Making a difference: From consistently inconstant towards consistent constancy

Improving business success by managing process volatility through lean process capabilities

By Alexander Wirth and Thomas Teltscher

Lean Management and Six Sigma provides a powerful methodology to enable an organization to constantly deliver high quality products and services and sustainably improve business results.

A supplier needs to be able to supply constant product quality in the agreed delivery time and the quantity agreed. Random outcomes of a process that should run constantly, are not desirable. Instead, the target is to be able to rely on quality outcomes as a result of constant and efficient processes. This is one of the main ideas of lean management – maximizing customer value while systematically minimizing waste and creating higher customer value while consuming fewer resources. Six Sigma methodologies on the other hand focus on optimizing quality characteristics. Consequently, Lean Management combined with Six Sigma provides a strong set of methodologies and tools that can support businesses in the pulp, paper and packaging industry to reduce process volatility and variation.

The combination of Lean Management (resource efficiency) and Six Sigma methodologies (output quality improvement) enables achievement of a number of benefits. One of the key objectives is to reduce process variation and therefore reduce deviations from the intended results to the six sigma level. Being able to run consistently performing processes is highly beneficial, from both external and internal perspectives.

This article starts with an overview on top- and bottom line benefits of process constancy, briefly introduces the DMAIC methodology to improve and stabilize processes, touches on change management improvement principles and concludes in a Lean Six Sigma case study, highlighting how DMAIC and Six Sigma methodologies have been utilized to improve process capability in the industry.

Process constancy is key for top-line results…

The key external perspective for any business is the customer view. The target for every supplier should be to deliver products as ordered, in the right quantity, on-time, at the right location, in constant quality, and priced as negotiated. Volatile production processes often endanger those objectives. A lot of time and money is invested in mitigating the damage done to a business relation by faulty products or services. Multiple steps are frequently required if the first attempt fails. Customers make efforts in checking the quality of products supplied, and often go through claims processes that can be laborious for both, customer and supplier. Process constancy and capability can be utilized as a valuable sales argument and, in addition, allows for competitive pricing. Last but not least, customer satisfaction and retention rates increase, as customers will benefit from the high reliability of their business partners.

Process capability top-line benefits

- Improved business development capabilities
- Enabler for competitive pricing
- High customer satisfaction & retention

Figure 1: Top line benefits of process capability

…and is as well key for bottom-line results

Process constancy in production is key to avoid “Muda”. Muda (Japanese for uselessness; idleness; waste – compare Figure 2), is a key concept originating in the Toyota Production System to reduce deviation from optimal allocation of resources and can in good conscience be called best practice with a proven history.

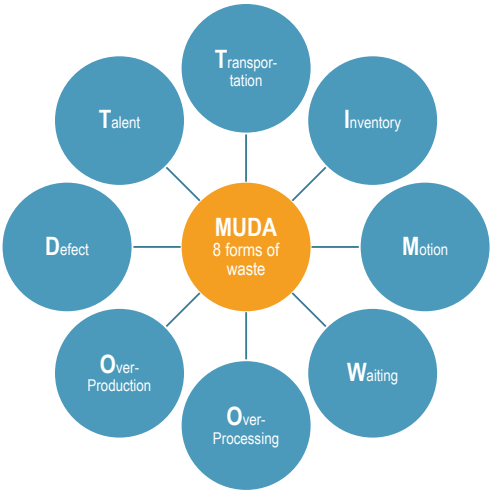


Figure 2: Muda - non value-adding activities waste resources, time and money

Benjamin Franklin and Henry Ford were pioneers in reduction of wastage, and Toyota refined the original ideas into an overall methodology. Activities to reduce Muda have proven to be effective in increasing a company’s success and profitability – but have often been not been applied in pulp, paper and packaging.

