Design of Experiments

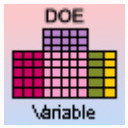
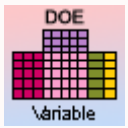
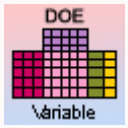
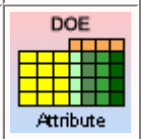
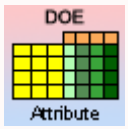
Bawani Ho
Acme
2007-Jan-16 : 14:22:50

Table of Contents

Project Introduction

Project Details	
Project Name	DOE
Description	Design of Experiments
Objective	To optimize an attribute response
Abstract	Solder boards have a high defect rate due to solder covering the holes for pin insertion.
Project Leader	Bawani Ho
Commencement Date	15-Jul-2006
Project Completion Date	15-Jul-2006
Completion Date	
Status	Not Completed

Project Flow

Stages	Objective	Activities	Deliverables	Applet
Design	To estimate the quality loss functio for a quality characteristic	Estimate the quality loss for nominal-the-best characteristics	Loss due to variability and loss due to bias	
Design	To conduct a simple experiment	Improve a process without considering quality loss function	Optimum process parameters	
Design	To optimize a paper gyrocopter	To conduct an L8 (2^7) gyrocopter experiment (Larger-the-better)	Optimum process parameters	
Experiment	To study the effect of parameters of carbon powder	To conduct an L9 (3^4) carbon powder microphone experiment (Smaller-the-better)	Optimum process parameter	
Research	To use a larger array	To conduct an L18 (3^1x2^7) experiment (Nominal-the-best)	Optimum process parameter	
Attribute	To improve an attribute response	To conduct an L8 (2^7) attribute experiment - 3 attributes	Optimization of soldering process to reduce the number of defect solder boards	
		To conduct an L8 (2^7) attribute experiment - 4 attributes	Optimization of soldering process to reduce the number of defect solder boards	

Design of Experiments

Quality Loss Function

Bawani Ho
Acme
2007-Jan-16 : 12:15:49

Applet Introduction

Applet Details	
Applet Title	QLF
Description	Quality Loss Function
Objective	To estimate the quality loss due to variability and bias
Abstract	The Quality Loss Function allows the calculation of monetary loss associated with the specification
Team Leader	Bawani Ho
Commencement Date	19-Aug-2006
Expected Completion Date	
Completion Date	
Status	Not Completed
Team Name	Quality Loss Function
Team Members	

1	IR0006	Azrin Othman
2	IR0003	Azizah Mamat

Quality Characteristics

Response Details	
Response Name	Output Voltage
Response Unit	Volt
Financial Unit	$
Quality loss coefficient	$ / (Volt^2)
Response measure	Output Voltage (Volt)

\ Response Type	
Noise Performance Measure (NPM)	Nominal the best
Target Performance Measure (TPM)	Y Bar

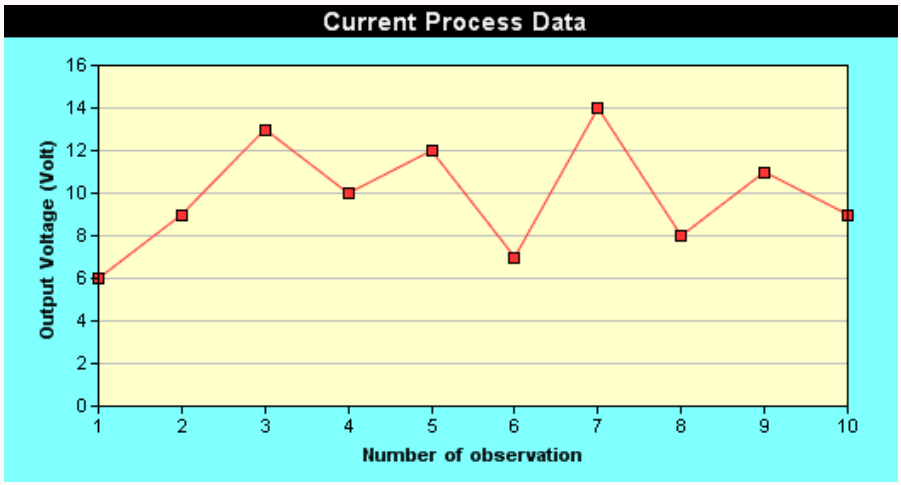
	Specification Limit	Financial Loss
Lower Specification Limit (LSL)	5 Volt	10 $
Center Specification Limit (CL)	10 Volt	0 $
Upper Specification Limit (USL)	15 Volt	10 $

Statement of Problem

Statement of the problem
Description of big problem to be solved by engineers.Description of big problem to be solved by engineers. Description of big problem to be solved by engineers.Description of big problem to be solved by engineers. Description of big problem to be solved by engineers.Description of big problem to be solved by engineers.

Current Process Performance

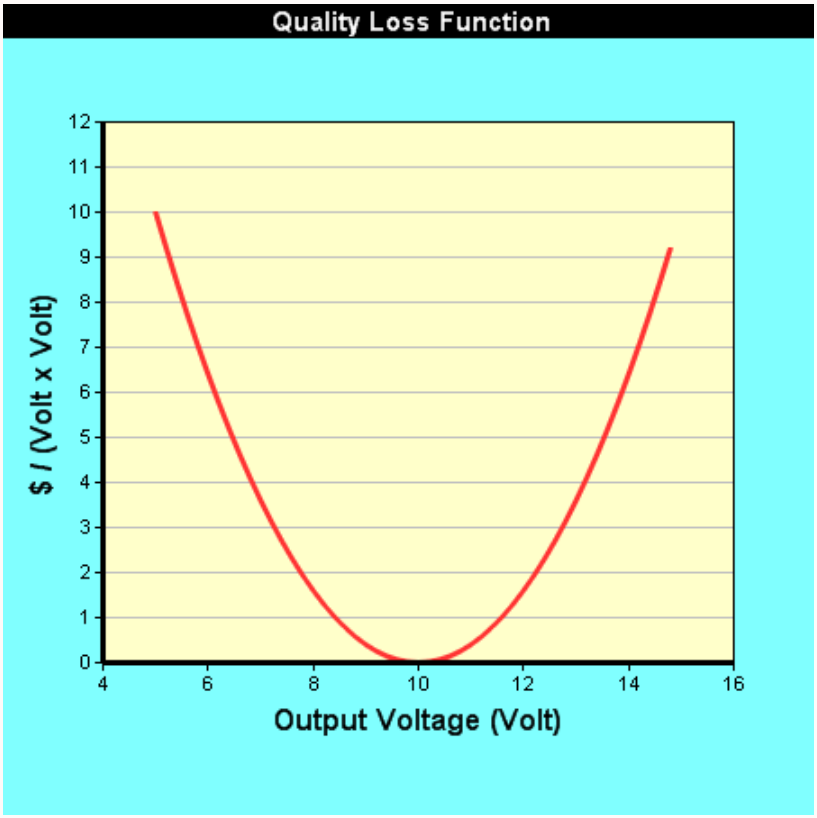
No	Before
1	6.00
2	9.00
3	13.00
4	10.00
5	12.00
6	7.00
7	14.00
8	8.00
9	11.00
10	9.00



Quality Loss Function

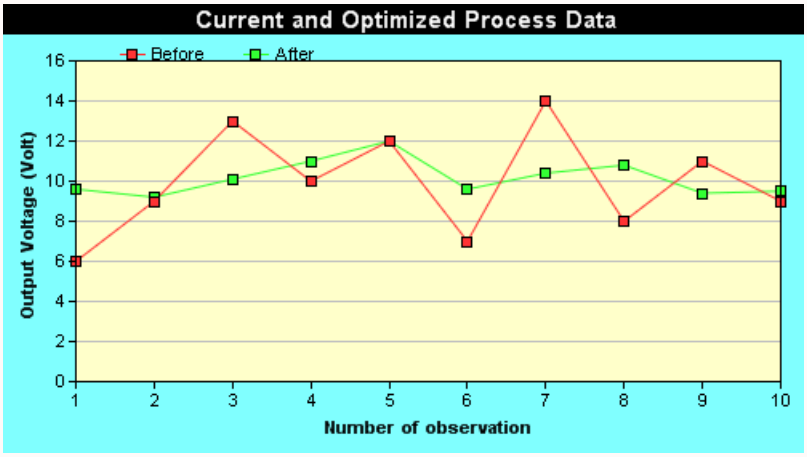
	A<10.000	A≥10.000
k	0.4	0.4
sigma	2.601	2.601
y Bar	9.900	9.900
L (Var)	2.707	2.707
L (Bias)	0.004	0.004
L (Total)	2.711	-

No.	Spec.	Loss
1	5.200	9.216
2	5.600	7.744
3	6.000	6.400
4	6.400	5.184
5	6.800	4.096
6	7.200	3.136
7	7.600	2.304
8	8.000	1.600
9	8.400	1.024
10	8.800	0.576
11	9.200	0.256
12	9.600	0.064
13	10.000	0.000
14	10.400	0.064
15	10.800	0.256
16	11.200	0.576
17	11.600	1.024
18	12.000	1.600
19	12.400	2.304
20	12.800	3.136
21	13.200	4.096
22	13.600	5.184
23	14.000	6.400
24	14.400	7.744
25	14.800	9.216



Comparison of Before and After

No.	Before	After
1	6.00	9.60
2	9.00	9.20
3	13.00	10.10
4	10.00	11.00
5	12.00	12.00
6	7.00	9.60
7	14.00	10.40
8	8.00	10.80
9	11.00	9.40
10	9.00	9.50



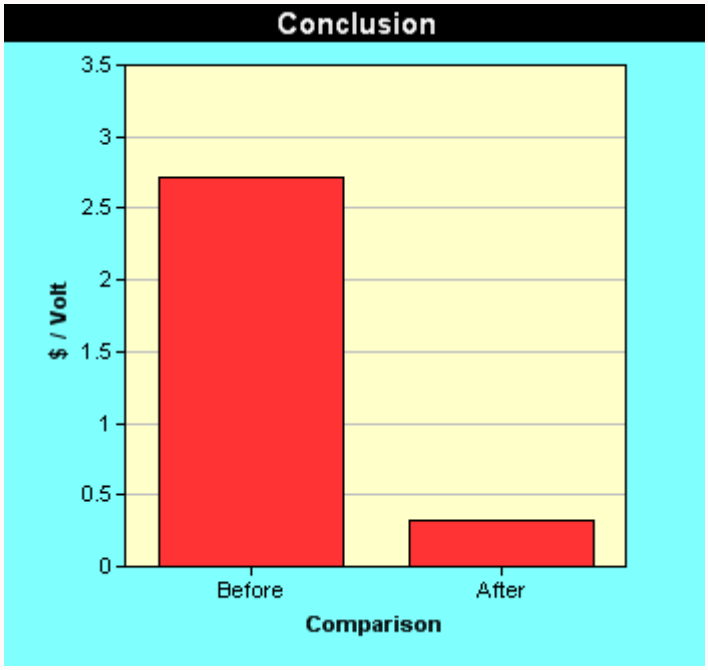
Conclusion

	Current Process	
	A<10.00	A≥10.00
k	0.4	0.4
sigma	2.60	2.60
y Bar	9.90	9.90
L (Var)	2.71	2.71
L (Bias)	0.00	0.00
L (Total)	2.71	-

	Optimum Process	
	A<10.00	A≥10.00
k	0.4	0.4
sigma	0.89	0.89
y Bar	10.16	10.16
L (Var)	0.32	0.32
L (Bias)	0.01	0.01
L (Total)	0.33	-

Gain Calculations

Gain Calculations	
Gain	2.38 $ / Volt
Improvement	87.94 %



Design of Experiments

Paper Bicopter L8 (2^7) orthogonal array experimen

Dr.Nic
Acme
2007-Jan-16 : 10:21:40

Applet Introduction

Applet Details	
Applet Title	L8 (2^7) Experiment
Description	Paper Bicopter L8 (2^7) orthogonal array experimen
Objective	To conduct an experiment using an orthogonal array
Abstract	Orthogonal array experiments are a simple but powerful method of product and process optimization
Team Leader	Dr.Nic
Commencement Date	15-Jul-2006
Expected Completion Date	
Completion Date	
Status	Not Completed
Team Name	Paper Bicopter
Team Members	

1	IR0020	Farida Sulaiman
2	IR0007	Azura Fariq

Quality Characteristics

Response Details	
Response Name	Time of flight
Response Unit	s
Financial Unit	$
Quality loss coefficient	$ / (s^2)
Response measure	Time of flight (s)

\ Response Type	
Noise Performance Measure (NPM)	Nominal the best
Target Performance Measure (TPM)	Y Bar

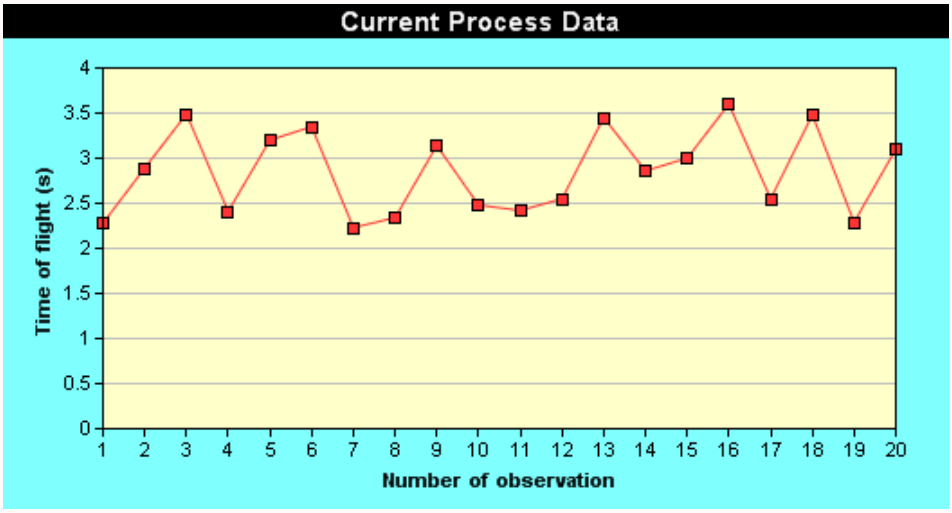
	Specification Limit	Financial Loss
Lower Specification Limit (LSL)	1 s	10 $
Center Specification Limit (CL)	3 s	0 $
Upper Specification Limit (USL)	5 s	10 $

Statement of Problem

Statement of the problem
The gyrocopter is a simple paper model that spins as it falls when dropped from a given height. There are several forces that act on the gyrocopter. Linear motion in a vertical direction. Rotational motion due to the torque on the wings Flight stability due to the centre of gravity of the gyrocopter. A diagram of the problem is attached.

Current Process Performance

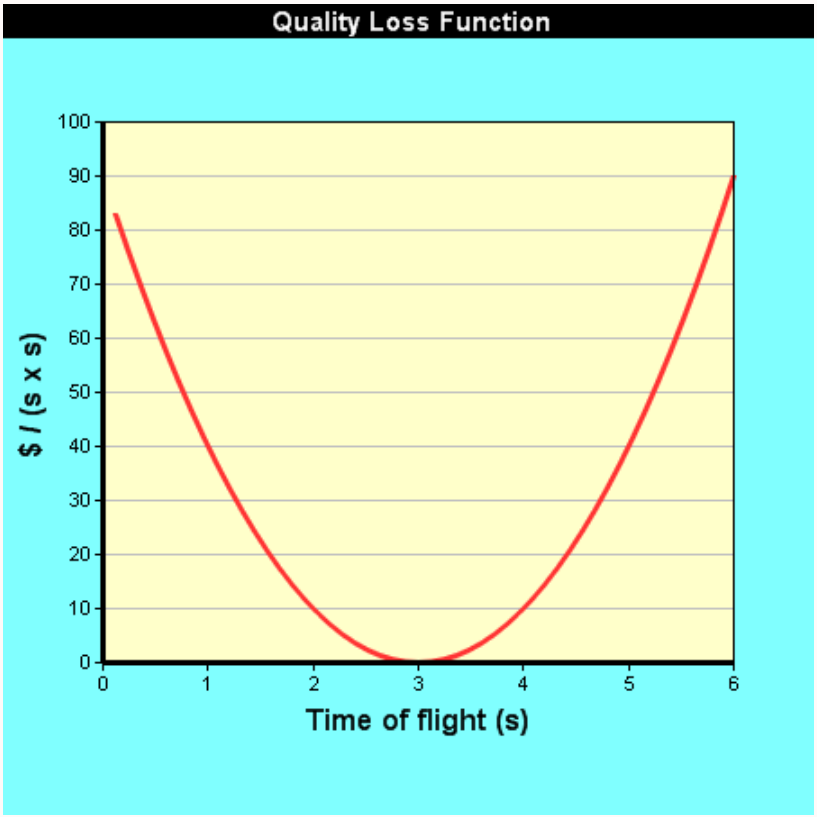
No	Before
1	2.28
2	2.89
3	3.49
4	2.41
5	3.20
6	3.35
7	2.23
8	2.34
9	3.14
10	2.48
11	2.42
12	2.55
13	3.45
14	2.86
15	3.00
16	3.60
17	2.55
18	3.48
19	2.29
20	3.10



Quality Loss Function

	NTB
k	10
sigma	0.47
y Bar	2.86
L (Var)	2.24
L (Bias)	0.21
L (Total)	2.45

No.	Spec.	Loss
1	0.24	76.18
2	0.48	63.50
3	0.72	51.98
4	0.96	41.62
5	1.20	32.40
6	1.44	24.34
7	1.68	17.42
8	1.92	11.66
9	2.16	7.06
10	2.40	3.60
11	2.64	1.30
12	2.88	0.14
13	3.12	0.14
14	3.36	1.30
15	3.60	3.60
16	3.84	7.06
17	4.08	11.66
18	4.32	17.42
19	4.56	24.34
20	4.80	32.40
21	5.04	41.62
22	5.28	51.98
23	5.52	63.50
24	5.76	76.18
25	6.00	90.00



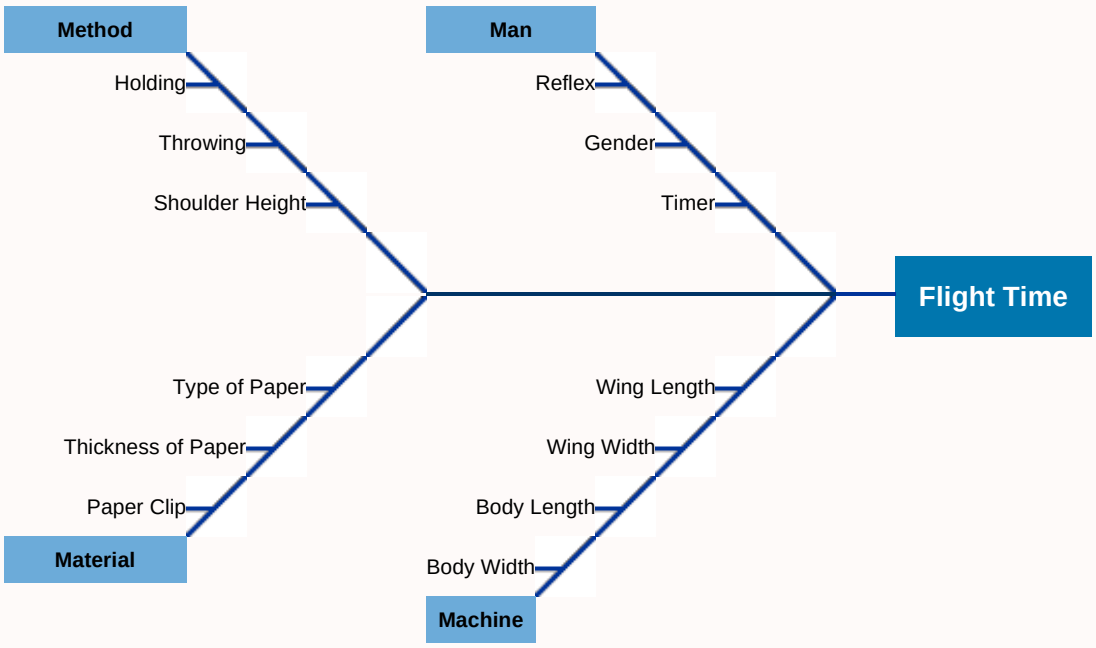
Selection of Factors

The Parameter diagram indicates the factors that can be studied in the experiment.

