FELTEST
EMPOWERING PAPERMAKERS

HOW TO ASSESS PRESS FELTS

The basics for continuous felt improvement

By Marcel Lensvelt, founder and CEO of Feltest Equipment BV

INTRODUCTION

In one way or another, we are all involved in getting the most out of our paper machines. More output means more profit for the company, more job security for us all and better chances for a promotion.

This whitepaper will show you how you can increase machine output through better performing press felts. Simply because there is still a lot of potential in this part of the machine.

> "So why be satisfied with 54% dry content after the nip?"

Hopefully, I will be able to inspire you to start a process of continuous improvement of press felts, in conjunction with your suppliers. In order for that process to be successful, you need to run trials and be able to assess the performance of both standard and trial felts.

On average, getting 1 percentage point dryer out of the press section results in 4% more output. So why be satisfied with 54% dry content after the nip, when it could be 55% or 56%? This would result in 4% and 8% more output respectively.

How many more tons would you produce if your machine has 4% or 8% more output?

Take a moment and think about it....

Marcel Lensvelt,
Founder & CEO of Feltest

CONTINUOUS IMPROVEMENT: THE MILL IS IN CONTROL

When I say 'continuous improvement' most of you will know what comes next: a picture of a cycle. And here it is.

Toward Better Felts

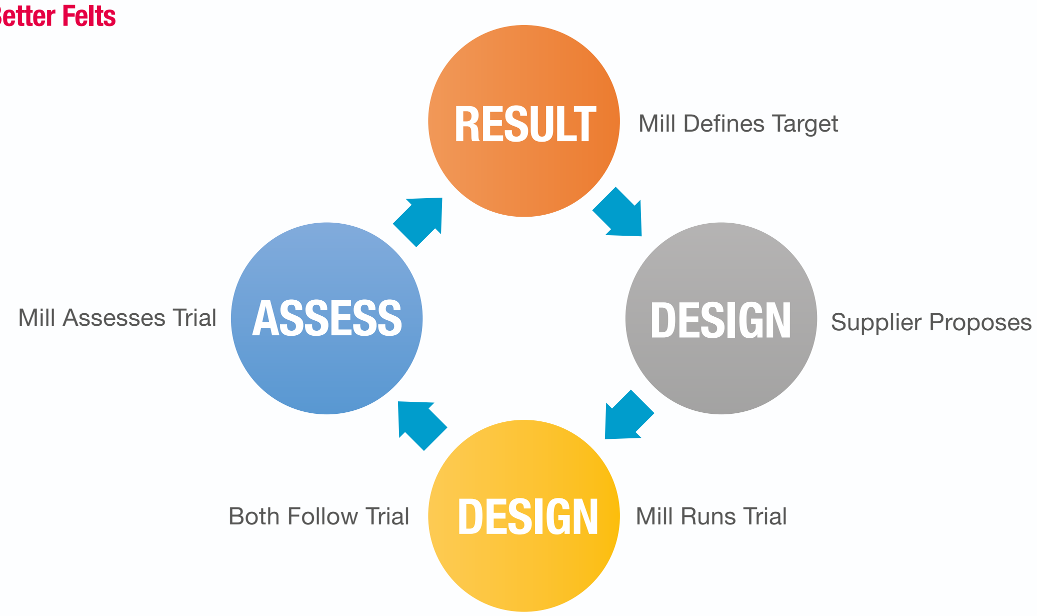

Figure 1

The process starts with setting a target. The mill and *only* the mill should set the target. We strongly advise you not to consult your felt supplier on this. The output of the machine is your responsibility; you know what you need to achieve.

When you consult your supplier, you immediately start compromising the target according to the capabilities and pitfalls of that one supplier. If you need something that the supplier does not feel comfortable about, he will advise you against it. That is not in *your* interest!

You should set the target, and from there your current, or new supplier should propose a design that brings you closer to that target. Here, the papermaker can rely on the expertise and experience of the felt manufacturer, especially when he can provide the supplier with extremely valuable felt data. More about this later.

"The output of the machine is your responsibility; you know what you need to achieve"

THE IMPORTANCE OF TRIAL FELTS

Next, the trial felt must be run. In Europe, too many mills have too many old trial felts in storage. Somehow there is always an excuse not to install the trial felt. But *not* installing a trial will keep you away from achieving your target and in the end that will cost you far more than a less successful trial. Both the supplier and mill should carefully follow the trial, as both have something at stake here.

