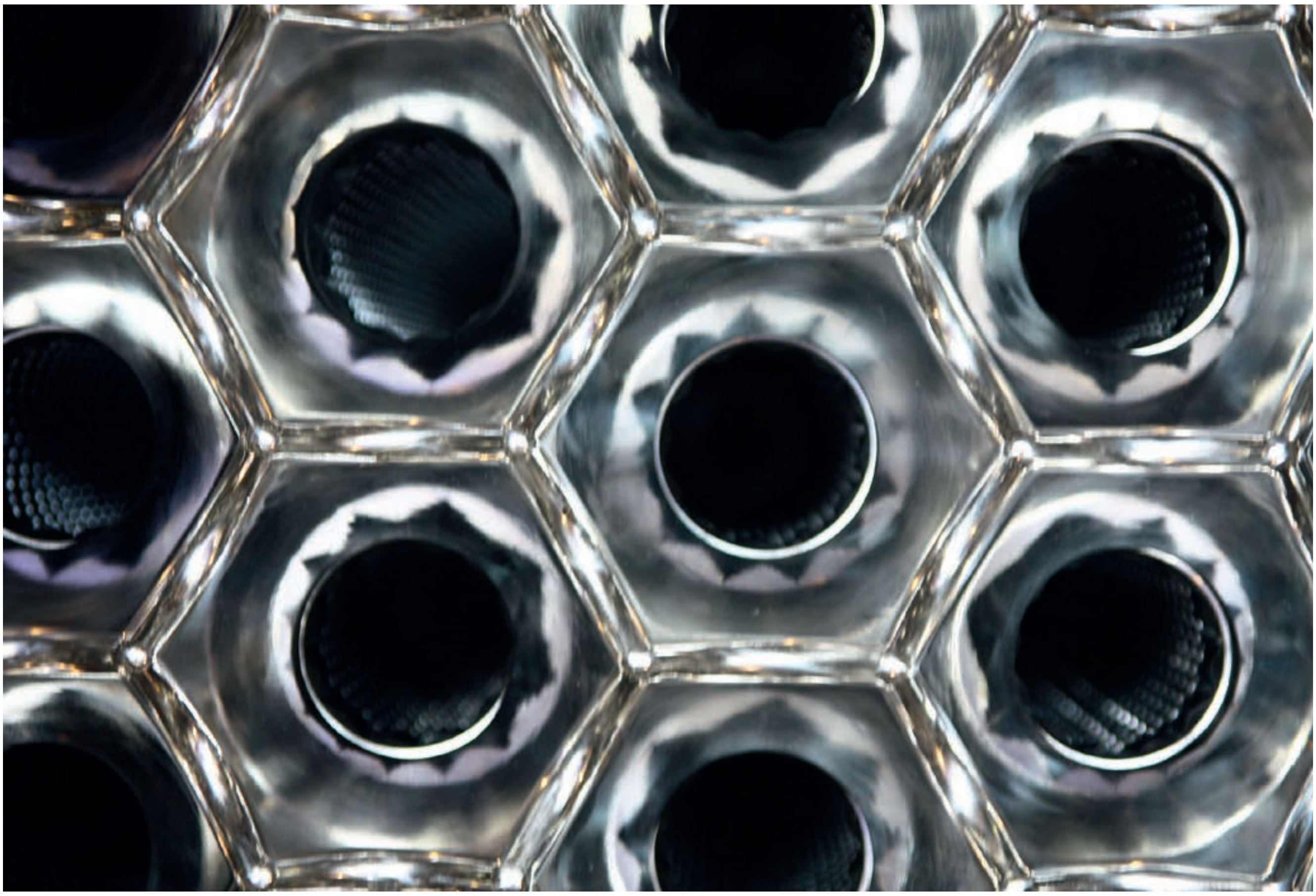
# The Agony of Filter Choice

## *The Right Filter Technology for the Chosen Polymer*

When constructing or redeveloping extrusion lines companies face a multitude of questions when deciding up which melt filter to match with the production. Which filter is right for a specific application? Which parameters need to be observed to create an efficient and low-maintenance filter system?



Large surface filter: rheological optimized housing for filter candles (© Seebach)

At present there are two general solutions for melt filtration available on the market: large surface filters and screen changers. Large surface filters are used if the production process is continuous, requires little to no recipe or batch changes and where the final product requires a high purity; for example products which must be crystal clear and without visible particles. This often requires filter ratings below 50 µm and – in special cases – sometimes below 5 µm (e.g. photo films, with which boards are exposed, or DVDs with extremely high areal density). Screen changers on the other hand are designed for discontinuous processes, for procedures involving (many) different recipes, where color changes are required or in situations with high amounts of contamination (e.g. recycling). Filter ratings of > 50 µm are generally used (**Table 1**).

