Improving Quality in Cars by Reducing Variation

Ford and Mazda were producing similar transmissions that were supposed to be made with the same specifications, but it soon became apparent that the Ford transmissions required many more warranty repairs than the Japanese-made Mazda transmissions. Ford researchers investigated this and found that their transmissions were meeting the required specifications, but the *variation* in the Ford transmissions was much greater than those from Mazda. Mazda was using a better and more expensive grinder, but the increased cost was offset through fewer warranty repairs. Armed with these important results, Ford made changes and proceeded to not only meet the required specifications but to improve quality by reducing variation. (See *Taguchi Techniques for Quality Engineering* by Phillip J. Ross.)

Table 14-2 Control Chart Constants

n: Number of Observations in Subgroup	R Chart		$\bar{x}$ Chart		s Chart	
	D_3	D_4	A_2	A_3	B_3	B_4
2	0.000	3.267	1.880	2.659	0.000	3.267
3	0.000	2.574	1.023	1.954	0.000	2.568
4	0.000	2.282	0.729	1.628	0.000	2.266
5	**0.000**	**2.114**	**0.577**	**1.427**	**0.000**	**2.089**
6	0.000	2.004	0.483	1.287	0.030	1.970
7	0.076	1.924	0.419	1.182	0.118	1.882
8	0.136	1.864	0.373	1.099	0.185	1.815
9	0.184	1.816	0.337	1.032	0.239	1.761
10	0.223	1.777	0.308	0.975	0.284	1.716

Source: Adapted from *ASTM Manual on the Presentation of Data and Control Chart Analysis*, © 1976 ASTM, pp. 134–136. Reprinted with permission of American Society for Testing and Materials.

The values of D_4 and D_3 were computed by quality-control experts, and they are intended to simplify calculations. The upper and lower control limits of $D_4\bar{R}$ and $D_3\bar{R}$ are values that are roughly equivalent to 99.7% confidence interval limits. It is therefore highly unlikely that values from a statistically stable process would fall beyond those limits. If a value does fall beyond the control limits, it's very likely that the process is not statistically stable.

Example 3 *R* Chart of Weights of Quarters

Construct a control chart for R using the weights of quarters listed in Table 14-1. Use the samples of size $n = 5$ for each of the 20 days of production.

Solution

Refer to Table 14-1 to see that the sample ranges are listed in the last column. $\bar{R}$ is the mean of those 20 sample ranges, so its value is found as follows:

$$\bar{R} = \frac{0.155 + 0.186 + \cdots + 0.602}{20} = 0.2054$$

The centerline for our R chart is therefore located at $\bar{R} = 0.2054$. To find the upper and lower control limits, we must first find the values of D_3 and D_4. Referring to Table 14-2 for $n = 5$, we get $D_4 = 2.114$ and $D_3 = 0.000$, so the control limits are as follows:

$$\text{Upper control limit:} \quad D_4\bar{R} = (2.114)(0.2054) = 0.4342$$
$$\text{Lower control limit:} \quad D_3\bar{R} = (0.000)(0.2054) = 0.0000$$

Using a centerline value of $\bar{R} = 0.2054$ and control limits of 0.4342 and 0.0000, we now proceed to plot the 20 sample ranges as 20 individual points. The result is shown in the Minitab display shown on the following page.