FILTER MEDIA PERFORMANCE AND ITS INFLUENCE ON FILTRATION RESULTS- EXPERIENCE, EXPECTATIONS AND POSSIBILITIES IN VACUUM AND PRESSURE FILTRATION

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ABSTRACT

Current demands and trends in various liquid-solid separation applications require that the filter media be adjusted to the specific product characteristics and process requirements of the user. In the past, the industry had the choice between two types of filter media: one with low resistance, providing a high level of permeability, but with lower mechanical strength; or one with higher resistance, resulting in a lower level of permeability, but mechanically strong and stable. Concessions had to be made, especially for the use in vacuum or pressure filtration. Design and characteristics of the filter media, such as number of pores, pore shape, pore size, pore size distribution and permeability, are all influencing the cake formation, cake filtration, filter media lifetime, as well as the resulting machine efficiency and productivity – in the end: the overall cost of ownership.

In recent years, new techniques and developments have enabled Sefar to increase the filter media performance without compromising the mechanical properties of the media, or its ability to be used on different types of filtration equipment. By decreasing the filter media's resistance, the filtration capacity can be increased significantly – sometimes to the point of reducing the size of the filter equipment required to achieve the objective. If new fabric designs are evaluated and implemented thoroughly, this can be a substantial contribution to achieving a higher production yield, while obtaining, or even improving, the final product quality.

This paper will highlight and describe the variables and performance criteria that require definition in order to properly select the most efficient filter media for a given application. Filter media utilization and resulting filtration capacity, filtrate clarity, the media's influence on cake dryness, and cake release, are part of the analysis for this presentation.

The intention is to show how a major filter media manufacturer has tackled these issues and what these developments could mean for the industry in the upcoming years. This paper compares the history, present, and future of different filter media, in terms of their pore count, pore sizes, and air permeability. Other presented topics will include: calculations, laboratory testing, customer trials, and the accordant filtration results during production scale up on vacuum filters. Theoretical expectations, laboratory experiments, and field case study results are analyzed and discussed. An actual example of the guidelines used to judge filter media performance and some of the properties of enhanced future filter media properties will conclude the presentation.

KEYWORDS

Filter cloth, Filter media resistance, Air permeability, Cake filtration, Vacuum filtration
Operation cost, Efficiency improvement

1. Introduction- history and development of woven filter media

Separation systems are used in many industries to remove undesired compounds or to recover desired ones. These systems are utilized for many purposes including purification, concentration and clarification of suspensions, washing of processed products and management of wastes. As one method of filtration, the cake filtration provides a particularly flexible way of the wide ranging array of physically different possibilities for the separation of particles from suspensions. In combination with different treatment possibilities (i.e. concentration, agglomeration), a particle range of several millimeters, down to some microns is covered. The various equipment designs and operating principles of cake forming filter devices require customized and specially matched filter media to meet the mechanical requirements of the filter unit (3). Solid liquid separation processes and used auxiliary material had to adapt to the increasing demands and the filter media has undergone a huge development over the last decades. As the requirements to the utilized filter media are depending and varying with the used filtration equipment and the processed materials, different aspects need to be considered when developing and selecting a filter media for a given filtration task. In recent years, new techniques have enabled Sefar to drastically increase the filter media permeability and its number of pores per cm^2 (Figure 1) without comprising on their mechanical properties.

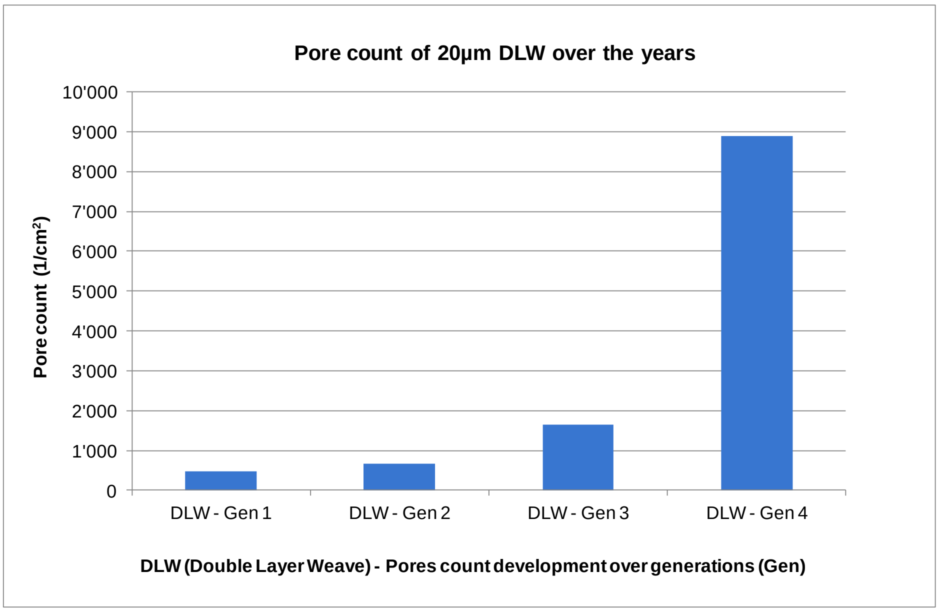


Figure 1: Pore count development of different Double Layer Weave fabric generations

The improvement of filter media design (i.e. number of pores) showed an impact on the performance when filter media with comparable pore size are analyzed and used in the field. This variables and performance influences are shown in this paper to make it obvious that filter media design and selection have an impact on the filtration process.

2. Filter media design

Woven fabrics are a major part of the type of filter media used in many solid-liquid separation processes. Design and characteristics of the woven filter media such as yarn raw material, yarn properties, weaving pattern as well as media density and finishing process directly influence the following filter media characteristics:

- Pore size and pore size distribution
- Number of pores
- Filter media air and liquid permeability
- Resulting flow and percolation resistance
- Suitability for the use on the filter equipment

As an example different structured filter media are displayed below:

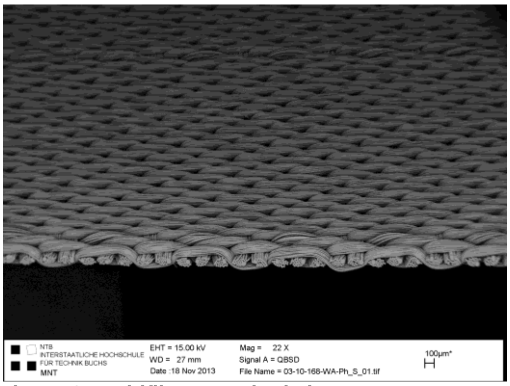


Figure 2: Multifilament, single layer

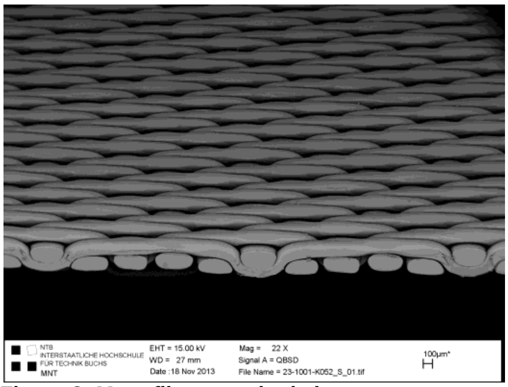


Figure 3: Monofilament, single layer

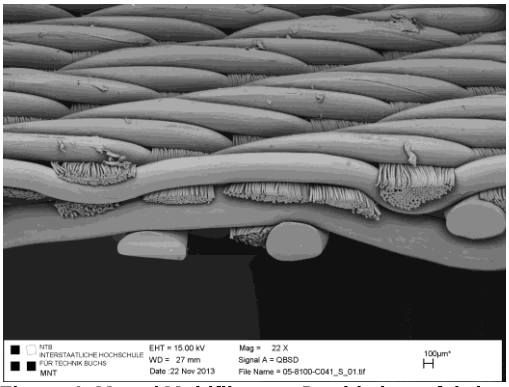


Figure 4: Mono/ Multifilament Double layer fabric

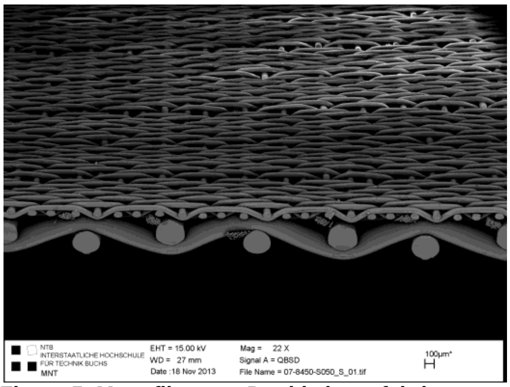


Figure 5: Monofilament, Double layer fabric

All these filter media parameters influencing the following aspects which need to be considered during filter media selection:

- Concentration, surface tension and particle size distribution of the suspension
- Required filtrate clarity
- Residual cake moisture content acceptance
- Desired filtration rate
- Easy cake discharge
- Mechanical and thermal performance & dimensional stability

The specific importance of these aspects is depending on the requirements of the currently used process and its auxiliary materials. Crucial for the success of the separation process is the perfect alignment and further interaction between filter media, suspension, utilized machinery and the operation conditions (3).

The following chapters compare the design and characteristics of woven filter media with aspects of the specific application requirements. Chapter 3 takes a more specific look at selected filter media design and filtration results in the laboratory, while Chapter 4 & 5 outlines the results in the fields using currently developed filter media.

3. Laboratory testing

Aim of the following filter tests is to compare different filter media with different pore size and/or different weaving construction to judge their filtration performance. Using the laboratory filtration results, filter media resistance and the filter cake resistance can be calculated through the measurement of the filtrate quantity. Also the filtration time as well as particle throughput, cake height and cake dryness can be determined. All these parameters are compared to ascertain filter media values.

3.1 Filter media characterization for laboratory testing

Table 1 shows the chosen filter media. Pore size MPF – Mean Pore Flow is determined by Bubble Point based on ASTM F 316-03 measurement (5) – ranges from 10 – 30 µm. Mainly DLW (Double Layer Weave) of different generations were chosen: outdated Generation 1 (Gen 1) going up to the standard Gen 2 and the newest developments of DLW Gen 3 and Gen 4. The development steps in number of pores of the different Generations were already shown in (chapter 1). Beside the DLW filter media, one Twill (TWL) and one Plain Reversed Dutch (PRD) pattern were chosen to compare their performance with Double Layer Weave fabrics.

No.	Material	Filament type	Weave pattern	Pore size MFP (µm)	Pore count ($1/cm^2$)	Air permeability @ 200 Pa ($l/(m^2 \cdot s)$)	Water permeabilty ($l/(m^2 \cdot s)$)
24	PP	Mono-multi	DLW - Gen 1	21	480	43	8
25	PP	Mono-multi	DLW - Gen 1	22	460	61	12
18	PP	Mono-multi	DLW - Gen 2	10	820	17	4
13	PP	Mono-multi	DLW - Gen 2	19	660	57	11
20	PP	Mono-multi	DLW - Gen 2	25	850	114	19
22	PP	Mono	DLW - Gen 2	32	780	178	28
19	PP	Mono-multi	DLW - Gen 3	25	1340	40	7
14	PP	Mono-multi	DLW - Gen 3	23	1640	70	13
21	PP	Mono-multi	DLW - Gen 3	33	1640	119	19
23	PP	Mono	DLW - Gen 3	38	1580	245	42
17	PET	Mono-multi	DLW - Gen 4	20	8890	203	35
16	PET	Mono	PRD	28	3450	657	117
15	PET	Multi	TWL	19	3220	251	44

Table 1: Filter media selection utilized for filtration tests

All chosen filter media were analyzed by determining the mean flow pore pressure (MFP), their air permeability and the water throughput (7). The air permeability and the (de-ionized) water throughput show a good correlation (Figure 6) – with increasing air permeability a corresponding increasing water throughput is determined.

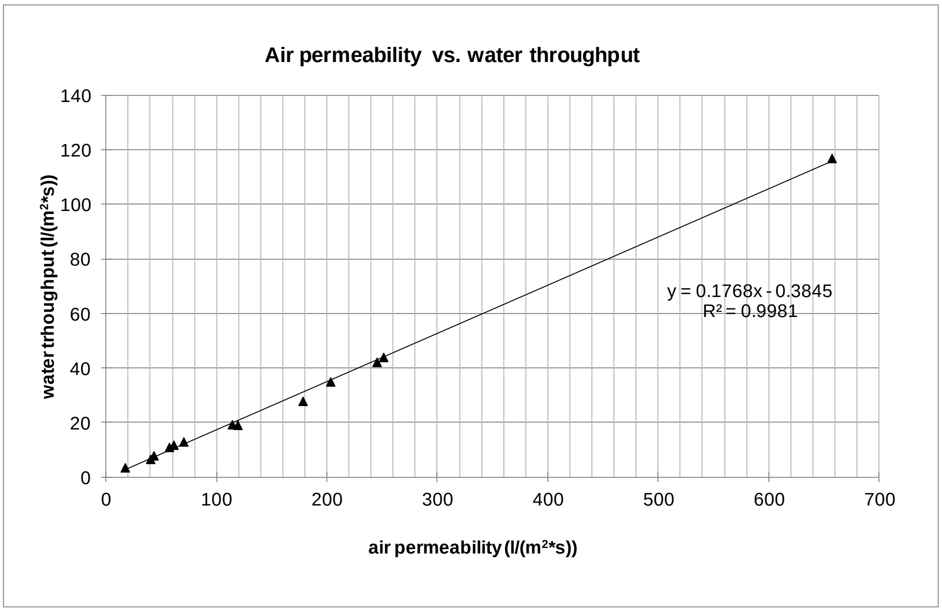
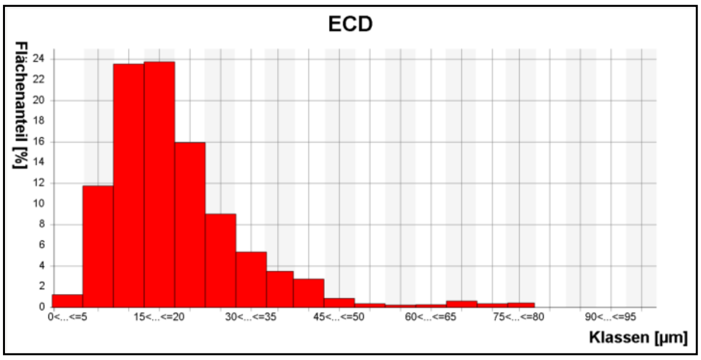


Figure 6: Air permeability vs. water permeability of different filter media

3.2 Filtration test equipment and test procedure

3.2.1 Test suspension

The used suspension has a solid content of 20%. After internal characterization with an optical microscope analysis (Pixelferber imaging software) calcium carbonate $CaCO_3$ (Omya 10H) was selected as solid content (Figure 7). The chosen filter media average pore sizes are around 1.2 – 2 times the D_{50} of the $CaCO_3$ particle size distribution. All filter tests are carried out with the same suspension to compare the filter media. Note that other suspensions or concentrations might lead to different filtration results.



