presentation is that fractional factorial designs can be laid out with less effort. This way of presenting fractional factorial designs uses orthogonal arrays, linear graphs and interaction tables. Variations to this way of presenting fractional factorial designs have been suggested by Tsui (1988), Wu and Chen (1992) and Robinson (1993).

In contrast, Taguchi's method called "accumulation analysis" has been shown to be inferior to the alternatives and should be ignored. See Hamada and Wu (1990) and the subsequent discussion.

I agree with Banks and with Box (1985) that industry should try to profit from Taguchi's insights but not suffer loss by copying inefficiencies.

Comment

William H. Woodall

This paper by David Banks serves a useful purpose in provoking discussion of some important ideas in industrial statistics. Many of Banks' comments are needed to counter some of the more exaggerated claims of those overselling TQM, SPC and designed experiments to industry. The audience of the paper is most likely to be academic statisticians who are not heavily involved in industrial applications. Because some readers may not be familiar with industrial statistics, I offer a much different view of process monitoring and control charting.

CONTROL CHARTING

Banks' radical, and perhaps overstated, opinion is that most research on control charting is useless and work in the area should be discontinued. This opinion is based, however, on an unrealistic premise. Although I agree that much of the information regarding process performance could be obtained by appropriate time series plots, knowledgeable process engineers are very rarely, if ever, available to regularly review plots and think about process performance. In industrial applications, one or more less-experienced operators are responsible for maintaining a number of charts. Increasingly, the charts are computerized. Under these conditions, a process engineer is called in only if a chart exhibits unusual behavior calling for investigation. With operators or computers, guidance in the form of control chart rules is required. Although there is no substitute for knowledge of the process, the fact that some decision rule is needed for ongoing monitoring is an unavoidable fact of life in practical applications. Much of Banks' criticism of research on control charting appears to stem from the assumption that no decision rules are needed with a time series plot to form a control chart.

Given that some rules are needed, the issue becomes rule selection. Standard Shewhart charts with 3σ limits are the most commonly used charts in industry. These charts have served industry well, but they are often used inappropriately. They can be very misleading in some applications, such as those involving autocorrelated data or several components of common cause variability.

Banks' brief description of the EWMA control chart is not accurate. He states that the EWMA chart of Roberts (1959) "examines residuals from a forecast of the process based on the discounted past." Actually, the EWMA control chart has limits which are based on the assumption of independence of the observations over time. It is easy to confuse this traditional EWMA chart with the forecasting methods recommended by Montgomery and Mastrangelo (1991) for autocorrelated data.

With the exception of that of Reynolds et al. (1988), Banks dismisses research on control charting as having corrupted a good idea. Since Banks chose work on the trend rule by Davis and Woodall (1988) as an example of misguided theoretical particularization, let us briefly summarize the contribution of this paper so that the reader can decide if Banks' view is correct. A trend rule signals that a process is not in statistical control if a specified number of consecutive points on a Shewhart chart are either all increasing or all decreasing. The trend rules were added to improve the detection of gradual drifts, or trends, in the mean. The trend rule based on seven points is one of two supplementary rules recommended by Deming (1986, p. 321). This rule is also widely used in the automobile industry in the U.S. and Europe. Davis and Woodall (1988) show, however, that the trend rule is ineffective in detecting trends in the underlying mean of the process. With the underlying variability of the quality characteristic, the Shewhart control limit is almost always crossed before

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