Achieving high performance levels with a process success rate of 99.7% (99.7% of data within 3 standard deviations from the mean) is the objective of the Six Sigma approach. The key internal benefit of applying process capability tools is to achieve a consistent quality and thus reduce costs. Saving opportunities are manifold across the cost base of pulp, paper and packaging companies, reaching from fiber and chemicals consumption via machine productivity to fixed personal cost.

Within a given environment, there usually is a "best way" of running a process. Dynamic environments have a big influence and may change the current "best way", like a shift in technology that may lead to new opportunities and additional improvements. The definition of the "best way" depends on the objectives of the process (target output), its factors (process input) and the trade-off to be made between these two. This trade-off is often of monetary nature, but not exclusively.

Taking into account the factors discussed above, the objective is naturally to run the process in a "best way" and to keep deviations within the defined boundaries. Any further deviation may result in material or time losses, additional processing requirements, or other "Muda". In other words, deviations from the "best way" will result in losses that are usually quantifiable in monetary terms.

The "best way" definition normally includes acceptable deviations. For example in paper production ranges for acceptable grammage variations on a paper machine may be +/-0,6%. It is crucial to objectively define and monitor such boundaries to ensure production at targeted levels.

It is important to mention that it is unrealistic to expect a 100% adherence rate to the "best way" and that no process is error free even if error rates can be reduced to an absolute minimum. A *sigma* rating indicates its yield or the percentage of defect-free products it creates. A six sigma level is one in which 99.99966% of all opportunities to produce some feature of a part are statistically expected to be free of defects. There are external circumstances that may be beyond control and may drive process deviations – therefore it is even more important to be ready to manage internal implications of such external effects. Further, human error cannot be fully eliminated – but it can be reduced to a minimum. Overall, 3.4 per one million opportunities are "allowed" to deviate from the "best way", based on the Six Sigma methodology.

The objective of Lean Management and Six Sigma in this context is ultimately to define this "best way" and to minimize deviations and "Muda". Lean Management focuses on the definition of the "best way", continuous improvement and the development of standard operating procedures. Six Sigma methodology supports this objective by providing analytical tools that measure deviation rates, analyze root causes and support the definition of actions to reduce deviations.

Quantification of improvement opportunities needs to be one of the first steps. The improvement opportunities usually vary across processes and across companies but typically range between 2%-20%.

Summary of process capability bottom-line benefits

- Less waste/inefficiencies
- Variable cost reduction
- Fixed cost reduction

Figure 3: Bottom-line benefits of process capability

Utilizing "DMAIC" to achieve top- and bottom line benefits

A clearly structured and predefined approach is necessary to provide an overall framework for the endeavor of establishing process constancy, and to successfully achieve top- and bottom line results. Besides, the approach needs to be fact- and data-based to neutrally and objectively deal with powerful subjective perceptions and impressions to take the "right" decisions. A well-known and highly practicable data-driven and collaborative improvement cycle used for improving, optimizing and stabilizing processes is "DMAIC" (**D**efine, **M**easure, **A**nalyze, **I**mprove, **C**ontrol), which can be applied in almost all business areas where process deviations need to be reduced. Applying DMAIC is a promising approach to improve process constancy and achieve top- and bottom-line improvements. The following key questions need to be answered in order to achieve relevant process improvements:

- To figure out what the problem is, you need to **define**...
  - …which business result should be improved (e.g. OTIF, PM waste, customer response time, LTI, etc.)
  - …what the target performance level is
  - …which processes are key for the business result in question
  - …what the scope of the improvement initiative is
  - …who needs to be involved directly, who the main stakeholders are, and which requirements they have
- To figure out how big the problem is, you need to **measure**…
  - …which KPIs the main drivers for the business result are and how they are currently measured
  - …how existing data and processes look like

  - …the meaningfulness and accuracy of current indicators

- To figure out what the reasons for the problem are, you need to **analyze**…
  - …what the current performance levels look like
  - …what the main issues and their root causes are
  - …which root causes can be controlled & erased
  - …what the overall effect will be
  - …if there will be any positive / negative side-effects on other metrics / processes

