factors in Table 5.1, they baked 3 batches of cookies with each of the four treatment combinations (1), t, w, and tw and produced the following result in Table 5.2.

Kilang Bread Maker memutuskan untuk menyiasat cara yang mungkin untuk meningkatkan hasil kuki bagi dua faktor Suhu dan Air di barisan pengeluaran seperti dalam Jadual 5.1. Dengan menggunakan hasil kuki untuk dua faktor dalam Jadual 5.1, mereka membakar 3 kelompok kuki dengan setiap satu daripada empat kombinasi rawatan (1), t, w, dan tw dan menghasilkan keputusan berikut dalam Jadual 5.2.

…16/-

Table 5.1: Yield Of Cookies For The Two Factors

Jadual 5.1: Hasil Kuki Untuk Dua Faktor

Goal */Matlamat*: Yield/ *Hasil*

Yield/*Hasil*	Temperature/*Suhu*	Water/*Air*	Batch/*Kumpulan*
1 31	-1	-1	1
2 29	-1	-1	2
3 30	-1	-1	3
4 40	1	-1	1
5 42	1	-1	2
6 38	1	-1	3
7 51	-1	1	1
8 49	-1	1	2
9 50	-1	1	3
10 61	1	1	1
11 60	1	1	2
12 60	1	1	3

Temperature / *Suhu*
- Low /*Rendah*: 140 ^{o}C
- High/ *Tinggi:* 180 ^{o}C

(Temperature/ *Suhu* A)

Water/*Air* :
- Low/*Rendah*: 50ml
- High/ *Tinggi:* 150ml

(Water B)

Table 5.2: Cookies Treatments

Jadual 5.2: Rawatan cookies

Treatment/ *Rawatan*	Temp/ *Suhu*	Water/ *Air*	Replication/ *Replikasi* 1	Replication/ *Replikasi* 2	Replication/ *Replikasi* 3	Average/ *Purata*
(1)	-	-	31	29	30	30
t	+	-	40	42	38	40
w	-	+	51	49	50	50
tw	+	+	61	60	60	60.3

(i). The 2^2 design can also be represented geometrically using a square with the four treatment combinations called *orthogonal design*. Draw the *orthogonal design square for* Table 5.2*.*

Reka bentuk 2^2 *juga boleh diwakili dengan menggunakan geometri persegi dengan empat gabungan rawatan yang dipanggil reka bentuk ortogon. Lukis reka bentuk ortogon persegi untuk Jadual* 5.2 *.*

(2 marks/*markah)*

…17/-

(ii). Calculate the main effects and interaction of water and temperature for the cookies yield using the *orthogonal design.*

Kirakan kesan utama dan interaksi air dan suhu untuk hasil kuki dengan menggunakan reka bentuk ortogon.

(4 marks/*markah)*

(iii). Use Surface Plot Yield versus Water and Temperature and the calculation results of 5a(ii) and provide your comparison analysis for the cookies yield if the current average treatment **tw=60.3** change to **tw=30**

Menggunakan Plot Permukaan Hasil melawan Air dan Suhu dan keputusan pengiraan 5a (ii) dan sediakan analisis perbandingan anda untuk hasil kuki jika purata semasa rawatan ***tw = 60.3*** *diubah kepada* ***tw = 30***

(6 marks/*markah)*

(5). (b). Use the Yield Of Cookies For The Two Factors in Table 5.1 information for further regression analysis.

Gunakan Maklumat Hasil Kuki Untuk Dua Faktor dalam Jadual 5.1 untuk analisis regresi selanjutnya.