The factors are classed into:

- Control factors
- Noise factors
- Signal factors
- Scaling factors
- Levelling factors

Cause-Effect Diagram



Factors of Experimentation

Control Factor Selection

No.	Label	Description	Label	Level 1	Level 2	Units	Current
1	A	Type of Paper	TP	100	80	gsm	
2	B	Wing Length	WL	10	12	cm	
3	C	Wing Width	WW	3	4	cm	
4	D	Shoulder Height	SH	1	2	cm	
5	E	Body Length	BL	10	12	cm	
6	F	Body Width	BW	4	5	cm	
7	G	Paper Clip	PC	1	2	cp	

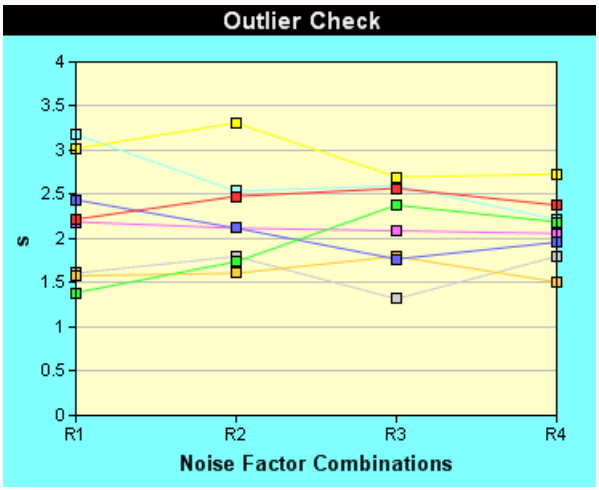
Noise Factor Selection

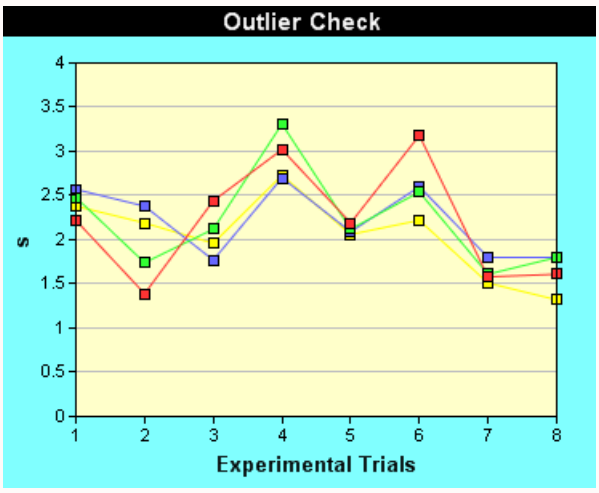
No.	Label	Description	Label	Level 1	Level 2	Units
1	H	Timer	TM	Casio	Alba	
2	I	Draft	DR	No	Yes	
3	J	Holding	HL	Body	Wings	

Conducting the Experiment

Experimental Design is L8 (2^7) X L4 (2^3)

							R	1	2	2	1		
							Q	1	2	1	2		
							P	1	1	2	2		
	A	B	C	D	E	F	G	R1	R2	R3	R4	TPM	NPM
1	1	1	1	1	1	1	1	2.22	2.48	2.57	2.38	2.41	24.13
2	1	1	1	2	2	2	2	1.39	1.74	2.38	2.19	1.93	12.69
3	1	2	2	1	1	2	2	2.44	2.12	1.77	1.96	2.07	17.27
4	1	2	2	2	2	1	1	3.02	3.31	2.70	2.73	2.94	20.25
5	2	1	2	1	2	1	2	2.19	2.12	2.09	2.06	2.12	31.59
6	2	1	2	2	1	2	1	3.18	2.54	2.60	2.22	2.64	16.38
7	2	2	1	1	2	2	1	1.58	1.61	1.80	1.51	1.63	22.35
8	2	2	1	2	1	1	2	1.61	1.80	1.80	1.32	1.63	17.15





Performance Measures Independent of Adjustment

The Noise Performance Measure is:

Nominal - Best $\eta = 10 \log \left(\frac{\bar{y}^2}{s^2} \right)$

The Target Performance Measure is:

Mean $\tau = \bar{y}$

Analysis of Variance

Analysis of Means (TPM)

	A	B	C	D	E	F	G
Level 1	2.34	2.27	1.90	2.06	2.19	2.28	2.40
Level 2	2.00	2.07	2.44	2.28	2.15	2.06	1.94
Rank	3	6	1	4	7	5	2
SSQ	0.90	0.33	2.35	0.41	0.01	0.35	1.74
Opt	1	1	2	2	1	1	1

Experimental modelling

Number of factors in the model: 3

Analysis of Variance (TPM)

Source	Pool	SSQ	Df	Var	F ratio	SSq	Rho
A	0	0.90	1	0.90	8.55	0.80	10.01
B	1	0.33	1	0.33			
C	0	2.35	1	2.35	22.28	2.24	28.23
D	1	0.41	1	0.41			
E	1	0.01	1	0.01			
F	1	0.35	1	0.35			
G	0	1.74	1	1.74	16.54	1.64	20.62
Err	1	1.84	24	0.08			
Pool		2.95	28	0.11	1.00	3.27	41.14
St		7.95	31	0.26		7.95	100.00
Sm		150.64	1				
ST		158.59	32				

The value of 41.14 as a pooled error suggests moderate error

Analysis of Means (NPM)

	A	B	C	D	E	F	G
Level 1	18.59	21.20	19.08	23.84	18.73	23.28	20.78
Level 2	21.87	19.25	21.37	16.62	21.72	17.17	19.68
Rank	3	6	5	1	4	2	7
SSQ	21.53	7.57	10.51	104.25	17.88	74.52	2.42
Opt	2	1	2	1	2	1	1

Experimental modelling

Number of factors in the model : 3

Analysis of Variance (NPM)

Source	Pool	SSQ	Df	Var	F ratio	SSq	Rho
A	0	21.53	1	21.53	2.24	11.94	5.00
B	1	7.57	1	7.57			
C	1	10.51	1	10.51			
D	0	104.25	1	104.25	10.87	94.66	39.66
E	1	17.88	1	17.88			
F	0	74.52	1	74.52	7.77	64.92	27.20
G	1	2.42	1	2.42			
Err	1						
Pool		38.38	4	9.59	1.00	67.16	28.14
St		238.68	7	34.10		238.68	100.00
Sm		3272.86	1				
ST		3511.54	8				

The value of 28.14 as a pooled error suggests moderate error

Response Tables

Calculation of Confidence Interval

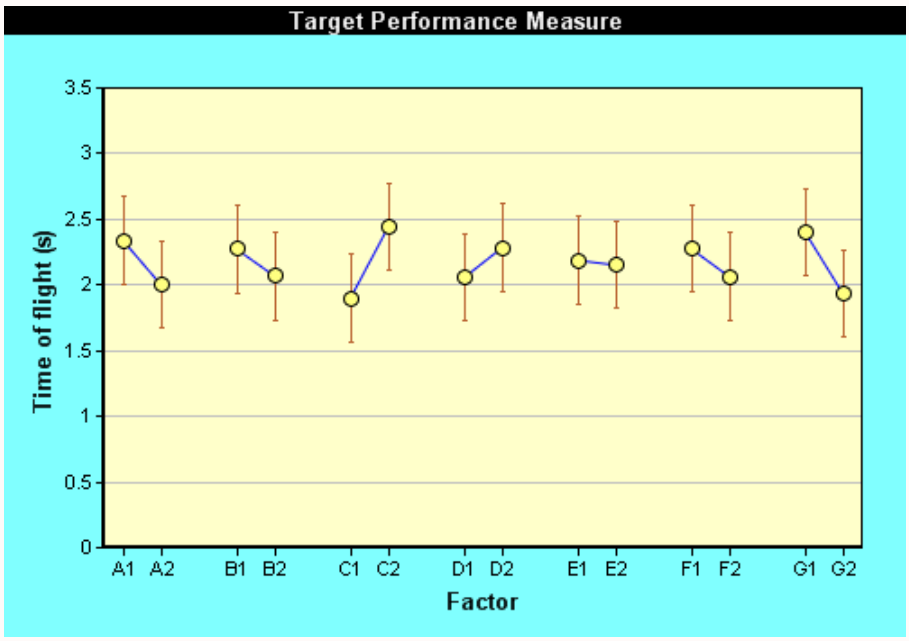
TPM			NPM		
	Mean	CI		Mean	CI
Overall	2.17	± 0.12	Overall	20.23	± 3.04
Predictions	-	± 0.20	Predictions	-	± 5.27
Confirmation	-	± 0.39	Confirmation	-	± 6.80

Table of Means

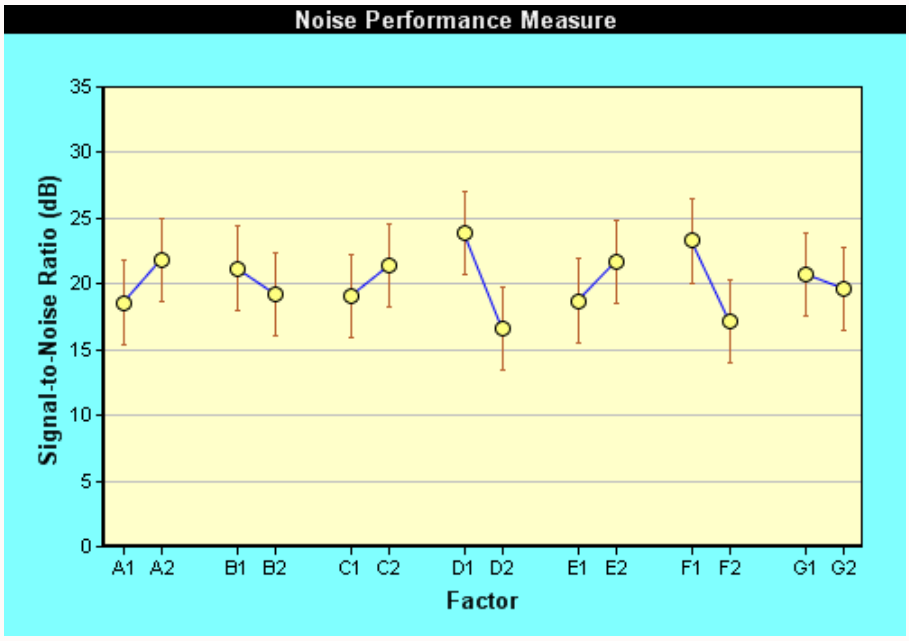
TPM			NPM		
Level	Value	CI	Level	Value	CI
A1	2.34	± 0.17	A1	18.59	± 1.59
A2	2.00	± 0.17	A2	21.87	± 1.59
B1	2.27	± 0.17	B1	21.20	± 1.59
B2	2.07	± 0.17	B2	19.25	± 1.59
C1	1.90	± 0.17	C1	19.08	± 1.59
C2	2.44	± 0.17	C2	21.37	± 1.59
D1	2.06	± 0.17	D1	23.84	± 1.59
D2	2.28	± 0.17	D2	16.62	± 1.59
E1	2.19	± 0.17	E1	18.73	± 1.59
E2	2.15	± 0.17	E2	21.72	± 1.59
F1	2.28	± 0.17	F1	23.28	± 1.59
F2	2.06	± 0.17	F2	17.17	± 1.59
G1	2.40	± 0.17	G1	20.78	± 1.59
G2	1.94	± 0.17	G2	19.68	± 1.59

Response Graphs

TPM



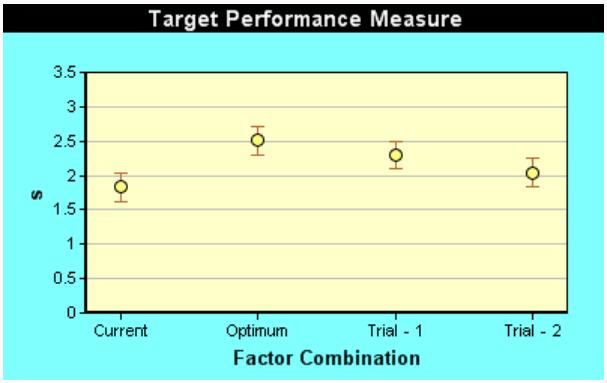
NPM

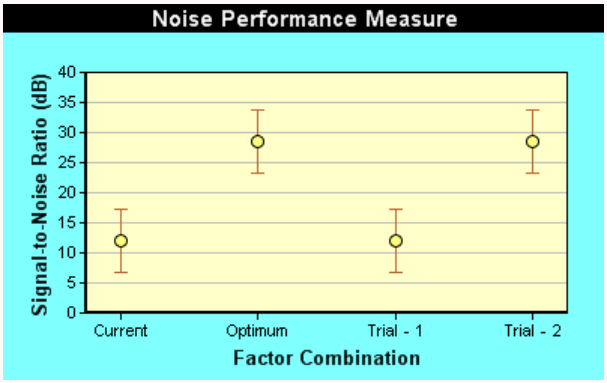


Prediction of Optimum Conditions

	TPM		NPM			Optimum			Current		
							TPM	NPM		TPM	NPM
Factor	Rank	Level	Rank	Level	Desc	Levels	PV	PV	Levels	CV	CV
A	3	1	3	2	Both	2	2.00	21.87	1	2.34	21.87
B	6	1	6	1	Neither	1			2		
C	1	2	5	2	TPM	2	2.44		1	1.90	
D	4	2	1	1	NPM	1		23.84	2		23.84
E	7	1	4	2	Neither	2			2		
F	5	1	2	1	NPM	1		23.28	2		23.28
G	2	1	7	1	TPM	1	2.40		2	1.94	
					Predicted Value (Lower limit)		2.30	23.26		1.63	6.66
					Predicted Value (Mean)		2.51	28.53		1.83	11.92
					Predicted Value (Upper limit)		2.71	33.80		0.00	17.19

	Trial - 1			Trial - 2		
		TPM	NPM		TPM	NPM
	Levels	PV	PV	Levels	CV	CV
	1	2.34	18.59	2	2.00	21.87
	2			1		
	1	1.90		2	2.44	
	2		16.62	1		23.84
	1			2		
	2		17.17	1		23.28
	1	2.40		2	1.94	
Predicted Value (Lower limit)		2.10	6.66		1.84	23.26
Predicted Value (Mean)		2.30	11.92		2.04	28.53
Predicted Value (Upper limit)		2.50	17.19		2.24	33.80





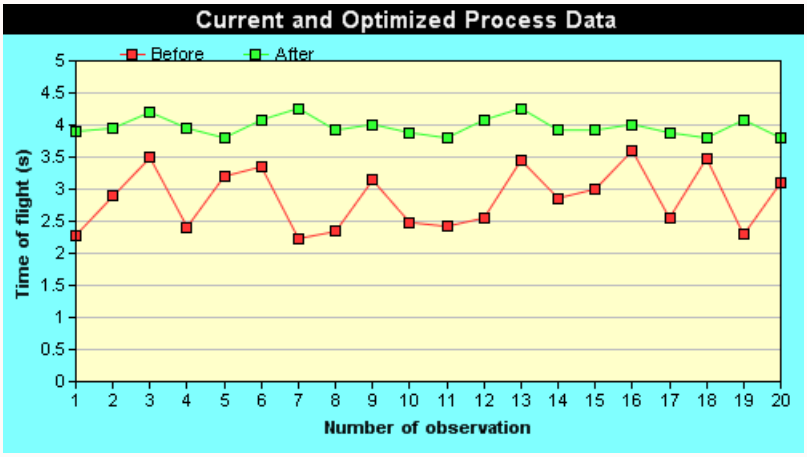
Confirmation Experiments

							R	1	2	2	1		
							Q	1	2	1	2		
							P	1	1	2	2		
	A	B	C	D	E	F	G	R1	R2	R3	R4	TPM	NPM
Current	1	2	1	2	2	2	2	2.50	2.46	2.75	2.80	2.63	23.66
Optimum	2	1	2	1	2	1	1	2.22	2.48	2.57	2.38	2.41	24.13
Trial - 1	1	2	1	2	1	2	1	2.44	2.12	1.77	1.96	2.07	17.27
Trial - 2	2	1	2	1	2	1	2	2.44	2.12	1.77	2.05	2.10	17.63

Chosen Optimum Condition is : Current

Comparison of Before and After

No.	Before	After Current
1	2.28	3.90
2	2.89	3.95
3	3.49	4.20
4	2.41	3.95
5	3.20	3.80
6	3.35	4.08
7	2.23	4.26
8	2.34	3.92
9	3.14	4.01
10	2.48	3.88
11	2.42	3.80
12	2.55	4.08
13	3.45	4.26
14	2.86	3.92
15	3.00	3.92
16	3.60	4.01
17	2.55	3.88
18	3.48	3.80
19	2.29	4.08
20	3.10	3.80