Particle size distribution	µm	0.4 – 80
D_{50}	µm	15
D_{80}	µm	25
D_{98}	µm	55
pH		8
Density Solution	g/ml	1.1

Figure 7: Particle distribution and particle characterization of $CaCO_3$ suspension

3.2.2 Test equipment

Laboratory tests are carried out using a pressure nutsch filter test. Figure 8 shows the schematic set up of the testing equipment as well as the used pressure nutsch. As the goal is to compare different filter media, constant filter test parameters at room temperature conditions are used: constant pressure of 0.7 bar, filter volume of 40 ml, filter area of 12.6 cm^2, maximum cake height of 25mm and using a standard suspension (details see chapter 3.2.1). A weighing scale is connected to a computer, recording the filtrate quantity at a specific time.

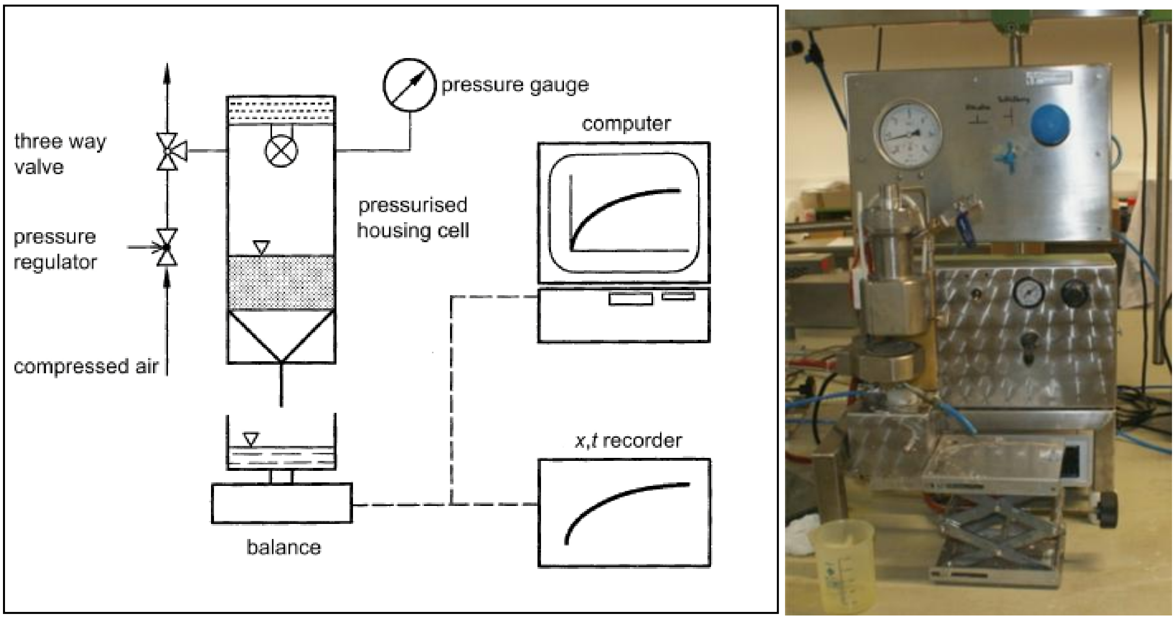


Figure 8: Left: test set up – schematic (1), right: pressure nutsch test equipment

3.2.3 Test procedure

The used filter media (see Table 1) is punched out, pre wetted with de-ionized water and clamped into the pressure nutsch. The used suspension is prepared in a glass beaker and stirred continuous with a constant speed to make sure that there is no sedimentation and the particle are dispersed homogeneous in the suspension. The volume of 40ml for one filter test is taken out using a syringe and is applied on the test equipment. Time measurement starts immediately. After 10 s pressure is applied and cake formation time starts. Measurement ends after the cake surface shows no more brightening and 60 s of ongoing pressure as cake drying time is over. Test procedure is carried out three times in a row on the same filter media, releasing and scraping cake of filter media. As pre-trials showed, after the third measurement results get repeatable and variability is low. After third measurement cake height and weight is measured. Wet cake is dried with 80°C at least 8 h and dry cake weight is measured afterwards. If required cake dryness (TS) is calculated using following formula:

$$TS = \frac{\mathrm{M\ (dry)}}{\mathrm{M\ (wet)}} * 100\ \% \quad (1)$$

Next to the filter cake the filtrate itself is centrifuged, decanted, dried and weight back and determining thereby the quantity of particles in the filtrate – particle throughput.

Filter media resistance R_T and filter cake resistance r_c are displayed and can be calculated as characterizing factor. It unifies all influences such as particle size and distribution, pore shape, porosity and structure of filter cake and filter media. Both factors are calculated, analyzing the measured filtrate quantity over time (1), (3).

$$R_T(\Delta p) = a \cdot \frac{A \cdot \Delta p}{\eta} \qquad (1)$$

R_T = filter media resistance (1/m)
a = axis intercept a
A = filter area (m^2)
Δp = pressure difference (Pa)
H = viscosity liquid (Pa*s)

Wherever possible testing equipment, procedure and calculation is based on recommendations of the VDI guideline 2762 (1).

3.3 Filtration Results

Filter media analysis of air permeability and water permeability (see Figure 6) implies that air permeability and throughput on liquids correlates quite well. When filter test are not only done with clean water, but using suspensions – as $CaCO_3$ – filtration results can show different tendencies.

Figure 9 compares the air permeability to the filtration time of two generations of Double Layer Weaves (DLW) with different pore sizes (see Table 1). There is a correlation between the measured filtration time and the air permeability but only if comparing the same generations of DLW. Filtration time of the same suspension not only depends on the air permeability, but also on the weaving pattern differences: DLW Gen 2 vs. DLW Gen 3. For example – see circled filter media Figure 9 – having similar air permeability, filtration time can be reduced by 10% through modifications of the filter media.

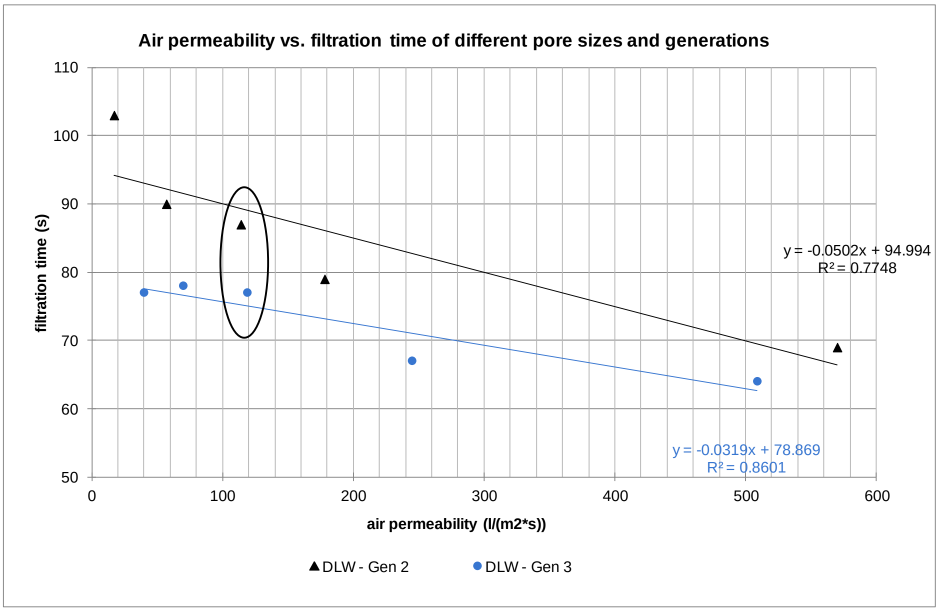


Figure 9: Air permeability vs. filtration time of two generations of DLW

If taking a look closer on filter media with a pore size of around 20 µm with different air permeability, it can be seen that there is no correlation (Figure 10). This makes it more obvious that there are other influences of the weaving construction e.g. the number of pores that have to be taken in account when looking at the flow behavior and resulting filtration performance.

