

## Lean Machine

### Case study – Lean workstream: Improving lost time from breaks

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This Lean Transformation project was conducted together with a European paper mill with 550.000 t in annual production. The overall target of the project supported by StepChange was to achieve a turnaround and improve financial results significantly. One of the workstreams was dedicated to “Lean Manufacturing”. This workstream targeted a significant increase of production volume by improving the overall equipment effectiveness (OEE) of both paper machines (Time Efficiency x Material Efficiency x Speed Efficiency). The following table shows the baseline performance and the target performance of one of the machines.

#### Baseline and targets

Targets PM1	Baseline	Target
<b>OEE</b>	<b>72,7%</b>	<b>81,5%</b>
Time Efficiency	86,0%	88,5%
Material Efficiency	89,0%	94,0%
Speed Efficiency	95,0%	98,0%

Figure 1: Targets PM1

The underlying objective was to implement a Lean philosophy which means significantly more than just elimination of waste. Our philosophy of Lean targets overall improvements and the delivery of real results that initiate a continuous improvement approach.

Altogether there were 11 subprojects defined to improve OEE, one of them (with the most significant impact on OEE) was the reduction of lost time from breaks. Time efficiency had deteriorated significantly due to the increase in lost time from breaks. Figure 2 shows the development before and after the project.

Break time development 2012

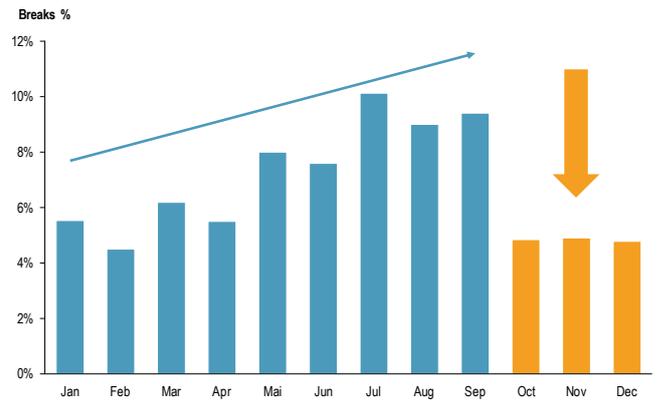


Figure 2: Development of break time during 2012

### Improving lost time on paper machine from breaks

To successfully achieve a reduction of lost time from breaks we identified a set of questions to answer:

- What was causing the deterioration in lost time from breaks in 2012?
- What was the impact of specific key process parameters on that development?
- What was the impact of different process controls on the four shifts and what were the improvement opportunities through the standardization of procedures and up-skilling of the teams?

To carry out the relevant analysis, the first step was to identify the data requirements and the appropriate sources of this data. In this case, the data was taken from the mill’s MES and QCS systems. Based on this data a Pareto analysis was completed.

Number of paper breaks / day



Figure 3: Development number of paper breaks per day 2012-2013

As a result of the initial analysis, StepChange concluded that there were significant differences in lost time for threading between the four shifts (A-D) (see Figure 3), but no significant

differences in number of break events between the four shifts. After observing and discussing work processes it became clear that there were different process capabilities and different procedures across the four shifts leading to significant differences in threading times after a break.

Lost time due to breaks by shift

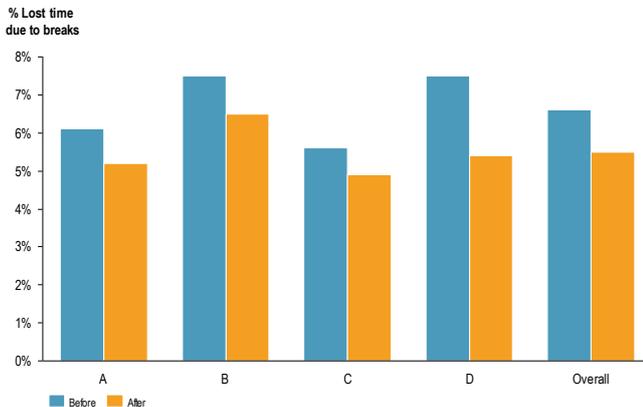


Figure 4: Lost time due to breaks analyzed by shift

Based on these initial results, a set of measures was defined.