Table 5.3: Two-way ANOVA: **Factorial Fit: yield versus water, temperature** in Minitab

Jadual 5.3: ANOVA Dua hala: Faktoran Berpadanan: Hasil Berbanding Air, Suhu di Minitab

Estimated Effects and Coefficients for yield (coded units)

Term	Effect	Coef	SE Coef	T
Constant		45.0833	0.3632	124.11
water	20.1667	10.0833	0.3632	27.76
temperature	10.1667	5.0833	0.3632	13.99
water*temperature	0.1667	0.0833	0.3632	0.23

S = 1.25831 PRESS = 28.5
R-Sq = 99.18% R-Sq(pred) = 98.15% R-Sq(adj) = 98.87%

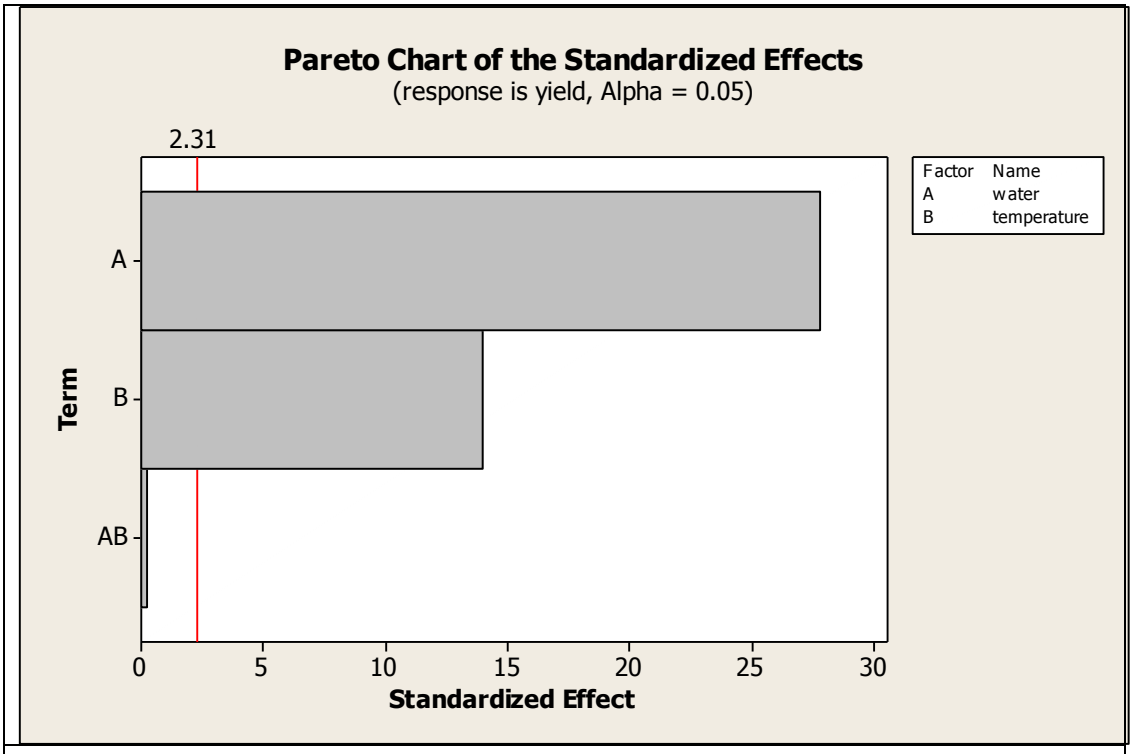


Figure 5.1: Pareto Chart of the standardized effects of yield of cookies.
Rajah 5.1: Carta Pareto kesan piawaian hasil kuki.

…19/-

(i). State the general linear model which can fit for this experiment. Use the corresponding ANOVA Table 5.3 to polynomial state the general model and calculate both coded and uncoded variables form of regression equations .

Nyatakan model linear am yang boleh muat untuk eksperimen ini. Gunakan jadual 5.3 ANOVA yang sepadan untuk keadaan polinomial model umum dan kira persamaan regresi untuk kedua-dua bentuk berkod dan pembolehubah tidak berkod.

