



Plotting a course through the fog

How Six Sigma resolved a complex manufacturing challenge and delivered record yields

Client Situation

A specialty chemicals plant in Frankfurt had been struggling to consistently produce product within specification for many months. The process itself involved six key steps: synthesis, methanol treatment, filtration and washing, drying, blending, and milling. The primary metric for the product, Mass Tone Purity, along with a number of secondary metrics, were designed to ensure the colour pigment being produced exactly matched customer requirements. However, in one campaign 65% of the batches failed to meet the primary metric specification and some of the secondary metrics were bordering on the edge of tolerance.

As a consequence of this, the company was incurring extra costs caused by sending the out-of-specification product to another organisation for additional drying treatment. The lead time was consequently extended and, to make matters worse, overall capacity was constrained on a product that was in short supply. If the company could make more product they could sell it.

Now obviously the people running the plant had a lot of expertise, were highly qualified chemists and chemical engineers, and had been working hard to bring the variables under control. Nevertheless, the solution had eluded them and the process was simply not delivering the required output consistently.

WCI were asked to provide a six sigma specialist to resolve the problem. The company had not used the six sigma methodology before so this was an opportunity to find out just how suitable it could be within their particular environment, as well as improving the performance on the specific production line.

A WCI Master Black Belt (MBB) was assigned to work with the plant team for a total of 20 man-days over a three month period to analyse the data, understand the variables and bring the process under control. The local personnel from the plant provided data and detailed knowledge of the process; they were not being trained in six sigma techniques as this would have extended the timescales too much, although they were engaged in the search for understanding root causes and identifying solutions.

WCI Solution

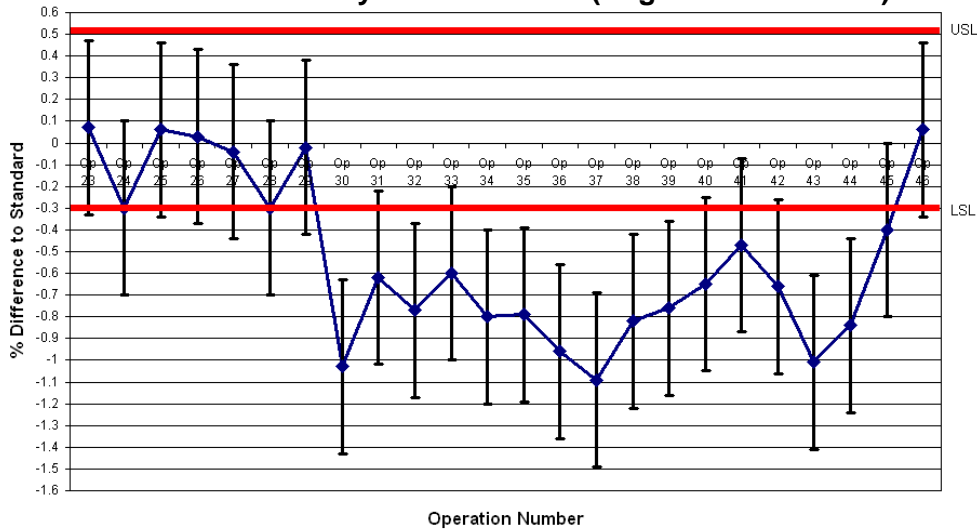
The MBB, who had no previous specific knowledge of the plant, followed the DMAIC¹ process and began by clearly defining the problem statement. Shortly afterwards he carried out an analysis of the measurement system to check the level of variability that was being introduced by the test process itself. This was accomplished by conducting an experiment with three operators to measure one good, one standard and one poor sample. Lacquer was mixed for each sample and these were then tested using the computer controlled measurement system. The results showed that although each operator was able to produce results consistent with their own tests, when they were compared with one another the variation was very significant.

¹ DMAIC identifies the standard five-step approach in six sigma methodology: Define, Measure, Analyse, Improve, Control

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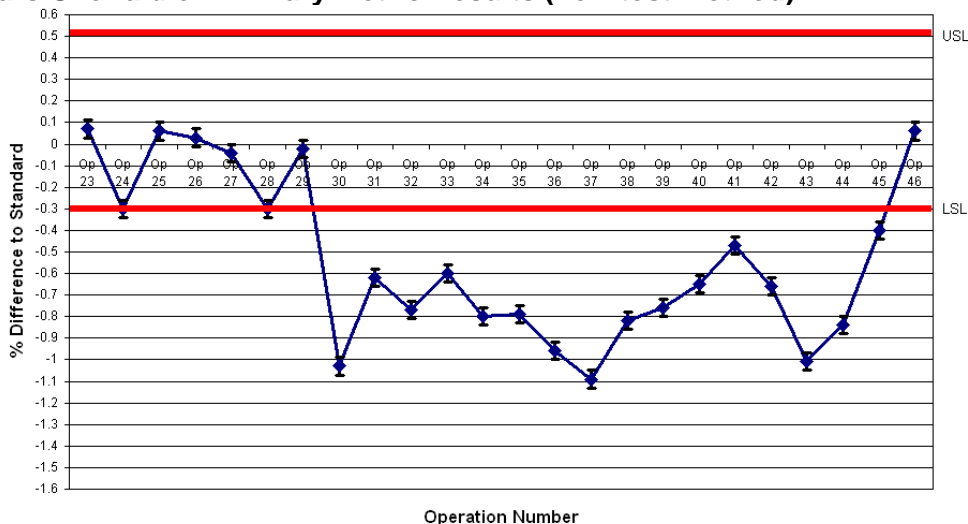
This is best illustrated by Figure 1 which shows the primary metric results overlaid with the error bars that the test variability would impose on them. From this it can be clearly seen that the measurement system variability was far too high, such that it was possible to pass product that should have been failed, and vice versa.