1. The first was to conduct workshops with key operators targeting the improvement of threading time after breaks by standardization of the threading and cleaning process
2. The second was the identification of root causes for the increase in paper breaks during 2012 and the creation of appropriate actions to reduce the number of break events

### 1. Workshops with key operators to improve and standardize “cleaning and threading process after paper breaks”

The StepChange role during the project was not only to provide content and analytical support but also to coach and train the organization. StepChange worked across the organization on all levels, helping to implement change as part of the Lean Transformation process. Knowledge was transferred to the people involved and awareness of required changes was built by a fact-driven and collaborative overall approach.

The steps of the approach included:

- Gathering process control differences across the four shifts
- Developing a standard process “cleaning and threading process after paper breaks” together with key operators

- Developing the roll-out procedure for the new process, defining a process champion responsible for roll-out, training and follow-up

During the workshops, we used brainstorming and other creativity development techniques to identify potential solutions. Next, the potential solutions were prioritized by using nominal group techniques and matrices based on criteria such as ease of implementation and value of impact. During such workshops, it is important to capture all existing ideas and develop new out-of-the-box ideas, thereby creating a comprehensive long-list.

Thus, the prioritized solutions were selected and a common “sense of urgency” developed. This in turn led to the required buy-in to enable the necessary change. The ultimate result was that the involved people developed a clear understanding of the solution and the confidence for trying out improvements in a structured manner to implement the necessary changes.

A key deliverable was written standard operating procedures (SOP) which were documented by the team (supported by StepChange), and introduced by the crew themselves following a “train-the-trainer” approach.

### 2. Reducing number of paper break events

To reduce the number of paper break events, we followed a structured approach to identify root causes why the frequency increased in 2012. The approach included:

- Interviews with key operators and study of logbooks to understand process modifications in 2012 possibly affecting the number of breaks
- Analyzing development of key parameters and correlation to number of break events
- Development of a step-by-step trial plan to verify the hypothesis

#### 2.1 Pareto analysis of reasons for break deterioration

By analyzing the number of breaks per month and per break reason, it was identified that the main driver of break frequency increase was “holes”.

Nr. of breaks / month by reason

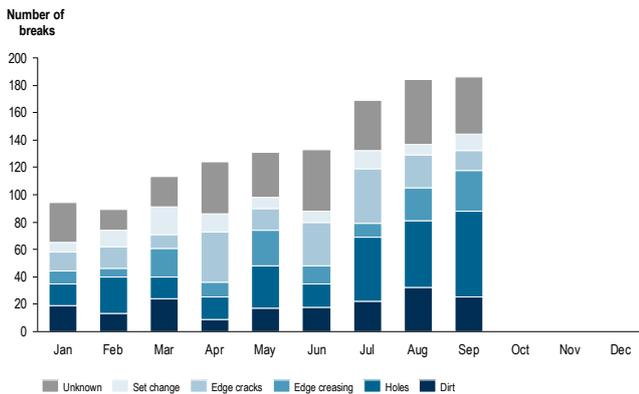


Figure 5: Number of breaks/month by reason

In the next step, it had to be clarified whether there was an increase of holes leading to more breaks or a weakening in paper strength properties leading to a higher probability of breaks due to a paper defect.

2.2 Identify the impact of “numbers of holes” on “number of breaks per day”

Correlation #holes / 100km / #breaks / day

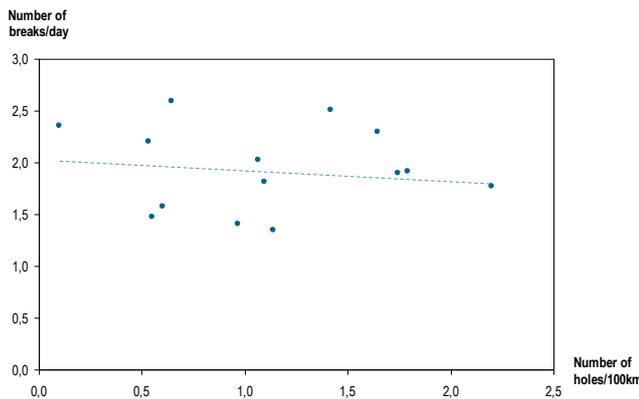


Figure 6: Correlation #holes/100km/ #breaks/day

To prove the impact of holes on the increase in breaks, two analyses were completed:

- One showing that there was no increase in holes in 2012 and
- Another showing that there is no correlation between the number of holes/100km and the number of breaks/day (see Figure 6)

**Conclusion:** The root cause for the increase of breaks was not an increase of holes, as originally accepted as the common company-opinion. Rather the increase was more likely attributed to a change of paper strength properties causing more breaks due to paper defects (i.e. holes). The latter also explained why other break reasons deteriorated in the same

period. These reasons were not as significant as holes, but were still visible.

2.3 Analysis of paper strength development and correlation to “number of breaks per day”

Product A 57 g/m<sup>2</sup> - tear cd

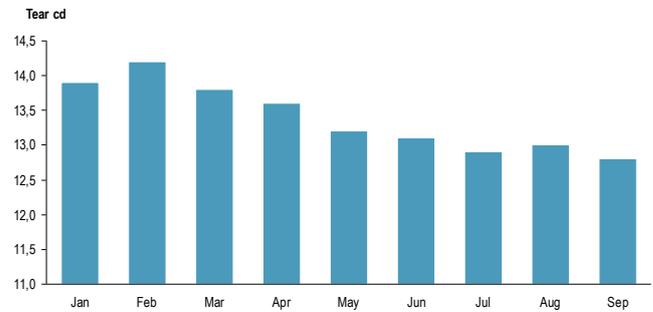


Figure 7: Paper strength properties, cross direction (CD). Example “A” 57 g/m<sup>2</sup>

Various analyses concerning strength development over time were completed to identify possible reasons for increased break frequency. It was identified that:

- Paper strength properties in cross direction (CD) decreased (see Figure 7)
- MD/CD ratio correlated significantly with the number of breaks (see Figure 9) in 2012

**Conclusion:** The root cause for the increase of breaks is a negative development of cross direction strength properties.

The next step was to identify the root cause for the negative strength development. Four possible reasons were identified in a StepChange moderated workshop with key operators from all shifts:

- Recipe (TMP, DIP, virgin pulp)
- Efflux ratio → MD/CD-strength ratio
- Headbox slice opening
- Wet end chemicals

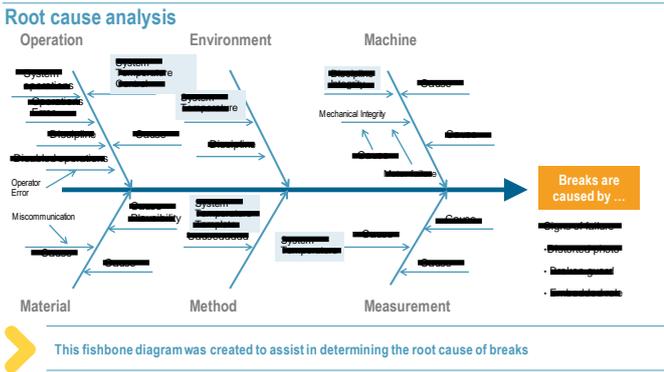


Figure 8: Exemplary fishbone diagram used for root cause analysis

Based on StepChange experience, many times teams conducting root cause analysis will experience difficulties identifying the real root causes of problems. When this occurs, the fishbone diagram can stimulate creative thinking and will help single out a more comprehensive set of potential causes that require investigation. An example of this analysis from a workshop is shown in the picture below. As there were no changes in the application of wet end chemicals during 2012, its impact was excluded and the focus was directed towards the other three process parameters: Efflux ratio, recipe, and slice opening.

