Case Study: White Millbase Dispersion Process

Automotive paint plant -- batch processing of white millbase.

Process begins by charging a sand grinder premix tank with resin, pigment, and other additives. Premix agitated. Small portion of slurry pumped thru sand grinder. Grinder output checked for fineness and gloss.

Batch may require adjustments (additions of pigment or resin) to achieve acceptable gloss. Batches require too many adjustments (adjustment/test takes 4 hours).
Quality Characteristic: Weight / Gallon

Overcharge of pigment (high density): too heavy
Overcharge of resin (low density): too light

Wts. from 30 consecutive batches recorded

Artificial sample size of 2 used.

See Table 11.1
\[ \bar{X} = 14.311 \]

\[ \bar{R}_m = 0.294 \]

\[ d_2 = 1.128 \text{ for } n=2, \text{ so estimate of } \sigma_x \text{ is } 0.294 / 1.128 = 0.261 \]

\[ LCL_R = 0 \cdot 0.294 = 0 \]

\[ UCL_R = 3.27 \cdot 0.294 = 0.963 \]

\[ LCL_X = 14.311 - 3(0.261) = 13.528 \]

\[ UCL_X = 14.311 + 3(0.361) = 15.094 \]
Chart Interpretation

- Generally can only use 4 of the rules on both X and Rm charts since no guarantee that Xs are normal.
Since X’s look normal -- can use all 8 rules.

Charts show no statistical signals -- process is in control

Only common causes present -- but, variability is way too high.

Study team re-examined process. Cause & effect diagram constructed.

Better method needed to help selecting amount of pigment to add. Batch adjustment chart established based upon experimental study. Single ash test used with chart to ascertain amount of pigment to add.
• Lots of evidence that system has changed.

• Process variability reduced

• Process mean reduced and now very close to target value.

• Re-chart only most recent data (after use of batch adjustment chart begins)
Conclusion

- Process is in control

- System has been changed -- level of common cause variability has been reduced.

- Average pigment level lowered by 2% -- Big $$$ saved

- First gloss check often met specs -- Big hours saved

- Batch-to-batch variation reduced by 1/3

- Similar approach can be applied to other processes
More on Control Charts for Individuals

Remember -- only makes sense to use such charts when the formation of a rational sample has no meaning.

The consequences of working with X and Rm charts.....

Very difficult to detect small shifts in the process mean or variability. Also, the charts are not independent of one another.

How to detect small shifts??
Exponentially Weighted Moving Average Control Charts

Basic concept:

\[ \text{Moving Average}_i = r \times X_i + (1 - r) \times \text{Moving Average}_{i-1} \]

or

\[ A_i = r \times X_i + (1 - r) \times A_{i-1} \quad \text{Using our definition}.... \]

\[ A_{i-1} = r \times X_{i-1} + (1 - r) \times A_{i-2} \quad \text{plugging this in} \]

\[ A_i = r \times X_i + (1 - r) \times [r \times X_{i-1} + (1 - r) \times A_{i-2}] \]