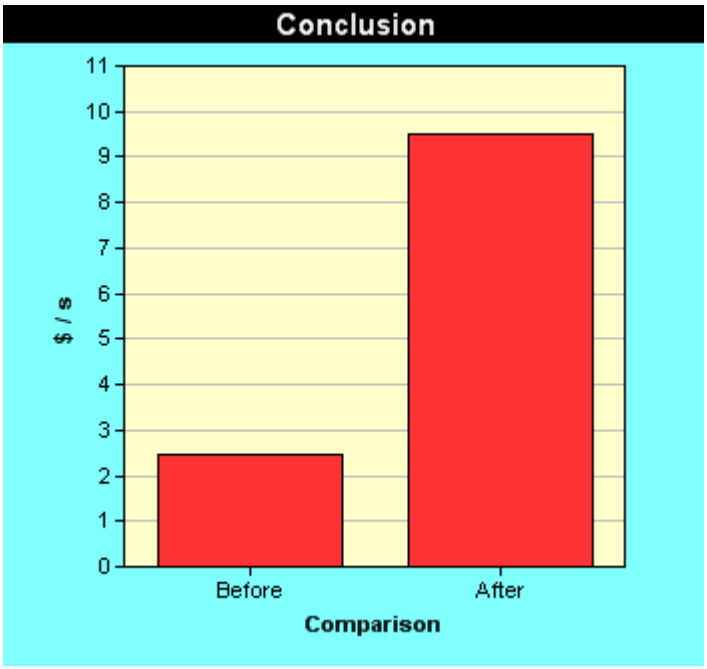
Conclusion

	Current Process
	NTB
k	10
sigma	0.473
y Bar	2.856
L (Var)	2.237
L (Bias)	0.209
L (Total)	2.446

	Optimum Process
	NTB
k	10
sigma	0.146
y Bar	3.975
L (Var)	0.213
L (Bias)	9.506
L (Total)	9.506

Gain Calculations

Gain Calculations	
Gain	-7.06 $ / s
Improvement	-288.635 %



Design of Experiments

Carbon powder treatment

Dr.Nic
Acme
2007-Jan-16 : 10:47:16

Applet Introduction

Applet Details	
Applet Title	L9(3^4)
Description	Carbon powder treatment
Objective	To study the characteristic of carbon powder treatment
Abstract	Carbon powder properties are very important to the electrical characteristics of microphones. This experiment aims to improve the electronic properties of a carbon powder microphone.
Team Leader	Dr.Nic
Commencement Date	15-Jul-2006
Expected Completion Date	
Completion Date	
Status	Not Completed
Team Name	Electeam
Team Members	

1	IR0025	Fauzi Rozita
2	IR0020	Farida Sulaiman

Quality Characteristics

Response Details	
Response Name	Diameter
Response Unit	nm
Financial Unit	$
Quality loss coefficient	$ / (nm^2)
Response measure	Diameter (nm)

\ Response Type	
Noise Performance Measure (NPM)	Smaller the better
Target Performance Measure (TPM)	Y Bar

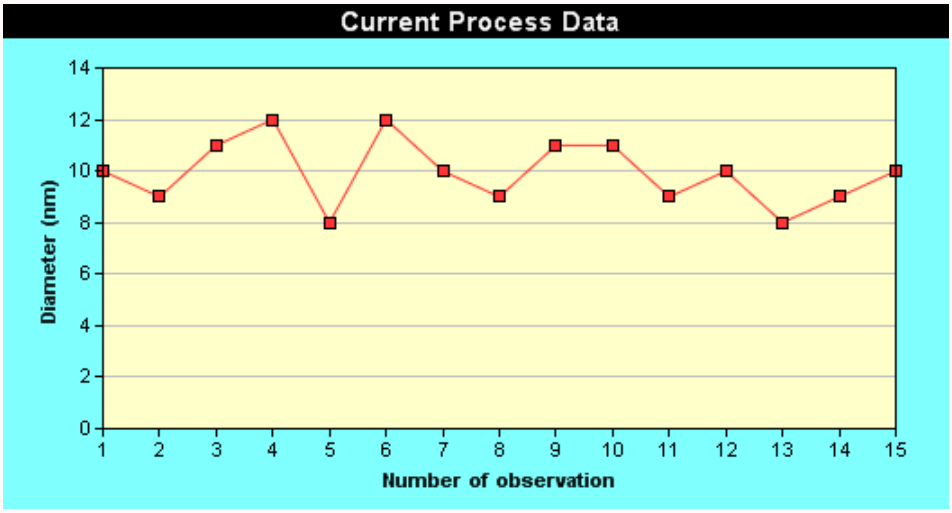
	Specification Limit	Financial Loss
Upper Specification Limit (USL)	10 nm	10 $

Statement of Problem

Statement of the problem
Carbon powder properties are an important aspect of electronic characteristics of carbon microphones. To improve the microphone it is essential to improve the fineness of carbon powder. Finer carbon powder can be anticipated to provide a higher sound fidelity necessary for public address systems.

Current Process Performance

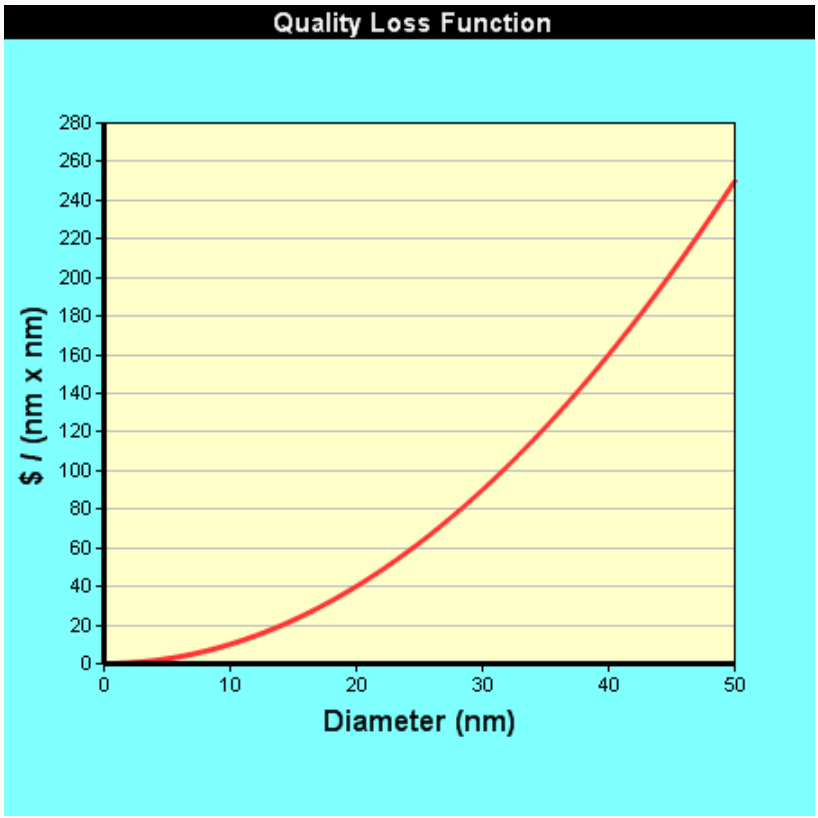
No	Before
1	10.00
2	9.00
3	11.00
4	12.00
5	8.00
6	12.00
7	10.00
8	9.00
9	11.00
10	11.00
11	9.00
12	10.00
13	8.00
14	9.00
15	10.00



Quality Loss Function

	STB
k	0.1
sigma	1.28
y Bar	9.93
L (Var)	0.16
L (Bias)	9.87
L (Total)	10.03

No.	Spec.	Loss
1	2.00	0.40
2	4.00	1.60
3	6.00	3.60
4	8.00	6.40
5	10.00	10.00
6	12.00	14.40
7	14.00	19.60
8	16.00	25.60
9	18.00	32.40
10	20.00	40.00
11	22.00	48.40
12	24.00	57.60
13	26.00	67.60
14	28.00	78.40
15	30.00	90.00
16	32.00	102.40
17	34.00	115.60
18	36.00	129.60
19	38.00	144.40
20	40.00	160.00
21	42.00	176.40
22	44.00	193.60
23	46.00	211.60
24	48.00	230.40
25	50.00	250.00



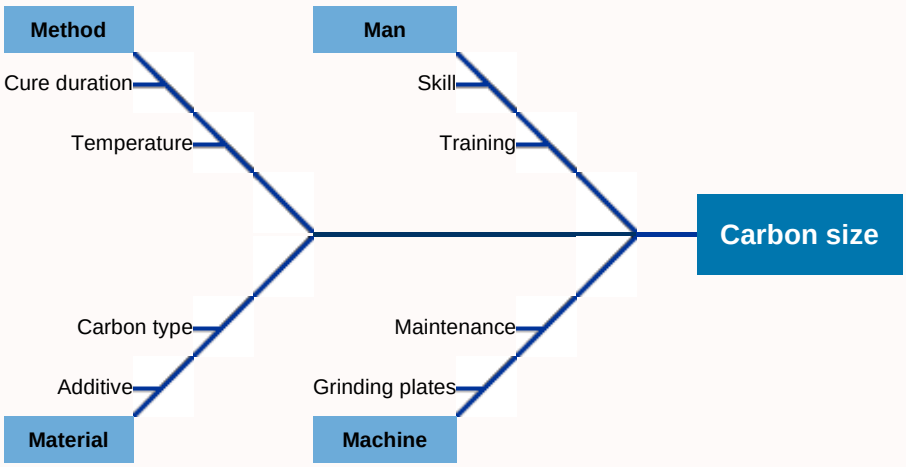
Selection of Factors

The Parameter diagram indicates the factors that can be studied in the experiment.

The factors are classed into:

- Control factors
- Noise factors
- Signal factors
- Scaling factors
- Levelling factors

Cause-Effect Diagram



Factors of Experimentation

Control Factor Selection

No.	Label	Description	Label	Level 1	Level 2	Level 3	Units	Current
1	A	Temperature	Tmp	1000	1100	1200	deg C	
2	B	Duration	Dur	60	120	180	hrs	
3	C	Material	Mat	Exist	Trt 1	Trt 2	Type	
4	D	Additive	Add	0.0	0.5	1.0	Type	

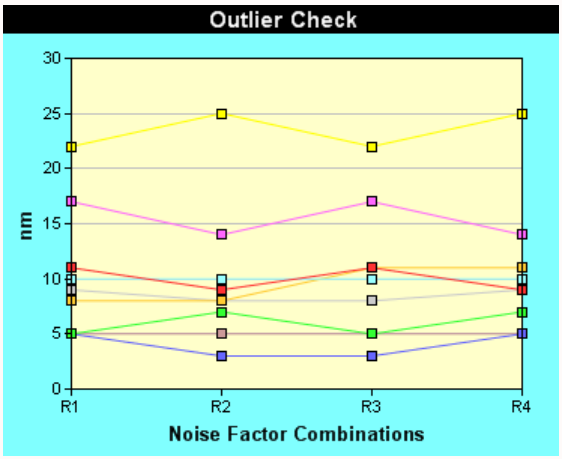
Noise Factor Selection

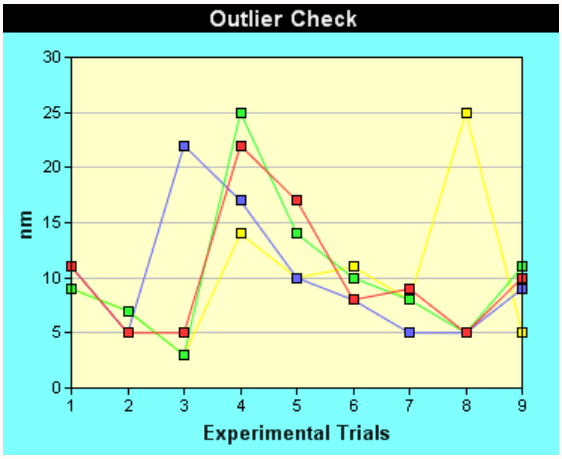
No.	Label	Description	Label	Level 1	Level 2	Units
1	E	Feed rate	FR	100	230	m/s
2	F	Gas shield	GS	40	39	mm
3	G	Coolant flow rate	Cl	23	34	mm/sec

Conducting the Experiment

Experimental Design is L9 (3^4) X L4 (2^3)

				R	1	2	2	1		
				Q	1	2	1	2		
				P	1	1	2	2		
	A	B	C	D	R1	R2	R3	R4	TPM	NPM
1	1	1	1	1	11.0	9.0	11.0	9.0	10.0	-20.1
2	1	2	2	2	5.0	7.0	5.0	7.0	6.0	-15.7
3	1	3	3	3	5.0	3.0	5.0	3.0	4.0	-12.4
4	2	1	2	3	22.0	25.0	22.0	25.0	23.5	-27.4
5	2	2	3	1	17.0	14.0	17.0	14.0	15.5	-23.9
6	2	3	1	2	10.0	10.0	10.0	10.0	10.0	-20.0
7	3	1	3	2	8.0	11.0	8.0	11.0	9.5	-19.7
8	3	2	1	3	9.0	8.0	9.0	8.0	8.5	-18.6
9	3	3	2	1	5.0	5.0	5.0	5.0	5.0	-14.0





Performance Measures Independent of Adjustment

The Noise Performance Measure is:

Smaller - Better $\eta = -10\log\left(s^2 + \bar{y}^2\right)$

The Target Performance Measure is:

Mean $\tau = \bar{y}$

Analysis of Variance

Analysis of Means (TPM)

	A	B	C	D
Level 1	6.67	14.33	9.50	10.17
Level 2	16.33	10.00	11.50	8.50
Level 3	7.67	6.33	9.67	12.00
Rank	1	2	4	3
SSQ	678.22	384.89	29.56	73.56
Opt	1	3	1	2

Experimental modelling

Number of factors in the model: 2

Analysis of Variance (TPM)

Source	Pool	SSQ	Df	Var	F ratio	SSq	Rho
A	0	678.22	2	339.11	73.46	668.99	55.46
B	0	384.89	2	192.44	41.69	375.66	31.14
C	1	29.56	2	14.78			
D	1	73.56	2	36.78			
Err	1	40.00	27	1.48			
Pool		143.11	31	4.62	1.00	161.58	13.40
St		1206.22	35	34.46		1206.22	100.00
Sm		3761.78	1				
ST		4968.00	36				

The value of 13.40 as a pooled error suggests low error

Analysis of Means (NPM)

	A	B	C	D
Level 1	-16.06	-22.40	-19.56	-19.30
Level 2	-23.77	-19.40	-19.05	-18.47
Level 3	-17.43	-15.46	-18.65	-19.48
Rank	1	2	4	3
SSQ	101.57	72.76	1.24	1.73
Opt	1	3	3	2

Experimental modelling

Number of factors in the model : 2

Analysis of Variance (NPM)

Source	Pool	SSQ	Df	Var	F ratio	SSq	Rho
A	0	101.57	2	50.78	68.36	100.08	56.45
B	0	72.76	2	36.38	48.97	71.27	40.20
C	1	1.24	2	0.62			
D	1	1.73	2	0.87			
Err	1						
Pool		2.97	4	0.74	1.00	5.94	3.35
St		177.30	8	22.16		177.30	100.00
Sm		3277.83	1				
ST		3455.13	9				

The value of 3.35 as a pooled error suggests low error

Response Tables

Calculation of Confidence Interval

TPM			NPM		
	Mean	CI		Mean	CI
Overall	10.22	± 0.73	Overall	-19.08	± 0.80
Predictions	-	± 1.46	Predictions	-	± 1.60
Confirmation	-	± 2.63	Confirmation	-	± 1.99

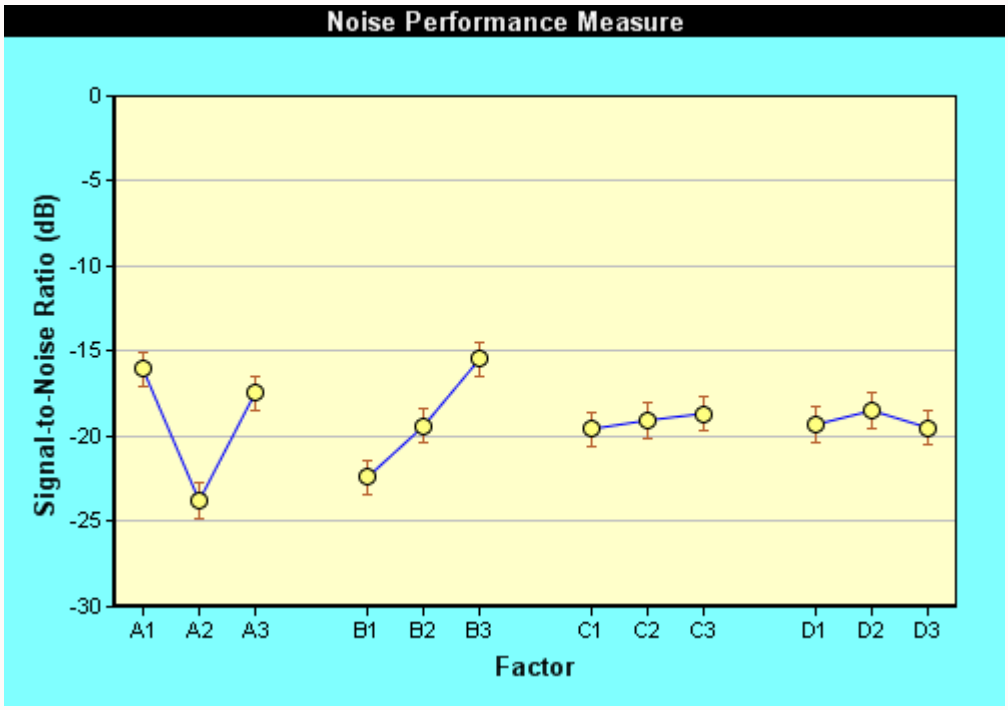
Table of Means

TPM			NPM		
Level	Value	CI	Level	Value	CI
A1	6.67	± 1.27	A1	-16.06	± 0.51
A2	16.33	± 1.27	A2	-23.77	± 0.51
A3	7.67	± 1.27	A3	-17.43	± 0.51
B1	14.33	± 1.27	B1	-22.40	± 0.51
B2	10.00	± 1.27	B2	-19.40	± 0.51
B3	6.33	± 1.27	B3	-15.46	± 0.51
C1	9.50	± 1.27	C1	-19.56	± 0.51
C2	11.50	± 1.27	C2	-19.05	± 0.51
C3	9.67	± 1.27	C3	-18.65	± 0.51
D1	10.17	± 1.27	D1	-19.30	± 0.51
D2	8.50	± 1.27	D2	-18.47	± 0.51
D3	12.00	± 1.27	D3	-19.48	± 0.51