Figure 1: Error Bars Overlaid on Primary Metric Results (original test method)



Root cause analysis identified that the problem was caused by inadequate and inconsistent mixing of the test samples. A new, reliable mixing process was developed, operators were re-trained and a Standard Operating Procedure implemented. The DMAIC process requires statistical confirmation that solutions have truly resolved the problems identified, so the test was repeated using the new process and the comparisons made again. This time the results conclusively showed that the test variation was within acceptable levels (i.e. less than 10% of the overall variation) and that there was now almost no chance of introducing error from the measurement system itself. Figure 2 shows the same set of primary metric results re-plotted with the error bars associated with the new test procedures in place.

Figure 2: Error Bars Overlaid on Primary Metric Results (new test method)



Simplify what you do

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Having eliminated the measurement system error the real work began to try to correlate input parameters with variation in product characteristics. There was no shortage of ideas here, or indeed of data. What was lacking was real information and statistical evidence. So, the MBB set about looking for correlations in the data set, assisted by the use of powerful analytical software (MiniTab). Several possible root causes were eliminated when the analysis showed there was no statistically significant correlation present. Statistics is, after all, no respecter of personal hobby-horses or pet theories!

Relatively quickly, however, the key variables were identified and a series of experiments were designed to investigate the relationship between input variation and quality of product. There was some interdependency amongst the variables so the experiments needed to be carefully designed and were, in fact, initially carried out on a pilot plant. On completion the results were analysed and further trials conducted until a full production run could be carried out with the new parameters. The six sigma discipline was maintained, of course (after all, it was a MBB running the project!) and the output of the full production run statistically analysed. The results were impressive. The primary and secondary metrics were well within specification and the results proved to be highly repeatable (see Figures 3 and 4).

Figure 3: Primary Metric Improvement

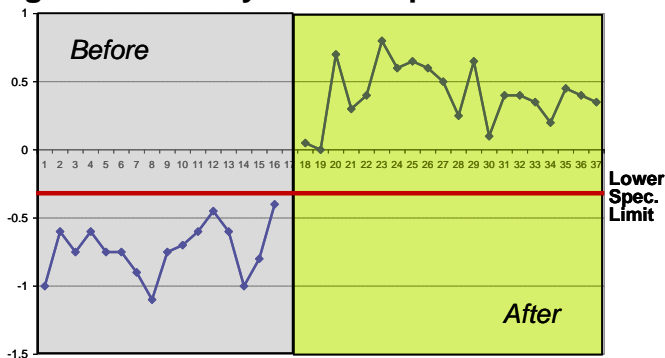
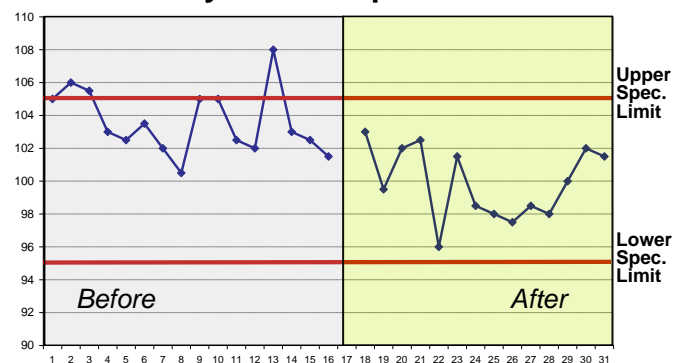


Figure 4: Secondary Metric Improvement



Benefits

With the process variables now well in control the cycle time was reduced by 26% and actual, realised capacity increased by a substantial 21%. The sales of the product had been constrained by manufacturing capacity and therefore the margin on the increased output went straight to the bottom line. There aren't too many projects that achieve a 20:1 return on consultancy fees, but this one did!

Needless to say the business was pretty quickly convinced of the applicability of the methodology and immediately made plans to use the approach elsewhere. In fact, over the next 12 months WCI trained almost 100 internal practitioners in the techniques so that the organisation could deploy them across a broad range of processes and, at the same time, become rapidly self-sustaining.

This case study demonstrates how well six sigma is suited to processes with complex variables, especially within a data rich (but information poor) environment where local expertise can be focused through this well structured, statistically based methodology.



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Client Testimony

Commenting on the project the Operations Manager said: 'This first optimization project was meant as a pilot study. Despite a multiplicity of process data collected by the control system there was no obvious solution to the problems of unstable quality and sub-optimal capacity. The very complex process chain was divided by the MBB into manageable parts and analysed using the DMAIC process. The cooperation of the MBB with our experts was excellent and all were highly motivated to improve the process. At the end of the six sigma project we had established process parameters which increased the yield and throughput, and led to the desired product quality. After this great success our company decided to continue with six sigma projects by qualifying own BB and GB.'

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