

Parallel processes and SPC

1. Introduction

One of the most common practical problems in a SPC implementation is how to setup control charts for parallel processes.

There are a large number of production situation where there are parallel processes:

- Multiple cavities with injection or blow moulding or glass production
- Multiple spindles in battery production
- Multiple heads with can production
- Multiple positions with the filling processes in the bottling industry
- Multiple lanes in food industry
- Etc etc

This list is almost endless.

SPC theory is quite clear: If you have a different process with different variation you should make separate control charts for each separate process. In practice however this is not so easy because with for example injection moulding of performs the number of cavities can be 96 or even more. If you would measure 2 or 3 dimensions it would mean you have 192 control charts with 2 dimensions for just 1 mould. So there must be alternatives to define a sampling plan and still be able to find differences between parallel processes.

The way to setup your control charts is very much depending on the type of variation which is found in the process.

2. Variation and parallel processes

When you have parallel processes there are typically 3 types of variation in the process. In figure 1 an example is given of 4 parallel processes where batteries or cans are produced and you want to measure dimension of the product.

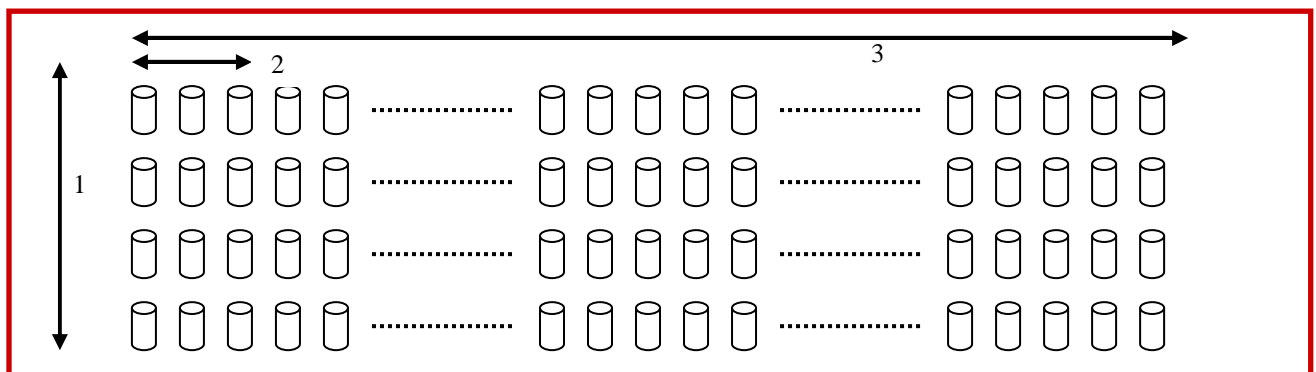


Figure 1: 4 parallel processes with 3 types of variation

The 3 types of variation in this example are:

1. Variation between processes
2. Cycle to cycle variation
3. Variation in time

The best way to analyze the data is to make a control chart per process with a subgroupsize of for example 3. This means in one control chart you see the variation between cycles as the within subgroup variation. The variation in time is the between subgroup variation. The variation between processes can be analyzed by comparing results like Cpk and Ppk for different charts. In paragraph 3 we will explain how you can compare processes in DataLyzer Spectrum.

But in a lot of cases making the analysis like this is not economically feasible so in most of these cases the subgroups are taken across parallel processes. Taking subgroups across processes also makes sense if the cycle to cycle variation is small compared to the 2 other types of variation. Applying the second method can also be chosen after a certain amount of time when the process is completely in control and all special causes of variation are eliminated.

If we take subgroups across parallel processes from the example in figure 2 we get a subgroupsize of 4 and the range chart is showing us variation between processes and the control chart is showing us variation in time. We are missing the cycle to cycle variation completely and also Cpk and Ppk values are representing other results than you normally have if you combine consecutive products in a subgroup but this discussion is out of the scope of this whitepaper. If you setup your SPC software like this you still want to be able to analyze the variation for one specific process. In paragraph 4 we will explain what tools DataLyzer Spectrum has available to make this analysis.

