Manufacturing of Filters, Sieves, Diffusers

Industrial Etching as an Alternative

A White Paper by
micrometal GmbH

micrometal
excellence in etching

1. General principles

In general the terms filter, sieve, separator, diffuser, etc., mean a surface or a three-dimensional structure with a countless number of small apertures. The ultimate goal for the designer of such a product is to build as much as possible functional geometry into a given surface or a given construction volume. The ultimate maxim for design would be creating a component consisting of nothing but functional apertures with no carrier material in-between. The carrier material between the apertures embodying the function thus acts as 'adaptor' of the functional element to the prevailing chemical-physical process conditions, the existing installation space and together with further possible mechanical elements, the connection to upstream and downstream process equipment.

Leaving aside this rather theoretical and philosophical view and taking a more technical approach on the above mentioned parts, the following table shows the characteristics of the components. It quickly becomes quite clear that apparently related components aim at completely different effects.

Component	***Purpose***	***Effect on medium***	***Characteristics***			***Need for replacement***
			Throughput	**Pressure loss**	**Efficiency**	
Filters	Retaining particles	Cleaning	High	Minor	Almost 100%	Filter full
Sieves	Zero loss separation	Classification	Medium	n/a	100%	Mechanically worn out
Diffusers	Even distribution	Distribution	High	High	0%	Mechanically worn out

Table 1: Characteristics of filters, sieves and diffusers

The wide area of application of **filtering** aims at the removal of unwanted, mostly solid particles in a medium. The efficiency may not necessarily be at 100% but 'only' at a very high degree (filter efficiency) to maximize throughput. The unwanted particle gets caught in the filter and is retained. Even a partial retention of the filtrate is acceptable as this is usually low-cost and only needs cleaning. Once the filter is overburdened with residues resulting in a significantly increased pressure drop (hydraulic gradient) the element is exchanged and is being disposed of. Filters are mostly three-dimensional components, e.g. filter cartridges or plates assembled by means of statistical methods. These are generally based on so-called nonwoven materials which can be brought into many different shapes so as to best support the corresponding filter application. Also yarns of different thread sizes and packing densities can be used to create a three-dimensional assembly of filter components.

There are cases where the above procedure cannot be followed, mainly if the physical and chemical parameters of the process exceed the limits for the prevalent synthetic materials and yarn raw materials. When dealing with high temperatures, aggressive media, extreme pressures, etc., the application of metal filter components is compulsory. The design engineer is challenged by achieving the ultimate design standard of maximizing the number of functional apertures and at the same time minimizing the carrier material in a cost-effective way. This mostly calls for the application of metallic mesh coming as cartridges, plates or in other shapes. As the individual aperture of metallic mesh can only be minimized up to a certain degree, the filtration effect for small-sized particles has to be optimized by trying to build in several steps or several layers in interaction with the piling up of the filter residues. What easily can be achieved using statistical methods in nonwoven production or by simply increasing the fabric thickness here turns into a complex exercise. Thus a metal filter part is an element of superior quality which can no longer be treated as a disposable.

These systems are assembled in a back-flush mode, i.e. cleaning of the contaminated filter is achieved by pressing clean medium or a purifier in reverse through the filter for a short time. Back-flushing increases the mechanical requirements for the stability of the filter assembly.

But not only process driven stresses and strains support usage of metal parts. There might also be difficult assembly circumstances, which prohibit an exchange in case of failure (life time filter or last chance filter). Often pure metal filters are here the only constructively possible solution.

Sieving is a technique where a certain class of particle sizes from the total of particles present is removed, i.e., a method of classification by allocating a dispersion of different particles to different classes. The majority of sieves are made of fabric. The basic materials used for fibers and wires depend on the respective application i.e., abrasiveness of the screening material, prevailing temperatures, productivity, etc.