Interestingly the mode of operation of the two filter types is exactly the opposite: most large surface filters are inline filters. They are permanently installed in the production line and must be removed and cleaned when terminal pressure loss is reached. With screen changers, a new, clean sieve is inserted when the contaminated one is driven out.

### *Pros and Cons in Process and Operation*

The main procedural difference between the two filter types is how filtration handles unwanted particles. With solid dirt like metallic abrasion (from the extruder or melt pumps) or hard particles from

| Criterion | Screen changer | Large surface filter |
|---|---|---|
| Particle size | > 50 µm | 2–50 µm (max. 80 µm) |
| Particle type | abrasion, burnt material | gels, degraded material |
| Type of filter | surface filter | surface and depth filtration |
| Type of production | batch | continuous |
| Filter element | flat screen | filter candles or discs |
| Filter area | 10 cm²– 1.5 m² (per cavity) | 0.5 m²–25 m² (per housing) |
| Multiple use | no, disposable | yes, cleanable |
| Down time | hours to days | weeks to months |

**Table 1.** Original development criteria of melt filter technologies (source: Seebach)

burnt material this is a relatively manageable task: particles can be simply separated with the correct filter rating. With flexible, soft particles such as gels, agglomerates or oligomers the process is different. Here a particle only settles if the flow velocity or the shear rate on (or in) the pores of the filter is low. If a certain threshold is exceeded, the particle is crushed into several smaller ones.

And this is the main difference between the two technologies: screen changers shear the particles. The resulting polymer melt will still contain gels, however so small, that they no longer interfere in the final product. Large surface filters on the other hand remove the flexible particles, especially if a depth filter medium is used. The result is an almost gel-free polymer melt. This difference is important. With screen changers small flexible gel particles remain physically and chemically active. These gel particles tend to re-agglomerate and there is a risk of recontamination in the filtered final product, particularly if there is a long distance between the filter outlet and the final processing stage. Re-agglomerated gels can be significantly larger than the filter pores.

Differences in the operation are more apparent: a screen changer – bolt screen changer or filter wheel – simplifies replacing the filter (sieve). The dirty screen is lead out from the polymer melt, removed, discarded, the intake is cleaned, a new sieve inserted and placed back into the melt stream. Normally this process takes only a few minutes. A large surface filter must be taken out of operation, disassembled from the line and roughly cleaned of polymer melt. Thereafter the filter elements with their mounting are removed and cleaned – by a specialized industrial cleaner or at a specialized facility – and the process usually takes several hours. However, the switching frequency with large area filters is lower. With screen changers screens are typically replaced after a few hours or a few days whereas large surface filters are generally in operation for several months before needing cleaning (**Title figure**).

## *Combination of Filter Technologies*

Providers of one of the main filter technologies are attempting to penetrate the other technology market by expanding their technologies. In particular, the manufacturers of screen changers have, in recent years, strongly invested in the further development of their solutions to mitigate the systemic imbalance (i.e. screen changers generally consist of a lot of machine and only a small filtration part). Providers are developing technologies to clean the screens in operation by back-flushing, but the major development was the adaptation of the concept which had proven valuable in the large surface filters: filter elements in screen changers.

Two well-known element geometries which have already been used in screen changers are available: filter candles and filter discs. The use of so-called disc stacks, i.e. a stack consisting of approximately 10 to 25 filter discs on a mandrel, where the melt drains through, has been proven with polymer melts with viscosities of about 300 Pa·s. With "tougher" polymers where excessive pressure loss is experienced in the inner tube a disc stack is lacking stability and filter candles can be used as an alternative: Cylindrical filter elements, where the melt flows through from the outside to the inside. Due to folding ("pleating") a filter candle can of-

