ASQ CRE Prep course

Lesson III. A. 7. k.

Design of Experiments

A Simple Taguchi Example

Making Cookies

- Baking cookies from scratch not only depends on the ingredients, it also seems to depend on the cookie size, oven temperature and baking time.
- We’ ve been asked to determine the best size, baking time and temperature for a new recipe.
- We have a limited amount of time and the judges can only eat a limited amount of cookies

- A select panel of judges will rate the resulting cookies on a 0 to 100 scale, where 100 is best. The panelist results are averaged for a final score.

Conducting a Main Effects Experiment

The objective

Optimize the recipe in order to achieve a high judging score.

The situation

We have time to bake 4 batches of cookies for the experimental judging.

Selecting the factors & levels

Factor	Level 1	Level 2
A: Oven Temperature	325	375
B: Cooking time	12 min	15 min
C: Cookie size	Small	Large

- Use engineering judgment, history, experience, previous experiments to select the factors and levels.

Assigning Factors to the Array

$L_4 (2^3)$			
Run no.	**A**	**B**	**C**
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

Assigning Factors to the Array

$L_4 (2^3)$

Run no.	Temp	Time	Size
1	325	12	Sm
2	325	15	Lg
3	375	12	Lg
4	375	15	Sm

Experimental results

Run	A	B	C	Y_1	Y_2	$\sum Y$	Avg Y	MSD	S/N
1	1	1	1	69	62	131	65.5	0.000235	36.29
2	1	2	2	38	37	75	37.5	0.000711	31.48
3	2	1	2	39	41	80	40.0	0.000626	32.03
4	2	2	1	26	23	49	24.5	0.001685	27.73

$$MSD = \frac{1/Y_1^2 + 1/Y_2^2 + \cdots + 1/Y_n^2}{n}$$

$$S/N = -10\log(MSD)$$

Only Four of Eight Possible Combinations

We could select the best of the four combinations. Yet, that is ignoring the ability to make a selection from all possible combinations.

With a little math we can determine the right mix of time, temperature and size for the highest scoring cookies.

A simple example continued

Factor	level	ΣY	$\overline{Y}$	$\overline{S/N}$
A	A_1	131 + 75	51.5	33.88
	A_2	80 + 49	32.25	29.88
	total		83.75	
B	B_1	131 + 80	52.75	34.16
	B_2	37.5 + 24.5	31.0	29.61
	total		83.75	
C	C_1	131 + 49	45.0	32.01
	C_2	75 + 80	38.75	31.76
	total		83.75	

Signal-to-Noise response table

Factor	A	B	C
Level 1	33.88	34.16	32.01
Level 2	29.88	29.61	31.76
Difference	4.00	4.55	0.25

Conclusions

Factor	Level 1	Level 2	Reason
A: Oven Temperature	325	375	Significant difference (>3dB) Select larger S/N
B: Cooking time	12 min	15 min	Significant difference (>3dB) Select larger S/N
C: Cookie size	Small	Large	Slightly higher S/N, could go either way

For More Information

Study

Reliability Improvement with Design of Experiments

By Lloyd W. Condra

Questions?

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Design of Experiments

Robust Design