As for **diffusers**, the medium itself should not at all be changed or undergo sorting. The medium should be distributed over a given cross-section in an ideal way e.g., to feed down-stream production processes. By generating a high difference in pressure (mostly supported by a high viscosity of the medium), material is piled-up on one side of the diffuser, exits through the apertures of the element and is thus distributed evenly on the other side. Per definition this part is exposed to high mechanical stress and due to high temperature e.g., directly after production of the medium itself, the surface loading increases over-proportionally. This results in high aspect ratios of the apertures (high ratio of cross-section opening to depth, as the mechanical stability needs to be ensured) or in a combination of diffusers mounted on robust substructures.

2. The exception: Metallic functional components

When taking a closer look at the manufacturing of filters, sieves/separators and diffusers, the following picture illustrates some basic differences:

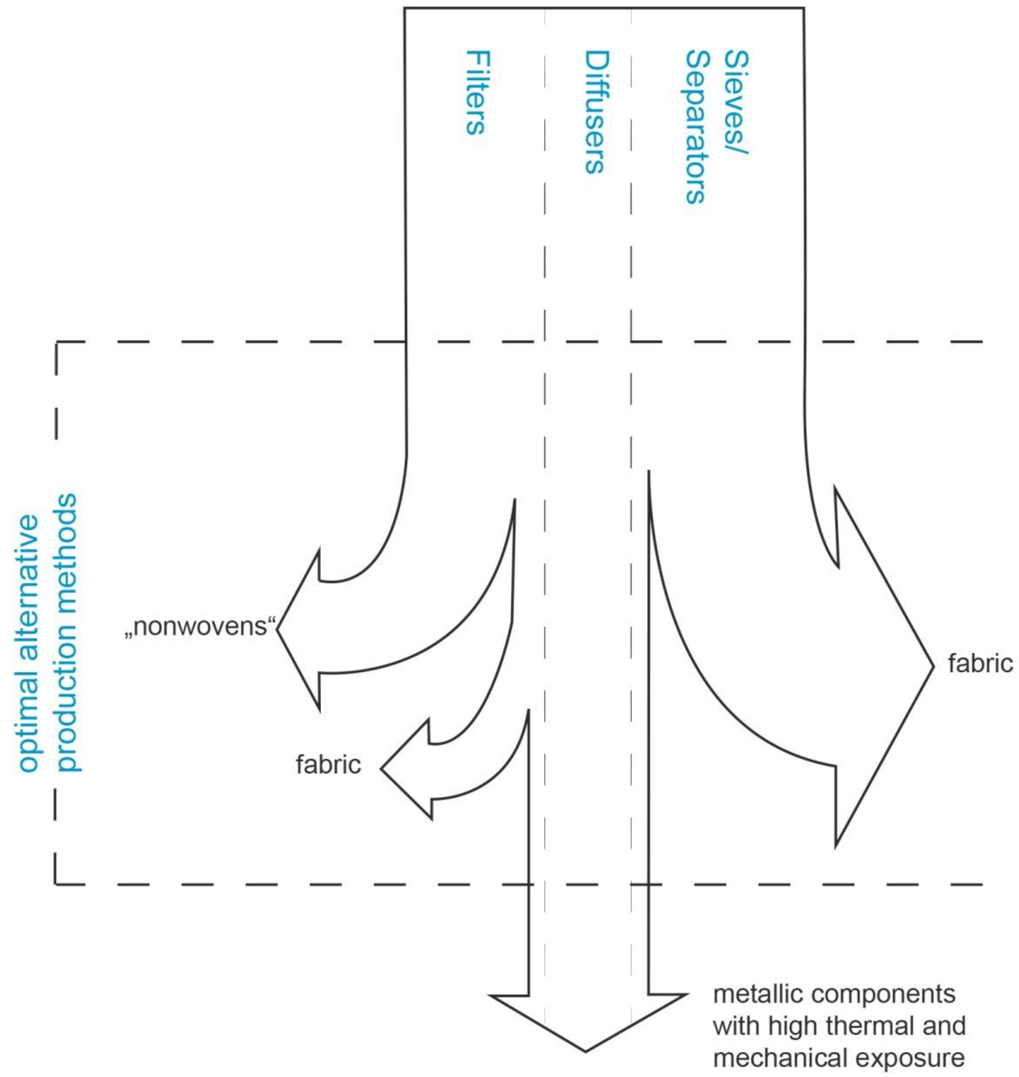

Fig.1: Production technique for filters, sieves and diffusers

Well-established and enhanced technologies actually meet manufacturing requirements for a large number of applications. In the field of filters, sieves and diffusers with high thermal and mechanical exposure there still is a demand for production techniques and constructive solutions which meet the requirements and are cost-effective at the same time.

