

Tech Tool Talk: Swap Tests



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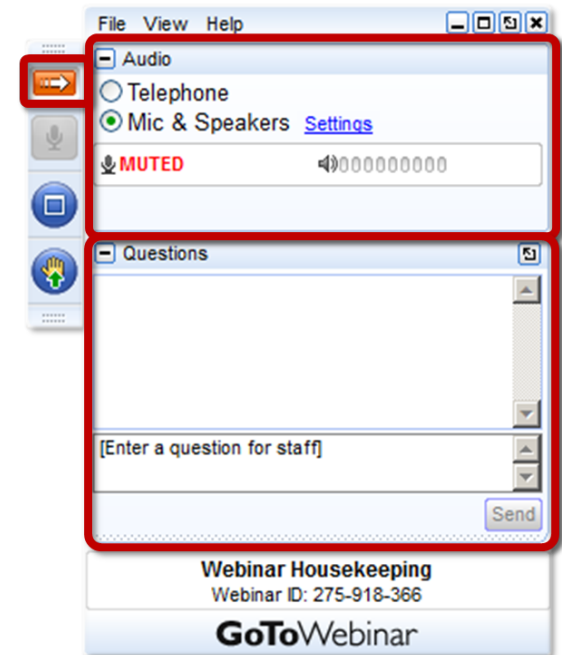
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- Welcome
- Introduction of MBB Webcast Series
 - Ellen Milnes
- “Tech Tool Talk: Swap Tests”
 - Kevin Keller
- Open Discussion and Questions



About Our Presenter



Kevin Keller, LSS Master Black Belt

- Anheuser-Busch InBev MBB
- Masters of Applied Statistics
- BS Chemical Engineering



Scenario

- Production is humming along day after day. Nothing has changed but all of a sudden some defect shows up.
 - Random / Infrequent
 - Can't be easily traced
 - Can't see it until the product is tested/evaluated at the end of the line
 - No idea where it is coming from



Designed Experiments

- Reflex action is to design experiment to isolate cause of defect
- However, in this scenario DOE is not possible or desirable
 - Process is not stable
 - Number of variables is not manageable for screening DOE's
 - Occurs under normal process conditions

Typical DOE framework is not appropriate



Real Scenario



- Customer reported that our product was failing intermittently
- Although producer had product traceability when the product was sent, at this point in the customer process product traceability was lost
- All product sent to customer tested out as “in specification”
- All product sent to that customer tested out as not being significantly different than similar product sent to other customers, and no complaints were received
- Did not have the ability to process the product to detect the defect



Swap Test

- Working together with the customer, a swap test was run
- Product traceability was managed at the customer
- Results: Some product failed while other product was defect-free
 - When the results were compiled, the defect was coming from the first major process of the four major processes
 - Further investigation showed that even though the product was in specification the specification was incorrectly assigned
 - Ultimately there was an interaction between the product and the customer's processing equipment which explained why no other customer saw it
 - The specification was changed and the problem went away

Without the swap test methodology, the root cause likely would have never been found and the supplier likely would have lost the customer.



Swap Tests

- Methodical approach
- Simple to design
- Flexible for any number of processes
- Designed to identify which process is contributing to the observed defect
- Uses binary response (defect exists or not)
- Requires only arithmetic. No statistical software or statistics necessary
- Can be used in batch manufacturing operations
 - Not conducive for continuous operations

Two (2) Process Swap Test Design

Master Batches

		Batch 1	Batch 2
PROBLEM	Process 1	A B	C D
	Process 2	A D	C B

		Batch 1	Batch 2
PROBLEM	Process 1	A B	C D
	Process 2	A D	C B

Three (3) Process Swap Test Design

Master Batches

		Batch 1	Batch 2	Batch 3
PROBLEM	Process 1	A B C	D E F	G H I
	Process 2	A H I	D B C	G E F
	Process 3	A H F	D B I	G E C

		Batch 1	Batch 2	Batch 3
PROBLEM	Process 1	A B C	D E F	G H I
	Process 2	A H I	D B C	G E F
	Process 3	A H F	D B I	G E C

