LEVERAGING HUMAN PROCESS KNOWLEDGE VIA PROCESS MINING

Summary

Veco has conducted a Process Mining project to reduce the manufacturing lead time of precision parts. With this project, we have not only halved the throughput time of our process, but we also proved that Process Mining is not just about data: It helps to unlock relevant process knowledge of key employees who have less of a feeling for statistical methods by making the process analysis accessible to them.

- **Process Mining case study in manufacturing environment**
- **Throughput time of the production process cut in half**
- **Key success factor was to unlock process knowledge from employees**

Company

Veco is the world leader in manufacturing customized precision parts via electroforming, photo-etching and laser cutting. The Process Mining project described in this case study concerns the electroforming department in Eerbeek, the Netherlands. Electroforming is a method to produce metal parts by the precise deposition of metals onto patterned substrates. Its uniqueness is that you can grow metal parts atom by

atom, providing absolute accuracy and high aspect ratios. Once you have discovered the benefits of electroforming, a whole new world of opportunities opens up. What if you could produce, atom by atom, stress- and burr-free precision metal parts with micron scale accuracy? It would give you the opportunity to raise the bar on precision, tolerance, cost-effectiveness and the capability to withstand higher temperatures.

One of the drawbacks of this technology is that the quality of the final product can — for the most part — not be detected until the whole process is completed. However, the quality is mainly determined by the lithography, which is the first step of the production process. For this reason, it is important that production lead times are short: The shorter the lead time, the earlier the feedback, and the earlier we know whether the lithography is performing within our capability window.

Veco has adopted Six Sigma as the tool to improve its performance, both internal and external towards customers and suppliers. Six Sigma has been developed within manufacturing environments and has demonstrated in recent decades to substantially improve the productivity of companies in many places. This methodology is characterized amongst others by:

a) An outside-in approach, which looks at the processes from the customer's point of view,
b) A search for those causes that cause variation in the process, and
c) Not only to pay attention to the quality of the solution, but also to the acceptance and assurance of the solution.

This is all supported by statistical methods that help to isolate those factors that cause (unwanted) spread in the processes.

"The results have been substantial and exceeding our expectations"

—JORIS KEIZERS, OPERATIONS MANAGER

In earlier attempts, Veco has applied Six Sigma to reduce the lead time in the factory. We have come a long way and have reduced lead times from up to eleven weeks down to four weeks. Then, we searched for new methods to expand our Six Sigma toolbox and Process Mining crossed our path. Although Process Mining has not yet gained a strong foothold in manufacturing environments, the Operations team had the strong belief that Process Mining could help them to further improve Veco's processes.

Within Veco, we have the philosophy that change should be initiated and carried out by line management, not by a staff department. This implies that we hire change catalysts for key management positions within the company. This way, we ensure that changes are not only initiated but also implemented with lasting results. Therefore, the Process Mining Project was led by the Operations Manager and the Supply Chain Manager in cooperation with the Maintenance Manager, the Inspection Manager, the Production Manager, and the Purchasing Manager of the company.

Process

In Veco's production process, batches are routed via several work stations in a pre-described sequence. There are three main routes, but some production batches require a routing which deviates in one or more workstations from the main routes. Although the production equipment is state-of-the-art and operated in a cleanroom environment, the transport between the workstations, the definition of the job sequence served at a workstation, and the operation of the workstation is done by operators.

Production batches have various processing times, and all work stations have different utilization rates. This means that not all work stations are fully operated — and thus staffed with operators — during a shift. As stated earlier, for the process it is very important to have short production lead times, because we can only determine at the end of the process whether all work stations are operating within their capability limits. Once a deviation has been detected, the process needs to be stopped to check the deviating workstation, whilst all jobs in progress that have already passed that workstation are suspected of having a poor quality.

Data

We have created an event log which consists of a case ID (i.e. the production batch number), an activity (i.e. the name of the workstation), and a timestamp (i.e. the time of completing a production batch at a certain workstation). As we are a Six Sigma-driven company, we are used to paying a lot of attention to the validation of our data. We have the belief that we can only trust the data for which we have performed an MSA, a Measurement System Analysis. During the MSA we check whether the difference between the data set and the real life process is sufficiently small, such that the conclusions we draw from analyzing this data are indeed valid.