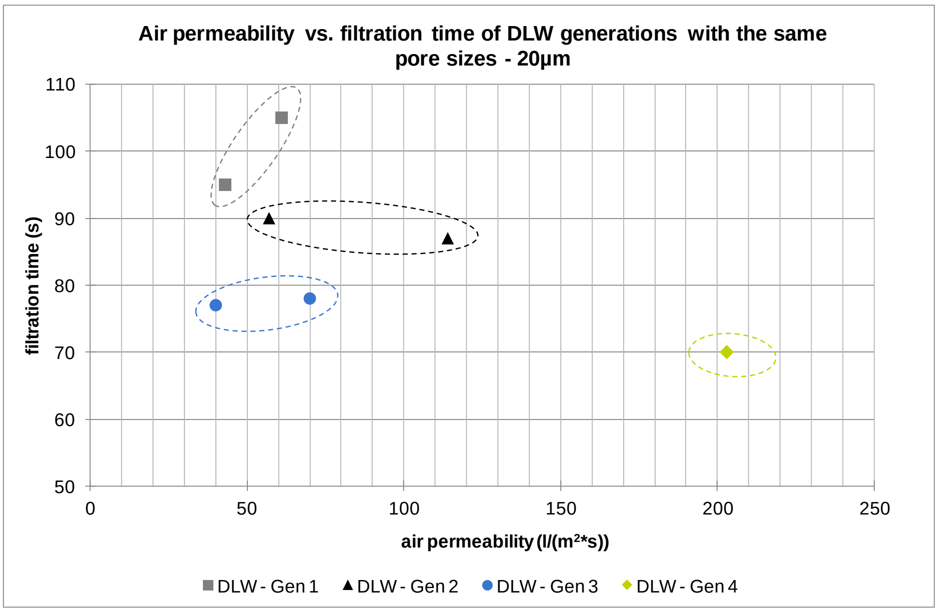


Figure 10: Air permeability and filtration time

Figure 11 compares the number of pores with the filtration time of DLW filter media Gen 1 to Gen 3 with a 20µm pore size (same filter media as in Figure 10): the higher the number of pores, the shorter the filtration time. This conclusion has significant influence on filter media selection: not only pore shape, pore size and air permeability are relevant, but also number of pores have to be taken in account.

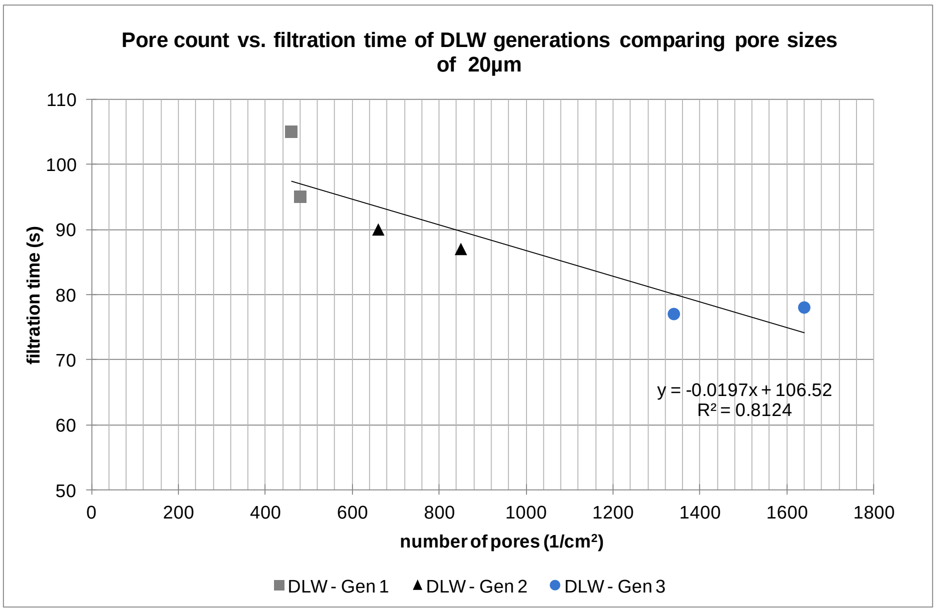


Figure 11: Number of pores vs. filtration time of DLW of the same pore size

This phenomenon can also be recognized when looking on the filter media resistance and cake resistance. Figure 12 compares selected fabrics in this matter and shows clearly that different filter media can react totally different using the same suspension. The filtration time depends on the filter media resistance – the higher the resistance the slower the filtration time. An improvement of the filtration time is possible by choosing a filter media with a comparable low filter media resistance. Particle retention for tested filter media is on a similar level and details have to be judged by individual acceptance level.

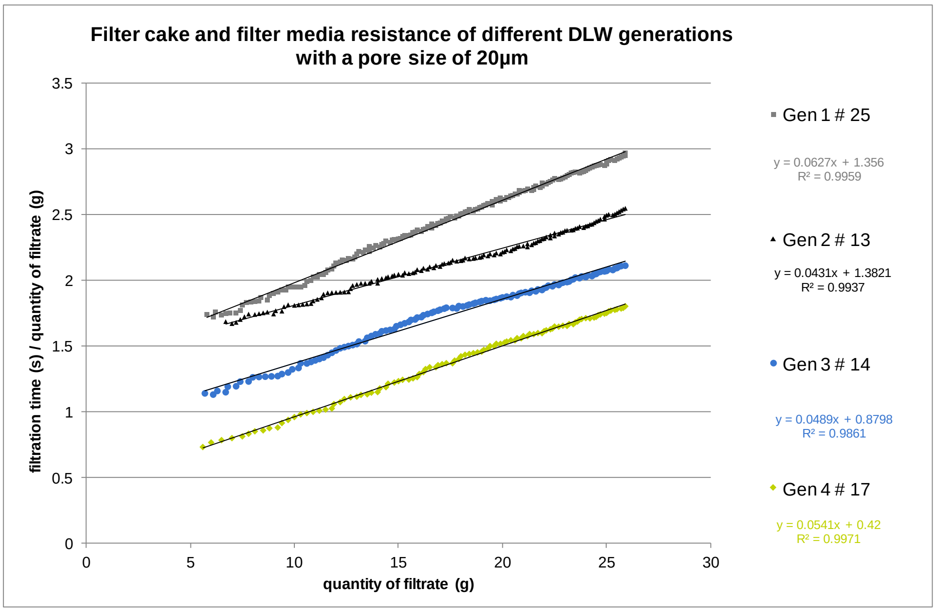


Figure 12: Filter media resistance vs. filtration time

Figure 13 shows that filtration time correlates with filter media resistance for all selected filter media (Table 1). The filtration time is lower when having a lower filter media resistance.