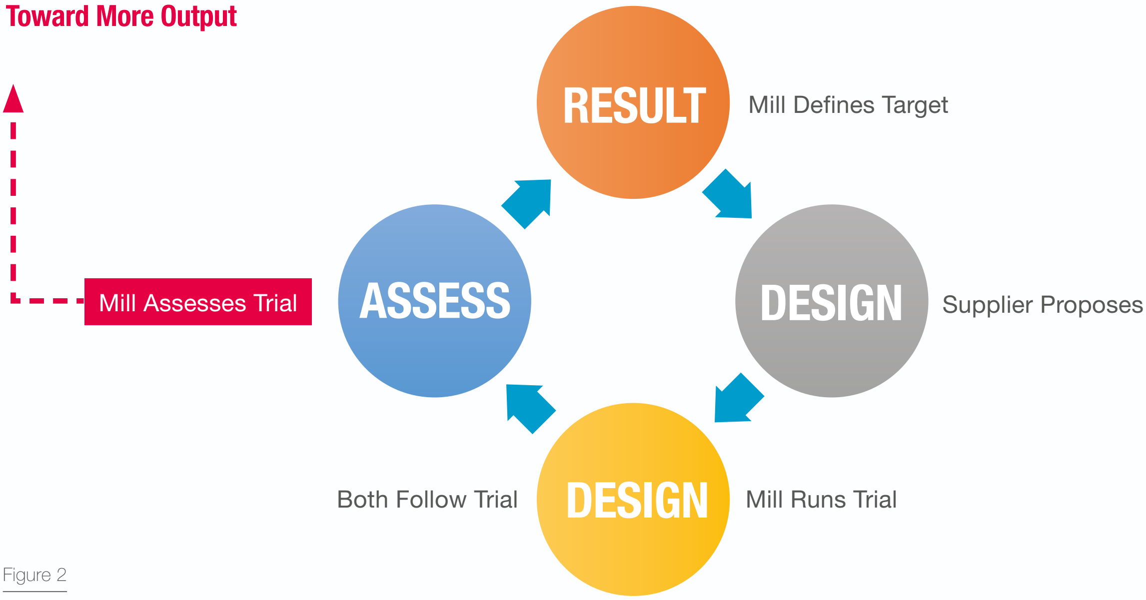

Figure 2

After the trial has run, in an ideal world, you simply draw your conclusions: the trial did or did not contribute to achieving the target. Of course, in reality it is not that simple: even under normal conditions, a felt is one of many variables in your machine. So how do you judge a *variant* of a variable in a machine full of variables?

Exactly *that* is the challenge I would like to describe in this whitepaper. Just an indication of where this whitepaper is going: it should be the papermaker who assesses the performance of the trial felt. It is the papermaker who truly judges, not the supplier, simply because he who pays the piper calls the tune.

Roles and responsibilities should be set up as follows:

- It is the papermaker's responsibility to produce more paper.
- It is the supplier's responsibility to provide the best possible felts to achieve this goal.

You don't have to be a chef to assess your meal in a restaurant. You can tell if it tastes good or not.

You don't have to be a suspension engineer to assess a car's road handling. You can tell if it's sporty or comfortable enough for you.

And you don't have to be a felt manufacturer to check if a felt brings you closer to your goals or not.

Then why do some papermakers leave 'those felts' completely to their suppliers?

"So how do you judge a variant of a variable in a machine full of variables?"

PRESS FELTS: LOVE ‘M OR LEAVE ‘M

Not everybody loves press felts. But with a clear division of tasks, is it really that complicated to improve felts? Or is it only *considered* to be complicated? Is there some kind of fear of the unknown?

Press felts are complex products. With all variations in base weaves, batt, needling procedures and chemical treatments, there are millions of theoretical product variants. It is a difficult task to pick the right one. But it is not the papermaker’s task. Remember, you don’t have to be chef to decide whether a meal is good.

Due to this complexity, it is not easy for a manufacturer to make 100% identical felts. For the papermaker, this means that installing a new felt in the machine is always adding a new variable into your system.