Response Graphs

TPM

NPM



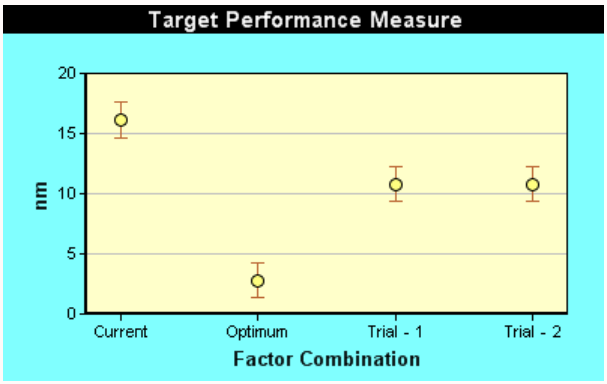
Prediction of Optimum Conditions

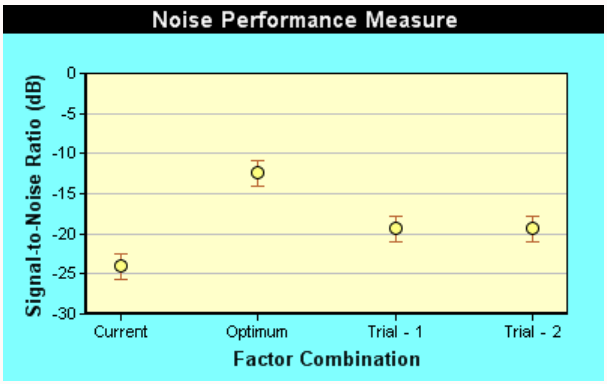
	TPM		NPM			Optimum		
							TPM	NPM
Factor	Rank	Level	Rank	Level	Desc	Levels	PV	PV
A	1	1	1	1	Both	1	6.67	-16.06
B	2	3	2	3	Both	3	6.33	-15.46
C	4	1	4	3	Neither	3		
D	3	2	3	2	Neither	2		
					Predicted Value (Lower limit)		1.32	-14.02
					Predicted Value (Mean)		2.78	-12.43
					Predicted Value (Upper limit)		4.24	-10.83

Current		
	TPM	NPM
Levels	CV	CV
2	16.33	-16.06
2	10.00	-15.46
2		
2		
	14.65	-25.68
	16.11	-24.08
	0.00	-22.49

Trial - 1		
	TPM	NPM
Levels	PV	PV
1	6.67	-16.06
1	14.33	-22.40
1		
1		
	9.32	-20.97
	10.78	-19.37
	12.24	-17.78

Trial - 2		
	TPM	NPM
Levels	CV	CV
1	6.67	-16.06
1	14.33	-22.40
1		
1		
	9.32	-20.97
	10.78	-19.37
	12.24	-17.78





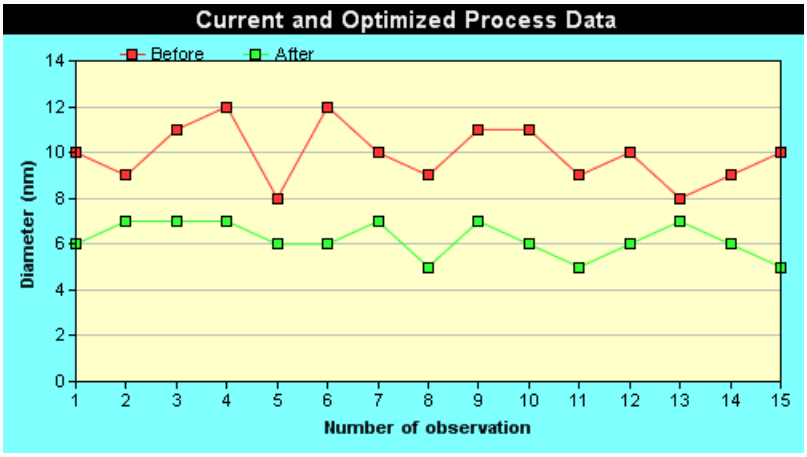
Confirmation Experiments

				R	1	2	2	1		
				Q	1	2	1	2		
				P	1	1	2	2		
	A	B	C	D	R1	R2	R3	R4	TPM	NPM
Current	2	2	2	2	2.3	2.5	2.4	2.2	2.3	-7.4
Optimum	1	3	3	2	3.4	3.7	3.8	3.7	3.6	-11.2
Trial - 1	1	1	1	1	2.5	2.3	2.4	2.5	2.4	-7.7
Trial - 2	1	1	1	1	2.3	2.5	2.4	2.5	2.4	-7.7

Chosen Optimum Condition is : Current

Comparison of Before and After

No.	Before	After
1	10.00	6.00
2	9.00	7.00
3	11.00	7.00
4	12.00	7.00
5	8.00	6.00
6	12.00	6.00
7	10.00	7.00
8	9.00	5.00
9	11.00	7.00
10	11.00	6.00
11	9.00	5.00
12	10.00	6.00
13	8.00	7.00
14	9.00	6.00
15	10.00	5.00



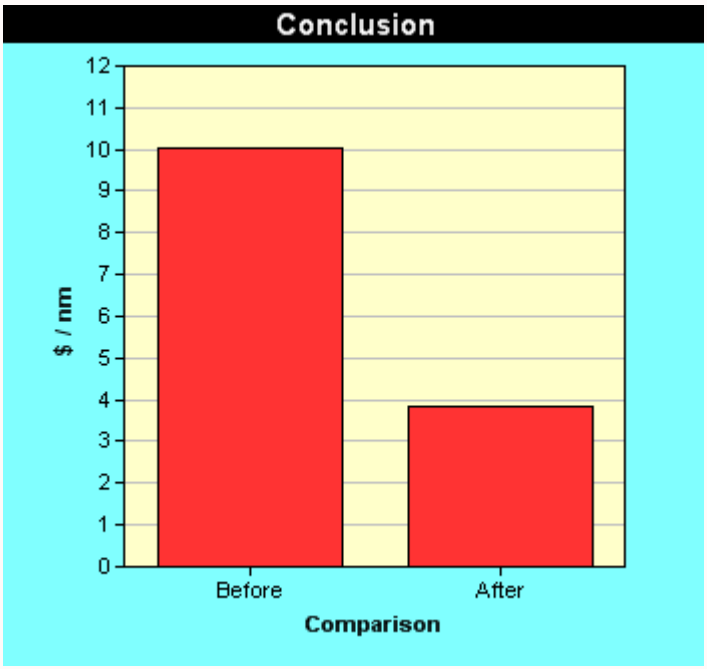
Conclusion

	Current Process
	STB
k	0.1
sigma	1.28
y Bar	9.93
L (Var)	0.16
L (Bias)	9.87
L (Total)	10.03

	Optimum Process
	STB
k	0.1
sigma	0.78
y Bar	6.20
L (Var)	0.06
L (Bias)	3.84
L (Total)	3.84

Gain Calculations

Gain Calculations	
Gain	6.19 $ / nm
Improvement	61.68 %



Design of Experiments

L18 Array

Dr.Nic
Acme
2007-Jan-16 : 11:44:19

Applet Introduction

Applet Details	
Applet Title	L18 (2^1 x 3^7)
Description	L18 Array
Objective	To improve plating thickness using Nominal the best
Abstract	The many factors in plating thickness are often very difficult to study in a quality improvement activity.
Team Leader	Dr.Nic
Commencement Date	15-Jul-2006
Expected Completion Date	
Completion Date	
Status	Not Completed
Team Name	Normalisers
Team Members	

1	IR0005	Azman Akhbar
2	IR0026	Fauziah Drus

Quality Characteristics

Response Details	
Response Name	Plating Thickness
Response Unit	micron
Financial Unit	$
Quality loss coefficient	$ / (micron^2)
Response measure	Plating Thickness (micron)

\ Response Type	
Noise Performance Measure (NPM)	Nominal the best
Target Performance Measure (TPM)	Y Bar

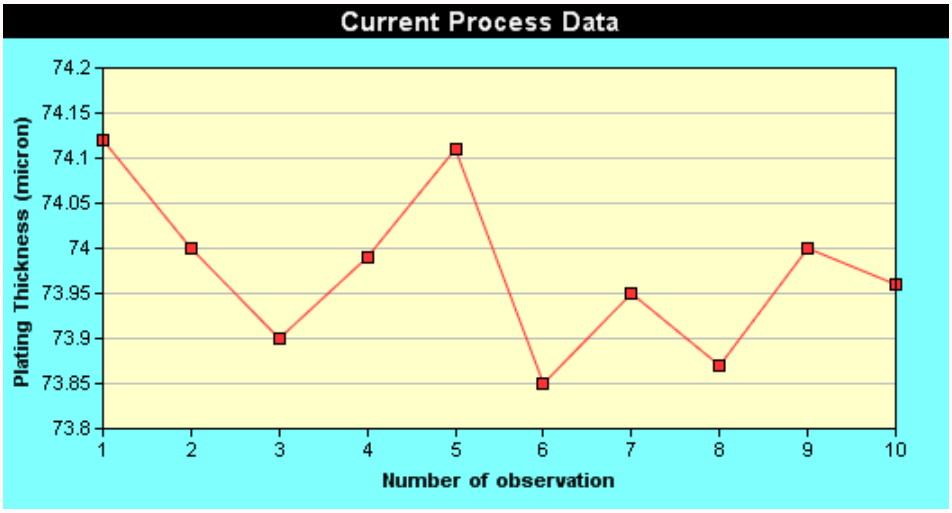
	Specification Limit	Financial Loss
Lower Specification Limit (LSL)	65 micron	100 $
Center Specification Limit (CL)	70 micron	0 $
Upper Specification Limit (USL)	85 micron	100 $

Statement of Problem

Statement of the problem
L18 (2^1 x 3^7) orthogonal array is used in this experiment.

Current Process Performance

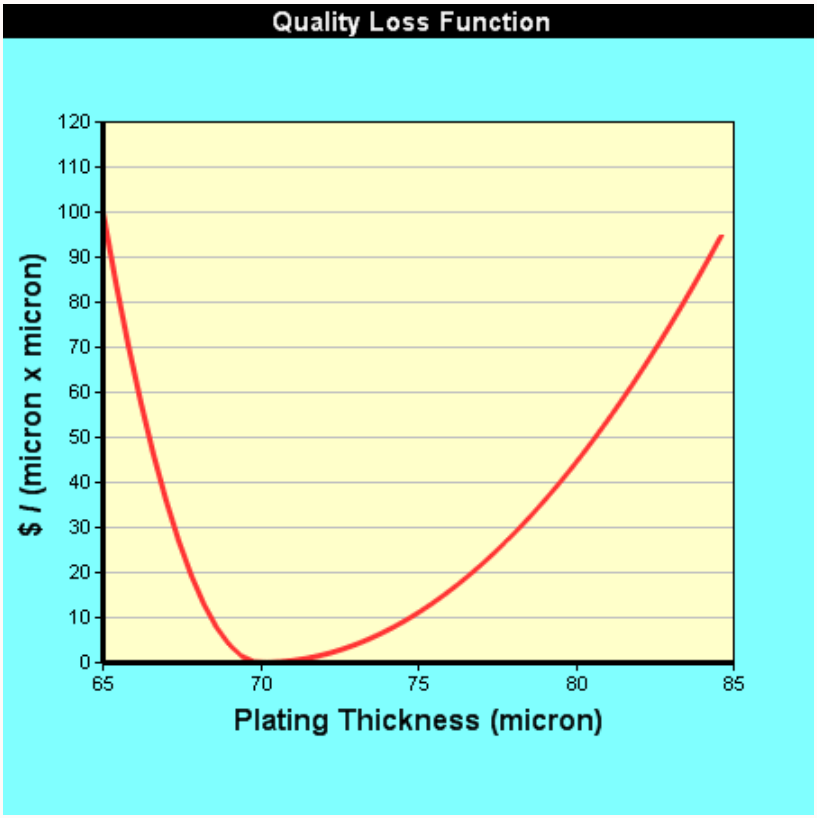
No	Before
1	74.12
2	74.00
3	73.90
4	73.99
5	74.11
6	73.85
7	73.95
8	73.87
9	74.00
10	73.96



Quality Loss Function

	A<70.00	A≥70.00
k	4	0.444
sigma	0.09	0.09
y Bar	73.98	73.98
L (Var)	0.03	0.00
L (Bias)	63.20	7.02
L (Total)	35.13	-

No.	Spec.	Loss
1	65.40	84.64
2	66.20	57.76
3	67.00	36.00
4	67.80	19.36
5	68.60	7.84
6	69.40	1.44
7	70.20	0.02
8	71.00	0.44
9	71.80	1.44
10	72.60	3.00
11	73.40	5.14
12	74.20	7.84
13	75.00	11.11
14	75.80	14.95
15	76.60	19.36
16	77.40	24.34
17	78.20	29.88
18	79.00	36.00
19	79.80	42.68
20	80.60	49.94
21	81.40	57.76
22	82.20	66.15
23	83.00	75.11
24	83.80	84.64
25	84.60	94.74



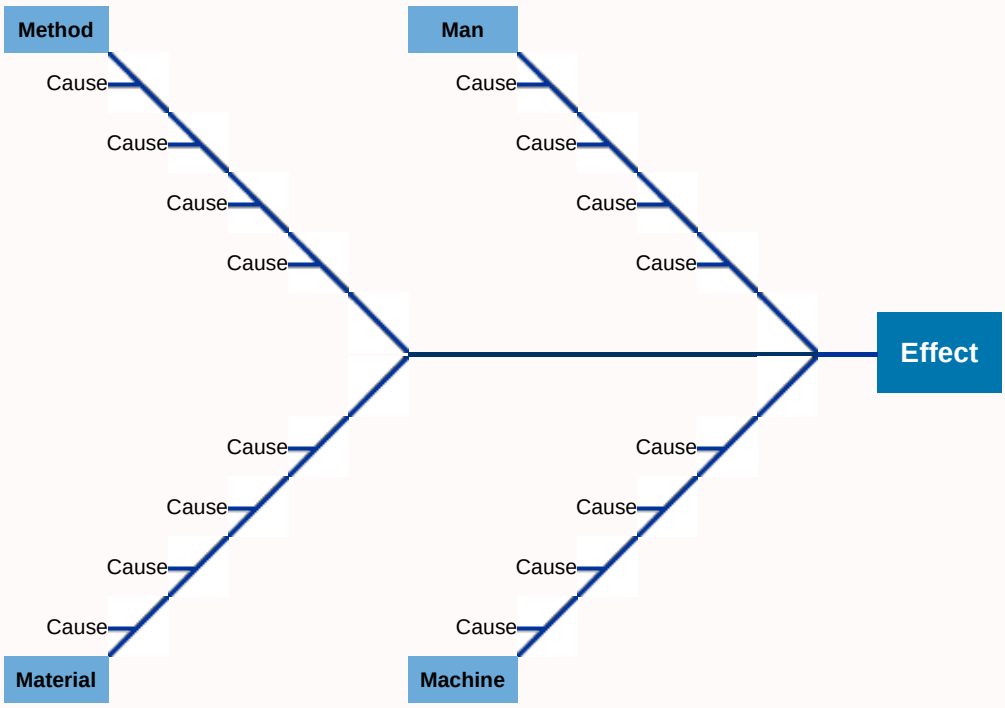
Selection of Factors

The Parameter diagram indicates the factors that can be studied in the experiment.

The factors are classed into:

- Control factors
- Noise factors
- Signal factors
- Scaling factors
- Levelling factors

Cause-Effect Diagram



Factors of Experimentation

Control Factor Selection

No.	Label	Description	Label	Level 1	Level 2	Level 3	Units	Current
1	A	Gold Concentration	GC	0.70-0.75	1.10-1.15			
2	B	Acidity	Acid	4.20	4.30	4.40	pH	
3	C	Temperature	Tmp	95	105	115	C	
4	D	Barrel Speed	BS	10	15	20	mm/s	
5	E	Anode Size	AS	0.25	0.50	1.00	mm	
6	F	Load Size	LS	0.25	0.33	0.50	kgf	
7	G	Current Density	CD	1.00	1.50	1.50	A	
8	H	Nickel Concentration	NC	600	650	700	mmol	

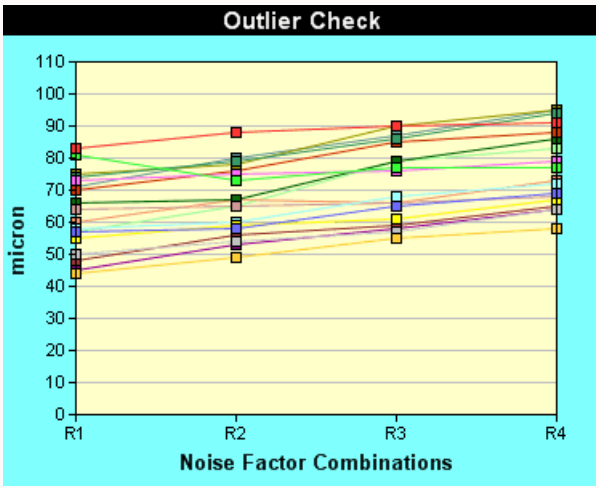
Noise Factor Selection

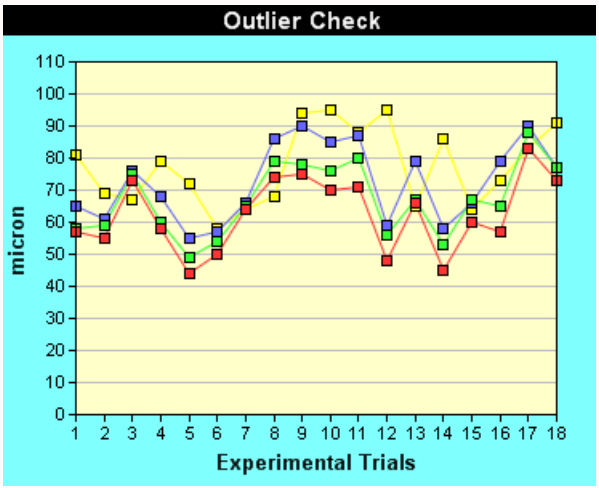
No.	Label	Description	Label	Level 1	Level 2	Units
1	I	Agitation	Agt	On	Off	
2	J	Rotate Direction	RD	CW	ACW	
3	K	Exhaust	Exh	In	Out	

Conducting the Experiment

Experimental Design is L18 (2^1 x 3^7) X L4 (2^3)