### 2.4 Analysis of MD/CD strength ratio to “number of breaks/day”

Correlation #breaks / tensile strength md/cd

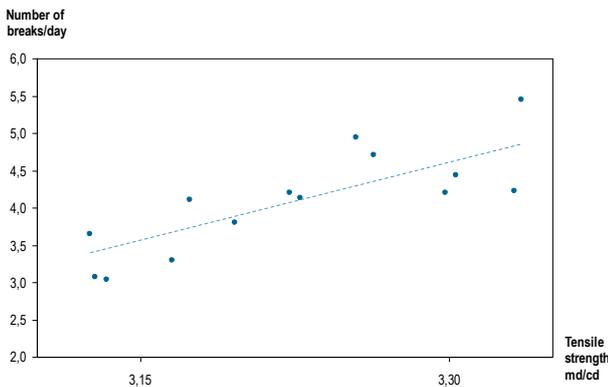


Figure 9: Correlation between number of breaks, tensile strength MD/CD

The analysis proved that the changed efflux ratio led to an increase in the MD/CD strength ratio which in turn had a negative effect on paper breaks.

#### Measures:

- Defining the MD/CD-strength ratio as a key process parameter and setting the target value to 3,1
- Using the efflux ratio of the headbox to control the MD/CD strength ration

### 2.5 Analysis of recipe development and its impact on paper strength development

Product A 57 g/m<sup>2</sup> raw material & tear cd

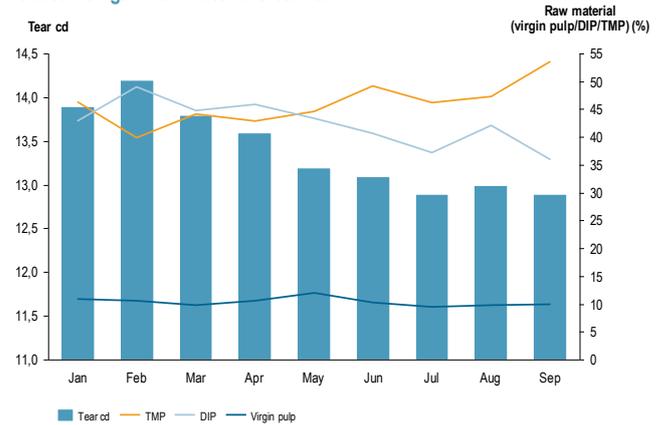


Figure 10: Raw material usage and tear CD strength development

Through the analyses of recipes development for all basis weights in 2012 it was identified that DIP with higher strength properties was reduced while TMP with lower strength properties was increased steadily over the last 6 months.

**Conclusion:** Weaker fiber mixture caused less paper strength and less resistance to paper defects – leading to a higher probability of breaks.

**Measure:** Defining the correct fiber mixture for every basis weight for achieving sufficient strength and implementing a recipe controlling tool to ensure consistency.

### 2.6 Analysis of headbox slice opening and number of breaks per day

### Correlation #breaks / headbox slice

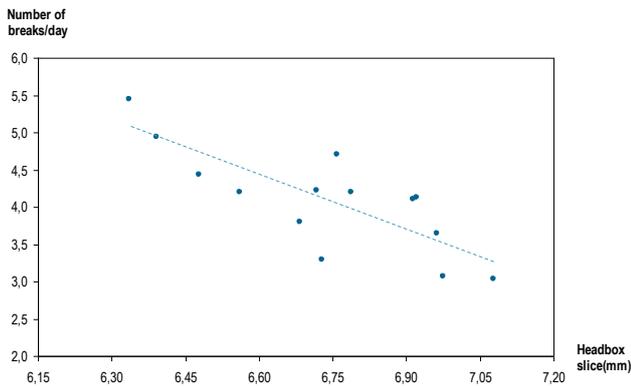


Figure 11: Correlation betw. development of breaks & headbox slice opening

By analyzing the headbox slice opening over the last 14 months, a significant day by day variation and a correlation with the number of breaks was identified.

**Conclusion:** Headbox slice opening has a significant impact on break events.

**Measure:** Defining headbox slice opening as a key process parameter and setting the target value to 7,0.

### Summary

The extensive data analysis based on mill MES and QCS data, combined with collaborative team workshops and an extensive root cause analysis leveraging the broad StepChange experience and manufacturing expertise, identified the main root causes of breaks as the following:

- Insufficient paper strength in cross direction increased the probability of paper breaks in case of paper defects
- The suboptimal fiber mixture applied decreased paper strength and had a negative impact on breaks
- Changed efflux ratio led to an increase in the MD/CD strength ratio which in turn had a negative effect on paper breaks
- There was no impact of the number of holes in paper on the break frequency
- The headbox slice opening had a negative impact on paper breaks caused by holes