However, it does not always come down to just reproducibility. Once the felt is installed and the machine starts running, the felt’s behavior gradually changes over its life in the machine.

Just think of it: a press felt changes more in 6 weeks than a roll cover does in a quarter or a gear box in a year.

The main reason for the changing behavior is the decreasing felt caliper, or felt thickness. As soon as new and bulky felt starts going through nip, the felt caliper will decrease. A new felt is resilient and expands again after the nip exit, but this resilience will decrease with every felt revolution.

This compression of the felt is not the only reason why a felt gets thinner: wear has to be taken into account as well. Static elements like Uhle boxes and slight speed differences create friction on the felt’s surfaces and wear down the batt over time.

Figure 3

COMPACTION AND WEAR, PERMEABILITY AND CALIPER

So, we have two different processes, compaction and wear, that both produce the same result: a thinner felt. There are two important felt properties that we need to monitor over the felt life: the permeability and the caliper.

To simplify, permeability is the resistance water experiences when it is flowing through the felt. The caliper is the distance the water needs to travel. Resistance and distance are interrelated: if you need to travel a long distance, you do not want too much resistance. On the other hand, you can accept a certain amount of resistance when it is only for a short distance.

Now look at the first line in the table below: when the permeability of a felt is low (or the flow resistance is high) and the felt is also relatively thick, it will not easily dewater. This combination indicates a contaminated felt that could do with a felt wash.

Permeability and Felt Caliper

Dynamic Perm.	Felt Caliper	Situation
▼ Low	▲ Thick	Contamination
▼ Low	▼ Thin	Compaction
▲ High	▲ Thick	Break-in period
▲ High	▼ Thin	Worn

Table 1

On the second line we see a scenario that is, to a certain extent, good for nip dewatering. The relatively high permeability will prevent rewetting at the nip exit and the relatively short travel distance is helpful in disposing the water asap.

Compaction only becomes problematic when the flow resistance becomes too high for the distance that needs to be covered. A relatively open felt will generally be more prone to rewetting, but it does make a difference if it is thick or thin. A thick, new felt in its break-in period can easily be compacted, but a thin, worn felts need to be replaced.

DYNAMIC PERMEABILITY

Here, it is important to define *dynamic permeability.*

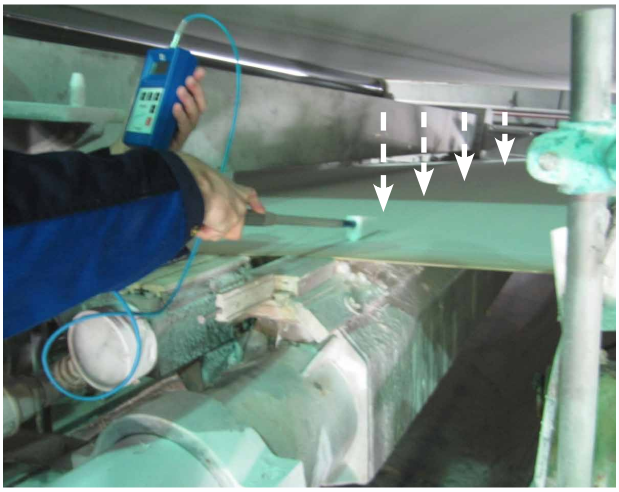

Figure 4

A cost-effective way to measure the felt permeability is to measure the airflow through the felt at the Uhle box, as shown in this picture. Obviously, the higher the vacuum, the higher the airflow will be. So only monitoring the airflow, or airspeed, is not enough. You have to take the applied vacuum into account as well. For this reason, I introduced the term *dynamic* permeability, which can be understood as 'airspeed at a standard vacuum level'.

Working in the metric system, I use 10 kPa (or -0.1 bar) as our standard vacuum level. For example, if you measure a vacuum of 40 kPa, this is 4 times our standard level of 10 kPa. If you measure an airspeed of 8 m/s at 40 kPa, the dynamic permeability of this felt would be 2 m/s @ 10 kPa – simply divide the 8 m/s by the factor 4 of the vacuum level.

Once you start monitoring the dynamic permeability on a daily basis, you will be able to extract a baseline like this. On the X-axis you see the felt life in days and on the Y-axis to the right the dynamic permeability in m/s @ 10 kPa. During the first 5 days of this felt's life you see a sharp drop in permeability. The felt is still in its start-up phase and is compacting a little bit more with every revolution. Near the end of its life you see that permeability is increasing due to felt wear.