								R	1	2	2	1		
								Q	1	2	1	2		
								P	1	1	2	2		
	A	B	C	D	E	F	G	H	R1	R2	R3	R4	TPM	NPM
1	1	1	1	1	1	1	1	1	83.0	88.0	90.0	91.0	88.0	27.9
2	1	1	2	2	2	2	2	2	73.0	77.0	77.0	81.0	77.0	27.5
3	1	1	3	3	3	3	3	3	57.0	58.0	65.0	69.0	62.3	20.7
4	1	2	1	1	2	2	3	3	55.0	59.0	61.0	67.0	60.5	21.7
5	1	2	2	2	3	3	1	1	73.0	75.0	76.0	79.0	75.8	29.6
6	1	2	3	3	1	1	2	2	58.0	60.0	68.0	72.0	64.5	19.8
7	1	3	1	2	1	3	2	3	44.0	49.0	55.0	58.0	51.5	18.3
8	1	3	2	3	2	1	3	1	50.0	54.0	57.0	64.0	56.3	19.6
9	1	3	3	1	3	2	1	2	64.0	65.0	66.0	68.0	65.8	31.7
10	2	1	1	3	3	2	2	1	74.0	79.0	86.0	94.0	83.3	19.6
11	2	1	2	1	1	3	3	2	75.0	78.0	90.0	95.0	84.5	19.0
12	2	1	3	2	2	1	1	3	70.0	76.0	85.0	88.0	79.8	19.7
13	2	2	1	2	3	1	3	2	71.0	80.0	87.0	95.0	83.3	18.2
14	2	2	2	3	1	2	1	3	48.0	56.0	59.0	65.0	57.0	18.1
15	2	2	3	1	2	3	2	1	66.0	67.0	79.0	86.0	74.5	17.7
16	2	3	1	3	2	3	1	2	45.0	53.0	58.0	64.0	55.0	16.7
17	2	3	2	1	3	1	2	3	60.0	67.0	66.0	73.0	66.5	21.9
18	2	3	3	2	1	2	3	1	57.0	65.0	79.0	83.0	71.0	15.4





Performance Measures Independent of Adjustment

The Noise Performance Measure is:

Fraction -Defective $\eta = -10 \log \left(\frac{1}{p} - 1 \right)$

The Target Performance Measure is:

Mean $\tau = \bar{y}$

Analysis of Variance

Analysis of Means (TPM)

	A	B	C	D	E	F	G	H
Level 1	66.83	79.13	70.25	73.29	69.42	73.04	70.21	74.79
Level 2	72.75	69.25	69.50	73.04	67.17	69.08	69.54	71.67
Level 3		61.00	69.63	63.04	72.79	67.25	69.63	62.92
Rank	4	1	7	3	6	5	8	2
SSQ	630.13	3952.75	7.75	1641.00	384.75	420.58	6.33	1818.75
Opt	2	2	1	2	1	2	1	2

Experimental modelling

Number of factors in the model: 3

Analysis of Variance (TPM)

Source	Pool	SSQ	Df	Var	F ratio	SSq	Rho
A	1	630.13	1	630.13			
B	0	3952.75	2	1976.38	30.19	3821.82	32.76
C	1	7.75	2	3.88			
D	0	1641.00	2	820.50	12.53	1510.07	12.94
E	1	384.75	2	192.38			
F	1	420.58	2	210.29			
G	1	6.33	2	3.17			
H	0	1818.75	2	909.38	13.89	1687.82	14.47
Err	1	2805.83	56	50.10			
Pool		4255.38	65	65.47	1.00	4648.18	39.84
St		11667.88	71	164.34		11667.88	100.00
Sm		350703.13	1				
ST		362371.00	72				

The value of 39.84 as a pooled error suggests moderate error

Analysis of Means (NPM)

	A	B	C	D	E	F	G	H
Level 1	24.08	22.38	20.40	23.31	19.74	21.18	23.95	21.63
Level 2	18.48	20.86	22.61	21.45	20.47	22.32	20.81	22.14
Level 3		20.60	20.83	19.09	23.64	20.34	19.08	20.07
Rank	1	8	5	3	4	7	2	6
SSQ	140.90	11.10	16.47	53.65	51.65	11.87	73.31	13.86
Opt	1	1	2	1	3	2	1	2

Experimental modelling

Number of factors in the model : 4

Analysis of Variance (NPM)

Source	Pool	SSQ	Df	Var	F ratio	SSq	Rho
A	0	140.90	1	140.90	21.14	134.24	35.97
B	1	11.10	2	5.55			
C	1	16.47	2	8.24			
D	0	53.65	2	26.82	4.03	40.32	10.80
E	0	51.65	2	25.83	3.88	38.32	10.27
F	1	11.87	2	5.94			
G	0	73.31	2	36.65	5.50	59.98	16.07
H	1	13.86	2	6.93			
Err	1						
Pool		53.31	8	6.66	1.00	100.35	26.89
St		373.21	17	21.95		373.21	100.00
Sm		8151.24	1				
ST		8524.45	18				

The value of 26.89 as a pooled error suggests moderate error

Response Tables

Calculation of Confidence Interval

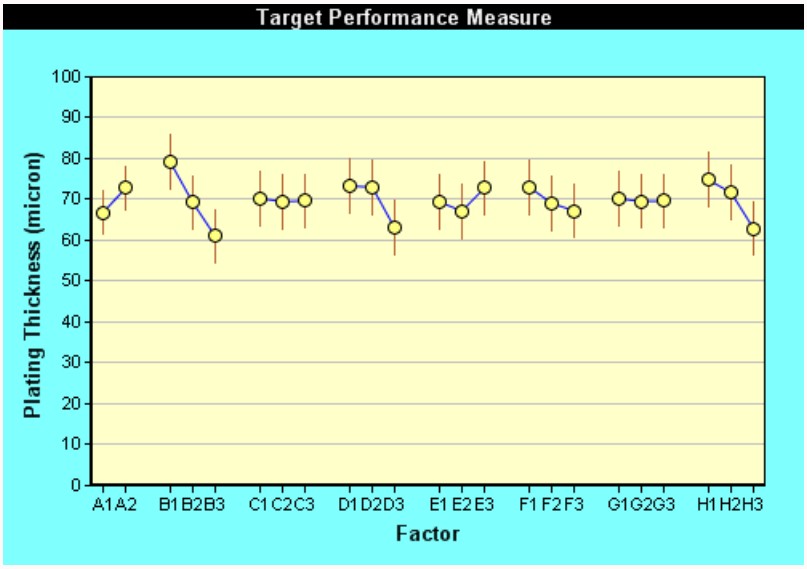
TPM			NPM		
	Mean	CI		Mean	CI
Overall	69.79	± 1.90	Overall	21.28	± 1.40
Predictions	-	± 4.67	Predictions	-	± 3.71
Confirmation	-	± 9.33	Confirmation	-	± 4.76

Table of Means

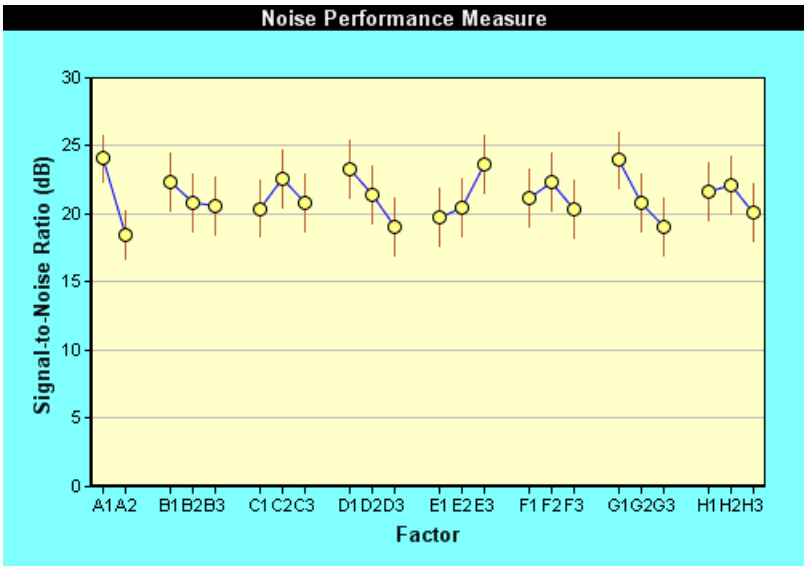
TPM			NPM		
Level	Value	CI	Level	Value	CI
A1	66.83	± 2.69	A1	24.08	± 0.86
A2	72.75	± 2.69	A2	18.48	± 0.86
B1	79.13	± 3.30	B1	22.38	± 1.05
B2	69.25	± 3.30	B2	20.86	± 1.05
B3	61.00	± 3.30	B3	20.60	± 1.05
C1	70.25	± 3.30	C1	20.40	± 1.05
C2	69.50	± 3.30	C2	22.61	± 1.05
C3	69.63	± 3.30	C3	20.83	± 1.05
D1	73.29	± 3.30	D1	23.31	± 1.05
D2	73.04	± 3.30	D2	21.45	± 1.05
D3	63.04	± 3.30	D3	19.09	± 1.05
E1	69.42	± 3.30	E1	19.74	± 1.05
E2	67.17	± 3.30	E2	20.47	± 1.05
E3	72.79	± 3.30	E3	23.64	± 1.05
F1	73.04	± 3.30	F1	21.18	± 1.05
F2	69.08	± 3.30	F2	22.32	± 1.05
F3	67.25	± 3.30	F3	20.34	± 1.05
G1	70.21	± 3.30	G1	23.95	± 1.05
G2	69.54	± 3.30	G2	20.81	± 1.05
G3	69.63	± 3.30	G3	19.08	± 1.05
H1	74.79	± 3.30	H1	21.63	± 1.05
H2	71.67	± 3.30	H2	22.14	± 1.05
H3	62.92	± 3.30	H3	20.07	± 1.05

Response Graphs

TPM



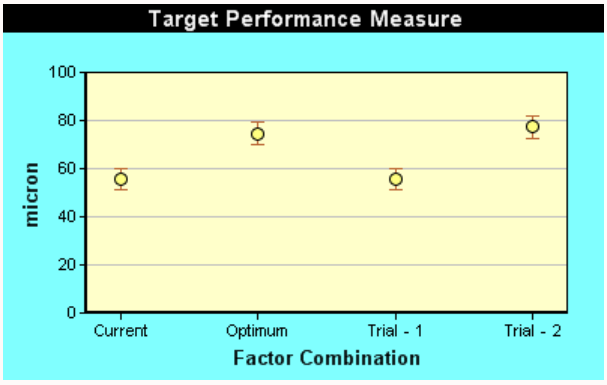
NPM

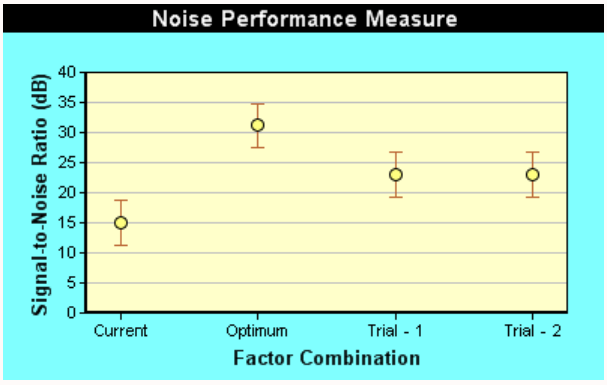


Prediction of Optimum Conditions

	TPM		NPM			Optimum			Current		
							TPM	NPM		TPM	NPM
Factor	Rank	Level	Rank	Level	Desc	Levels	PV	PV	Levels	CV	CV
A	4	2	1	1	NPM	1		24.08	2		24.08
B	1	2	8	1	TPM	2	69.25		2	69.25	
C	7	1	5	2	Neither	2			3		
D	3	2	3	1	Both	1	73.29	23.31	3	63.04	23.31
E	6	1	4	3	NPM	3		23.64	2		23.64
F	5	2	7	2	Neither	2			2		
G	8	1	2	1	NPM	1		23.95	2		23.95
H	2	2	6	2	TPM	2	71.67		3	62.92	
					Predicted Value (Lower limit)		69.96	27.42		50.96	11.29
					Predicted Value (Mean)		74.63	31.14		55.63	15.00
					Predicted Value (Upper limit)		79.29	34.85		0.00	18.72

	Trial - 1			Trial - 2		
	TPM	NPM		TPM	NPM
Levels	PV	PV	Levels	CV	CV
1		24.08	1		24.08
2	69.25		1	79.13	
1			1		
3	63.04	19.09	3	63.04	19.09
1		19.74	1		19.74
1			1		
1		23.95	1		23.95
3	62.92		1	74.79	
Predicted Value (Lower limit)	50.96	19.30		72.71	19.30
Predicted Value (Mean)	55.63	23.01		77.38	23.01
Predicted Value (Upper limit)	60.29	26.73		82.04	26.73





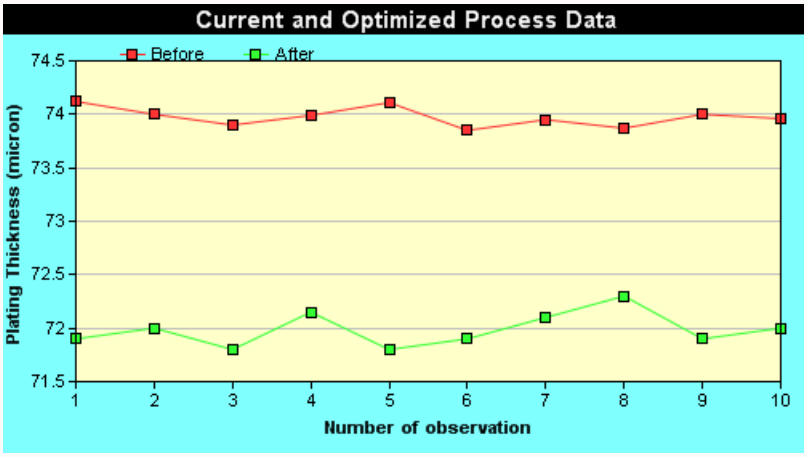
Confirmation Experiments

								R	1	2	2	1		
								Q	1	2	1	2		
								P	1	1	2	2		
	A	B	C	D	E	F	G	H	R1	R2	R3	R4	TPM	NPM
Current	2	2	3	3	2	2	2	3	75.00	77.00	68.00	72.00	73.00	25.41
Optimum	1	2	2	1	3	2	1	2	69.00	78.00	71.00	69.00	71.75	24.50
Trial - 1	1	2	1	3	1	1	1	3	72.00	68.00	71.00	70.00	70.25	32.28
Trial - 2	1	1	1	3	1	1	1	1	72.00	68.00	76.00	72.00	72.00	26.87

Chosen Optimum Condition is : Optimum

Comparison of Before and After

No.	Before	After Optimum
1	74.12	71.90
2	74.00	72.00
3	73.90	71.80
4	73.99	72.15
5	74.11	71.80
6	73.85	71.90
7	73.95	72.10
8	73.87	72.30
9	74.00	71.90
10	73.96	72.00



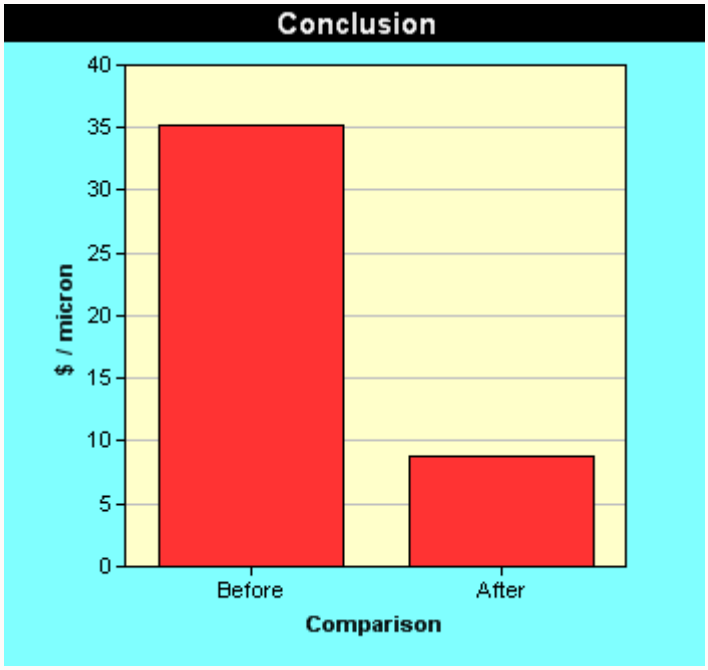
Conclusion

	Current Process	
	A<70.00	A≥70.00
k	4	0.444
sigma	0.09	0.09
y Bar	73.98	73.98
L (Var)	0.03	0.00
L (Bias)	63.20	7.02
L (Total)	35.13	-

	Optimum Process	
	A<70.00	A≥70.00
k	4	0.444
sigma	0.16	0.16
y Bar	71.99	71.99
L (Var)	0.10	0.01
L (Bias)	15.76	1.75
L (Total)	8.81	-

Gain Calculations

Gain Calculations	
Gain	26.32 $ / micron
Improvement	74.91 %



Design of Experiments

Reduction of attribute defects

Acme
2007-Jan-16 : 12:08:20

Applet Introduction

Applet Details	
Applet Title	Attribute
Description	Reduction of attribute defects
Objective	To improve quality in attribute analysis
Abstract	Solder boards have a high defect rate due to solder covering the holes for pin insertion.
Team Leader	
Commencement Date	15-Jul-2006
Expected Completion Date	
Completion Date	
Status	Not Completed
Team Name	Attribute
Team Members	

1	IR0019	Ernie Cho
2	IR0015	Cho Boon Siah

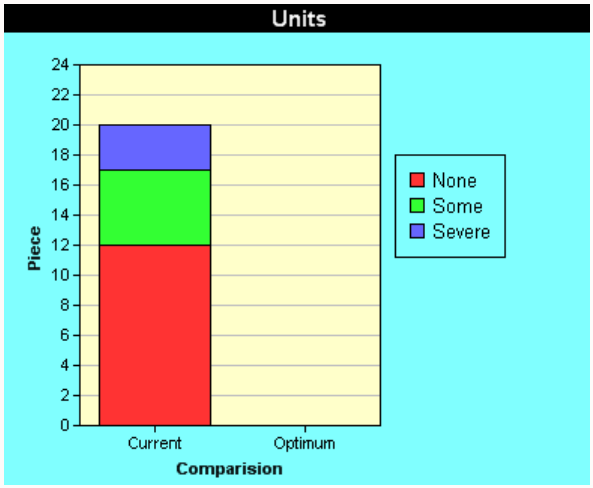
State of Problem

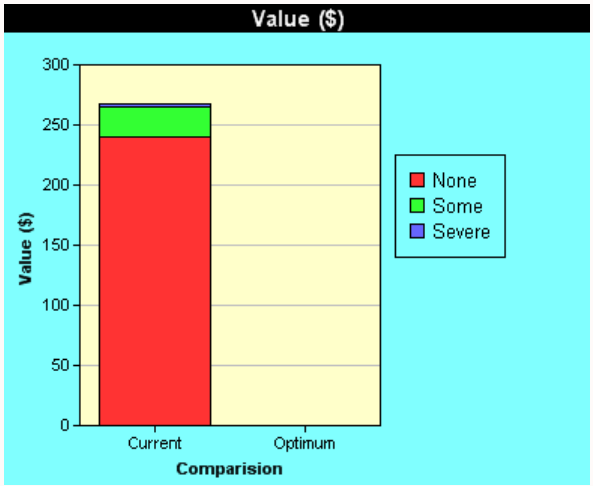
Statement of the problem
Design of Experiments for Attribute analysis is seldom found in standard software. ICTM provides a novel method of improving quality in attribute response characteristics.