		Batch 1	Batch 2	Batch 3
PROBLEM	Process 1	A B C	D E F	G H I
	Process 2	A H I	D B C	G E F
	Process 3	A H F	D B I	G E C

Four (4) Process Swap Test Design

Master Batches

		Batch 1	Batch 2	Batch 3	Batch 4
PROBLEM	Process 1	A B C D	E F G H	I J K L	M N O P
	Process 2	A N O P	E B C D	I F G H	M J K L
	Process 3	A N K L	E B O P	I F C D	M J G H
	Process 4	A N K H	E B O L	I F C P	M J G D

		Batch 1	Batch 2	Batch 3	Batch 4
PROBLEM	Process 1	A B C D	E F G H	I J K L	M N O P
	Process 2	A N O P	E B C D	I F G H	M J K L
	Process 3	A N K L	E B O P	I F C D	M J G H
	Process 4	A N K H	E B O L	I F C P	M J G D

		Batch 1	Batch 2	Batch 3	Batch 4
PROBLEM	Process 1	A B C D	E F G H	I J K L	M N O P
	Process 2	A N O P	E B C D	I F G H	M J K L
	Process 3	A N K L	E B O P	I F C D	M J G H
	Process 4	A N K H	E B O L	I F C P	M J G D

		Batch 1	Batch 2	Batch 3	Batch 4
PROBLEM	Process 1	A B C D	E F G H	I J K L	M N O P
	Process 2	A N O P	E B C D	I F G H	M J K L
	Process 3	A N K L	E B O P	I F C D	M J G H
	Process 4	A N K H	E B O L	I F C P	M J G D

How to Swap:

Example of a three process swap test design

Master Batches

Batch 1

Process 1 A B C

Process 2 A H I

Process 3 A H F

Batch 2

D E F

D B C

D B I

Batch 3

G H I

G E F

G E C

Three mini-batches
within a master batch



Example

- A manufacturing operation has four processes
- Intermittent, random defects were found at the end of the line
- Based upon the defect, it was not clear which process was generating the defect, so the plant didn't know where to start
- A four process swap test was employed
- After conducting the swap test, the product was evaluated at the end of the line
 - Mini-batches A, B, C, D, I, J, K, L had defects
 - Mini-batches E, F, G, H, M, N, O, P did not have defects

Example

		Batch 1	Batch 2	Batch 3	Batch 4
PROBLEM	Process 1	A B C D	E F G H	I J K L	M N O P
	Process 2	A N O P	E B C D	I F G H	M J K L
	Process 3	A N K L	E B O P	I F C D	M J G H
	Process 4	A N K H	E B O L	I F C P	M J G D

	Master Batch 1				Master Batch 2				Master Batch 3				Master Batch 4			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Process 1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
Process 2	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1
Process 3	1	0	1	1	0	1	0	0	1	0	1	1	0	1	0	0
Process 4	1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1

Process 1	4	0	4	0
Process 2	1	3	1	3
Process 3	3	1	3	1
Process 4	2	2	2	2

If the mini-batch had a defect, it gets a 1.

If the mini-batch did not exhibit defects, it gets a 0

For each Master Batch, sum each row

The row that has 0's and 4's is the problem process

Swap tests are not always successful in isolating the defect due to the infrequent nature of the defect appearing

		Probability of Successful Swap Test						
		Master Batches						
Prob (Defect)	Prob (No Defect)	2	3	4	5	6	7	8
0.01	0.99	2%	3%	4%	5%	6%	7%	8%
0.05	0.95	10%	14%	19%	23%	26%	30%	34%
0.10	0.90	18%	27%	34%	41%	47%	52%	57%
0.20	0.80	32%	48%	59%	67%	74%	79%	83%
0.30	0.70	42%	63%	75%	83%	88%	92%	94%
0.40	0.60	48%	72%	84%	91%	95%	97%	98%
0.50	0.50	50%	75%	88%	94%	97%	98%	99%