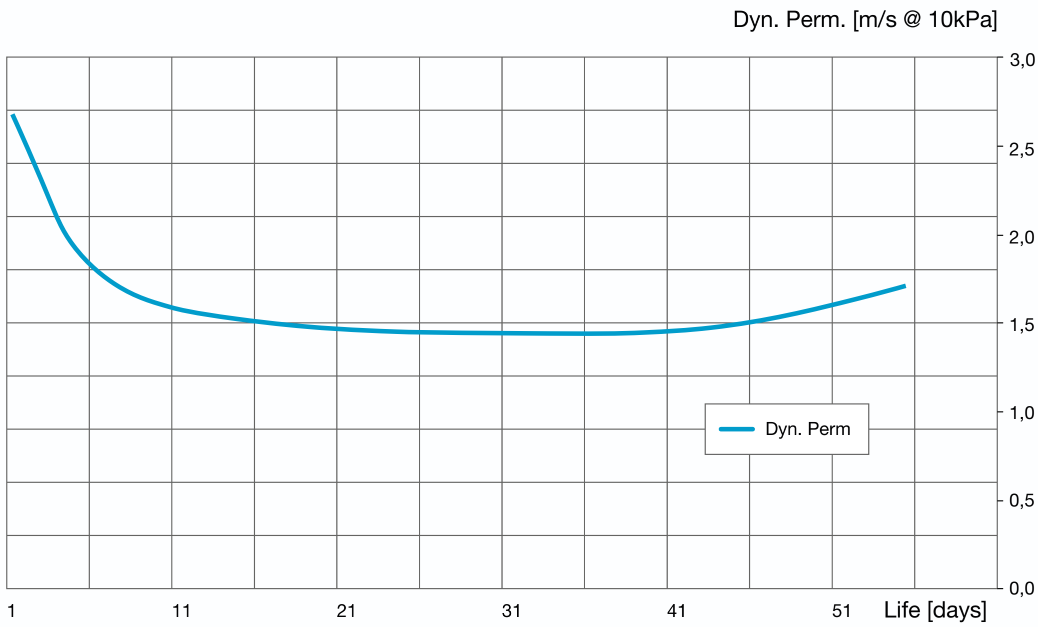

Figure 5

COMPACTION

Now let's discuss compaction in a little more detail, as this is the second important property when assessing press felts.

You may have a sense of what felt compaction is. You can imagine a new and fluffy, bulky felt with lots of pores and void volume, slowly losing more and more void volume, becoming less bulky and more rigid, massive. But how do we convert that into a number?

This is a schematic representation of a piece of felt running in the machine.

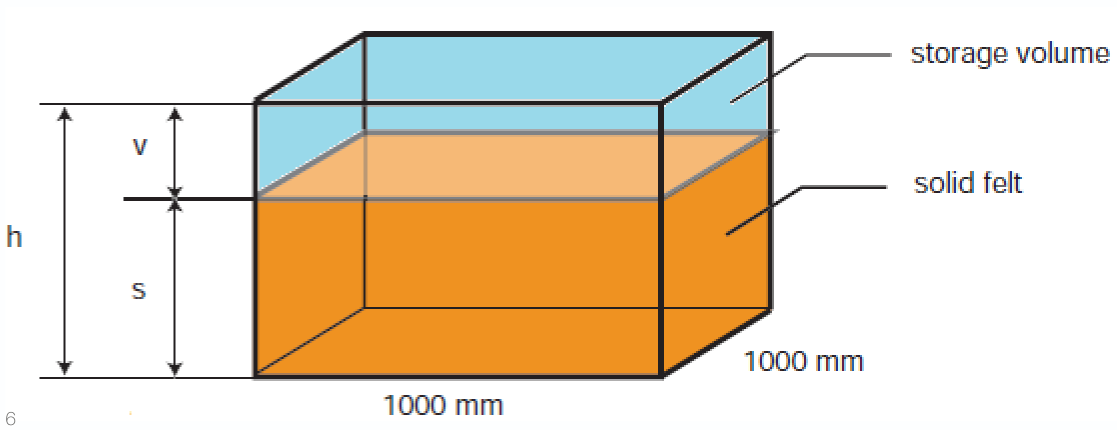

Figure 6

What we call 'the felt' mainly consists of two elements: water and the solid felt material. Normally the water is distributed all over this cube, but just imagine that all the water is on top and all the solid felt material is at the bottom, as shown here.