- In order to **improve** the situation, the solution approach needs to be shaped by assessing…
  - …how root-causes can be removed
  - …how new processes will look like
  - …who needs to be involved
  - …which responsibilities to be assigned to whom
  - …how the timeline needs to look like
  - …which risks exist and how they can be mitigated

- To obtain sustainability, you need to **control**…
  - …the institutionalization of the improved process
  - …the need for training that people require to stick to the new process
  - …the way how the process is documented
  - …which KPIs are monitored and how
  - …the development of the performance level
  - …if the targets have been met

Agreeing views on benefits, contrasting views on approach

There are contrasting views on the appropriate implementation approach to process constancy in the pulp, paper and packaging industry. Some focus strongly on very detailed assessment work in order to understand each and every detailed aspect prior to improvement work. Others suggest a more pragmatic and "high-level" approach. Similarly, some people suggest to first stabilize a process and then improve it later; others believe that both can be done in parallel in order to save time and achieve improvements more quickly. Independent of the preferred approach there are four key change management principles that are imperative to success when optimizing process constancy (compare Figure 4).:

1. clear target setting,
2. focus on value,
3. organizational buy-in
4. proper measurement

Key principles to successful change

- Ensure the **organization is convinced** of the initiative
  - Explain the initiative
  - Persuade people to give it a try
  - Provide space to experiment and to make mistakes
- Set **clear targets**
  - Define improvement scope
  - Communicate target performance
  - Explain reasoning
- **Focus** on **value**
  - Identify key business drivers and focus on them
  - Resist the temptation to be diverted
  - Implement quick wins to show effectiveness
- Use **proper measurements**
  - Identify current KPIs
  - Adjust them if needed
  - Measure constantly to provide improvement guidance

Figure 4: Key principles to successful change

Apart from following these principles, a value-driven approach that attempts to implement first improvements quickly turns out to be most successful. Some differentiation, however, needs to be made across the various levels of complexity across processes as well as the cultural background of the organization in question. Some company cultures might require more deliberation, analysis and discussion than others. Such cultural differences need to be respected; however, they must not be used as an excuse to delay or hinder improvements. Likewise, highly complex processes such as paper production with vast influencing factors and interdependencies, require extensive analysis in order to understand the specific drivers and the correlations between the different parameters.

Case study: Improving quality consistency in the paper production process

The following case study will provide insight into an assignment with the objective to improve operational efficiency and quality constancy and consequently reduce Muda in a paper mill in pulping processes and paper production. Several focus areas were identified in order to achieve this target – one of them was to develop process standards and exception handling procedures to reduce process variation. Lean Six Sigma methodologies including the DMAIC approach and process variation analysis were applied – the case study summarizes

the project approach, analysis conducted, methodology applied and results achieved.

After having defined the scope (pulping process and paper production) and the key stakeholders (pulping, paper production, customers), it was necessary to establish a performance baseline. Typical production KPIs, e.g. waste and broke, were already commonly used and tracked. These KPIs were used for internal and external benchmarking, analyzing how the KPIs had developed over the last three years. Based on this analysis, it was possible to create fact-based hypotheses of potential causal connections. As a simple example (but analyzed more complexly), the high variation in waste paper quality appeared to have a negative impact on paper production.

After establishing the hypotheses, they were prioritized collaboratively with the client. Workshops were held in order to identify drivers that were expected to have the biggest impact on process variation. These drivers were of external (e.g. raw material quality supplied to the mill) and internal nature (e.g. lack of standard operating procedures and process variations between shifts). Moving forward, the key drivers were examined in detail, following the main question: What are the root causes triggering these drivers?

In this case study, the variation of grammage of paper produced is taken as an example to describe process variation analysis. First, the online-measured paper grammage over time was analyzed and put in context to target, warning levels and upper (USL) and lower (LSL) specification limits as shown in Figure 5. Both, the high variation of grammage over time for one specific product, and the numerous violations of warning and specification limits can be impressively observed in the chart.

