PART I

GENERAL

CONTROL CHARTS: AN APPLICATION IN SHRIMP CANNING

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INTRODUCTION

The produced items in any production process will not be all identical in every respect. Certain amount of variation in any quality characteristic is inevitable. This variation is considered to be due to the operation of chance causes, tracing and elimination of which are not economical and hence generally not attempted. This type of variation is thus taken as the inherent variation associated with the process. Another kind of variation, the causes of which lend themselves to economical elimination by suitable remedial action to obtain a more uniform end product, is the one caused by what are known as assignable causes. Thus a production is affected by one or both of chance and assignable causes. The process is said to be under control when chance causes only are operating. In addition, if assignable causes are also present in the process, it is said to be out of control. Thus it is important to find out whether a process is under control or not. Control chart is a statistical tool which can be employed with advantage to learn the situation in the process (whether it is under control or not). There are different kinds of control charts but one which is most commonly used is the control chart for variables, known as $\overline{X}$-R chart. This chart can be used for measurable characteristics in food industry like appearance, colour, sizes, dimensions etc, for chemical properties such as moistuse, fat etc and many other analytical counts and measurements. Since construction and maintenance of such charts involve a recognizable amount of time and effort, they should not be used indiscriminately but only where it can be definitely shown that their use improves the overall operation. Since one control chart can be used for only one quality attribute, those for which the charts are used should be selected with care (Kramer and Twigg, 1962). In this article, the procedure of setting up a variable control chart is described with observations taken on filling operation of cans in a shrimp canning factory.

PRELIMINARY CONTROL LIMITS

The chart consists of two parts, one for average weights of sampled cans, known as $\overline{X}$ chart and the other for the variability in the sample, the R chart. To start with, preliminary control limits for both these charts are to be worked out. The contents of each can of a fixed sample size from the processing line are to be weighed at particular intervals till observations on atleast ten sets are collected. Generally each set consists of 5 cans and the interval for the observations is taken as 20 to 30 minutes. After making sufficient number of observations in the above manner, calculations for setting up preliminary limits are to be carried out. The average for each set ($\overline{X}$) given as the sum of observations divided by the number of units in the set and the range for each set (R) given by the difference between the maximum and minimum values of the set are noted. Next we have to work out $\overline{\overline{X}}$ and $\overline{R}$ which are the mean of means and mean range respectively. $\overline{\overline{X}}$ is the value obtained by summing the individual averages and divided by the number of sets and $\overline{R}$, the sum of ranges divided by the number of sets. These two values give the values of central lines for the respective charts. The control lines for each of the charts are obtained through the following calculations (UCL and LCL imply upper control limit and lower control limit respectively).

$\overline{X}$ chart UCL: $\overline{\overline{X}} + A_2\overline{R}$

LCL: $\overline{\overline{X}} - A_2\overline{R}$

R chart UCL: $D_4\overline{R}$

LCL: $D_3\overline{R}$

A_2, D_3, and D_4 are values which depend on the number of units included in each set (the number of units in each set should remain same throughout). For the sample size of 5, their values are A_2: 0.577, D_3: 0 and D_4: 2.114.

The preliminary limits thus obtained and the central lines are drawn in the charts and the average and range values are plotted in the respective charts. If any of the averages used for the calculation of the preliminary limits lies above UCL, that particular set of observations is discarded, the limits are recalculated with the rest of the data and the procedure repeated till a set of lines, which contain between them the average and range values of the sets used for the calculation of the preliminary control limits are obtained. It is however important to see that atleast 10 sets (preferably 20) of observations are used to calculate the preliminary control limits. Thus the control chart for variables is got ready which can be used subsequently to locate any trouble in the process when it crops up.

Procedure for maintenance of control charts

Observations from the processing line are to be continued as before and the average and range for each set obtained are to be plotted on the charts. Action is indicated when a point goes above UCL or below LCL on $\overline{X}$ chart and above UCL on R chart. If the point is above UCL on $\overline{X}$ chart the fill can be reduced and if it is below LCL, it has to be increased. If the point for any set is above UCL on R chart there is erratic weighing in some individual can. It has to be watched further and if the out of control situation continues, the cause of trouble has to be traced and suitable action taken to rectify it. If points on control charts show out of control situation, it is advisable to take observations more often at frequent intervals, so that if the out of control situation is confirmed, remedial action can be initiated.

A set of data obtained on the fill-weights from a shrimp canning factory is used here to explain the procedure of calculations for control charts. The data recorded for each set give the weights of shrimps (in grams) for a can over and above the actual intended fill-weight.