(6 marks/*markah*)

(ii). Let say “Bread Maker” factory decided to increase their cookies yield by changing their current factor treatments from Temperature(A) =150 ^{o}C and Water (B) = 60ml to Temperature(A) =160 ^{o}C and Water (B) = 100ml. Do you think Bread Maker factory able to get better Yield for this experiment? Justify your answer with quantitative analysis and pareto chart of standardized effects of yield of cookies in Figure 5.1.

Katakan kilang “Bread Maker” memutuskan untuk meningkatkan hasil cookie mereka dengan menukar faktor rawatan semasa mereka dari Suhu (A) = 150^{o}C dan Air (B) = 60ml untuk Suhu (A) = 160^{o}C dan Air (B) = 100ml. Adakah anda fikir kilang Bread Maker mampu untuk mendapatkan hasil yang lebih baik untuk eksperimen tersebut? Jelaskan jawapan anda dengan analisis kuantitatif dan Carta Pareto kesan piawaian hasil kuki dalam Rajah 5.1 .

(7 marks/*markah*)

(6). (a). An Article in Talanta (2005, Vol 65. pp 895-899) presented a 2^3 factorial design to find lead level (Lead Recovery) by using flame atomic absorption spectrometry (FAAS). The data are in the following Tables 6.1 and 6.2. Assume there is model adequacy and the α = 0.05.

Satu Artikel di Talanta (2005, Vol 65. pp 895-899) mempersembahkan 2^3 reka bentuk faktorial untuk mencari tahap Pemulihan Plumbum (Lead Recovery) dengan menggunakan spektrometri penyerapan atom api (FAAS). Data adalah seperti dalam Jadual 6.1 dan Jadual 6.2. Anggapkan ada kecukupan model dan α = 0.05.

Table 6.1: Factors of Variations for Lead Recovery

Jadual 6.1: Faktor-faktor Perubahan untuk Pemulihan Plumbum

Factor/*Factor*	Factor Levels *Tahap Faktor*	
	Low (-1) *Rendah*	High (+1) *Tinggi*
Reagent Concentration (RC) / Kepekatan Reagen (RC) (mol 1^{-1})	$5x10^{-6}$	$5x10^{-5}$
pH	6.0	8.0
Shaking Time (ST) / Masa Menggoncang (ST) (min)	10	30

Table 6.2: DOE coded design for Lead Recovery

Jadual 6.2: Reka bentuk kod DOE untuk Pemulihan Plumbum

Run Larian	Coded Factors *Faktor terkod*			Lead Recovery *Pemulihan Plumbum*	
	RC	*pH*	*ST*	Replicate 1 *Replikasi*	Replicate 2 *Replikasi*
1	-	-	-	39.8	42.1
2	+	-	-	51.3	48
3	-	+	-	57.9	58.1
4	+	+	-	78.9	85.9
5	-	-	+	78.9	84.2
6	+	-	+	84.2	84.2
7	-	+	+	94.4	90.9
8	+	+	+	94.7	105.3

…21/-

(i). Which factors significantly affect Lead Recovery? Analyze the data from Table 6.3 dan Figure 6.1.

Faktor manakah yang lebih signifikan mempengaruhi Pemulihan Plumbum? Buat analisis data daripada Jadual 6.3 dan Rajah 6.1.

Table 6.3: Factorial Fit for Lead Recovery versus RC, pH, ST

Jadual 6.3: Kesesuaian Faktorial untuk Pemulihan Plumbum berbanding RC, pH, ST

Analysis of Variance : Lead_Recovery versus RC, pH, ST

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	7	6391.61	913.09	67.04	0.000
Linear	3	5992.81	1997.60	146.67	0.000
RC	1	4057.69	4057.69	297.92	0.000
pH	1	1470.72	1470.72	107.98	0.000
ST	1	464.40	464.40	34.10	0.000
2-Way Interactions	3	368.54	122.85	9.02	0.006
RC*pH	1	131.10	131.10	9.63	0.015
RC*ST	1	133.40	133.40	9.79	0.014
pH*ST	1	104.04	104.04	7.64	0.025
3-Way Interactions	1	30.25	30.25	2.22	0.174
RC*pH*ST	1	30.25	30.25	2.22	0.174
Error	8	108.96	13.62		
Total	15	6500.57			