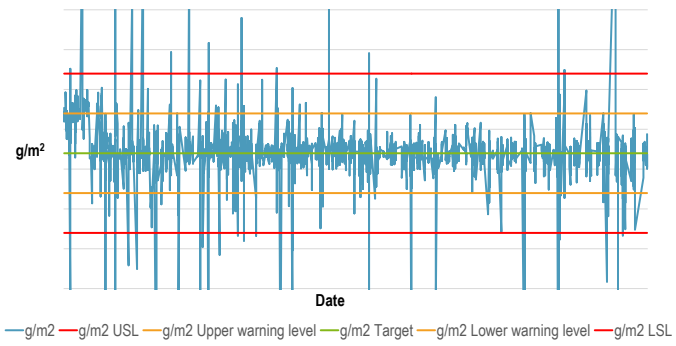


Figure 5: Process variation timeline

The variation of the moving average of paper grammage over time was analyzed and deviations from the mean were highlighted. Based on a snip of manufacturing data from Figure 5, this analysis is illustrated in Figure 6. In this specific time frame, four periods of significant grammage deviations can be observed.

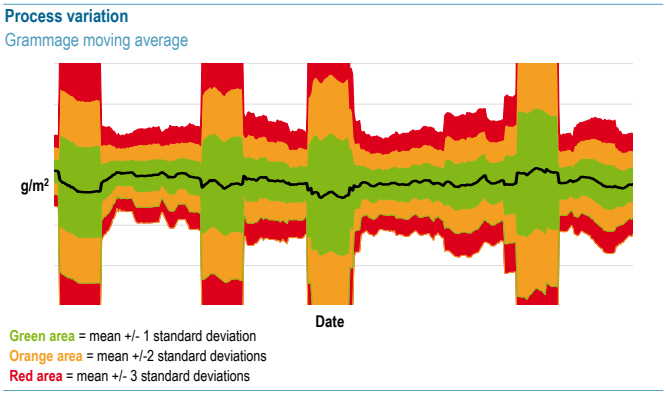


Figure 6: Process variation example

Alongside the workshops, further data analysis was conducted. As process variation had been identified as a key issue in production, appropriate KPIs had to be introduced in order to measure process variation properly. Two Six Sigma process capability measures were chosen to analyze process variation (Figure 7 showing further details)

- C_p measuring the process variation within given lower and upper specification limits, while "estimating", that the mean of the process is centered between the lower and the upper specification limit.
  - C_p=1: Process variation exactly equals the tolerance
  - C_p>1: Process variation is less than the tolerance
  - C_p<1: Process variation is higher than the tolerance
- C_{pk} measuring the process variation within given lower and upper specification limits, and its position around the average.
  - C_{pk} can never exceed C_p
  - The larger the C_{pk} index, the less likely it is that any item will be outside the specs

Six Sigma process capability measures

C_p measures the overall level of variation of a process.

"Is the process running on a constant level? How significant are variations?"

C_p is defined as [(USL – LSL) / 6*standard deviation] (a standard deviation estimator is often used).

USL (Upper Specific Limit) and LSL (Lower Specific Limit) define the boundaries for the desired process results. For example, a 45gsm paper might be allowed to weigh between 44,7 and 45,3 gsm and still be accepted.

C_{pk} measures the process deviation from the target level.

"How strongly does the process deviate from the target?"

C_{pk} is defined as min(Cp_{ku}, Cp_{kl}).
Cp_{ku} is defined as [(USL-Mean) / 3*standard deviation]
Cp_{kl} is defined as [(Mean-LSL) / 3*standard deviation]

C_p and **C_{pk}** are applicable to any process, as both are index figures. If both C_p and C_{pk} are above 1, a "Six Sigma level" is reached. Excellent processes achieve levels of 1,67 (meaning that 1 part per million is defect).