My definition of compaction is the ratio between the solid felt component and the overall dimensions of the cube, so including the water component. As the length and width of this cube are identical for both the water and the solid felt component, we only have to monitor the heights.

If we divide the solid part s by the overall height h we get compaction as a very practical percentage. The lower the compaction percentage, the more void volume you have to store water. The higher the compaction percentage, the denser the felt is and the less water it will be able to hold.

Compaction = s / h [%]

Dividing s by h may sound like you need to measure two datapoints, but that is not the case because s, the solid felt component, is already defined by the felt weight.

$$Compaction\ [\%] = \frac{felt\ weight\ [gsm]}{11.4 * h\ [mm]}$$

As you can see in this formula you need to know the felt weight and only need to measure h, the total felt caliper, in order to calculate the felt compaction as a percentage.

FELT WEAR

Now you may wonder about felt wear. Because when the felt wears over time, the solid component s in figure 6 will decline.

Fortunately, this is not too serious for our compaction calculation because at the same time worn felts can hold less water. What you see on positions with high felt wear, is that both the s and the v component decline. As they are interconnected, the ratio between s and h – our calculated compaction – is hardly affected.

Over a period of more than 30 years, this calculation has proven to be a very reliable indicator for the felt compaction under all circumstances and on all types of machines. Just like with the dynamic permeability, if you measure on a daily basis, you can create a baseline for the compaction of each press felt position. Here you see an example of a pickup felt. Again, on the X-axis the days of felt life and on the Y-axis the compaction percentage.

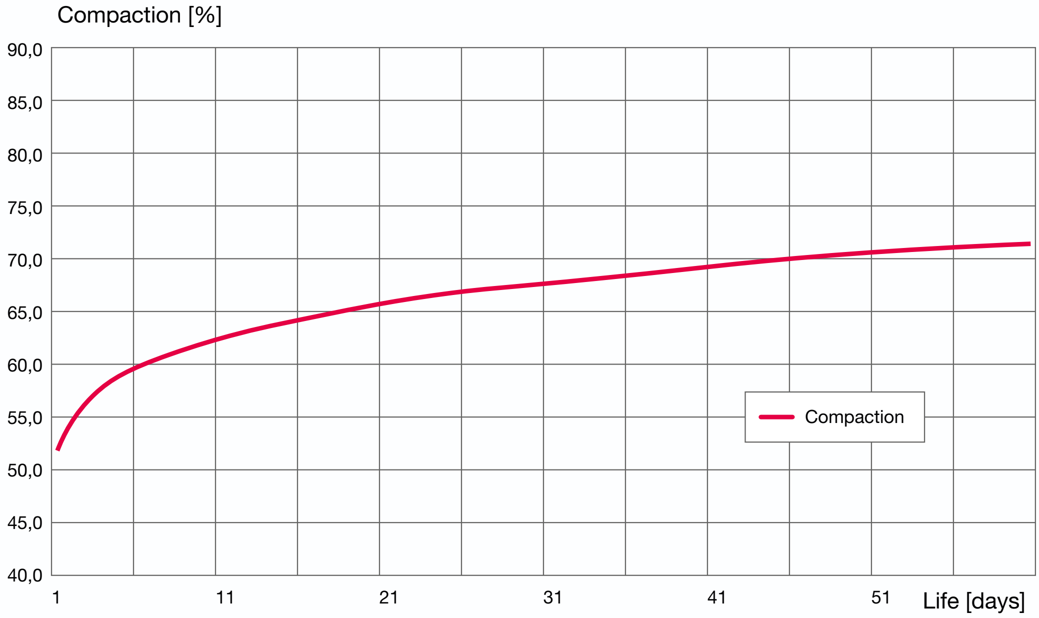

Figure 7

During the first few days, or the break-in period, compaction increases rather fast. Then the process stabilizes and the compaction increases only slowly. In a perfect world you would have a flat horizontal line: a felt without a break-in period, behaving consistently throughout its life.