In practice you can also use a combination of these methods by using separate charts in case you have out of controls on the range chart but the combination of methods is not making it easier for operators in practice.

3. Comparing different control charts for the same characteristic of parallel processes

In DataLyzer Spectrum there are several tools to compare data of different charts:

- Combined capability report (See figure 2)
- Bat chart report (See figure 3)
- Correlation analysis
- Multiple chart screens (See figure 4)
- Special summary reports to compare parallel processes or similar machines
- Calculation functions

The methods in DataLyzer SPC software gives the engineer more then enough possibilities to compare processes. If it is important to monitor the average different parallel processes an extra chart can be easily created which simply calculates the average of the other charts.

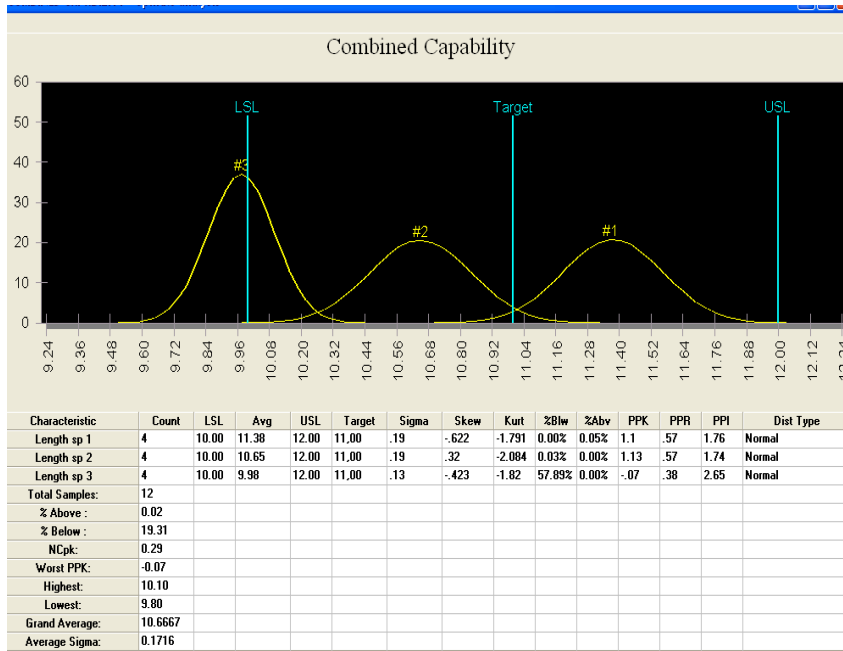


Figure 2: Combined capability

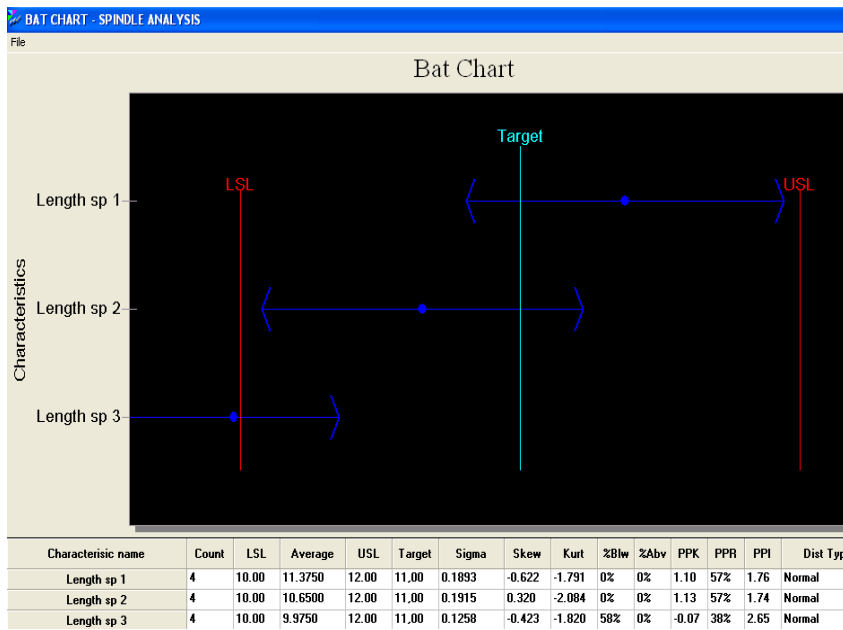


Figure 3: Bat chart report

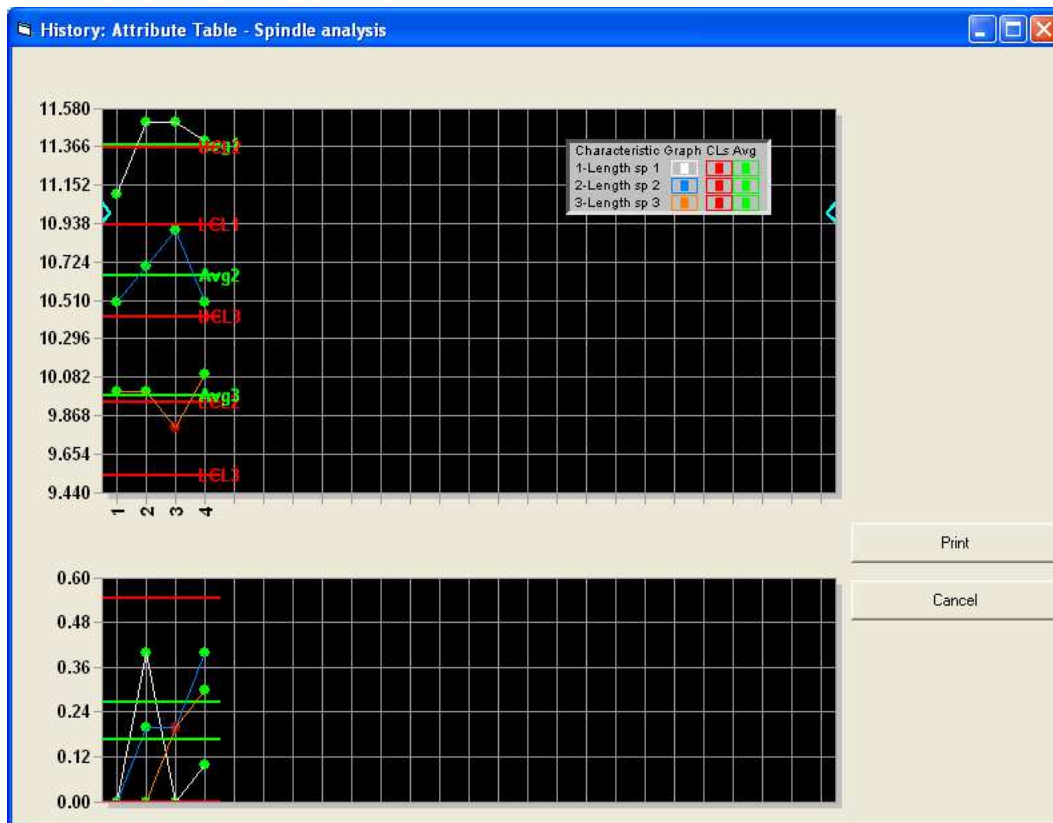


Figure 4: Multiple chart report

4. Comparing parallel processes within a subgroup

DataLyzer Spectrum has several features available to show the variation between processes if they are combined within one subgroup.

- High Low readings visible in chart (See figure 5)
- Multiple readings per chart (like figure 4)
- Correlation analysis
- Option to show control chart for selection of processes
- Bat chart with option to show deviation from process average and select a specific number of subgroups
- Optional parameter indicating process number

The chart showing the highest and lowest reading shows the lines for the maximum and minimum values in the subgroup and puts the process number next to it. If you see the same number too often you need to investigate that specific process because the process average is deviating from the overall average. Next step could be to analyze the data with the batchart.

To compare processes the operators or engineer often start by showing the individual measurements in a data table (Figure 6) and from this data table the user can select which rows and columns he wants to include in the analysis. Let's say the user wants to see the variation between parallel processes for the last 3 subgroups. The user highlights the 3 subgroups and selects the batchart report. In figure 7 you see the results.