Example: If a three process swap test was run with three master batches and the defect rate was 20%, the test would have a 48% chance of determining the problem process. If it was repeated a second time, the likelihood would increase to 74%

The more master batches run, the more likely the defect can be detected

The more likely the defect, the more likely the process creating it can be identified



Limitations

- ▶ Time-sensitivity between processes
- ▶ Defect would turn on and off within a Master Batch
- ▶ Product Traceability
- ▶ “Batch” sizes going into a “Master Batch” (or lot)



Conclusions



- These designs offer Operations the ability to run carefully designed experiments to pinpoint the source of intermittent defects without disrupting regular production.
- Since no variables are altered all product is saleable (no qualifications of “special” or “test” material required)
- Using the knowledge of the frequency of the defect, the number of general Process areas and associated constraints, the experiment can be designed to maximize potential success.
- These tests can be expanded to any size, limited only by Operations’ ability to manage the test, time between process limitations, and work-in-progress (Production Control).
- These tests could be expanded across supplier and customer boundaries if necessary

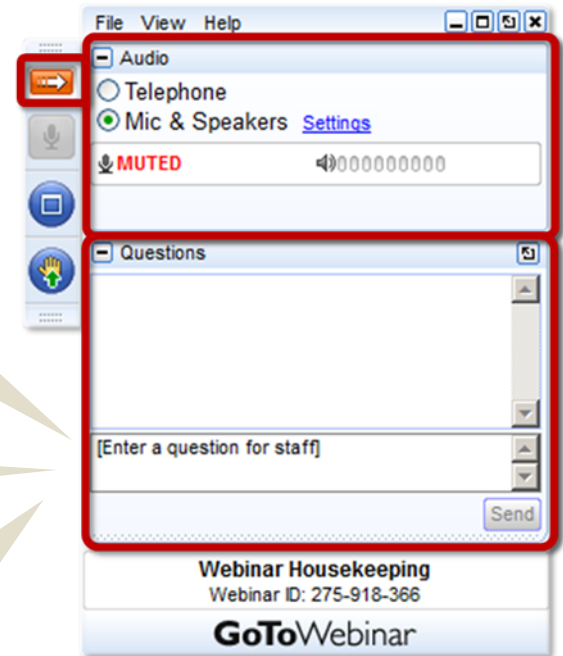
Questions



How have you handled

Have you ever encountered

Would you explain how you've approached



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The screenshot shows the homepage of MoreSteam.com. At the top left is the logo, a blue gear with a white 'M' inside, followed by the text 'MoreSteam.com®'. To the right of the logo is the tagline 'The Engine Room of Continuous Improvement'. In the top right corner, there is a 'Contact us' link, a search bar with the placeholder text 'search keywc', and a 'Login' button. Below the login button are fields for 'username' and 'password', and a link for 'Forgot Username/Password?'. A navigation bar below the login section contains links: 'HOME', 'ABOUT US', 'E-LEARNING & SOFTWARE & CERTIFICATION TECHNOLOGY', 'BLENDED LEARNING', 'KNOWLEDGE CENTER', and 'MORESTEAM UNIVERSITY'. The main content area features a large image of a woman in a red shirt working on a laptop. Overlaid on this image is the 'EngineRoom' logo and the text: 'Web-based Data Analysis Software', 'We built it with a drag-and-drop interface so you can concentrate on the analysis.', and '- Smita Skrivaneek, Product Manager'. To the right of the image, the number '508,114' is displayed in large green font, with the text 'The number of professionals that have trained through MoreSteam programs.' below it. Further down, a section titled 'POPULAR PRODUCTS' lists four items: 'Black Belt Training', 'Green Belt Training', 'EngineRoom', and 'TRACtion', each preceded by a small gear icon. At the bottom right of this section is a 'View All Products' link. The footer of the main content area contains the text 'More flexibility. More capability. MoreSteam.' with five small dots above it.

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Join us next month – Wednesday, May 18th
“Project Completion – Why Is It So Hard?”
Lutz Tückmantel, LSS Master Black Belt

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