Approach

In a traditional Six Sigma approach, we first would have generated a Pareto to detect which routings have the longest waiting times and the highest variation in throughput times. For this selection of paths, we would have performed additional analyses in Minitab to create so-called probability plots (shown on the right in the figure below). The probability plots show how the closest adjacent paths in the factory perform in terms of throughput time. Probability plots are a very effective and accurate method. However their creation is very time consuming and they cannot be easily communicated to people who do not have a statistical background.

In this project, the probability plots were initially skipped and the Process Mining software Disco was applied first to analyze the business processes. Within Veco we have the following philosophy on change: The "Effectiveness of a

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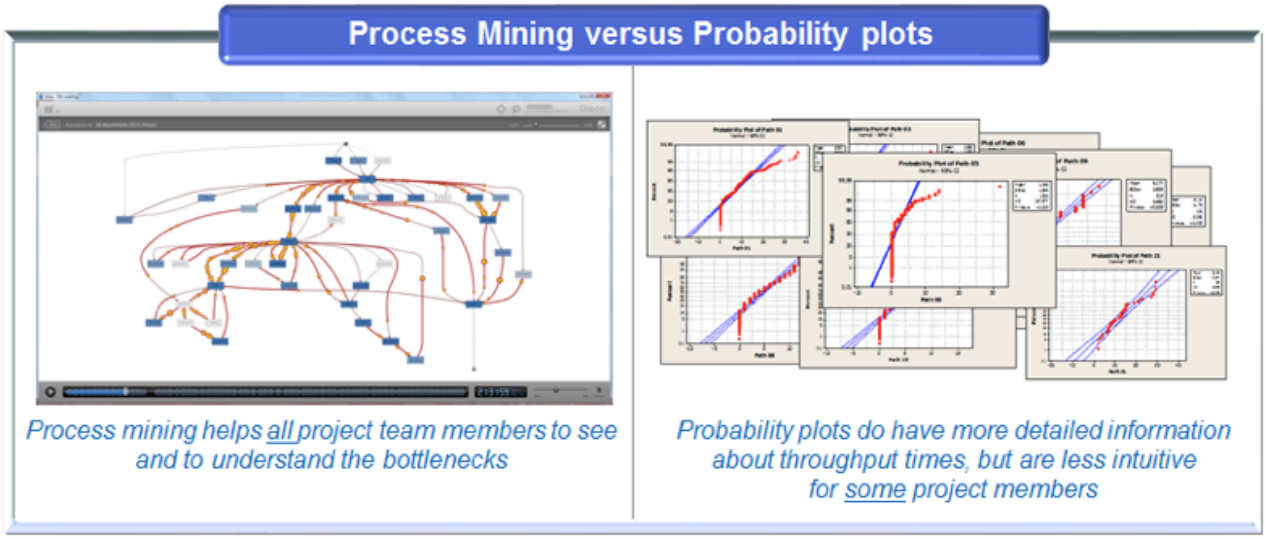
solution" equals the "Quality of the solution" times the "Acceptance of the solution". With Process Mining, we found the missing link between the statistically oriented people and the people with the actual process knowledge and the authority to actually change the process. It was shown that the use of Process Mining is complementary to Six Sigma: Process Mining accelerates the analysis phase and is very inviting to employees who have a lot of process knowledge, but who have less of a feeling for the statistical data analysis methods.



The first advantage is immediately visible: Within minutes it is possible with Disco to get a complete visual overview of the business processes and their bottlenecks. An animation shows at a glance which are the workstations with high occupancy rates, and which workplaces cause delays in the supply chain. This understanding is impossible to acquire and to communicate with the traditional probability plots.