Current

Response Details	
Response	Quality Loss
Unit	Piece
Financial unit	$
Quality loss Coefficient	$ / (Piece x Piece)
Response Measurement	Quality Loss (Piece)

Units	None	Some	Severe	Total
Worth	20	5	1	-
Current	12	5	3	20
Value ($)	240	25	3	**268**





Quality Loss Function

	Attribute Data
Cost	20 $ / Piece
Number	20 Piece
Worth	400 $
Value	268 $
Loss	132 $
Average Loss	6.6 $ / Piece

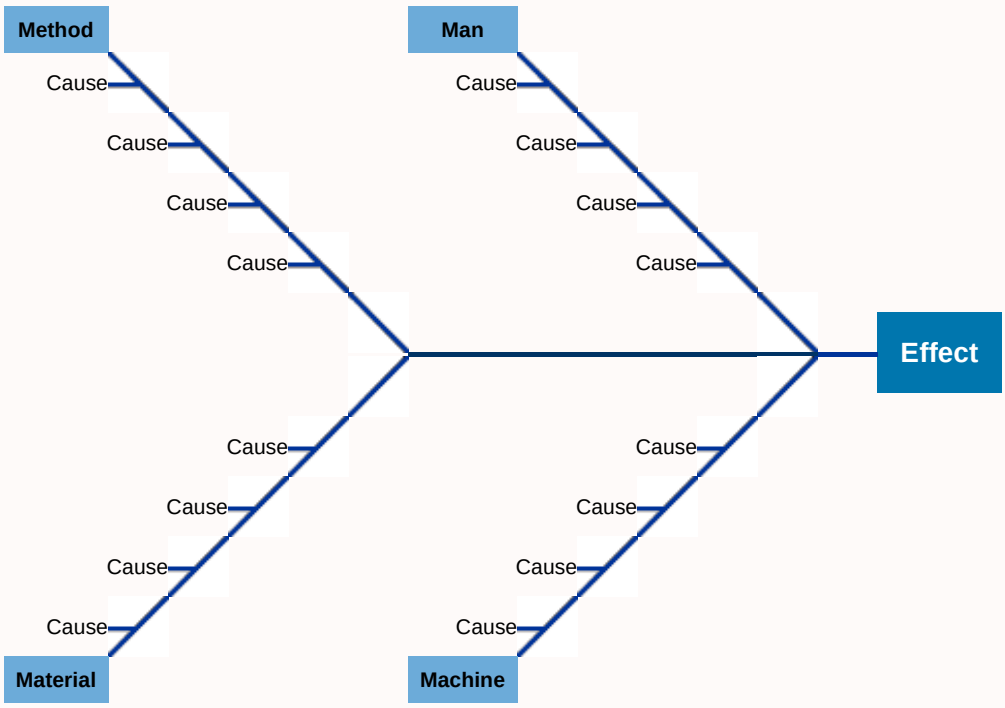
Selection of Factor

The Parameter diagram indicates the factors that can be studied in the experiment. The factors are classed into:

- Control factors
- Noise factors
- Signal factors
- Scaling factors
- Levelling factors

These factors affect the response characteristic.
Please insert a diagram of the factors to be studied.
The diagram shows the key factors affecting flight time.

Cause-Effect Diagram



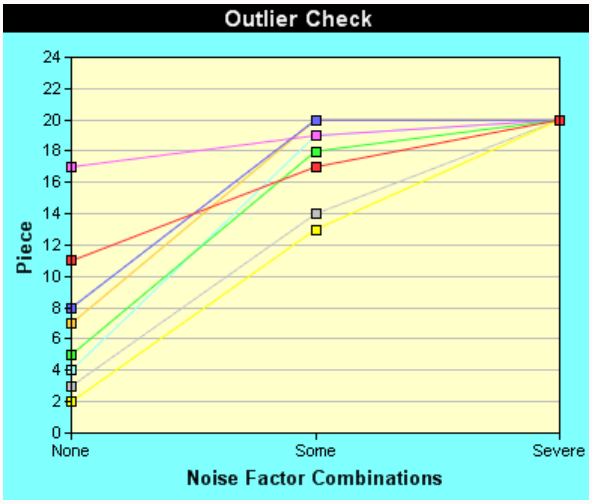
Factor for Experimentation

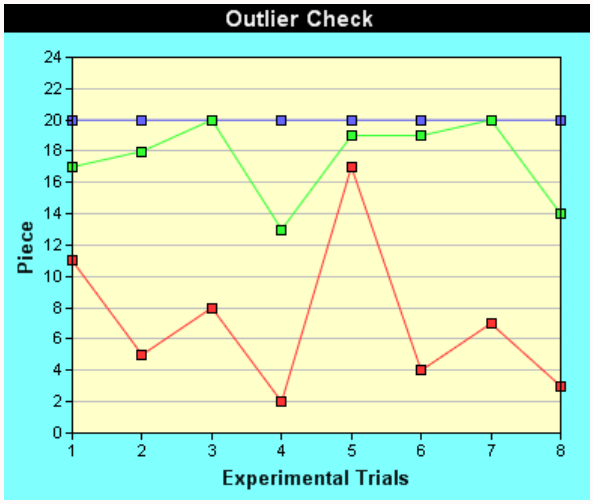
No.	Label	Description	Label	Level1	Level2	Units	Current
1	A	Temperature	TM			deg C	1
2	B	Pressure	PR			kN / m^2	2
3	C	Speed	SP			m/s	2
4	D	Knife angle	KA			deg	1
5	E	Dross removed	DR			-	1
6	F	Solder depth	SD			cm	2
7	G	Solder hardness	SH			-	2

Conducting the Experiment

Experimental Design is : L8 (2^7)
Attributes in "()" are cumulative.

	A	B	C	D	E	F	G	None	Some	Severe		(None)	(Some)	(Severe)
1	1	1	1	1	1	1	1	11	6	3		11	17	20
2	1	1	1	2	2	2	2	5	13	2		5	18	20
3	1	2	2	1	1	2	2	8	12	0		8	20	20
4	1	2	2	2	2	1	1	2	11	7		2	13	20
5	2	1	2	1	2	1	2	17	2	1		17	19	20
6	2	1	2	2	1	2	1	4	15	1		4	19	20
7	2	2	1	1	2	2	1	7	13	0		7	20	20
8	2	2	1	2	1	1	2	3	11	6		3	14	20
							f	**57**	**83**	**20**	**(f)**	**57**	**140**	**160**
							p	**0.356**	**0.519**	**0.125**	**(p)**	**0.356**	**0.875**	**1**
											(var)	**0.229**	**0.109**	**0**
											(w)	**4.36**	**9.143**	**0**





Performance Measure Independent of Adjustment

Target Performance Measure is:

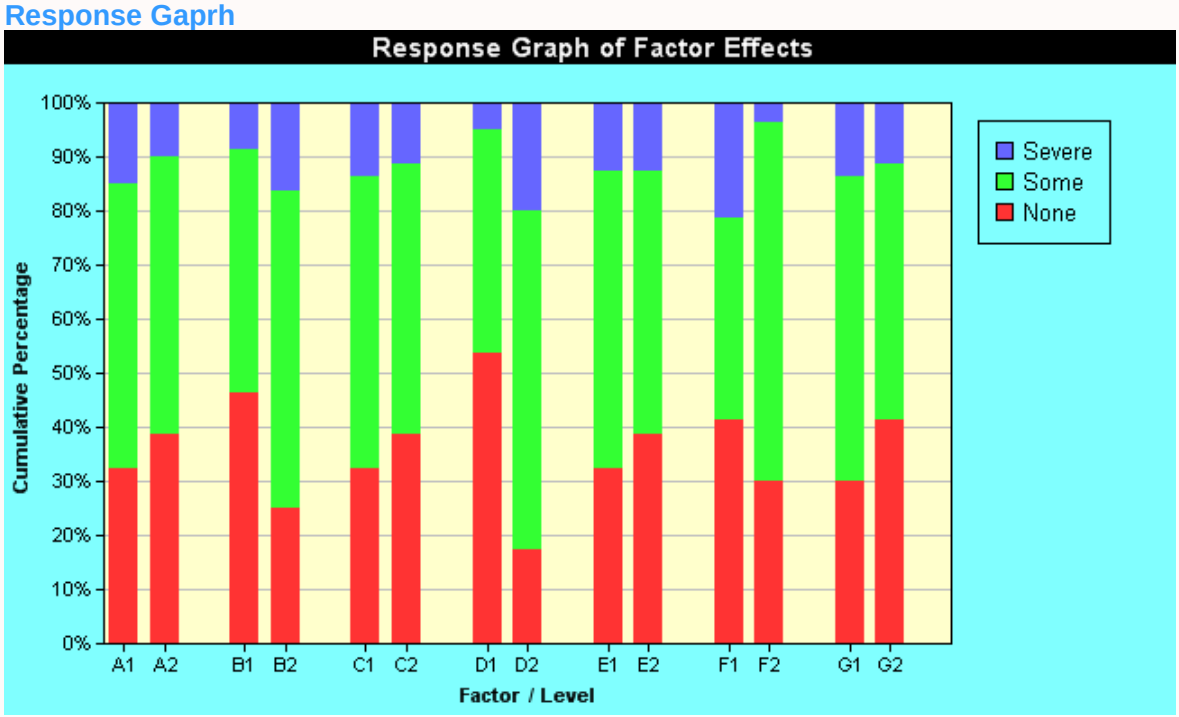
Fraction - Defective $\eta = -10 \log \left(\frac{1}{p} - 1 \right)$

Response

Response Table

	None	Some	Severe	(None)	(Some)	(Severe)
A1	26	42	12	26	68	80
A2	31	41	8	31	72	80
B1	37	36	7	37	73	80
B2	20	47	13	20	67	80
C1	26	43	11	26	69	80
C2	31	40	9	31	71	80
D1	43	33	4	43	76	80
D2	14	50	16	14	64	80
E1	26	44	10	26	70	80
E2	31	39	10	31	70	80
F1	33	30	17	33	63	80
F2	24	53	3	24	77	80
G1	24	45	11	24	69	80
G2	33	38	9	33	71	80

Response Gaprh



Anova

Number of factors in the model : 3

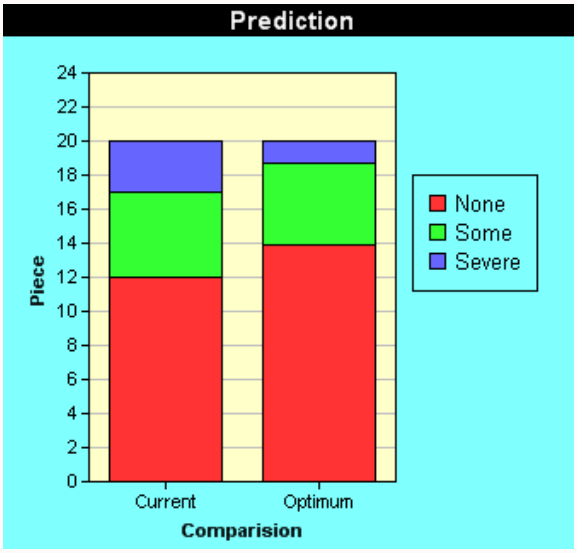
Source	Pool	SSQ	df	Var	SSq	Rho
A	1	1.60	1	1.60		
B	0	9.93	1	9.93	9.09	2.84
C	1	0.91	1	0.91		
D	0	31.15	1	31.15	30.31	9.47
E	1	0.68	1	0.68		
F	0	13.41	1	13.41	12.56	3.93
G	1	2.44	1	2.44		
Error	1	259.89	311	0.84		
Pool		265.51	315	0.84	268.04	83.76
St		320.00	318		320.00	100.00
Sm		1208.54				

Prediction of Optimum Conditions

Maximize None	A	B	C	D	E	F	G	Y Bar	F Ratio	3.871	
Level	2	1	2	1	2	1	2		neff	63.6	
Mean		37		43		33		57	0.7		
Omega		-0.653		0.653		-1.536		-2.57	3.603		
									0.696	+/-	0.104
									0.592	0.696	0.8

Maximize Some	A	B	C	D	E	F	G	Y Bar	F Ratio	3.871	
Level	2	1	2	1	2	1	2		neff	63.6	
Mean		73		76		63		140	0.9		
Omega		10.182		12.788		5.689		8.451	11.757		
									0.937	+/-	0.055
									0.882	0.937	0.992

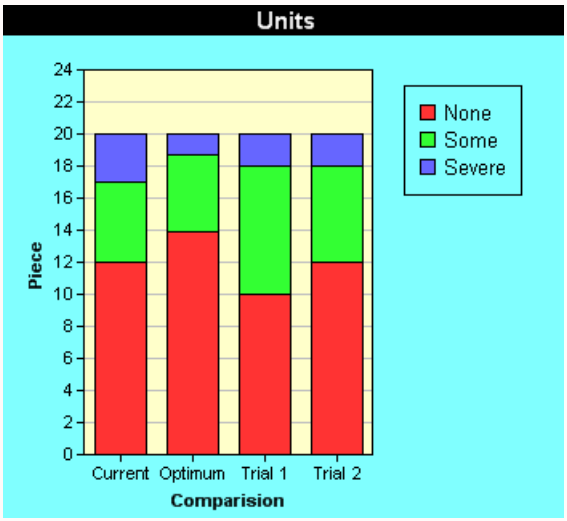
	Current	Optimum
None	12.00	13.93
Some	5.00	4.82
Severe	3.00	1.25

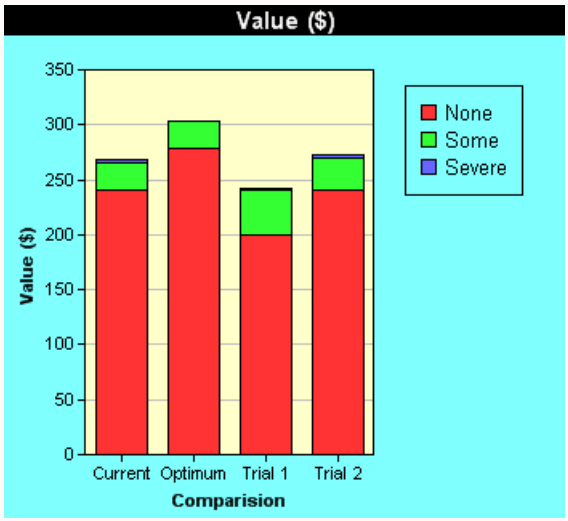


Confirmation Experiments

	A	B	C	D	E	F	G	None	Some	Severe	(None)	(Some)	(Severe)
Current	1	2	2	1	1	2	2	12	5	3	12	17	20
Optimum	2	1	2	1	2	1	2	14	5	1	14	19	20
Trial 1	1	2	2	1	1	2	1	10	8	2	10	18	20
Trial 2	2	2	2	2	1	1	2	12	6	2	12	18	20

	Units			Value		
	None	Some	Severe	None	Some	Severe
Current	12	5	3	240.00	25.00	3.00
Optimum	14	5	1	278.52	24.11	1.25
Trial 1	10	8	2	200.00	40.00	2.00
Trial 2	12	6	2	240.00	30.00	2.00

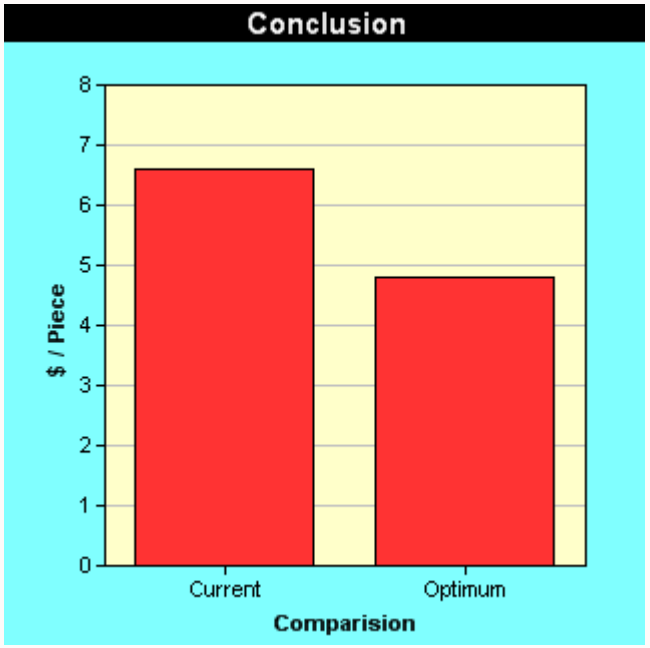




Conclusion

Chosen optimum condition is : Optimum

	Current	Optimum	
Cost	20	20	$ / Piece
Number	20	20	Piece
Worth	400	400	$
Value	268	303.884	$
Loss	132	96	$
Average Loss	6.6	4.806	$ / Piece



Gain Calculations

Gain Calculations	
Gain	1.79 $ / Piece
Improvement	27.182 %

Conclusion

The experiment showed a **poor** process improvement.