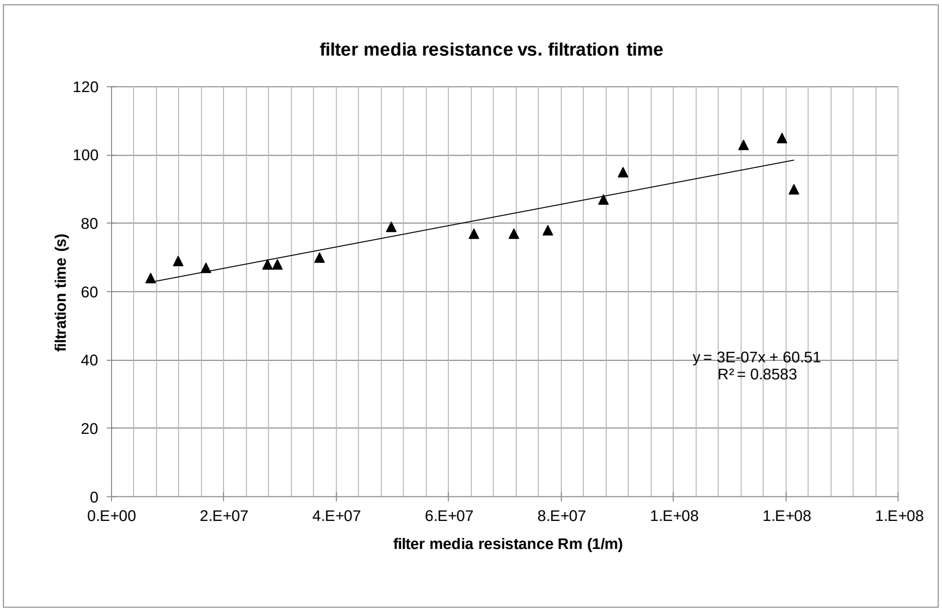


Figure 13: Filter media resistance vs. filtration time (all filter media from Table 1)

Summarized, the filtration time depends on the filter media resistance – the lower the resistance, the shorter the filtration time. The filter media resistance is defined by the filter fabric and its combination of pore shape, pore size, pore count, air permeability and weaving construction, parameters which are directly influenced by the filter media manufacturer.

Choosing a filter media with a low filter media resistance is essential for the shortest possible filtration time. Comparing current double layer weave fabrics, standard multifilament twill weaves and monofilament plain reverse dutch fabrics we see a significant influence of the filter media construction on the filtration performance. Table 2 shows that fabrics (i.e. sample no. 17) with a higher pore count and lower air permeability could achieve an equal or better filtration performance.

Sample no.	17	15	16
Weave pattern	DLW - Gen 4	TWL	PRD
Filament type	Mono-multi	Multi	Mono
Pore size MFP (µm)	20	19	28
Pore count (1/cm2)	8890	3220	3450
Air permeability @ 200 Pa ($l/(m^2 \cdot s)$)	203	251	657
Filtration time (s)	70	68	68
Particle in filtrate (mg)	36	34	67

Table 2: **Polyester single vs. DLW**

Next to filtration time, other aspects have to be taken in account. The particle retention of the filter media might be an important issue. To judge the retention Figure 14 and Figure 15 show the solid content in the filtrate – the higher the content the worse the retention. Figure 14 shows that there is no real correlation of the pore size MFP and the particles in the filtrate – only tendencies can be found. If looking at the DLW Gen 1- 3 (see circle Figure 14) with the similar pore size it can be determined again, that the construction itself influences the flow behavior of the filter media, which has influence during initial cake formation and on the particle retention.

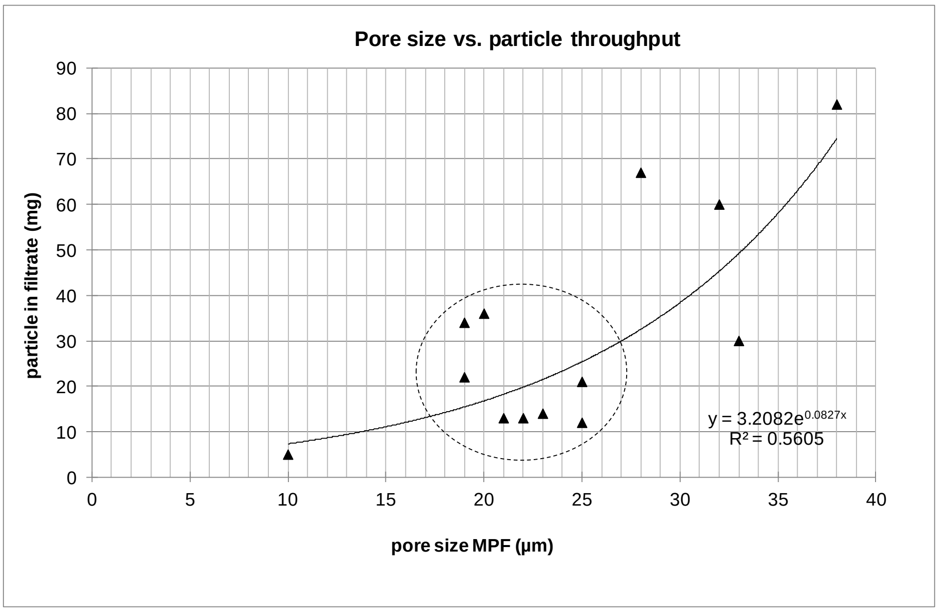


Figure 14: Pore size vs. particles in filtrate

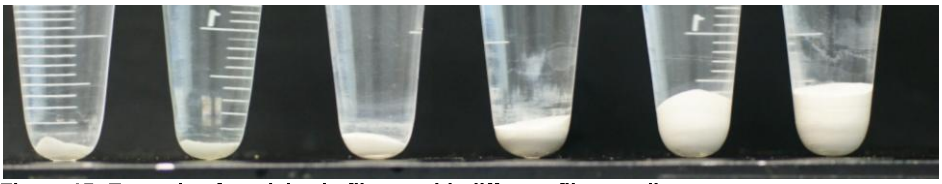


Figure 15: Example of particles in filtrate with different filter media

3.4 Conclusion of laboratory results

Depending on the given suspension – in this case $CaCO_3$ – the selected average pore size "range" of the filter media needs to be chosen. When having a selection of more than one available filter media further filter media parameters have to be taken in account: Air permeability, number of pores and weaving pattern. All these parameters influence the filter media resistance and resulting overall filtration resistance. By choosing the lowest possible filter media resistance while still retaining an acceptable level of fines, the filtration behavior can be influence positively.

In above shown filtration tests no significant differences were found in cake height and cake dryness. Information from the field show differences concerning this matter, which leads to the conclusion that the internal filtration test is too small of size and filtrate volume to point out more clear results. Additionally it has to be taken in account, that the formed cake undergoes further processes as washing and drying in which a different cake formation can also have influences on general behavior and results. These parameters are highlighted in the following field test cases.

4. Results from the field – case 1: Ore beneficiation

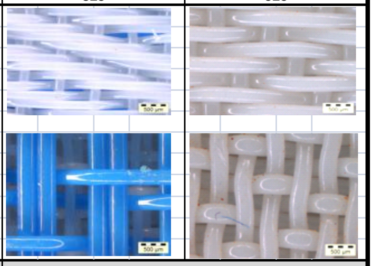
The following chapter describes the initial results achieved in the customer`s laboratory (vacuum nutsch testing) and followed by the production scale up on a vacuum belt filter. It compares the influence and results of changing from a single layer filter cloth to a double layer weave fabric (Figure 16). The application processes calcined zinc ore by leaching with sulfuric acid. The selection was limited to fabrics, which suit the thermal and mechanical requirements for vacuum belt filters within this specific application, considering the customers' demands:

- Provide a more stable filter belt in terms of lifetime (4000 hrs +) and elongation
- Improve average filtration rate and throughput ($m^3/(m^2*h)$) to cope with increased production rate and slurry feed
- Filtrate clarity shall be kept stable (≤ 1 g/l)
- Moisture content target: less than 45%

4.1 Results of trials in laboratory and production scale up

First step taken was the analysis of the current used filter media. The selection was based on the already utilized single layer fabric by determination of the physical fabric data. At the same time the customer demands in respect to the desired reduction of residual cake moisture, while keeping the condition of the filtrate, had to be taken in account. The replacing double layer weave fabric was selected in accordance to the measured pore size distribution compared to the already used single layer fabric. The replacement fabric was selected by considering the thermal, chemical (max. peak temp. 90°C, pH ~2) and mechanical requirements (longer belt lifetime, lower elongation). Meaning the polymer and fabric finishing was selected in terms of stability against temperature and pH value of the suspension and the constriction was chosen in order to deliver a prolonged belt lifetime.