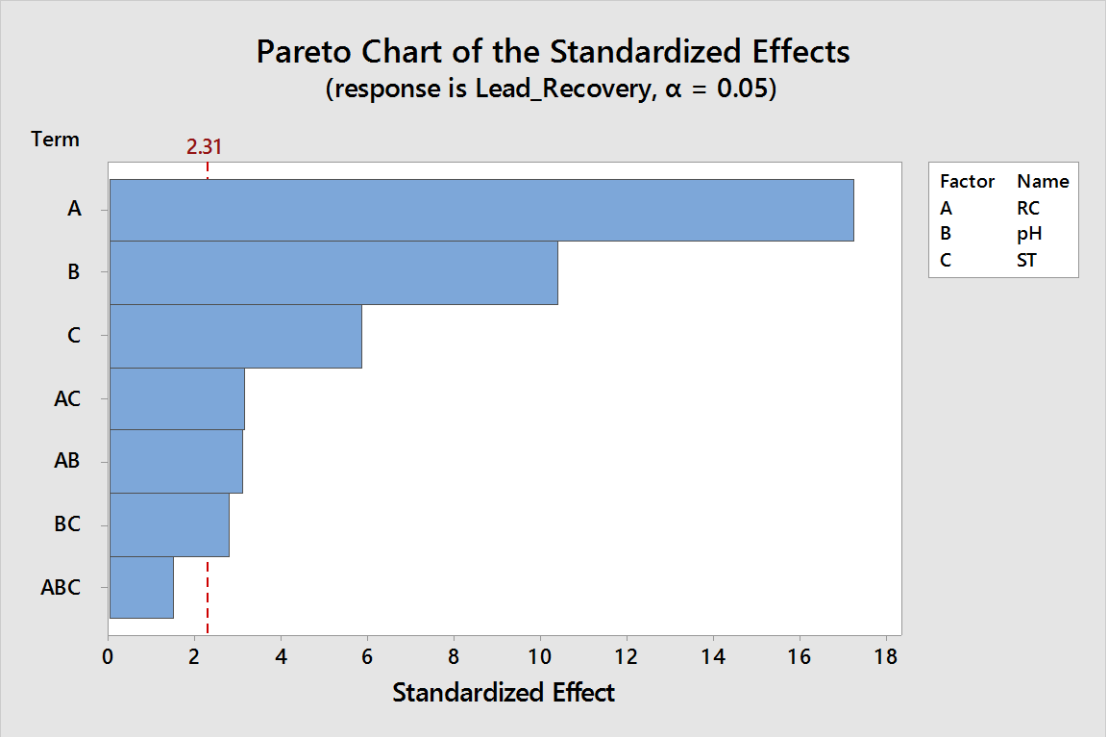
Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3.69053	98.32%	96.86%	93.30%

…22/-

Figure 6.1: Pareto Chart of the Standardized Lead Recovery

Rajah 6.1: Carta Pareto Kesan Piawaian Pemulihan Plumbum



(5 marks/*markah*)

(ii). The new model from Table 6.4 has been employed after the elimination of the unwanted interaction which is ABC for predicting Lead Recovery. Use R-sq, R-sq(adj) R-sq(pred) to compare Table 6.3 and Table 6.4 and conclude the better preference for Lead Recovery Process.

Model baru dari Jadual 6.4 telah digunakan setelah penghapusan interaksi yang tidak sesuai iaitu ABC untuk meramalkan Pemulihan Plumbum. Gunakan R-persegi, R persegi (adj) R persegi (pred) untuk membandingkan Jadual 6.3 dan Jadual 6.4 dan membuat kesimpulan pilihan yang lebih baik untuk Proses Pemulihan Plumbum.