TABLE I PRELIMINARY LIMITS FOR CONTROL CHARTS: OBSERVATION TO THE NEAREST GRAM OVER THE MINIMUM FILL-WEIGHT

	I	II	III	IV	V	VI	VII	VIII	IX	X
	7	5	8	9	6	8	3	8	2	4
	9	8	5	6	11	5	7	4	6	3
	8	6	10	10	9	12	9	5	7	4
	6	6	9	10	5	7	5	3	5	5
	6	5	9	8	10	5	8	4	8	4
Sum	36	30	41	43	41	37	32	24	28	20
$\overline{X}$	7.2	6.0	8.2	8.6	8.2	7.4	6.4	4.8	5.6	4.0
R	3	3	5	4	6	7	6	5	6	2

$\overline{\overline{X}}$: 7.2 + ... + 4.0/10 = 66.4/10 = 6.64 $\quad$ A_2 : 0.577 $\quad$ D_3 : 0 $\quad$ D_4 : 2.114

$\overline{R}$: 3 + ... + 2/10 = 47/10 = 4.7

$\overline{X}$ chart: UCL: $\overline{\overline{X}} + A_2\overline{R} = 6.64 + 2.71 = 9.35$

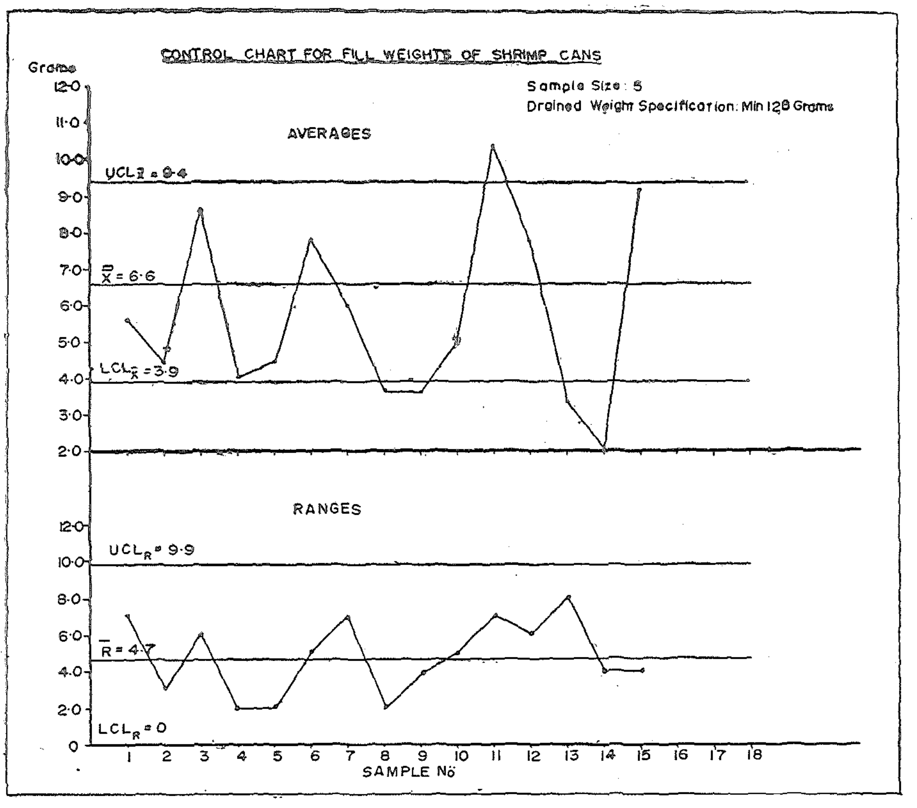
LCL: $\overline{\overline{X}} - A_2\overline{R} = 6.64 - 2.71 = 3.93$

R chart: UCL: $D_4\overline{R}$: 9.94

LCL: $D_3\overline{R}$: 0

TABLE II FURTHER OBSERVATIONS ON FILL-WEIGHTS.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
	9	6	7	4	4	10	5	5	5	5	15	12	4	4	10
	8	5	6	5	4	8	7	3	5	2	11	6	-2	3	9
	5	4	10	4	4	5	10	3	1	7	9	6	5	1	11
	4	3	12	4	4	9	3	4	4	5	8	7	4	2	9
	2	4	8	3	6	7	5	3	3	6	9	8	6	0	7
$\overline{X}$	5.6	4.4	8.6	4.0	4.4	7.8	6.0	3.6	3.6	5.0	10.4	7.8	3.4	2.0	9.2
R	7	3	6	2	2	5	7	2	4	5	7	6	8	4	4



All calculations are carried out in the tables explained above and the charts are also given to illustrate the procedure. Tables I and II give the data used for calculation of preliminary limits and those for follow up of the chart, respectively. The $\bar{X}$ chart shows certain out of control points which were brought under control subsequently. No out of control point was countered on R chart for these observations.

Action is called for not only when the points fall above or below the control limits, but also where they exhibit a trend by consecutively six or more points falling on the same side of central line in either of the charts. When such a trend is made out on the $\bar{X}$ chart, the limits are to be recalculated with the latest observations. This may effect savings in material. A similar trend in R chart above central line means certain individual observations are not in line with others. That calls for rectification. If on the other hand the trend is below the central line on R chart, limits are to be recalculated which means savings in material.

Where there is minimum specification for fill-weight, the LCL on $\bar{X}$ chart should be adjusted accordingly. In canned shrimps, the specification refers only to minimum drained weight. Hence this aspect is not being covered in this article. A comprehensive description of the procedure for different kinds of control charts, the kinds of action to be taken under different conditions and the adjustments necessary in the filling process to suit the minimum specified fill-weight are dealt with in the references cited at the end. Application of control charts to filling performance in particular has led to good deal of savings of material in many industries. The application of control chart, however, need not be restricted to the filling performance only. It can be applied at different stages of

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processing, chosen with discretion, to get an end product of uniform quality.

REFERENCES

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