Parameter fabric	unit	SEFAR TETEX® DLW HD	Single layer fabric
Material		PET	PET
Filament		Mono	Mono
Weave construction		DLW (Double layer weave)	STN (Satin)
Thickness	µm	1540	1000
Weight	g/m²	739	721
Air permeability	l/m²/s	2380	1790
Pore size average (MFP)	µm	139	139
Pore count	cm-2	825	525



Parameter test production	Unit	Details & Values	
Test reference	12,13	Vacuum Belt Filter no.3 RDno. 21/14	
Suspension		Jarosite slurry (zinc calcine leaching with sulfuric acid).	
Vacuum	bar	-0.6 bar - -0.7 bar	
Filtration area	m²	80	
Duration	days	Average values from 40 day testing peroid	
Filter media		**SEFAR TETEX® DLW HD**	**Single layer fabric**
Residual cake moisture	%	**38**	**42**
Solid content filtrate	g/l	**0.78**	**0.81**
Filtration capacity suspension	(m3/m2/h)	**8.32**	**8.05**
Elongation running direction	%	**0.5**	**1.5**

Parameter filter test lab	Unit	Details & Values							
Test reference		Vacuum Nutsch Test RDno.21/14							
Suspension		Jarosite slurry							
PSD D_{50}	µm	74							
Solid content	g/l	131.8							
Flocculant		FA 920							
Flocculant content	g/l	1 (450 g.floc/Tsolid)							
Vacuum pressure	mmHg	450							
Filter media		**SEFAR TETEX® DLW**				**Single layer fabric**			
Filtration rate $_{avg}$	(ml/ sec)	18.00		17.42		17.11		16.78	
		17.71				**16.95**			
Fitration capacity	(m³/m²/h)	**11.02**				**10.38**			
Solid content filtrate	g/l	0.77		0.73		1.01		0.90	
		0.75				**0.95**			
Residual cake moisture	%	54.40		55.72		56.70		57.10	
		55.06				**56.90**			
Thickness of cake	mm	1.10		1.20		1.00		0.90	
		1.15				**0.95**			
Test no.		Test 1		Test 2		Test 1		Test 2	
Filtrate volume	ml	sec	ml/ sec	sec	ml/ sec	sec	ml/ sec	sec	ml/ sec
10		0.3	40.0	0.3	40.0	0.3	40.0	0.3	40.0
20		0.5	40.0	0.5	40.0	0.5	40.0	0.5	40.0
30		1.0	20.0	1.0	20.0	1.0	20.0	1.0	20.0
40		1.5	20.0	1.5	20.0	1.5	20.0	1.5	20.0
50		2.0	20.0	2.0	20.0	2.0	20.0	2.0	20.0
60		2.5	20.0	2.5	20.0	2.5	20.0	2.5	20.0
70		3.0	20.0	3.0	20.0	3.0	20.0	3.0	20.0
80	ml	3.5	20.0	3.5	20.0	3.5	20.0	3.5	20.0
90		4.0	20.0	4.0	20.0	4.5	20.0	4.5	10.0
100		5.0	10.0	5.0	10.0	5.5	10.0	5.5	10.0
110		6.0	10.0	6.0	10.0	6.5	10.0	6.5	10.0
120		7.0	10.0	7.0	10.0	7.5	6.7	8.0	6.7
130		8.0	10.0	8.0	10.0	9.0	5.0	10.0	5.0
140		10.0	5.0	10.0	5.0	11.0	5.0	12.0	5.0
150		12.0	5.0	12.0	5.0	13.0	5.0	14.0	5.0

Figure 16: Results of fabric measurement, laboratory trials and production trials

4.2 Conclusion:

By choosing the right double layer weave fabric compared with the used single layer fabric the following targets can be achieved:

- 7% increase of the filtration rate
- Reduced cake moisture (%) and solid content (g/l) in the filtrate
- Confirmation of the lab data during 40 production days
- Improved mechanical performance / lifetime due to the double layer weave construction

In comparison to the conventional single layer filter media, the belt made from double layer weave fabric delivered improved filtration results by combining the functions of fine filtration and enhanced belt durability.

Laboratory tests and field tests confirmed that apart from pore size and permeability other factors as pore count and fabric construction need to be considered.

5. Results from the field – case 2: Coolant filtration

After significant changes in the production of crankshafts for the car industry the coolant filtration from the honing process went out of control. Fines in the filtrate increased and at the same time coolant throughput decreased. As a consequence costs for the tools and the secondary safety filter grow to an unacceptable level.

5.1 Laboratory results of pre- evaluation

First step taken was the analysis of the current used filter media and the amount of particles in the current coolant emulsion. The fabric selection was based on the already utilized fabric by determination of the physical fabric data and the pore size distribution (based on ASTM F 316-03 (5)). At the same time the customer demands in respect to the desired reduction of fine particles in the filtrate entering the production cycle again, had to be considered.

The replacement fabric has been selected in accordance with

- Pore size (equal or lower pore size)
- Number of pores (higher number of pores)
- Pore shape (rectangular instead of square shaped pores)
- Mechanical and chemical aspects had to be considered as well in order to achieve a reasonable lifetime

All results are displayed in Figure 17and Figure 18.

Application laboratory report 1128: Filter fabric with higher separation efficiency

Client Internal
Industry Code 65000 Metal working/coolants
Projekt AG/mG 3
Filter Pressure belt filter
Sefar contact A.Seitz
Sefar intern des

Situation:
Currently used fabric 07-1005-W118 has too high fine particle penetration. A fabric with higher separation efficiency is required.

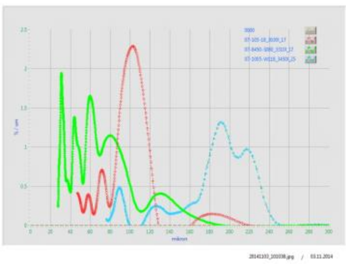
Result (Summary):
Particle size:
- Particle collected in the filtrate vessel and particles of the filter feed suspension (Fig.1 & 2)

Filtration results:
- Fig. 3-8 show the cake formation at the begin of filtration
- 50 ml of suspension with 0.6 g/l solids were filtered on a 20 mm-diameter filter pressure nutsch
-07-1005-W118 shows highest amount of fines in the filtrate
- Increasing separation performance with 07-105/18 ==> 07-88-W103 ==> 07-8450 W 080

1. Physical fabric measurement values

Value	unit	Reference	Alternative 1	Alternative 2
Material		PET	PET	PET
Abrevation		07-1005 W 118	07-105/18	07-8450 W 080
Filament		Mono	Mono	Mono
Construction		STN (Satin)	Twill (2:1)	DLW (Double layer)
Thickness	µm	697	275	850
Weight	g/m^2	418	190	280
Air permeability	l/m^2/s	3336	3030	3330
Water permeability	l/m^2/s	472	441	471
Pore size abs.	µm	216	121	158
Mean flow pore size	µm	133	102	84

Pore size distribution



3. Particle size distribution of 'filtrate vessel' and of 'filter feed suspension'

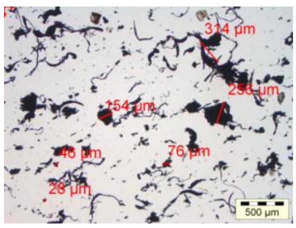


Fig.1: particles filtrate vessel

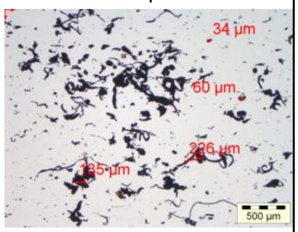


Fig. 2 Particles 'filter feed suspension'