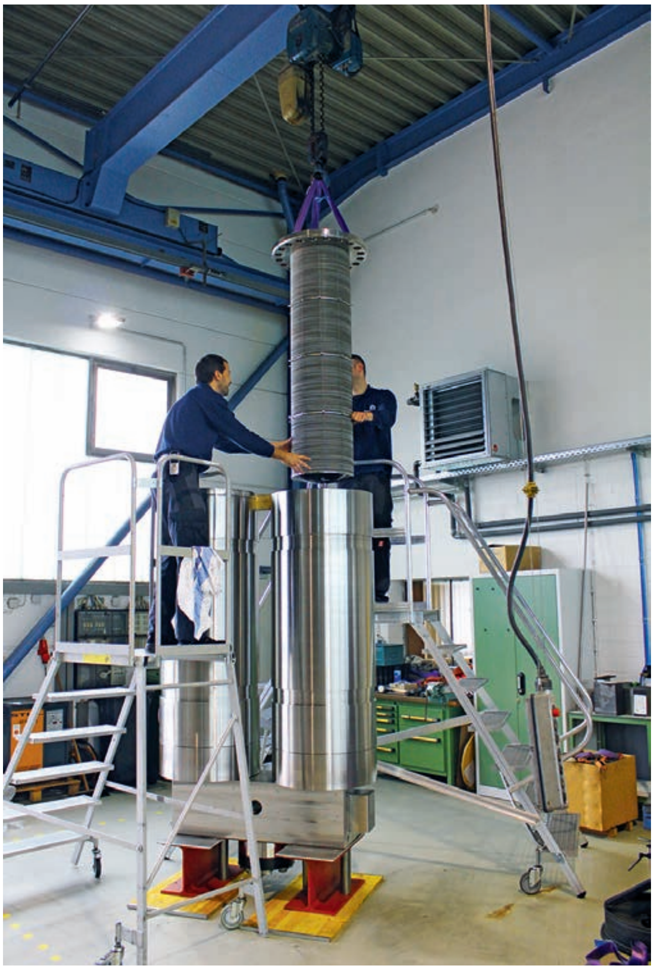


**Fig. 1.** Switch-over: this large surface filter can work continuous, as the operating team can switch between the filter disc stacks during operation (© Seebach)

fer a larger surface area than flat sieves. In addition as each filter candle has a core, pressure loss problems associated with disk stacks can be circumvented and internal stability is improved.

Further experiments by screen changer manufacturers, such as with cassettes, have not yet proved viable in the market. In parallel to developments made by screen changer manufacturers the manufacturers of the large surface filters had developed as first trend switchable double filters whereby the construction allows for a fully continuous process.

Even if most of the operating teams today can change a large surface inline filter within an hour (from the initial stop to normal production throughput), an hour production loss at large plants with continuous polymerization is often not acceptable or feasible. Many manufacturers have developed "switch-over" logics that switch during operation from the contaminated filter to a clean filter (without loss of production). This allows enough time for cleaning the filter after it has been taken out of operation (**Fig. 1**). Attempts have been made to automatize the switch-over logics however to date such solutions have not been competitive from a price-performance perspective. With approximately two to three switch overs per year manually operated hand wheels are just as efficient and much cheaper.

A second trend of large surface filters is miniaturization. For processes where relatively low filter surfaces are necessary, small one or three candle solutions are available which are intended for the coextrusion or filtration on a laboratory scale.

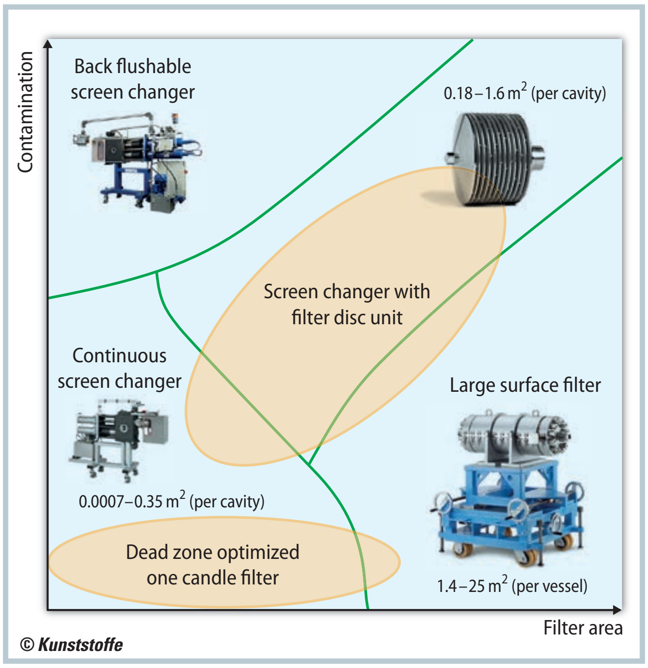



**Fig. 2.** Requirements for melt filters: depending on area requirements (x axis) and contamination risk (y axis) different technologies are available (source: Seebach)

## *The Right Solution for the Process*

When choosing a melt filter system product characteristics and/or financial requirements are often more prominent in the decision making process than the required product cleanliness (**Fig. 2**). Most users find it difficult to clearly define their requirements and in the vast majority of cases empirical values are the only available benchmark and even these are not regularly checked. Many providers of melt filters do have a technical center, but processing to evaluate final, actual product results is often not part of the normal scope of work.