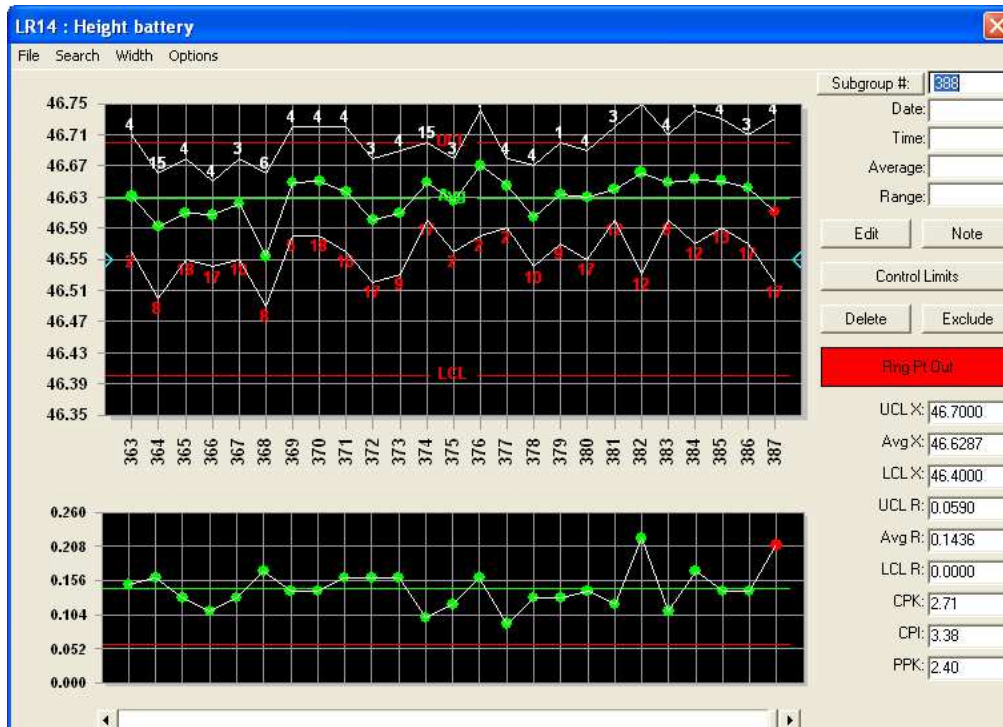


Figure 5: Highest and lowest parallel process indicated in the chart

LR14 : Height battery

Options

	382	383	384	385	386	387
Control Chart	3-2006	7-3-2006	8-3-2006	9-3-2006	10-3-2006	13-3-2006
Capability Analysis/Pareto	6:55:58	06:55:40	06:42:58	06:54:41	07:07:37	07:19:33
Bat Chart	217	4217	4217	4217	4217	4217
Print						
Search...						
Export to Excel Spreadsheet	46.66	46.66	46.64	46.62	46.64	46.63
Exit	46.67	46.65	46.62	46.63	46.63	46.57
	46.57	46.69	46.70	46.70	46.71	46.64
Samp#4	46.69	46.75	46.71	46.74	46.73	46.67
Samp#5	46.61	46.69	46.64	46.64	46.63	46.67
Samp#6	46.64	46.66	46.61	46.66	46.66	46.63
Samp#7	46.63	46.72	46.63	46.64	46.64	46.65
Samp#8	46.64	46.69	46.60	46.65	46.61	46.64
Samp#9	46.62	46.64	46.61	46.63	46.63	46.64
Samp#10	46.62	46.68	46.64	46.63	46.65	46.62
Samp#11	46.66	46.68	46.68	46.64	46.65	46.63
Samp#12	46.60	46.53	46.62	46.57	46.65	46.60
Samp#13	46.63	46.67	46.67	46.72	46.59	46.68
Samp#14	46.62	46.68	46.67	46.65	46.68	46.63
Samp#15	46.68	46.66	46.66	46.65	46.67	46.69
Samp#16	46.68	46.69	46.69	46.69	46.67	46.62
Samp#17	46.61	46.60	46.62	46.63	46.65	46.57
Samp#18	46.64	46.66	46.62	46.65	46.66	46.63