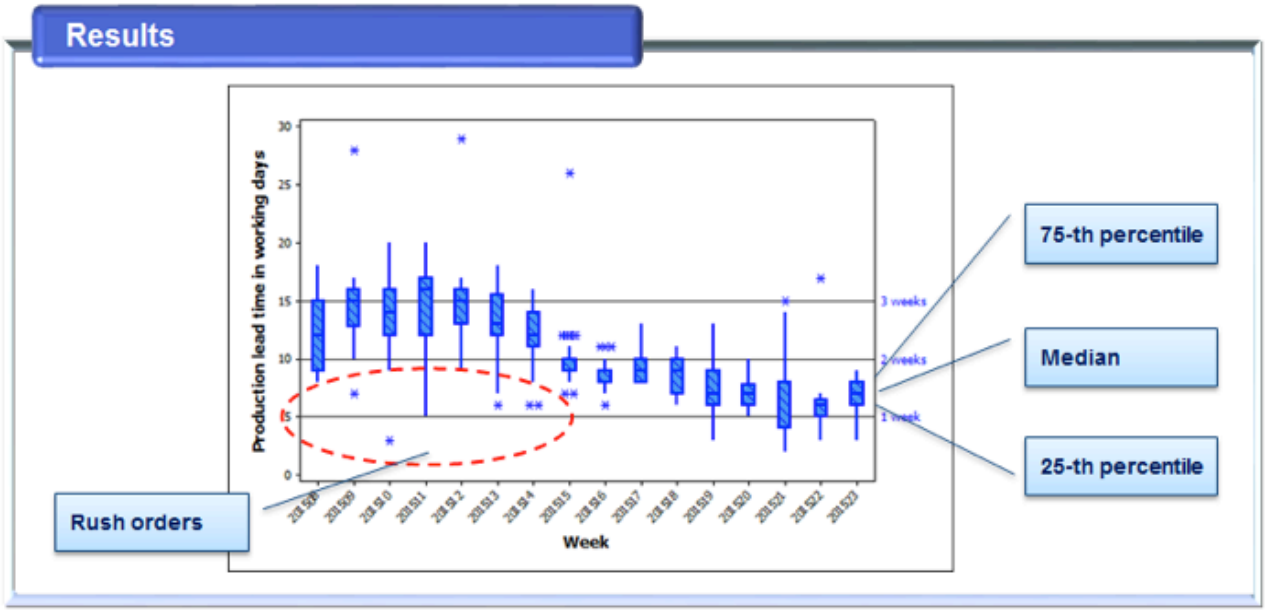
Process Mining provides highly accessible results: The animations speak to the imagination and ensure that each member of the improvement team can combine the new insights with their process knowledge. This process ensures that as much employee knowledge as possible can be combined with the statistical insights from the analysis phase. This enhances both the quality and the speed of the analysis phase. Once the bottlenecks are known, the probability plots can then be used to focus on and further investigate these pain points.

Results

The results have been substantial and exceeding our expectations. During the analyses of the animated production process, we drew various conclusions:

- The process has a huge variation in tact-times between the various workstations, resulting in a huge variation of throughput times and delays in various workstations. Based on this finding, our production manager came to the conclusion that we had to re-combine workstations to level tact-times and introduce production baskets with equal work load which could move from work station to work station without delays.

- Based on this new basket system, our maintenance manager drew the conclusion that the new way of working resulted in a lot of scheduled down time. Based on that finding, he could plan preventive maintenance way more easily, without impacting the running business.
- Our supply chain manager and purchasing manager came to the conclusion that the heartbeat of our internal production process differed from the heartbeat of our subcontractor, who is an integral part of our production system for one of the main production lines. Based on that finding, they implemented new procedures with our subcontractor to synchronize these heartbeats.
- Our inspection manager saw that — since his department operates at the end of the process — he is facing the largest variation in workload. He took the appropriate measures to further improve the flexibility of his workforce to be better able to cope with this variation.
- We also saw huge queues before one workstation, which we could eliminate by a technical solution of only a few thousand Euros.



The figure above shows that factory lead times have been reduced substantially within weeks after the start of the project. And with lower variation. In addition, we have improved efficiency: The same amount of work can now be performed by fewer people.

Impact

This project resulted not only very quickly in financial savings and a reduced risk profile due to shorter lead times, but also generated a few learnings from which we will benefit in the future.

- This pilot has confirmed our initial hypothesis that Process Mining can be a very valuable tool within our Six Sigma toolbox.

- We do not see Process Mining as a tool which can only be used in a project anymore, but it is now an integral part of our production and supply chain processes. We regularly run Process Mining to check whether we are performing within our new standards.
- It is crucial to have Process Mining knowledge organized in the line, rather than in a consulting department of your company.
- The results from our Process Mining pilot have been the basis of a new program, in which we further want to cut our factory lead time in half by means of applying lean thinking in all our (new) bottlenecks. Currently, all our employees in production and inspection are being trained in Lean.
- We have side-scaled this knowledge to our factory in the UK, where we currently also are using Process Mining to improve performance.
- This project has also served as a proof that the knowledge from Data Science can also be of interest for medium-sized manufacturing companies in a B2B environment.

As a next step after this pilot, we have written a digital strategy for our worldwide operations. The first steps have already been executed: We recruited a data scientist who closely works with our operations management team to further unlock data from our processes and products to improve the predictability and quality of our processes. Secondly, we have educated more people in Big Data. Thirdly, we have started an investment project to start collecting all kinds of process and product parameters throughout the entire production process.

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