…23/-

Table 6.4: Newly Estimated Analysis of Variance for Lead Recovery

Jadual 6.4: Analisis Anggaran Baru *untuk Pemulihan Plumbum*

Analysis of Variance : Lead_Recovery versus RC, pH, ST

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	6	6361.36	1060.23	68.54	0.000
Linear	3	5992.81	1997.60	129.15	0.000
RC	1	4057.69	4057.69	262.33	0.000
pH	1	1470.72	1470.72	95.08	0.000
ST	1	464.40	464.40	30.02	0.000
2-Way Interactions	3	368.55	122.85	7.94	0.007
RC*pH	1	131.10	131.10	8.48	0.017
RC*ST	1	133.40	133.40	8.62	0.017
pH*ST	1	104.04	104.04	6.73	0.029
Error	9	139.21	15.47		
Lack-of-Fit	1	30.25	30.25	2.22	0.174
Pure Error	8	108.96	13.62		
Total	15	6500.57			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3.93291	97.86%	96.43%	93.23%

(7 marks/*markah*)

(b). Use the data from Table 6.2 to construct Surface Plots to assist in interpreting the results of the experiment.

Gunakan model di atas daripada data Jadual 6.2 untuk membina Plot Permukaan untuk membantu mentafsir hasil eksperimen.

