with ease and their nature quickly analyzed. Sometimes our simple tests failed at first to give a clear indication of the presence of assignable causes. This was to be expected, since from their very nature, statistical tests occasionally reject true hypotheses or fail to reject false ones. One of our great problems is to adjust significance levels so that both types of errors are reduced to an economic minimum.

In each of the cases considered the use of rational subgrouping provided samples which revealed the presence of the trouble introduced. Wherever chance subgrouping was applied, results were obtained which were easily explainable on the basis of chance. This was a matter of good luck, as there was some probability, as previously noted, that the reverse situation might have eventuated.

In conclusion, the hope is expressed that the methods outlined in this paper may prove of some slight help in increasing the general understanding of statistical methods for the control of quality. Although many of our larger companies have been using these methods with beneficial results, some organizations have been hesitant to try them until their engineers could examine the theory more closely and gain more knowledge of its operation. Perhaps this discussion will be of assistance in that direction.

Discussion

G. J. Meyers, Jr.[22] The question was asked in connection with this paper why statistics were used to show things which would have in any case become observable in the course of the normal use of common sense. This question seemed to the writer to be quite in order, since it is one being asked many places by manufacturing people who are being told about statistical methods of quality control. The reason behind the question is that, in describing statistical methods, it is often necessary to use conditions which are sufficiently extreme to enable the average person to see the gain made by the use of statistics. In actual use, statistical methods are applied to borderline cases where the answers are not as obvious as in those cases which are only used as examples of statistical methods.

Statistical methods serve as landmarks which point to further improvement beyond that deemed obtainable by experienced manufacturing men. Hence, after all obvious correctives have been exhausted and all normal logic indicates no further gain is to be made, statistical methods still point toward a reasonable chance for yet further gains; thereby giving the man who is doing trouble shooting sufficient courage of his convictions to cause him to continue to the ultimate gain, in spite of expressed opinion on all sides that no such gain exists.

Author's Closure

Mr. Meyers reports that the question was asked why statistics were used to show things which would have in any case become observable in the course of the normal use of common sense. In so far as I understand the question, I quite agree with the answer he has suggested. However, a certain amount of clarification of the question and amplification of the answer seems to be in order.

I am not clear as to what is meant by "common sense" or the "normal use" of it. If this is translated as being the ordinary use of good judgment, then I must assert that, in my opinion, any judgment, to be good, must be arrived at by the collection and correct interpretation of pertinent facts. But the science of statistics is concerned with the collection, classification, and interpretation of numerical data. It would seem, then, that good judgment about quantitative matters must be based on statistics of some sort. As to the amount and type of the arithmetical calculations necessary, this seems to depend somewhat on the relation of its cost to the value of increased precision in discrimination between possible decisions.

Let us look at the data given in Table 1 (*b*) of the paper. Without any statistical theory, how can we decide whether or not it came from a controlled process? We are restricted from assuming that the samples in any way represent the lots from which they were taken; we cannot compute any measure of central tendency or dispersion; we cannot even think about any expected number of defects in samples of size twenty. With these aids to jugment ruled out, I doubt that we can reach any decision in which we would have much confidence.

Judging from past experience, I suspect that the real point at issue is not the desirability of the use of some statistical principles and techniques but of the use of such elaborate ones. "If the process has been averaging 8 defects out of 20 pieces, cannot anyone see, without a control chart, that something must be wrong when there are 16 defects in a sample of 20?" is the usual question.

It would seem that the proper rejoinder would be the following interrogations:

1 Just what chain of reasoning leads to the inescapable conclusion that something must be wrong?

2 Would you say that something was wrong if there were 15 defects? How about 14 or 13 or 12? Where would you draw the line, and why?

3 Would 16 defects out of 20, 8 defects out of 10, or 4 out of 5 give you equal assurance that something was wrong? Why or why not?

Anyone who gives careful consideration to these question should begin to perceive that one needs to have some systematic knowledge of the kind of samples different sorts of lots are likely to produce. Having such knowledge, he is likely to agree that the methods of control-chart analysis provide efficient application of it. And, since many industrial organizations have been able to save money and material by the use of these methods, it would seem to be uncommonly bad common sense not to try them.

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