Design of Experiments

Reduction of attribute defects

Bawani Ho
Acme
2007-Jan-16 : 14:06:29

Applet Introduction

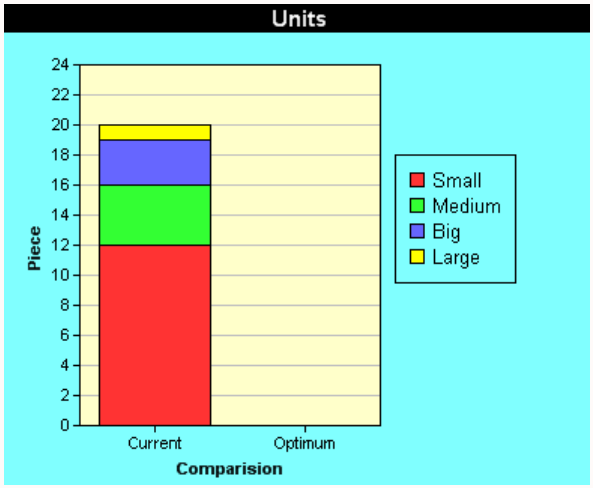
Applet Details	
Applet Title	Attribute
Description	Reduction of attribute defects
Objective	To improve quality in attribute analysis
Abstract	Solder boards have a high defect rate due to solder covering the holes for pin insertion.
Team Leader	Bawani Ho
Commencement Date	13-Dec-2006
Expected Completion Date	
Completion Date	
Status	Not Completed
Team Name	Attribute
Team Members	

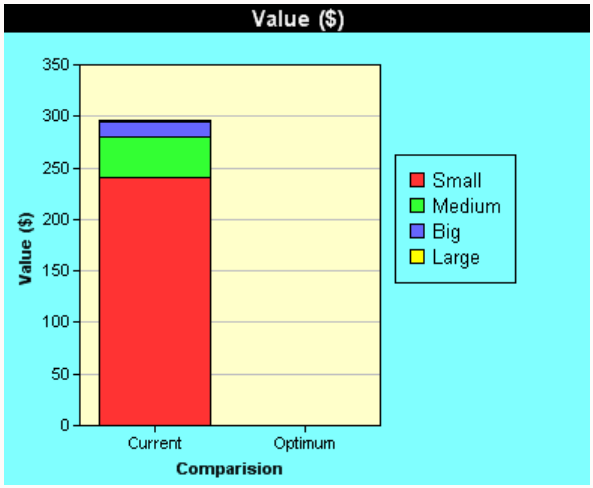
1	IR0019	Ernie Cho
2	IR0015	Cho Boon Siah

Current

Response Details	
Response	dents
Unit	Piece
Financial unit	$
Quality loss Coefficient	$ / (Piece x Piece)
Response Measurement	dents (Piece)

Units	Small	Medium	Big	Large	Total
Worth	20	10	5	1	-
Current	12	4	3	1	20
Value ($)	240	40	15	1	**296**





Quality Loss Function

	Attribute Data
Cost	20 $ / Piece
Number	20 Piece
Worth	400 $
Value	296 $
Loss	104 $
Average Loss	5.2 $ / Piece

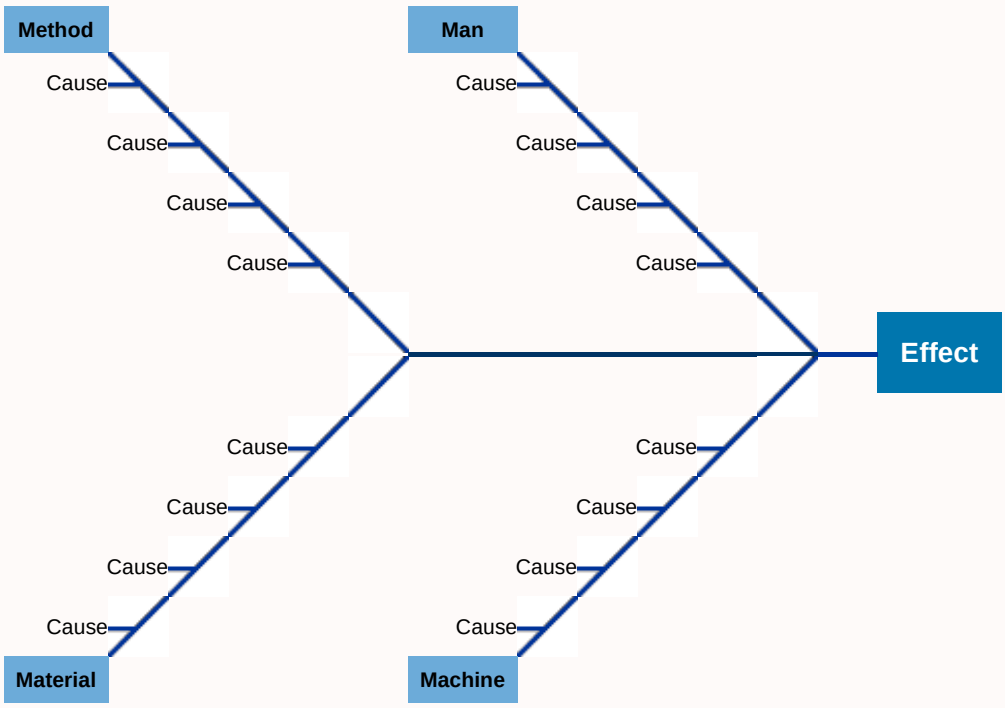
Selection of Factor

The Parameter diagram indicates the factors that can be studied in the experiment. The factors are classed into:

- Control factors
- Noise factors
- Signal factors
- Scaling factors
- Levelling factors

These factors affect the response characteristic.
Please insert a diagram of the factors to be studied.
The diagram shows the key factors affecting flight time.

Cause-Effect Diagram



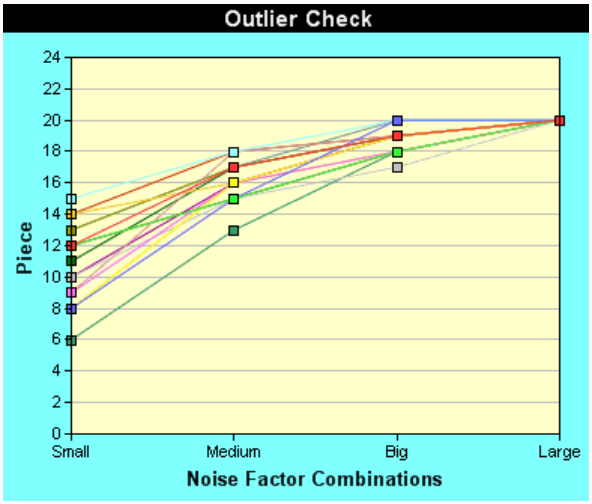
Factor for Experimentation

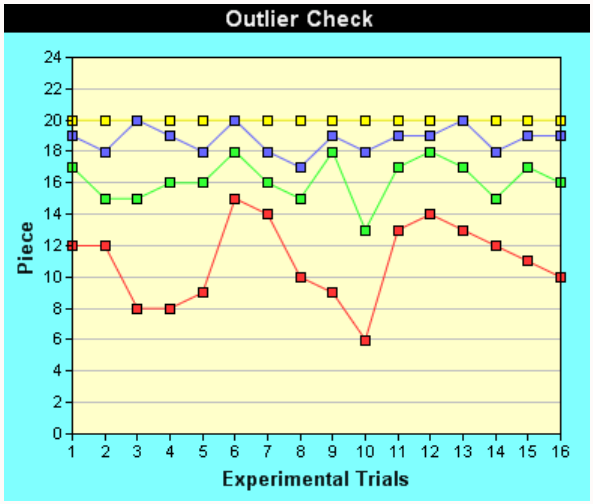
No.	Label	Description	Label	Level1	Level2	Level3	Level4	Units	Current
1	A	Aaaa	A	A1	A2	A3	A4		3
2	B	Bbbb	B	B1	B2	B3	B4		3
3	C	Cccc	C	C1	C2	C3	C4		3
4	D	Dddd	D	D1	D2				1
5	E	Eeee	E	E1	E2	E3	E4		1
6	F	Ffff	F	F1	F2				1
7	G	Gggg	G	G1	G2				1

Conducting the Experiment

Experimental Design is : L16 (4^4 x 2^3)
Attributes in "()" are cumulative.

	A	B	C	D	E	F	G	Small	Medium	Big	Large		(Small)	(Medium)	(Big)	(Large)
1	1	1	1	1	1	1	1	12	5	2	1		12	17	19	20
2	1	2	2	1	2	2	2	12	3	3	2		12	15	18	20
3	1	3	3	2	3	1	2	8	7	5	0		8	15	20	20
4	1	4	4	2	4	2	1	8	8	3	1		8	16	19	20
5	2	1	2	2	1	2	1	9	7	2	2		9	16	18	20
6	2	2	1	2	2	1	2	15	3	2	0		15	18	20	20
7	2	3	4	1	4	2	2	14	2	2	2		14	16	18	20
8	2	4	3	1	3	1	1	10	5	2	3		10	15	17	20
9	3	1	3	1	4	2	2	9	9	1	1		9	18	19	20
10	3	2	4	1	3	1	1	6	7	5	2		6	13	18	20
11	3	3	1	2	2	2	1	13	4	2	1		13	17	19	20
12	3	4	2	2	1	1	2	14	4	1	1		14	18	19	20
13	4	1	4	2	2	1	2	13	4	3	0		13	17	20	20
14	4	2	3	2	1	2	1	12	3	3	2		12	15	18	20
15	4	3	2	1	4	1	1	11	6	2	1		11	17	19	20
16	4	4	1	1	3	2	2	10	6	3	1		10	16	19	20
							f	**176**	**83**	**41**	**20**	**(f)**	**176**	**259**	**300**	**320**
							p	**0.55**	**0.259**	**0.128**	**0.063**	**(p)**	**0.55**	**0.809**	**0.938**	**1**
												(var)	**0.248**	**0.154**	**0.059**	**0**
												(w)	**4.04**	**6.481**	**17.067**	**0**





Performance Measure Independent of Adjustment

Target Performance Measure is:

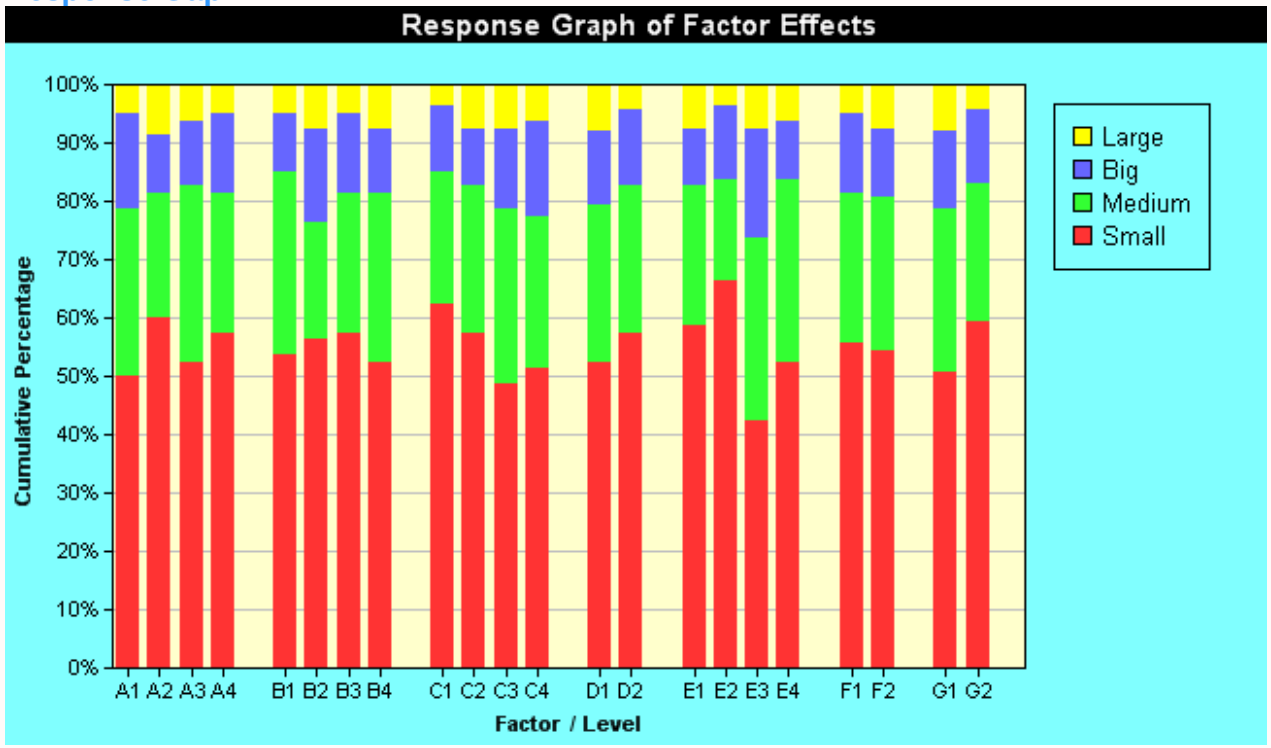
Fraction - Defective $\eta = -10 \log \left(\frac{1}{p} - 1 \right)$

Response

Response Table

	Small	Medium	Big	Large	(Small)	(Medium)	(Big)	(Large)
A1	40	23	13	4	40	63	76	80
A2	48	17	8	7	48	65	73	80
A3	42	24	9	5	42	66	75	80
A4	46	19	11	4	46	65	76	80
B1	43	25	8	4	43	68	76	80
B2	45	16	13	6	45	61	74	80
B3	46	19	11	4	46	65	76	80
B4	42	23	9	6	42	65	74	80
C1	50	18	9	3	50	68	77	80
C2	46	20	8	6	46	66	74	80
C3	39	24	11	6	39	63	74	80
C4	41	21	13	5	41	62	75	80
D1	84	43	20	13	84	127	147	160
D2	92	40	21	7	92	132	153	160
E1	47	19	8	6	47	66	74	80
E2	53	14	10	3	53	67	77	80
E3	34	25	15	6	34	59	74	80
E4	42	25	8	5	42	67	75	80
F1	89	41	22	8	89	130	152	160
F2	87	42	19	12	87	129	148	160
G1	81	45	21	13	81	126	147	160
G2	95	38	20	7	95	133	153	160

Response Gaprh



Anova

Number of factors in the model : 5

Source	Pool	SSQ	df	Var	SSq	Rho
A	0	3.69	3	1.23	0.74	0.08
B	0	3.36	3	1.12	0.42	0.04
C	0	6.86	3	2.29	3.92	0.41
D	1	3.23	1	3.23		
E	0	14.70	3	4.90	11.76	1.23
F	1	0.92	1	0.92		
G	0	5.39	1	5.39	4.41	0.46
Error	1	921.84	942	0.98		
Pool		926.00	944	0.98	938.75	97.79
St		960.00	957		960.00	100.00
Sm		6549.80				

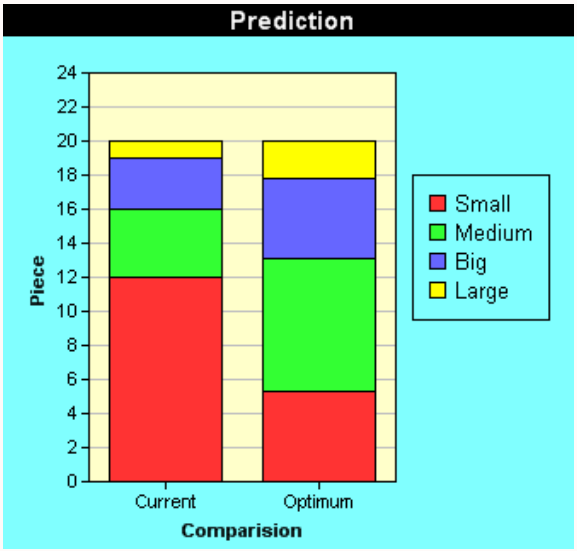
Prediction of Optimum Conditions

Minimize Small	A	B	C	D	E	F	G	Y Bar	F Ratio	3.851	
Level	1	4	3	1	3	2	1		neff	59.813	
Mean	40	42	39		34		81	176	1.344		
Omega		0.435	-0.217		-1.313		0.109	0.872	-4.473		
									0.263	+/-	0.111
									0.152	0.263	0.374

Minimize Medium	A	B	C	D	E	F	G	Y Bar	F Ratio	3.851	
Level	1	4	3	1	3	2	1		neff	59.813	
Mean	63	65	63		59		126	259	2.294		
Omega	5.689	6.368	5.689		4.486		5.689	6.28	2.802		
									0.656	+/-	0.119
									0.537	0.656	0.775

Minimize Big	A	B	C	D	E	F	G	Y Bar	F Ratio	3.851	
Level	1	4	3	1	3	2	1		neff	59.813	
Mean	76	74	74		74		147	300	2.769		
Omega	12.788	10.911	10.911		10.911		10.534	11.761	9.01		
									0.888	+/-	0.079
									0.809	0.888	0.967

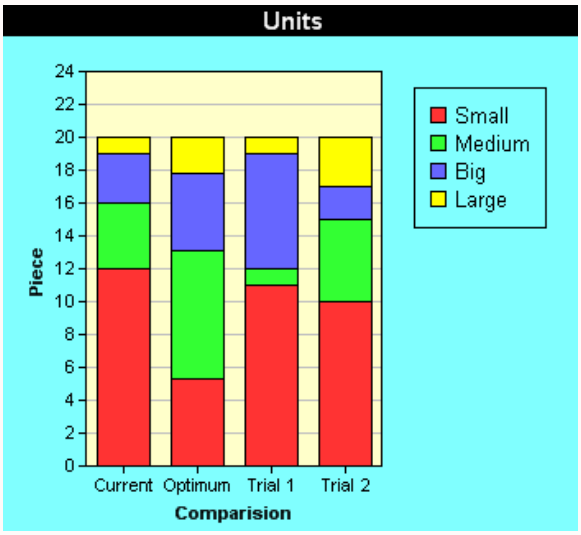
	Current	Optimum
Small	12.00	5.26
Medium	4.00	7.86
Big	3.00	4.65
Large	1.00	2.23

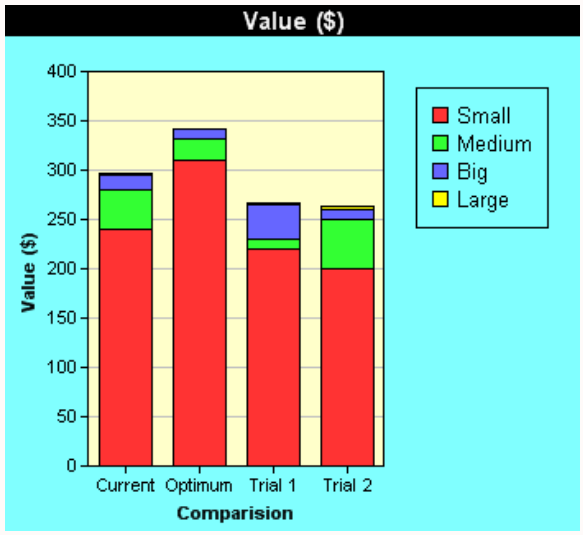


Confirmation Experiments

	A	B	C	D	E	F	G	Small	Medium	Big	Large	(Small)	(Medium)	(Big)	(Large)
Current	3	3	3	1	1	1	1	12	4	3	1	12	16	19	20
Optimum	1	4	3	1	3	2	1	5	8	5	2	5	13	18	20
Trial 1	1	1	1	1	1	1	1	11	1	7	1	11	12	19	20
Trial 2	1	1	1	1	1	1	1	10	5	2	3	10	15	17	20

	Units				Value			
	Small	Medium	Big	Large	Small	Medium	Big	Large
Current	12	4	3	1	240.00	40.00	15.00	1.00
Optimum	5	8	5	2	309.90	21.90	9.37	0.44
Trial 1	11	1	7	1	220.00	10.00	35.00	1.00
Trial 2	10	5	2	3	200.00	50.00	10.00	3.00

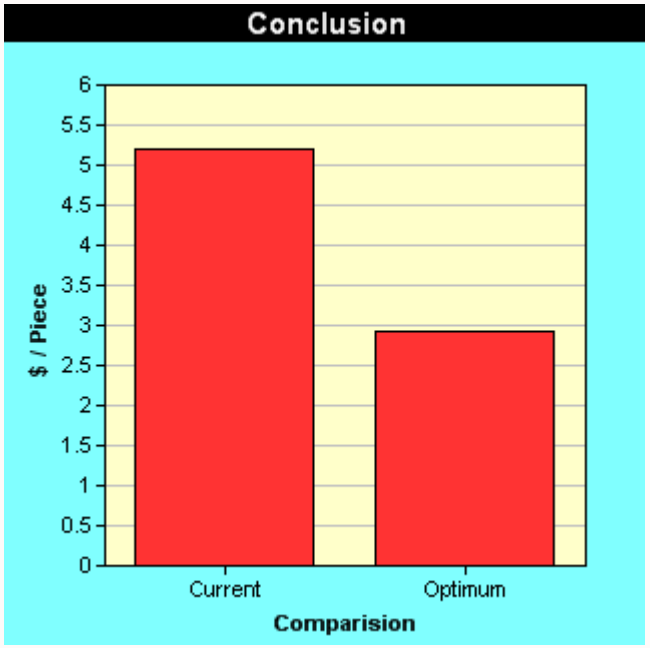




Conclusion

Chosen optimum condition is : Optimum

	Current	Optimum	
Cost	20	20	$ / Piece
Number	20	20	Piece
Worth	400	400	$
Value	296	341.61	$
Loss	104	58	$
Average Loss	5.2	2.919	$ / Piece



Gain Calculations

Gain Calculations	
Gain	2.28 $ / Piece
Improvement	43.865 %

Conclusion

The experiment showed a "**fair**" process improvement.