Particle size distribution

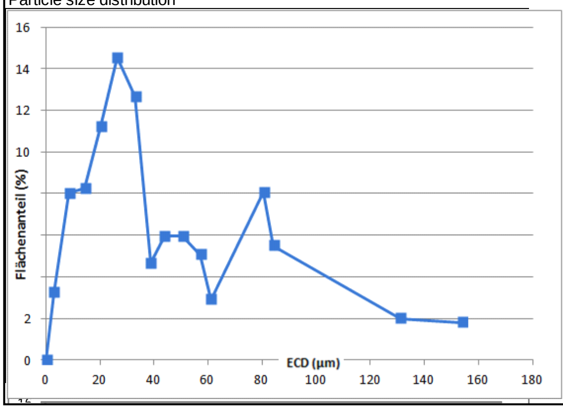


Figure 17: Laboratory evaluation of alternative fabric – Part 1 (Physical fabric data, filtration test)

4.Filtration trials

Kunde:	Internal	**Umgebung**	21.6 °C , 32 %
Laborauftrag:	1128	**Datum:**	24.10.2014
Filtergewebe:	keine Vorbehandlung	**Ausführer:**	Des

Test Nr.		1	2	3
Suspension		KSS Kunde	KSS Kunde	KSS Kunde
Temperatur		RT	RT	RT
Dichte theoretisch		2.7	2.7	2.7
Feststoffgehalt (%)		20	20	20
Test Conditionen 2. Filtration				
Zeit in Sekunden	Filtrationszeit, Kuchenbildungszei	114	122	198
	Entfeuchtungszeit	90	90	90
Beobachtungen:				
Kuchenverhalten (Risse)		klebrig	kompakt, klebrig	kompakt, trocken
Kuchenablösung		3	2	2
Kuchendicke (cm)		0.3	0.5	0.6
Test Conditionen 3. Filtration				
Zeit in Sekunden	Filtrationszeit, Kuchenbildungszei	112	140	208
	Entfeuchtungszeit	90	90	90
Beobachtungen:				
Kuchenablösung		3	2	2
Kuchendicke (cm)		0.3	0.5	0.6
Filtratklarheit, Durchlass (g)		0.096	0.034	0.014
Gewicht Kuchen nass (g)		10.20	11.57	11.80
Filtrat (ml)		33.0	34.0	34.0
Resultat				
Restfeuchte Kuchen (%)		21.9	17.2	16.4
Gewicht Kuchen trocken (g)		8.2	9.04	8.98
Feststoff in Filtrat (g)		0.096	0.034	0.014
Konzentration Feststoff im Filtrat (g/ml)		0.0029	0.0010	0.0004
Porosität ?		0.1634	0.4466	0.5419

5.Cake release on different fabrics

6. Particle retention behavior of analyzed fabrics

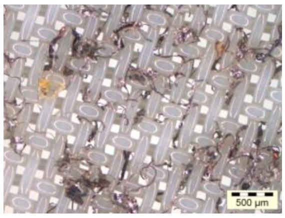


Fig. 3: Cake formation on reference fabric

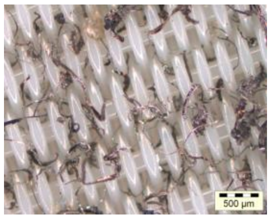


Fig. 4: Cake formation on alternative 1

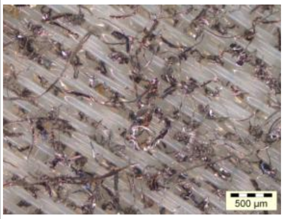


Fig.5: Cake formation on alternative 2

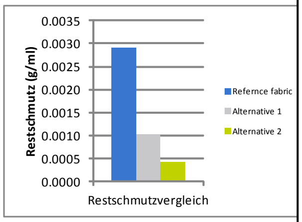


Fig.6: particles in filtrate (g/ml)

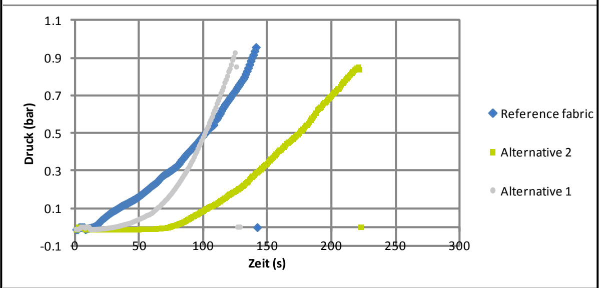


Fig 6: Pressure increase versus filtration time

Figure 18: Laboratory evaluation of alternative fabric – Part 2(Physical fabric data, filtration test)

To achieve the target of keeping back finer particles, it was recommended to change from the currently utilized single layer fabric to a double layer filter media with the matching pore size with similar permeability to achieve production rate.

5.2 Production results during scale- up

After the evaluation of different fabrics in the laboratory scale, the most promising option – Alternative 2 – was used for the scale up trials in production on a pressure belt filter. The results from production at different pressure levels during filtration cycle regarding metal impurities in the coolant are shown below (Figure 19 and Figure 20).

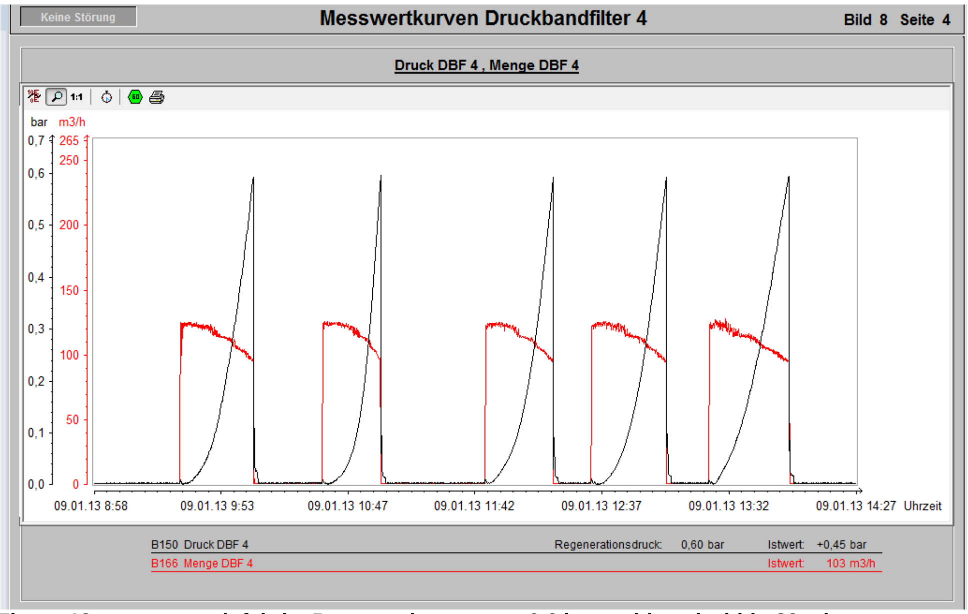


Figure 19, square mesh fabric: Pressure increase to 0.6 bar- achieved within 30 min. Throughput rate avg. is at 103m³