…24/-

Figure 6.2: Surface Plot of Lead Recovery Versus ST,pH

Rajah 6.2: Plot Permukaan Pemulihan Plumbum lawan ST, pH

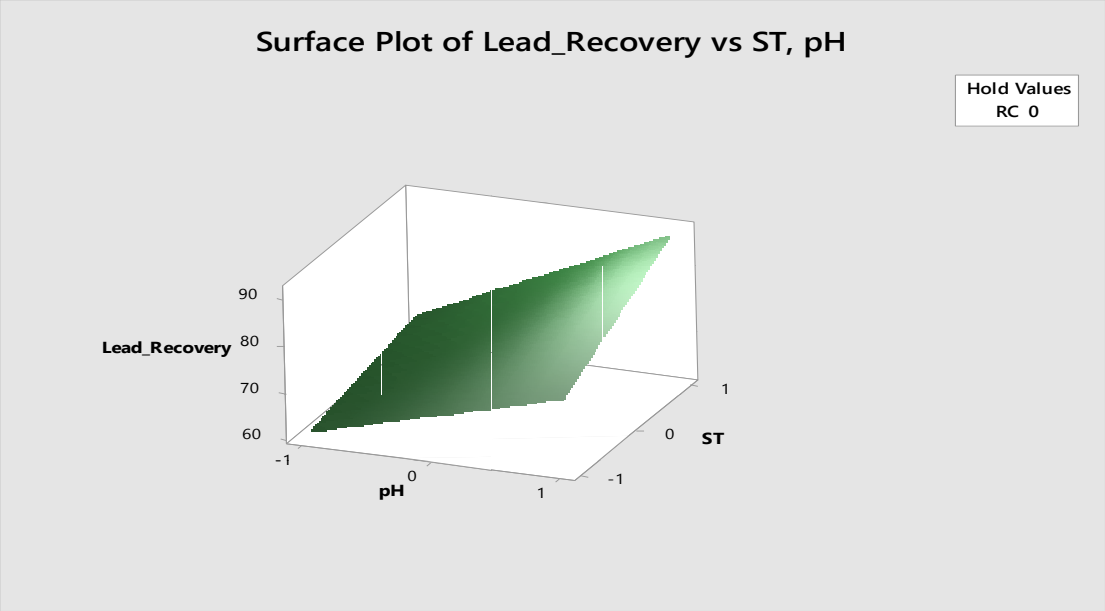
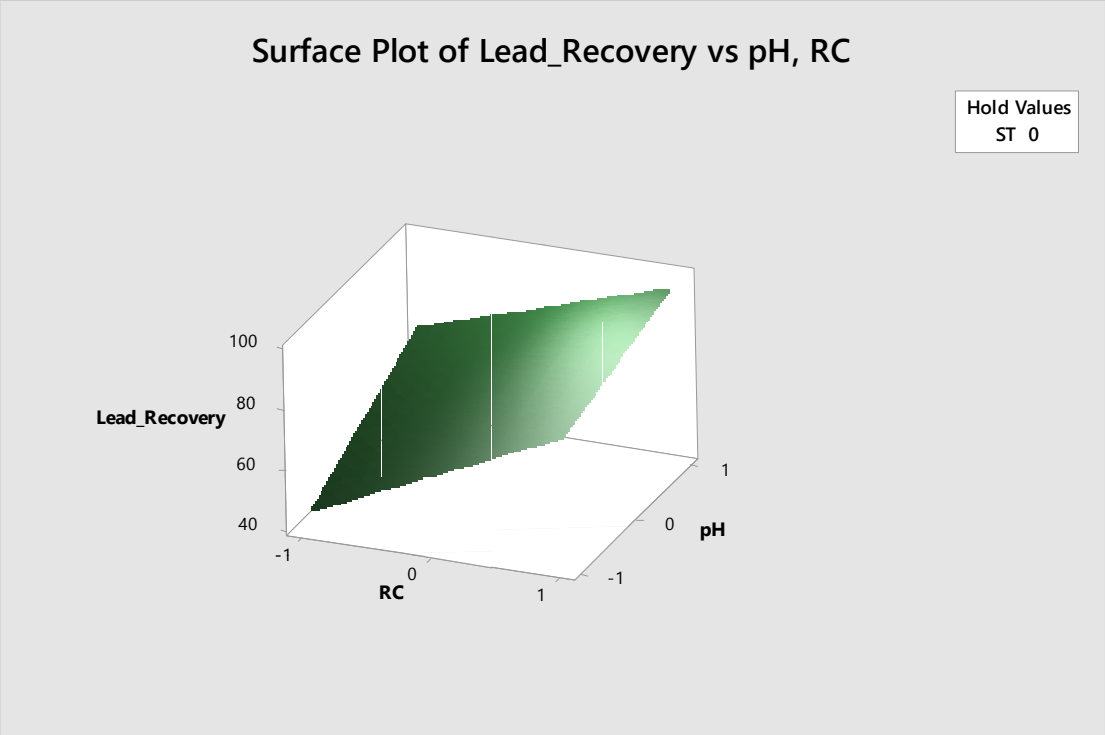