Design of Experiments

Design of Experiments

Bawani Ho
Acme
2007-Jan-16 : 12:36:12

Applet Introduction

Applet Details	
Applet Title	Experiment
Description	Design of Experiments
Objective	To demonstrate the use of experiments.
Abstract	Design of Experiments allows a wide range of experiments to be conducted.
Team Leader	Bawani Ho
Commencement Date	19-Aug-2006
Expected Completion Date	
Completion Date	
Status	Not Completed
Team Name	Experiments
Team Members	**1** IR00107 Salman Shaari

Quality Characteristics

Response Details	
Response Name	Time
Response Unit	s
Financial Unit	$
Quality loss coefficient	$ / (s^2)
Response measure	Time (s)

\ Response Type	
Noise Performance Measure (NPM)	Smaller the better
Target Performance Measure (TPM)	Y Bar

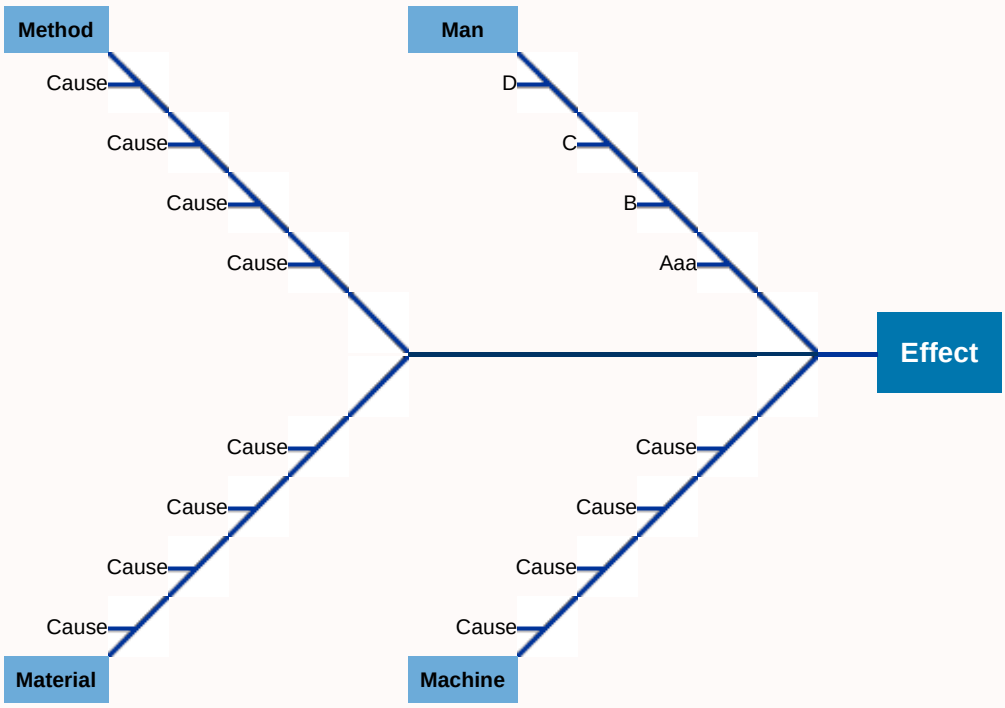
Selection of Factors

The Parameter diagram indicates the factors that can be studied in the experiment.

The factors are classed into:

- Control factors
- Noise factors
- Signal factors
- Scaling factors
- Levelling factors

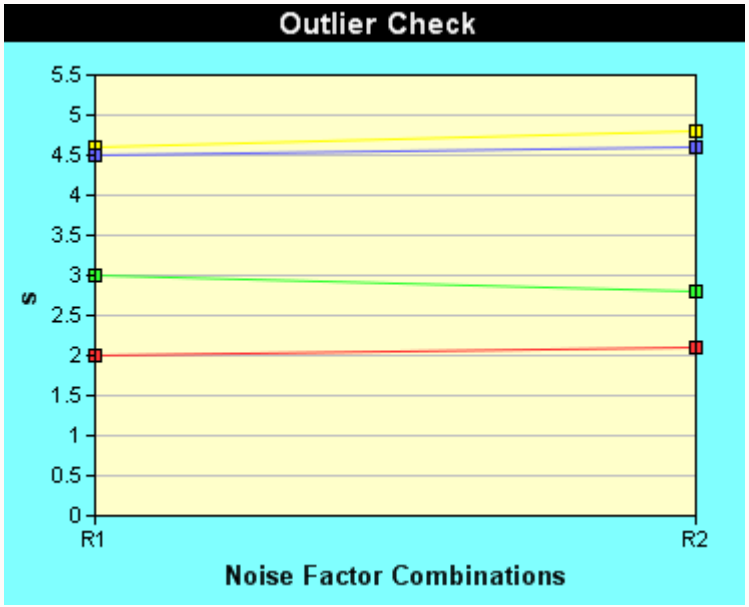
Cause-Effect Diagram

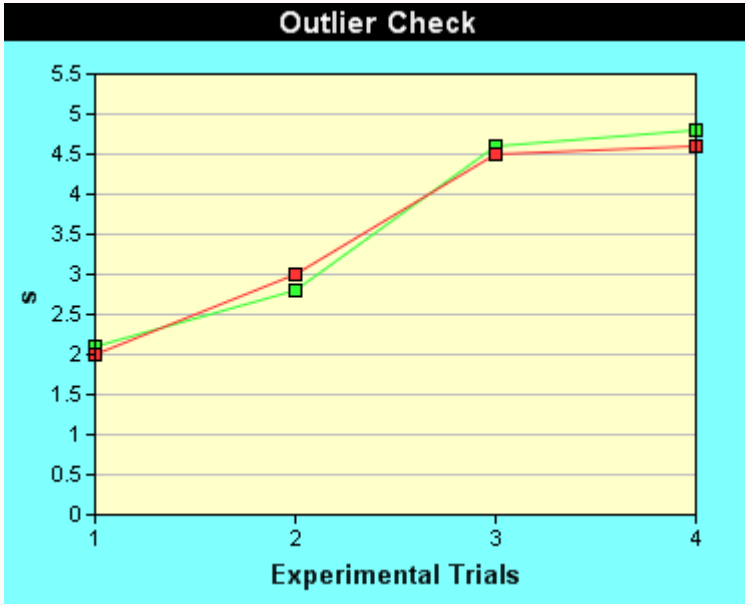


Conducting the Experiment

Experimental Design is L4 (2^3) X F2

			P	1	2		
	A	B	C	R1	R2	TPM	NPM
1	1	1	1	2.0	2.1	2.1	-6.2
2	1	2	2	3.0	2.8	2.9	-9.3
3	2	1	2	4.5	4.6	4.6	-13.2
4	2	2	1	4.6	4.8	4.7	-13.5





Performance Measures Independent of Adjustment

The Noise Performance Measure is:

Smaller - Better $\eta = -10\log\left(s^2 + \bar{y}^2\right)$

The Target Performance Measure is:

Mean $\tau = \bar{y}$

Analysis of Variance

Analysis of Means (TPM)

	A	B	C
Level 1	2.48	3.30	3.38
Level 2	4.63	3.80	3.73
Rank	1	2	3
SSQ	9.25	0.50	0.25
Opt	1	1	1

Experimental modelling

Number of factors in the model: 2

Analysis of Variance (TPM)

Source	Pool	SSQ	Df	Var	F ratio	SSq	Rho
A	0	9.25	1	9.25	156.69	9.19	91.49
B	0	0.50	1	0.50	8.47	0.44	4.39
C	1	0.25	1	0.25			
Err	1	0.05	4	0.01			
Pool		0.30	5	0.06	1.00	0.41	4.11
St		10.04	7	1.43		10.04	100.00
Sm		100.82	1				
ST		110.86	8				

The value of 4.11 as a pooled error suggests low error

Analysis of Means (NPM)

	A	B	C
Level 1	-7.75	-9.70	-9.84
Level 2	-13.30	-11.35	-11.21
Rank	1	2	3
SSQ	30.85	2.73	1.87
Opt	1	1	1

Experimental modelling

Number of factors in the model : 2

Analysis of Variance (NPM)

Source	Pool	SSQ	Df	Var	F ratio	SSq	Rho
A	0	30.85	1	30.85	16.52	28.98	81.77
B	0	2.73	1	2.73	1.46	0.86	2.42
C	1	1.87	1	1.87			
Err	1						
Pool		1.87	1	1.87	1.00	5.60	15.81
St		35.45	3	11.82		35.45	100.00
Sm		443.22	1				
ST		478.67	4				

The value of 15.81 as a pooled error suggests low error

Response Tables

Calculation of Confidence Interval

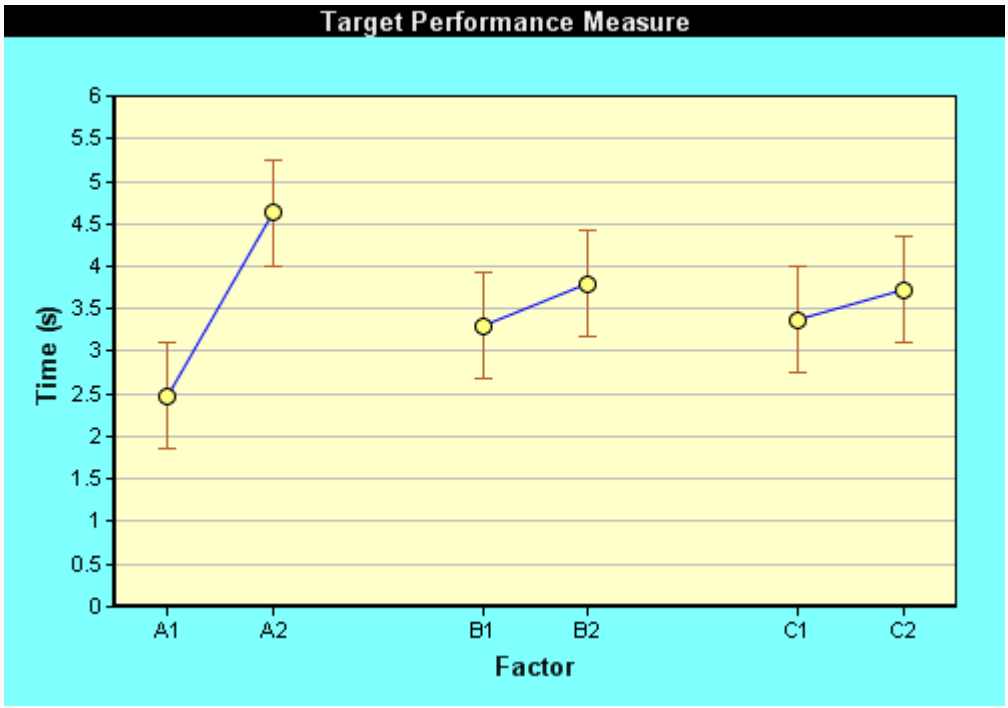
TPM			NPM		
	Mean	CI		Mean	CI
Overall	3.55	± 0.22	Overall	-10.53	± 8.68
Predictions	-	± 0.31	Predictions	-	± 12.28
Confirmation	-	± 0.54	Confirmation	-	± 17.37

Table of Means

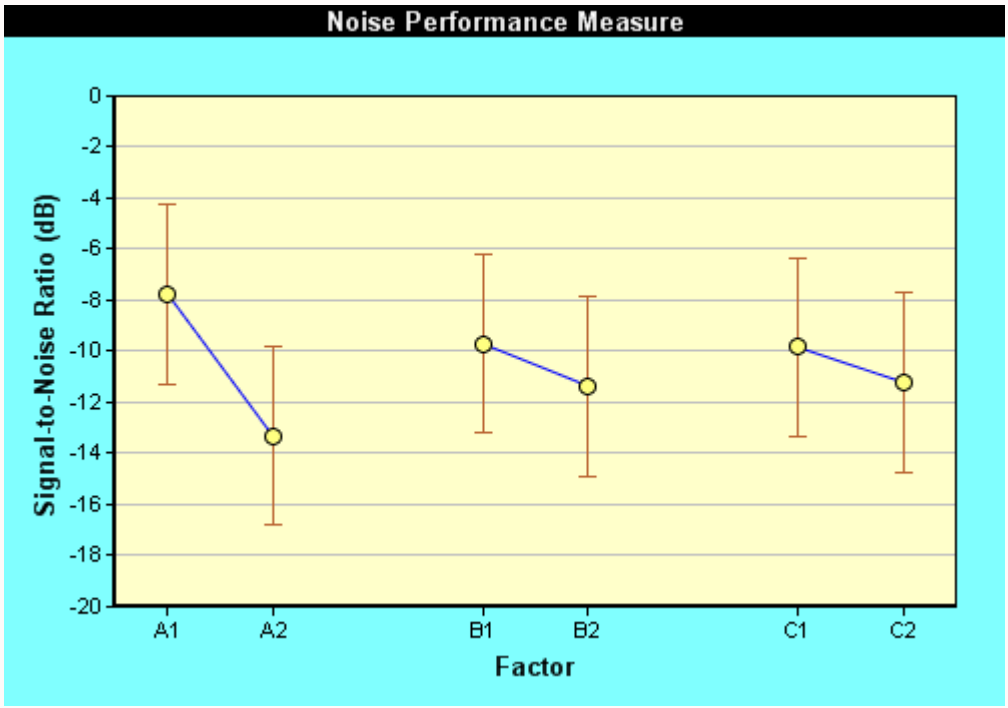
TPM			NPM		
Level	Value	CI	Level	Value	CI
A1	2.48	± 0.31	A1	-7.75	± 1.76
A2	4.63	± 0.31	A2	-13.30	± 1.76
B1	3.30	± 0.31	B1	-9.70	± 1.76
B2	3.80	± 0.31	B2	-11.35	± 1.76
C1	3.38	± 0.31	C1	-9.84	± 1.76
C2	3.73	± 0.31	C2	-11.21	± 1.76

Response Graphs

TPM



NPM



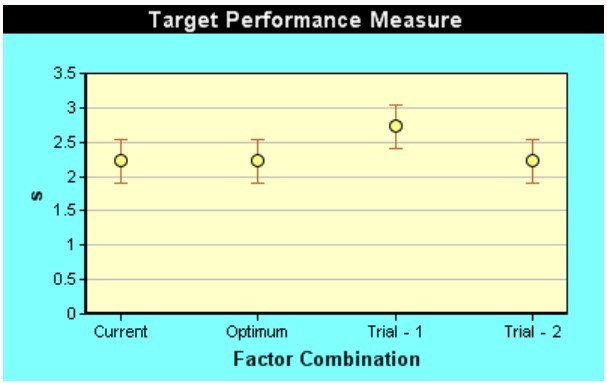
Prediction of Optimum Conditions

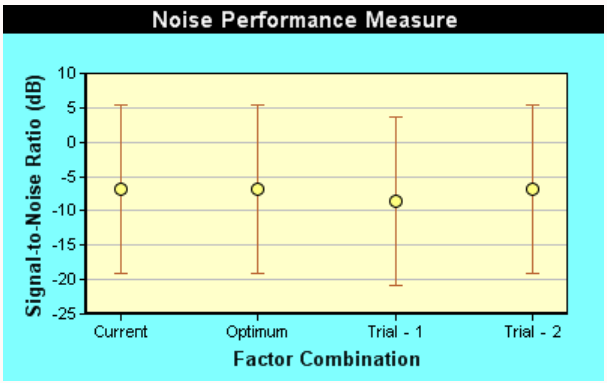
	TPM		NPM			Optimum		
							TPM	NPM
Factor	Rank	Level	Rank	Level	Desc	Levels	PV	PV
A	1	1	1	1	Both	1	2.48	-7.75
B	2	1	2	1	Both	1	3.30	-9.70
C	3	1	3	1	Neither	1		
					Predicted Value (Lower limit)		1.91	-19.20
					Predicted Value (Mean)		2.23	-6.92
					Predicted Value (Upper limit)		2.54	5.36

	Current		
		TPM	NPM
	Levels	CV	CV
	1	2.48	-7.75
	1	3.30	-9.70
	1		
		1.91	-19.20
		2.23	-6.92
		0.00	5.36

	Trial - 1		
		TPM	NPM
	Levels	PV	PV
	1	2.48	-7.75
	2	3.80	-11.35
	2		
Predicted Value (Lower limit)		2.41	-20.85
Predicted Value (Mean)		2.73	-8.58
Predicted Value (Upper limit)		3.04	3.70

	Trial - 2		
		TPM	NPM
	Levels	CV	CV
	1	2.48	-7.75
	1	3.30	-9.70
	1		
		1.91	-19.20
		2.23	-6.92
		2.54	5.36





Confirmation Experiments

			P	1	2		
	A	B	C	R1	R2	TPM	NPM
Current	1	1	1	2.20	2.50	2.35	-7.46
Optimum	1	1	1	4.50	5.40	4.95	-13.96
Trial - 1	1	2	2	3.50	4.50	4.00	-12.17
Trial - 2	1	1	1	4.10	3.90	4.00	-12.05

Chosen Optimum Condition is : Trail - 2