If we add the baseline of the dynamic permeability with the compaction curve, we get a graph like this.

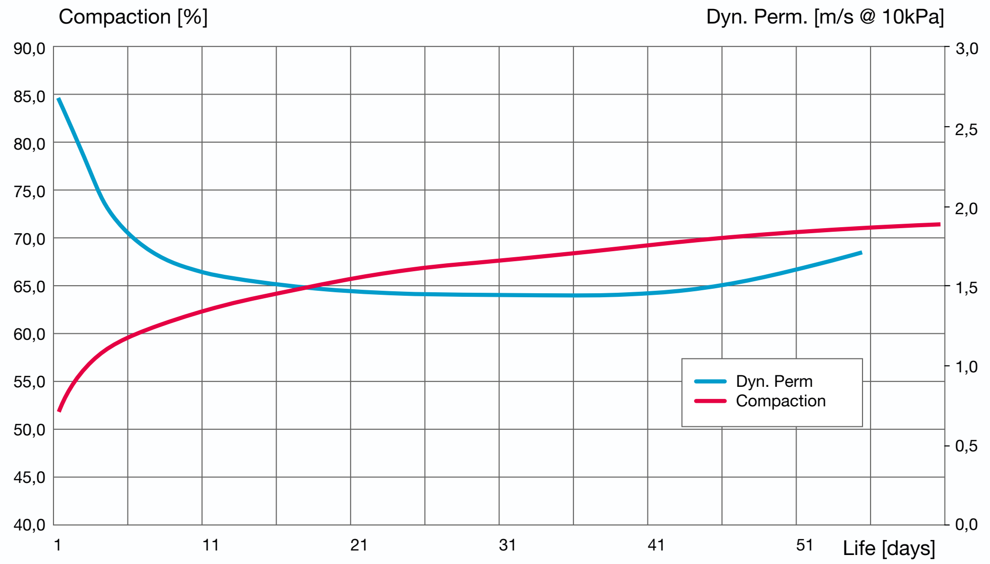

Figure 8

This represents the normal behavior of your press felts during the time they are in your machine. These curves are independent of the felt supplier and the felt weight; they are your basic reference point for felt assessments. With every felt running in this position, you can compare today's values with these baselines and predict where the felt is going the next few days.

This brings us back to the main topic of this whitepaper: assessing press felts to improve machine output. It is very simple:

Step 1 – re-organize your machine data

Remember that our baselines had the number of days of felt life on the X-axis. To relate the felt condition to the machine output, we also need machine data "per day" or "per ton".

The most obvious datapoint is of course: the output itself. Depending on your situation, you can also add other machine or production related KPIs like the number of breaks per day, the consumption of felt cleaning agent per day, or steam consumption per ton.

You can monitor anything you want that is related to either the output of your machine, the cost of your product or the performance of your felts, as longs as it can be expressed as a number on a daily basis.

With all the automation nowadays, most papermakers already have a list of data per date. For example, on May 3, we produced X tons, we had Y breaks and used Z tons of steam.

The only new thing is that you start organizing this daily data from the machine to match the felt life. Just take a look at this example.

Felt life	Prod.	breaks	steam	Compaction	Dyn. Perm.
1	375	3.8	791	53	2.50
2	770	2.8	1112	54.6	2.43
3	905	2.2	905	55.8	2.34
4	970	1.0	802	56.9	2.26
5	989	1.0	800	58.1	2.19
6	986	1.1	800	59.1	2.11
7	986	1.0	800	60.2	2.03
8	992	0.9	800	61.0	1,96
9	990	1.0	800	61.7	1.88
10	995	0.9	800	62.4	1.81
...	...	...	...	...	...

Table 2

For simplicity's sake, let's assume you install a new pickup felt the first day of every month and every day you note the production, number of breaks, steam consumption, etc. A month later, on February 1, you do the same. You install a new felt and note the machine KPIs. Again, on March 1, April 1, etc.

After a while you get average values of machine data that are related to the felt life. That is what you see in this table. Every row starts with the days of felt life and every column shows an average of a machine or felt KPI.

Step 2 – create your felt baselines

The second step is to distinguish between the properties that describe the felt behavior over its lifetime. Previously in this whitepaper, we saw that the dynamic permeability and the compaction percentage are very suitable for that.