### Correlation #breaks/d caused by holes / headbox slice

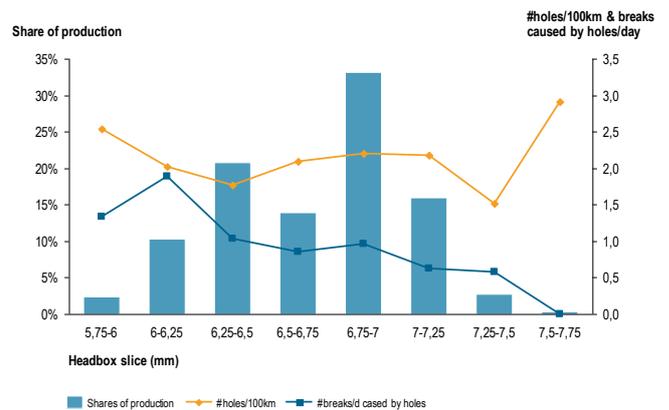


Figure 12: Correlation no. of breaks per day caused by holes/headbox slice

Several measures to reduce paper breaks were agreed and implemented. Among them were:

- Defining the MD/CD strength ratio as a key process parameter and setting the target value to 3,1 and using the efflux ratio of the headbox to control the MD/CD strength ratio
- Defining the correct fiber mixture for every basis weight to have sufficient strength and implementing a recipe controlling tool to track consistent raw material application
- Defining headbox slice opening as a key process parameter and setting the target value to 7,0

All of these were documented in the standard operating procedures.

### Results in a nutshell

The subproject “Reducing lost time on the paper machine from paper breaks” was successful based on:

- Optimization and standardization of threading process to reduce threading time
- Reduction of break events

Consequently, the time lost from paper breaks and the number of breaks per month decreased significantly – as can be seen in the following charts – starting as of October 2012, all relevant KPIs improved and volatility was reduced. The improvements from this project alone translated into benefits of €2,0m. The StepChange methodology used in this project and in general is characterized by an analytical and fact based approach combined with a pragmatic and team oriented working style. We ensure that results can be measured and tracked accordingly. Improvement workshops following a lean structure were established as part of the whole continuous improvement process and all shift operators were trained applying a “train-the-trainer” approach.

Lost time from breaks development (before and after the project)

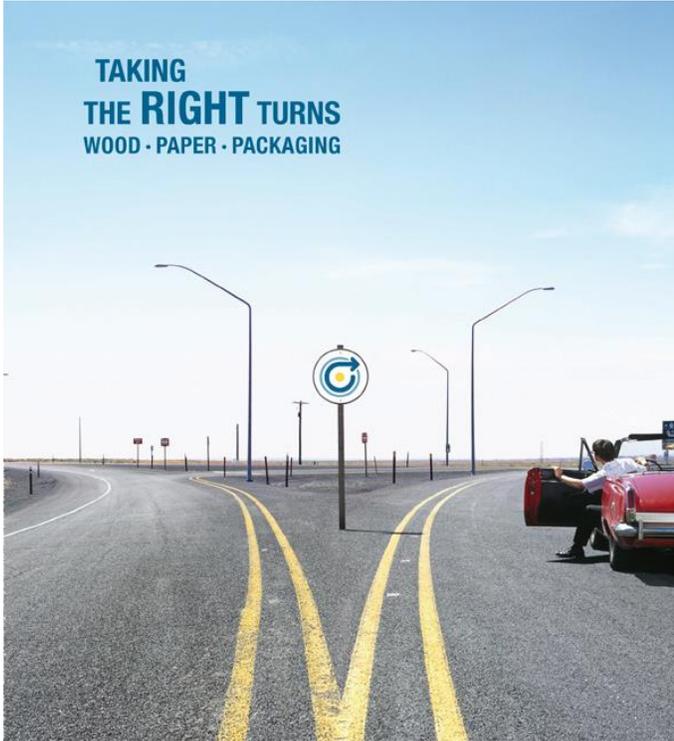


Figure 13: Development of lost time due to breaks (before/after project)

Number of paper breaks/day (before and after the project)



Figure 14: Development of number of paper breaks / day (before/after project)



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