Reviewing actual production results generally means additional effort, but test equipment in laboratory-scale is usually available for a relatively small additional investment and there really is no substitute for actual product results. When testing actual results it is important to understand two main parameters: first, the right filter medium based on specific process requirements and second, the proper filter rating – determined by trial and error.

Wire mesh in different webbing types, wire mesh laminates, as well as metal fiber fleece (all usually in stainless steel (1.4301/1.4401/1.4404)) are generally suitable for melt filters. For special applications (e.g. with strong acids as a solvent) special alloys such as Hastelloy, Monel or Inconell can be used.

The comparison is made quickly: all wire mesh and wire mesh laminates are surface filters and induce high (extreme high for some types of webbing) shear on a polymer. Metal fiber fleeces are depth filters and produce a significantly lower shearing (due to extreme high porosity and fiber surface). If the particles to be removed are more flexible and shear-sensitive, such as gels, one should switch to a depth filter media. If the particles are rather hard, a surface media is recommended based on process and cost sensitivity (**Table 2**).

After selecting the right filter rating and the right filter medium, the initial pressure loss and the material data (in particular the viscosity curve) decide all other design data. The filter size is determined by taking the necessary filter

| Filter medium | Surface or depth filter | Suitable for shear-sensitive particles | Chemical and thermal resistance | Mechanical strength | Open area | Cleanability |
|---|---|---|---|---|---|---|
| Wire mesh/ dutch weave | SF | -/-- | + | ++ | 0 | ++ |
| Metal fiber fleeces | DF | + | + | 0 | ++ | + |
| Wire mesh laminate | SF | -- | + | ++ | 0 | + |

**Table 2.** Characteristics of filter media: metal fiber fleeces i.e. are depth filters (DF) and suitable for shear-sensitive particles (+), they are chemical and thermal resistant, but mechanically less reliable than surface filters (SF). They have a large (++) open area and are easy to clean (source: Seebach)

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| Requirement | Screen changer | Large surface filter |
|---|---|---|
| Operation | continuous and discontinuous | continuous and discontinuous |
| Filter rating | 50–500 µm | 3–100 µm |
| Throughput | 50–5,000 kg/h | 250–15,000 kg/h |
| Effect on flexible particles | shearing | removing |
| Back flushing | yes (optional) | no |
| Dirt quantities | max. 3–5 % | < 0.1 % |
| Downtime | hours to days | weeks to months |

**Table 3.** Today's requirements for melt filter technology (source: Seebach)

area for the desired throughput at a certain filter rating and adding a factor (depending on the type and amount of contamination to be removed). For this the pressure loss calculation in all components is then repeated, to identify any weaknesses in the rheology or design (too high or too low shear rates etc.).

If this complies with the requirements, the right system has been found. It is however often not clear what size is right, as e.g. the necessary filter surface and the allowable residence time are contradictory. Leading filter manufacturers address this by using flow simulations, which – if updated with non-Newtonian fluid data like for polymers – allow an exact prediction of the real filter performance.

## *Which Filter, when?*

The selection of the right melt filter is not an either/or decision. Often certain requirements lead the decision for one technology over another. Basically two modes of operation are available in the market, one for users who continually produce the same material where every minute of uptime counts and one for a second user group that produces in campaigns and can live with down time in between to clean the system and prepare for the next campaign. Both screen changers and large surface filters are available for both operating modes and choosing one over the other should be based on specific process/product requirements (**Table 3**).

Large surface filter are used when complex filter tasks (removal of gels, high throughput rates, very fine filtration) need to be solved. Screen changers are used when requirements such as back flushing and/or the removal of high amounts of dirt are present. If all requirements are available, mixed forms filters – such as a screen changer with filter elements or even a 2-stage filtration (screen changer before a large surface filter) – are often recommended. Both technologies are very strong in the areas for which they were originally designed: screen changers for processes with high switching frequency, large surface filter for fine filtration with high service life. ■


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**Masthead**

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