Step 3 – combine both and draw your conclusions

Now let's go back to our felt baselines: felt compaction and dynamic permeability over felt life. With the table from the previous step, we can easily add new graphs, for example steam consumption (the green graph) or daily production (the bronze graph).

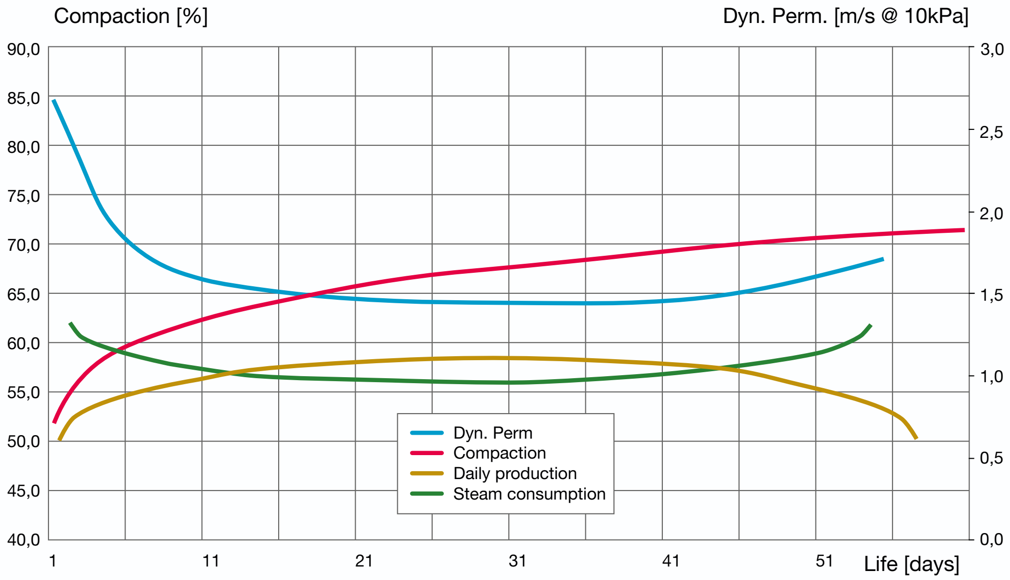

Figure 9

In this example you can see that around day 44 things start to get bad: daily production (bronze) is decreasing and the steam consumption (green) is rising. You can also see that the blue line, the dynamic felt permeability, starts rising around that day. This indicates felt wear, more rewetting at the nip exit and, apparently, reduced daily output.

> "Daily felt data combined with daily machine data powers your production"

Now you might want to add more data, like the number of breaks, to see whether the lower daily output is caused by the poorer dry content only, or if you also have more breaks near the end of the felt life.

The insight that this kind of graph offers helps you to set realistic goals for your suppliers to improve their press felt designs. For example: in this case you could ask your supplier to design a felt that maintains a dynamic permeability of max. 1.5 until day 51. Or a compaction of 60% compaction within 3 days. These are clear and, very important, objectively measurable targets for a new press felt design.

CONCLUSION

To sum up, better felts can do a lot for your machine output. Probably the best way to produce more tons of paper without an investment or CAPEX is to start optimizing your press felts. The first step is something you already have: daily data from the machine.

Now start with monitoring the dynamic permeability and compaction of the felts on a daily basis. You can't leave this to a number of suppliers that come by once a week, or only when the machine is running bad. You really need *daily* data.

Next step is to organize all this data according to the days of felt life. Press felts are the big variables in your machine and using their age as the X-axis for your graphs promises many new insights and will make it easier to set good development targets.

What I consider very important is that these graphs are based on the felt life are also shared with the suppliers. They are the felt experts, they can figure out what to do with a design, but they also need to be clear on the current situation and the goals you want them to achieve.

Finally, trial felts have to run and have to be monitored on a daily basis. With the newly established baselines for that position, it is much easier to see where a trial felt is going and how it is performing compared to the standard felt.

With the baselines, you can reduce the risks of trials because you can make a better prediction about where a felt will be going the next few days and how it will affect your productivity. Better understanding of trial felts will boost innovation and, sooner or later, will boost the output of the machine.

Remember: Daily Data Powers Production.
It will really help you increase the output of your machine.

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