Both C_p and C_{pk} are important figures. For example, a high C_p value in combination with a low C_{pk} value means that a process is constant, but outside of the boundaries (see illustrations shown in Figure 8 for further examples), which is not desirable.

Figure 7: Six Sigma process capability measures

To determine whether a process runs constantly and within specification limits both C_p and C_{pk} need to be calculated. Figure 8 visualizes the importance of having both C_p and C_{pk} calculated to measure process constancy and derive the correct conclusions.

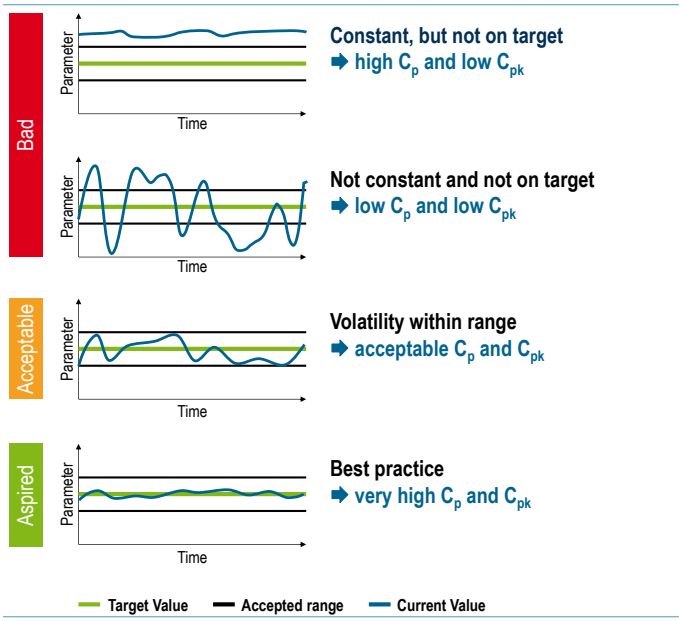


Figure 8: Illustration of Cp and Cpk – spread and deviation

Figure 9 shows the process capability parameters C_p and C_{pk} of the online measured paper grammage for same time frame as shown in Figure 6. Here, the four periods with significant grammage volatilities show up as periods of very low C_p and C_{pk} values indicating both low process constancy/high variations and even stronger deviations from the target.

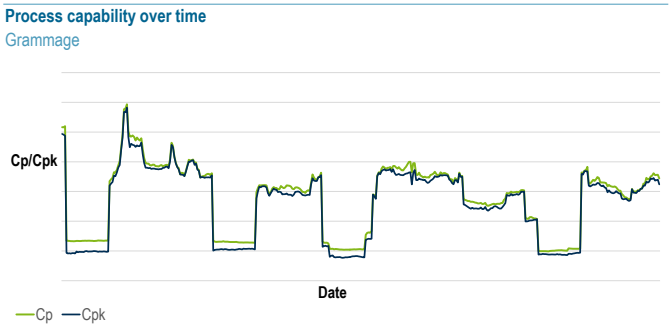


Figure 9: Process capability analysis

A correlation analysis with numerous parameters was conducted to identify root-causes for the volatility in grammage. Consequently, workshops with machine operators as well as other stakeholders were held in order to identify actions to manage/eliminate root-causes to consequently reduce process variation. Sample results included improved quality control of incoming raw material, standard operating procedures in pulping and paper production, changes in chemicals usage/dosage, etc.

A further key action was the inclusion of sales personnel in the project. Aside from production efficiency, a key concern was, of course, customer satisfaction.

Sales personnel helped the project in defining new USL and LSL values to meet customer requirements. It was identified that, in several areas, the boundaries had been actually set too broadly, i.e. the production process was allowed to deviate further from the target than what customers actually were willing to accept.

The **production department** took responsibility to follow the newly defined limits. Several standard operating procedures for the pulping process, the stock preparation process and the production process were developed and introduced to reduce exception handling / "firefighting" activities. A KPI based monitoring and reporting framework was introduced to transparently track developments and take counteractions if necessary.

