Technique Review – Short Run SPC

Symphony Technologies
Planning, Design & Analysis

With consumers' tastes changing frequently, companies are forced to adopt small batch production schedules. To conduct SPC studies on these short runs, where the batch may get over before sufficient data is collected, is a new challenge. We need to focus on the actual Process Parameters that produces the part rather than the traditional method of measuring a part characteristic to control the process. This technique review is based on Thomas Pyzdek's famous book - The Six Sigma Handbook.

Preamble:

This technique review is based on ‘The Six Sigma Handbook ’ by Thomas Pyzdek. We are grateful to Mr. Pyzdek for granting us permission to use the information from his world-class book.

The Need

Statistical Process Control has been run on mass-producing and long spanning processes. The traditional view of SPC has been as shown in the figure 1 below:

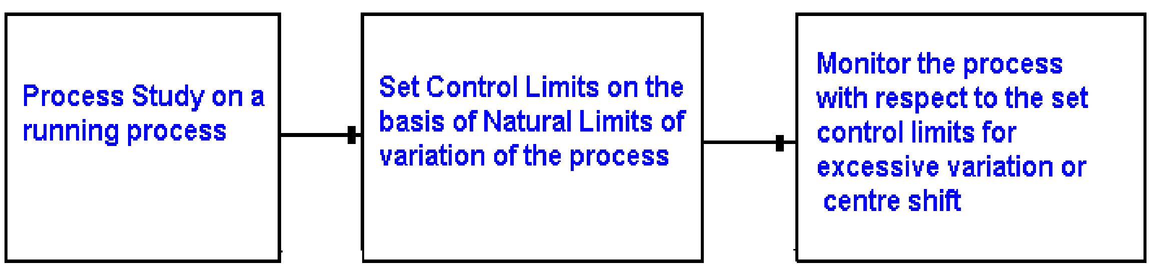

Figure 1

In the age of JIT the batch sizes are becoming smaller by the day, many times reducing to even one component. Adding to this is the need for a greater variety for any product. This too makes production runs smaller, reducing them to a few components in a batch.

Production and Quality personnel are very often faced with a situation where the production run is over before adequate process study data is gathered. The SPC initiative thus ends before any tangible results are seen.

Special considerations are needed for implementation of SPC under such circumstances.

Emphasis on Planning

A Quality improvement process as visualized by Juran classifies the activities in three sequential phases:

- Planning Phase.
- Control Phase.
- Improvement Phase.

Short run SPC focuses strongly on the Planning Phase, since the control phase has to be a short one. The process has to be brought under control 'by design ', that is at the process design stage.

Pyzdek emphasizes on the need to do a lot of pre-production research to identify and deal with as many potential causes of variation as possible. The production run thus starts with a well-planned process.

One of the important aspects of the planning phase is to prepare a matrix relating parts and the processes that can produce them. Every part thus has a set of documented 'Approved Processes' that can produce it. Similarly every process is associated with an 'Approved Parts List' based on the parts the process is capable of producing.

The above relationship is based on Process Capability index Cpk. For the detailed explanation on Cpk, refer to the article on Process Capability [http://www.symphonytech.com/articles/processcapability.htm] by Dr. M. M. Kapadia, published on our website.

Since we are dealing with short runs, it is not likely that the mandatory minimum number of readings (typically 50 raw data points) will be available for process capability computation. The acceptability criteria based on Cpk thus need to be modified. Pyzdek recommends the process spread to be treated as $\pm 4\sigma$ instead of the usual $\pm 3\sigma$. Also the acceptable Process Capability index should be Cpk = 1.5 instead of the traditionally accepted 1.33.

Process Focus

It is important to note the SPC stands for Statistical Process Control and not Statistical Product Control. The focus thus needs to be on the Process than the product. Unfortunately, most of the SPC initiative is directed towards the product characteristics that are perceived as Critical to Quality. Small batch sizes for each of such products thus become major hurdles in SPC implementation.

It is actually the process that produces a product that is responsible for the Quality of the output. Once we realize this, we start focusing on process characteristics irrespective of which variety of product it produces. For example, a cylindrical grinding process will have it's own process characteristics while machining a certain grade of steel. The process centering or spread will be fairly independent of which specific variety of a product comes out of the cylindrical grinding process. The process centering or variation will be governed by a small number of process control elements (like speed of machining or in-feed or coolant temperature). Thus process control can be performed to span across dissimilar jobs.

Short Run SPC Techniques for Variable Data:

Thomas Pyzdek describes the major approaches to Short and Small runs.

He describes a short runs as ones that get over fast. These may produce a large number of units, but the runs are short by the virtue of their high production rate. Small runs are defined as runs with small number of pieces. Again, these need not be short. A classic example stated is that of the Hubble Space Telescope program that produced only one piece but took 15 years to get it into orbit.

Approaches to Short and Small runs are:

1. **Exact Method:** Control Limits are calculated on the basis of production study carried out on limited number of subgroups. The constants used for calculating the control limits on limited data come from special tables. These control limits are updated as more data becomes available, until enough data is available to calculate control limits the regular way. The process control is thus implemented in three phases.

2. **Code Value Charts:** Code value charts are plotted on transformed data. They are typically created by subtracting the nominal from the reading so that they represent only the deviation from the nominal. Code value charts enable different parts from the same process or many features from the same part on a single control chart. In case the initial data is limited, the exact method can be used to compute the initial control limits. A typical example of these is a grinding process producing thread plug gauges, each gauge with a different nominal size.

3. **Stabilized Control Charts:** Stabilized control charts are scaled in such a way that they are independent of the unit of measure, and several different characteristics, irrespective of their units can be plotted on the same control chart. Stabilized control charts can be useful to get a overview of processes since they encompass a broad range of features of a process.

Detailed statistical treatment of the above techniques is not given in this text. For a detailed reference, please refer 'Process Control for Short and Small runs' under Intermediate Six Sigma Methods in 'The Six Sigma Handbook' by Thomas Pyzdek (2001).

One of the procedures in the above treatise, ' The Setup Approval Procedure' can prove to be very useful for determining whether a process setup is acceptable on the basis of small number of pilot samples. It is described below.

Setup Approval Procedure:

This procedure is used to determine if a process setup is acceptable on the basis of a small number of samples.

1. Perform initial setup. Run 3 to 10 pieces without disturbing or adjusting the process. This will reveal the natural variation in the process.
2. Compute the average and the range of the sample.
3. Compute
   T = (Average – Target value)/range
   Compute the absolute value, ignoring any minus signs.
   Target Value is the Nominal value
4. Compare T with the critical values given in the table below. If computed T is less than the critical T, accept the setup. Else adjust the setup to bring it closer to the target.

N	3	4	5	6	7	8	9	10
Critical T	0.885	0.529	0.388	0.312	0.263	0.230	0.205	0.186

Where, N = Number of pieces in the sample.

Note: There is a 5% risk that a process on target may fail this Setup Approval Test.

Conclusion:

SPC is a powerful technique that has been applied effectively on continuous and large batch size processes. Practitioners of Statistical Process Control must appreciate that the focus of an SPC initiative needs to be shifted from product characteristics to process parameters, as it is the process that builds quality into the product. With special considerations discussed above, and a process focus, SPC can be equally effective for small and short runs as well.

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