One Factor Experiments

{Source: Chapter 5, Moen, Nolan, and Provost, Improving Quality Through Planned Experimentation, McGraw-Hill.}

Typical Analysis Steps:

1. Plot a run chart or control chart of the data with the factor levels indicated.
2. Reorder the run chart according to factor level.
3. Remove the effects of the background variables and plot the adjusted data by factor level.

Using the Control Chart for a One-Factor Experiment

Passive mode: wait until a change in the effect and then determine causes. (visualize cause-and-effect diagram)

Active mode: change one or more causes and observe the change in the effect.

Example:
A company wants to determine the effect of clamp pressure on a critical dimension. A control chart of the process indicates the process is in control for the past 6 weeks.

Response variable: Dimension variation.
Factor to study: Clamp pressure at 20, 40 and 80 pounds.

Examined over four days. Starting with current pressure and then randomized change of factor level. Look x-bar and R control chart as shown below.

Second Example

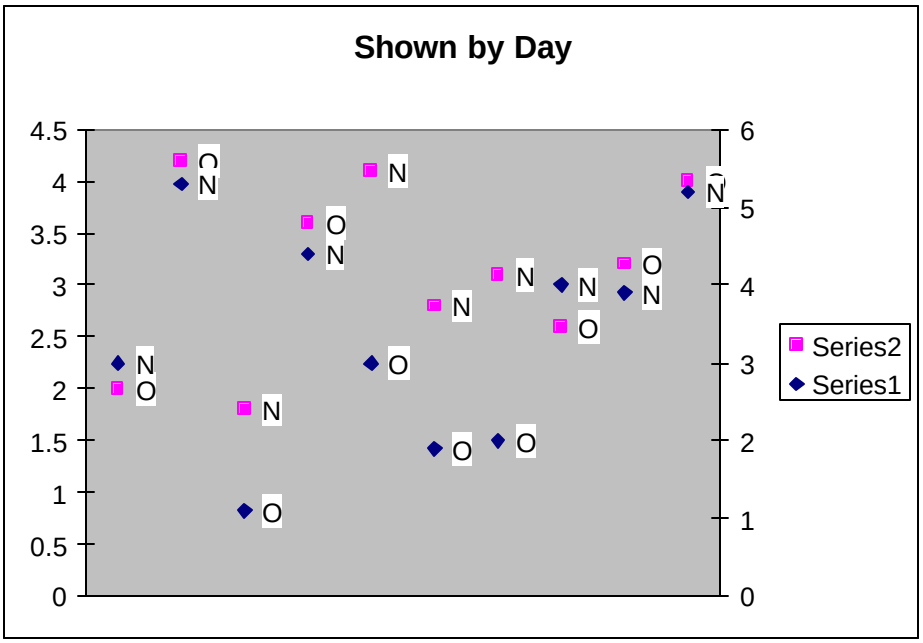
An operator in a machining section has suggested an alternative way to set up the machine to increase tool wear. The single factor to be studied is set up procedure. The factor is studied at two levels: current and new. The response variable is the wear rate of the tool.

An important background variable is the quality of the blanks of steel prior to machining. The blanks are purchased in lots representing a single heat at the foundry with each lot large enough for one shift's production in the machining section.

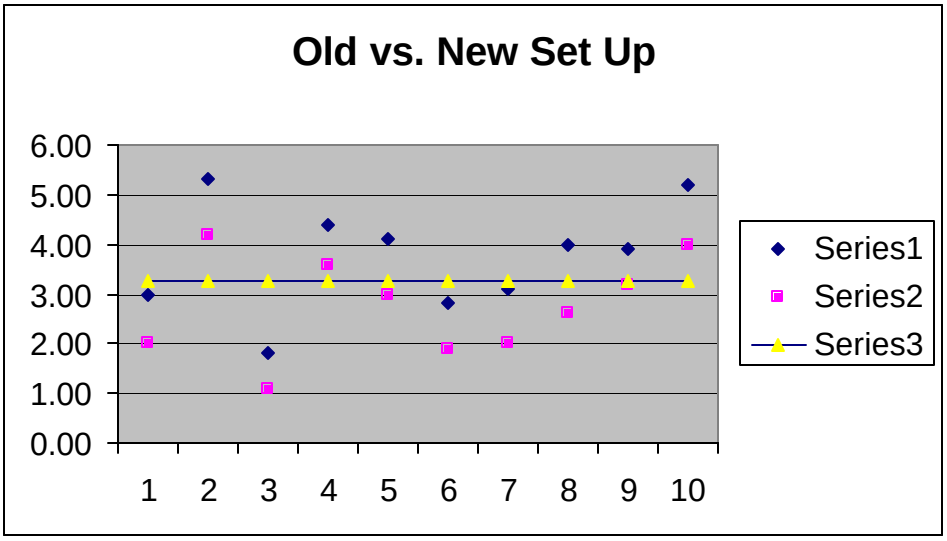
A paired-comparison experiment was used for the study. Each shift was designated a block. The two set up procedures were paired on each shift, and each used for a four-hour period. The assignment of a particular set-up to the first or second four-hour period was done by flipping a coin. The experiment was run for ten days. Four parts were selected every 15 minutes, and a critical dimension was measured. From this data a procedure was used to calculate the wear.

We first look at the data and a run chart.

Day	Prior 4 hrs Set Up	Tool Wear	Second Set Up	Tool Wear	AVG FOR DAY
1	N	2	O	3	2.5
2	N	4.2	O	5.3	4.75
3	O	1.8	N	1.1	1.45
4	N	3.6	O	4.4	4
5	O	4.1	N	3	3.55
6	O	2.8	N	1.9	2.35
7	O	3.1	N	2	2.55
8	N	2.6	O	4	3.3
9	N	3.2	O	3.9	3.55
10	N	4	O	5.2	4.6
					3.26



Reordered data to group the levels of the factor together.



In a paired-comparison experiment it is possible to remove the effect of the background variable, but still evaluate the factor of interest. This is done by computing the average of the response variable for each block and then subtracting the appropriate block average from the original data. Then the overall average of all data is added back to keep the data in the original units. The run chart of adjusted wear rates shows a clear difference. The old procedure was around 3.75 where the new procedure is around 2.76.

	Old Set Up				**New Set Up**			
Day	Wear	minus Daily Avg	plus Overall Avg	Adjusted	Wear	minus Daily Avg	plus Overall Avg	Adjusted
1	3.00	2.50	3.26	3.76	2.00	2.50	3.26	2.76
2	5.30	4.75	3.26	3.81	4.20	4.75	3.26	2.71
3	1.80	1.45	3.26	3.61	1.10	1.45	3.26	2.91
4	4.40	4.00	3.26	3.66	3.60	4.00	3.26	2.86
5	4.10	3.55	3.26	3.81	3.00	3.55	3.26	2.71
6	2.80	2.35	3.26	3.71	1.90	2.35	3.26	2.81
7	3.10	2.55	3.26	3.81	2.00	2.55	3.26	2.71
8	4.00	3.30	3.26	3.96	2.60	3.30	3.26	2.56
9	3.90	3.55	3.26	3.61	3.20	3.55	3.26	2.91
10	5.20	4.60	3.26	3.86	4.00	4.60	3.26	2.66
			Average	3.76			Average	2.76