Figure 6: Data table

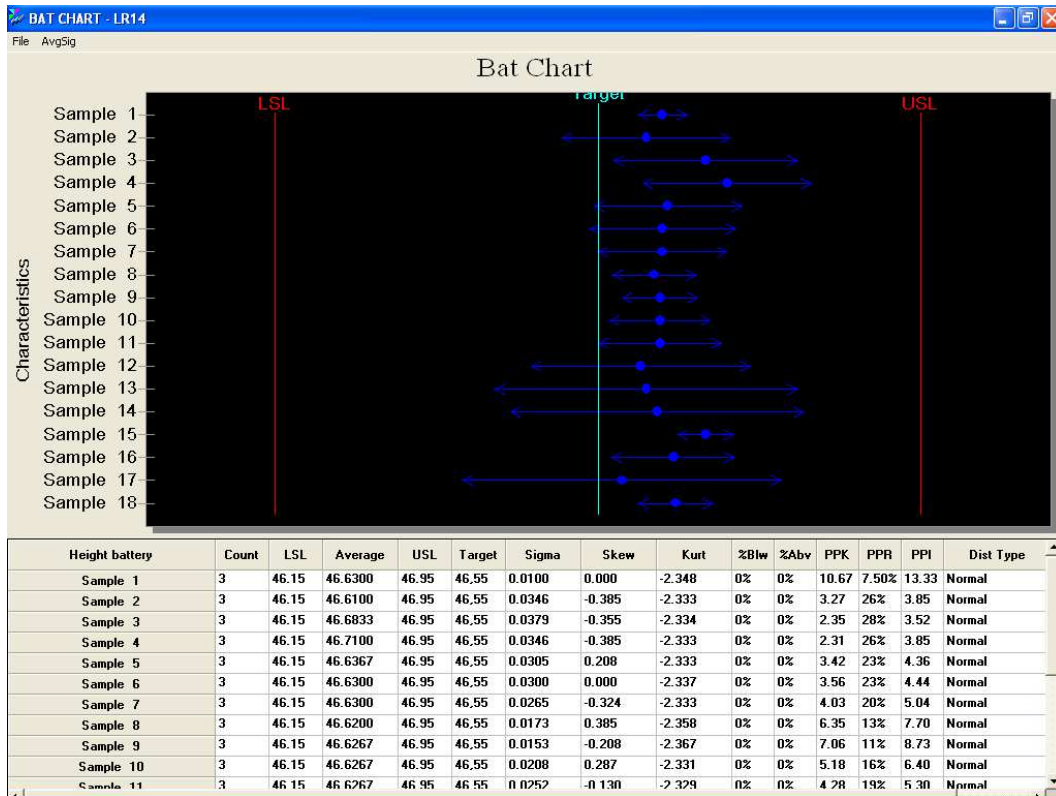


Figure 7: Bat chart of different subprocesses

The problem with this batchart is that if you want to correct an individual process you don't know exactly how much you need to correct the individual process.

The blue dot shows the average of the subprocesses and in the graph you can see how far the individual process is from the target. In the example you see for example for process 1 that the average is 46.63 and the target is 46.55 which means process 1 is producing 0.08 above target. The problem however is that this deviation from target is the sum of the total deviation of the whole process (machine) from target + the deviation of the individual process from the process average.

To see how much the individual process needs to be corrected we would like to see the average of the process compared to the process average of the total machine and we would like to see the variation of the measurements from process 1 to the subgroup averages to check how reliable it is to make the correction based on the measurements.