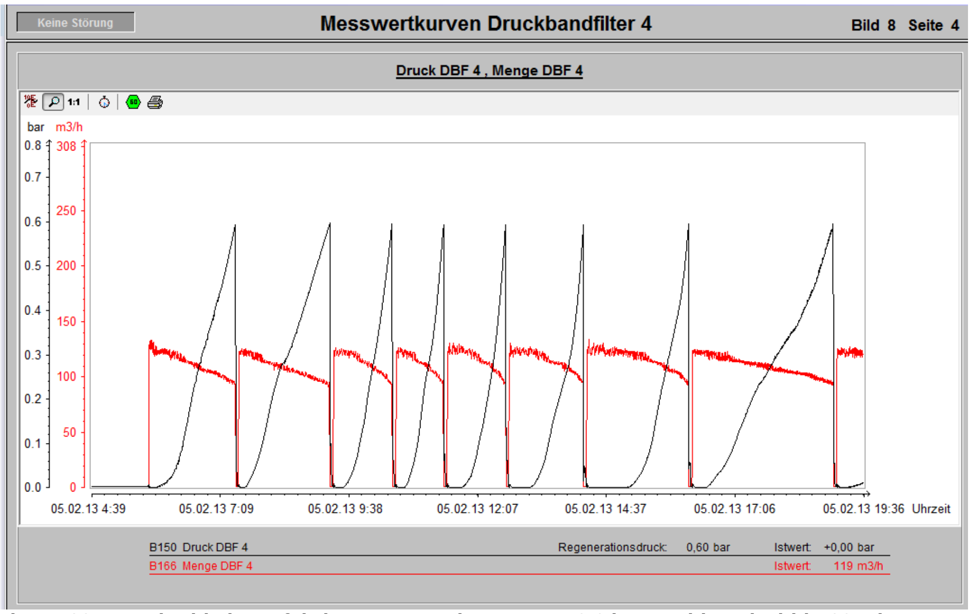


Figure 20, new double layer fabric: Pressure increase to 0.6 bar - achieved within 90 min. Throughput rate avg. is at 119m³

The needed filtration time to achieve the limiting pressure level was increased from 30 min (Figure 19) to 90 min (Figure 20). Through this increase, the triple amount of coolant emulsion was processed. This lead to an increase in filtration capacity and a higher cake could be built up. In addition, the amount of fines in the filtrate was reduced to an acceptable level again (Figure 21).

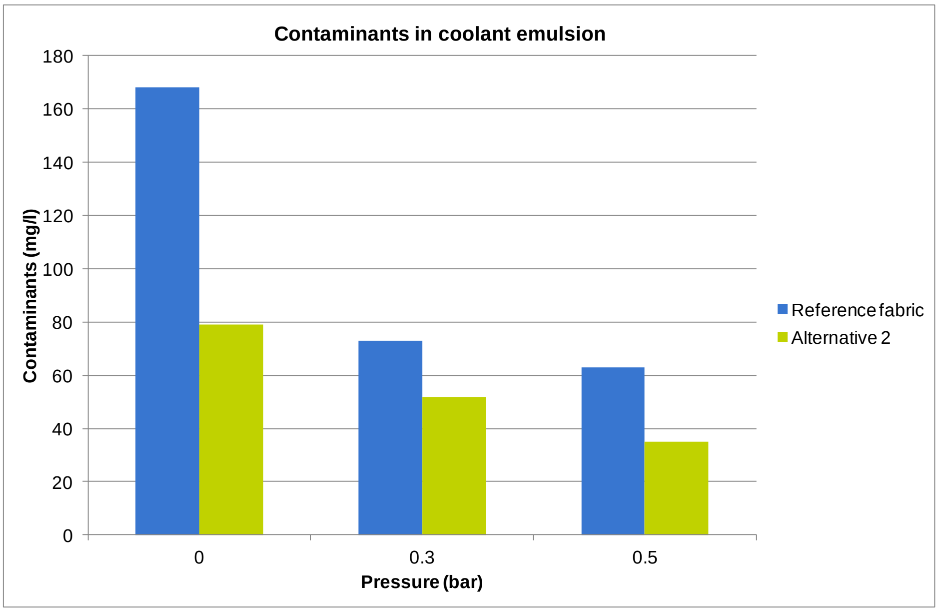


Figure 21: Comparison of metal impurities at different pressure levels

5.4 Conclusion production scale up

The field tests confirmed the theoretical thoughts and the laboratory tests as follow:

- Fines in the filtrate have been reduced by 29%
- Liquid throughput increased by up to 66%
- Lifetime of the pressure belt doubled as a not undesired side effect

Media resistance and resulting cake resistance depending on fabric construction, pore size, pore shape, pore count permeability and are one key element for a successful filtration.

6. Overall summary and guideline for filter media selection

Laboratory results as well as highlighted field test cases showed the importance of the filter media type selection on filtration results. Before starting to carry out laboratory or field trials, important suitability criteria of used filter device and the applications environment have to be considered:

- Chemical requirements (Selection of filter media polymer)
  - Characteristics of suspension (max. working temperature, pH)
  - Post cake treatment (compatibility with used washing agents)

- Temperature resistance (Selection of filter media polymer and finishing)
  - Process temperature filtration (keep dimensional stability)
  - Post cake treatment (compatible with washing, drying process)

- Mechanical requirements (Selection of filter media polymer and construction)
  - Size of filter unit (light fabrics may not withstand)
  - Filter media treatment (intensive washing/ cleaning processes)
  - Fabrication and conversion from roll good to filter media in accordance to equipment requirements and installation conditions

This pre-selection reduces the possible filter media utilized within the specific application. Next topic to be clarified is the separation performance:

- Required filtration capacity (Selection of filter media resistance)
    - Characteristics of suspension
    - Particle size distribution
    - Throughput in $m^3/(m^2*h)$
    - Filtrate clarity
    - Cake dryness and quality

First step is to analyze the current processed suspension (see chapter 3.2.1). This gives the user a first indication which pore sized filter media has to be chosen. As a large variation of different weaving styles is available, following aspects need to be considered:

- Pore size
- Filter media air permeability
- Number of pores per cm^2
- Weaving pattern

Underlined by the results in chapter 3 – 5 not only the air permeability but even more important the number of pores and the weaving pattern have significant influences on the resulting flow resistance and liquid/ particle percolation. These differences influence the results in the given filter media resistance, which itself is a major factor for the filtration capacity. Next to the throughput, the filter test results help to judge the acceptable particle retention behavior and residual cake moisture. To answer this question laboratory testing can help before scaling up production.

Summarized: **Filter media resistance and resulting cake resistance depend on the fabric construction, pore size, pore shape, pore count, permeability - which are key elements for a successful filtration.**

Not only filter media manufacturer but also Original Equipment Manufacturer point out, that the choice of filter media is an important factor to be considered during filter process layout and definition (4). Considering the filter media as important part in the filtration process, the industry can use this provided knowledge for upcoming challenges in the next years. Adequate selected filter media help when defining new processes or when optimization of current process is done. Through that the overall cost of ownership can be reduced and the competitiveness increases.

Source s & references

(1) VDI Guideline 2762, “Mechanical solid-liquid separation by cake filtration, Determination of filter cake resistance”, part 1 &2 Beuth Verlag GmbH, Berlin
(2) B.Sc Textile Christoph Maurer/ Publication, next generation of vacuum belt filter media, Achema 2012
(3) H. Anlauf, 2007 Filtermedien zur Kuchenfiltration - Schnittstelle zwischen Suspension und Apparat CITplus 12/2003, GIT Verlag GmbH & Co. KG
(4) E. Ehrfeld- BoKeLa “Influence of Filter cloth behaviour on the layout of cake forming filters”
(5) Sefar, PA Standard Porengrössenmessung, Stand: November 2014
(6) Sefar, PA Standard Luftdurchlässigkeit und Wasserdurchlässigkeit, Stand: November 2014