The **Procurement department** introduced a KPI-based recovered paper quality control processes and tighter quality parameters. After implementing the process, proactive claiming, tracking and reporting of quality variations towards the production department became daily routines.

At last, a new reporting functionality was developed to allow for automatic monitoring of C_p and C_{pk} levels (in addition to the KPIs already in use). Improvements in process capability can now be monitored and deteriorations easily spotted and mitigated.

Conclusion

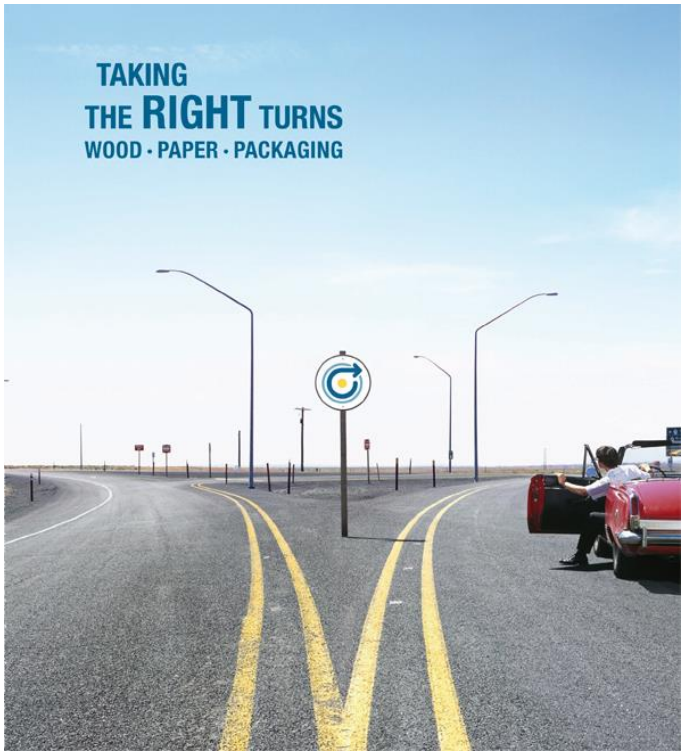
Being able to run key processes continuously within defined parameters is a key success factor in the highly commoditized pulp, paper and packaging industry.

Process constancy strongly supports safeguarding and improving the competitive position of a company by optimizing margins and therefore is an important enabler for overall competitiveness. Constancy is not only a driver for profitability, it also is critical in order to achieve customer satisfaction due to constant and reliable product quality and service.

Numerous parameters directly and indirectly affect process constancy, and those parameters need to be stabilized, monitored and managed. A collaborative, target oriented project approach is crucial to resolve issues and develop Standard Operating Procedures to eliminate/reduce firefighting and process volatilities.

Setting clear targets and applying fact-based Lean and Six Sigma methodology is the foundation to improve process capability. Applying a predefined and structured approach (DMAIC) strongly helps to align all stakeholders involved and therefore to effectively manage improving process capabilities. Conducting fact-based root-cause analyses and KPI measurement reduces the risk of overestimating subjective impressions and assumptions.

Collaborative solution design and implementation is necessary in order to achieve sustainable improvements, and in parallel is a powerful driver for cultural change within an organization. Often, people have their own way of doing things. Applying the approach described in this Point of View demands a high level of collaboration. Employees need to share their best practices, to synchronize with their colleagues (e.g. across shifts), to agree on their mutual "best way" and to accept a perceived reduced level of freedom. Experience and expert knowledge in managing such an endeavor is crucial for success. However, it remains a challenge that must not be underestimated – but in the end, it is a challenge more than worth tackling!



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With an international team of industry experts StepChange can hit the ground running. StepChange provides innovative and yet pragmatic solutions, placing an emphasis on delivering measurable business results.

For further inquiries and comments regarding this Point of View please contact us at *leapfrog@stepchange.com*.

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