To see this new graph click in the menu option of the batchart on avgSig. A new batchart will appear

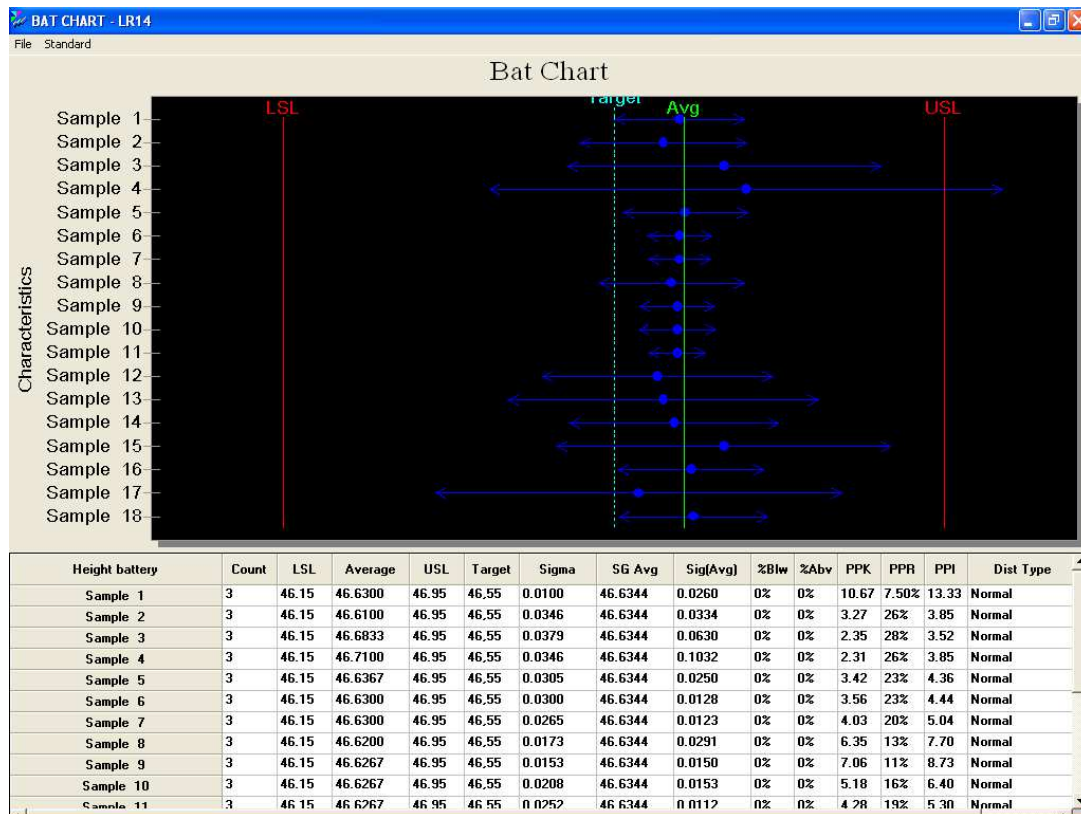


Figure 8: Averages and standard deviation per subprocess compared to subgroup averages

In this bat chart you will see the average of the process in a green line. The target is visible in a dotted light blue line. The arrows now show 3 x the standard deviation of the individual measurements from the subgroup averages.

For example if you have 3 subgroups and the value of measurement 1 is 3 times exactly the same as the subgroup average then the standard deviation would be 0 in this graph.

5. Exceptional situations

If you select a specific method to apply SPC in case of parallel processes you have to take into account that there are exceptional production situations which will influence the results or reduce the efficiency of the SPC solution implemented. For different types of industry there are different exceptions but we limit ourselves here to 2 common exceptions:

1. One of the subprocesses is not active
2. The subprocesses are operating at a different level

Ad 1: In many situation in parallel processes one of the subprocesses is not active for example a blocked cavity in injection moulding, a lane which is not used with solar cell manufacturing, etc.

Your SPC program should allow you to efficiently handle these exceptions in real time on the shop floor.

Ad 2: If processes are operating at a different level and you combine subprocesses in one subgroup and you are not able to eliminate the difference, this will strongly influence the calculations of your control limits. In this case you have to use a different method of calculating your control limits. There is a separate white paper available on the website.

6. *Final comments*

DataLyzer Spectrum facilitates SPC for parallel processes in many ways including handling all the exceptions efficiently. The most important aspect of setting up a correct SPC method is to analyze the 3 types of variation and take into account what the consequences are of selecting one of the two methods or a combination of these methods. Consequences need to be defined in terms of time and money for measurements but certainly also user friendliness and acceptance of the chosen method by the organization and customers.

If you have any questions please contact DataLyzer International

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