Figure 6.3: Surface Plot of Lead Recovery versus pH, RC

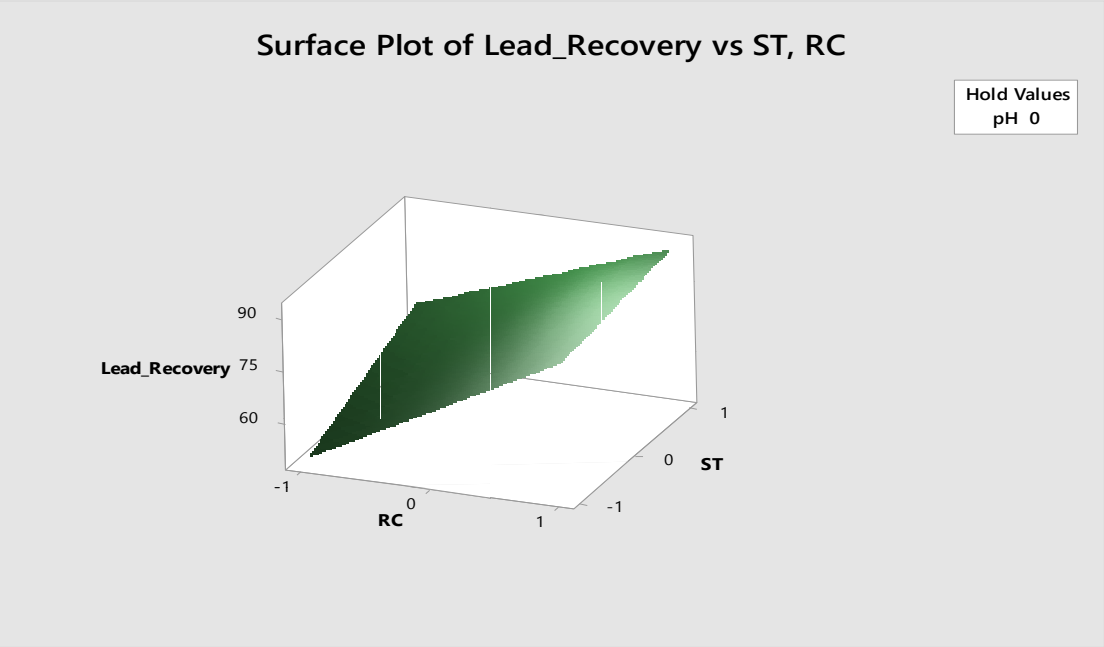
Rajah 6.3: Plot Permukaan Pemulihan Plumbum lawan pH, RC



…25/-

Figure 6.4: Surface Plot of Lead Recovery versus RC, ST

Rajah 6.4: Plot Permukaan Pemulihan Plumbum lawan RC, ST



(i). The above Surface Plots in the Figure 6.2,6.3,6.4 identifiy the Lead Recovery. Provide your analysis on the above Surface Plots if the manufacturer wanted to maximize the Lead Recovery.

Plot Permukaan di atas dalam Rajah-rajah 6.2,6.3,6.4 *mengenal pasti pemulihan Plumbum. Sediakan analisa anda di Plot-plot Permukaan di atas jika pengeluar ingin memaksimumkan Pemulihan Plumbum.*

(5 marks/markah)

(ii). If the manufacturer use the coded values and not actual values as given for *Reagent Concentration (RC) = 0.8,* pH = -0.9 and Shaking Time (ST) = 0.5, calculate the Lead Recovery from Table 6.5 using the coded regression equation and provide your suggestion to improve the Lead Recovery with the support of R-Sq(pred) from Table 6.5.

…26/-

Sekiranya pengilang menggunakan nilai berkod dan bukan nilai sebenar seperti yang diberikan untuk Kepekatan Reagen (RC) = 0.8, pH = -0.9 dan Masa Menggoncang (ST) = 0.5, hitung Pemulihan Plumbum dari Jadual 6.5 menggunakan persamaan regresi berkod dan berikan cadangan untuk meningkatkan Pemulihan Plumbum dengan sokongan R-Sq (pred) dari Jadual 6.5.

Table 6.5: Factorial Regression: Lead_Recovery versus RC, pH, ST for Lead Recovery

Jadual 6.5: Regresi Faktorial: Lead_Recovery berbanding RC, pH, ST untuk Pemulihan Plumbum

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		73.675	0.983	74.93	0.000	
RC	31.850	15.925	0.983	16.20	0.000	1.00
pH	19.175	9.587	0.983	9.75	0.000	1.00
ST	10.775	5.387	0.983	5.48	0.000	1.00
RC*pH	-5.725	-2.863	0.983	-2.91	0.017	1.00
RC*ST	-5.775	-2.887	0.983	-2.94	0.017	1.00
pH*ST	5.100	2.550	0.983	2.59	0.029	1.00

Regression Equation in coded Units

Lead_Recovery = 73.675 + 15.925 RC + 9.587 pH + 5.387 ST - 2.863 RC*pH - 2.887 RC*ST + 2.550 pH*ST

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3.93291	97.86%	96.43%	93.23%

(8 marks/*markah*)

–oooOooo –