This paper essentially elaborates on how industrial etching – also known as **photo chemical etching** - as a technology for sieves, filters, diffusers, can contribute to an effective production process. For example: what is the added value of industrial etching for the individual metal construction and the manufacturing of a complete system?

3. Industrial metal etching

The industrial technique of **metal etching** is mostly known in the field of printed circuit boards (PCB). A thin layer of an electrical conductor is etched out (mostly just a few micrometers of copper) from a carrier material following a certain pattern in order to create the desired conductor path structure on the board. But etching can also be used to produce complex functional metal components. Here the metal is coated by a photosensitive laquer or a corresponding laminate and the desired array is transmitted lithographically. The unexposed spots are developed, i.e. washed out, thus bringing out the basic material. In a chemical etching bath the complete metallic structure is cleared i.e., etched out.

Continuous industrial etching of metal is a manufacturing technique where the strip material is continuously processed through the unit (Fig. 2) with all necessary production steps interlinked. This technique is especially suitable for large industrial volumes and has the advantage of high process stability. Using photo chemical etching technology, component thicknesses ranging from approx. 20 microns until up to several hundreds of micrometers can be produced cost-effectively. Amongst others, stainless steel, brass, bronze, copper and aluminum and its alloys can be processed. By using a coil it is possible to produce virtually 'endless' structures. The structures to be reproduced are thus only limited by the width of the coil which is available in dimensions of up to 330mm in the required grades.

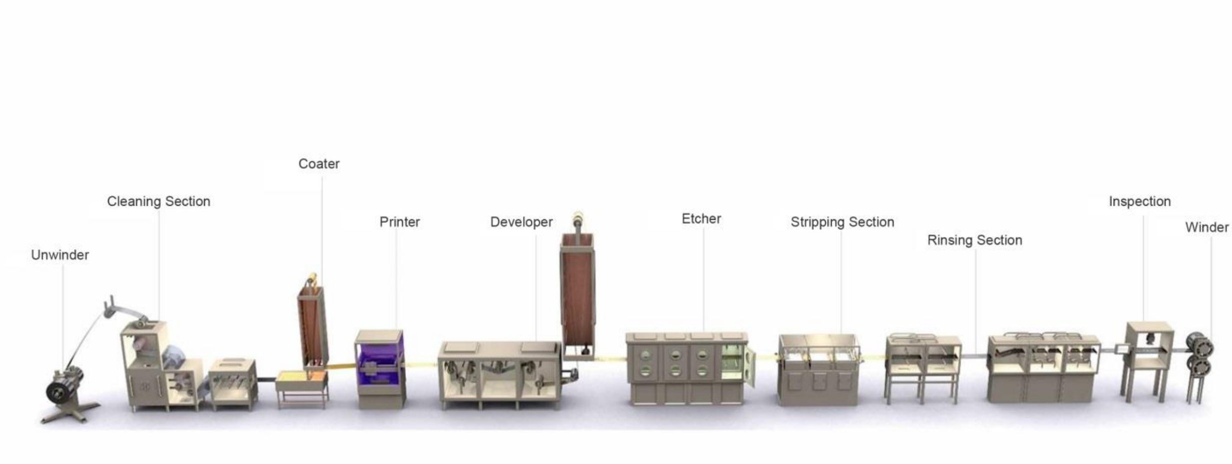

Fig. 2: Industrial metal etching - continuous chemical etching technology

4. The specific advantages of metal etching

But what are the specific advantages of these components?

In **photo chemical etching** no conventional tools are used. The respective array is copied lithographically and therefore the fluid etching medium can only access certain areas on the metal surface, etching out the basic material. During this process no mechanical and only negligible thermal strain is applied to the basic material. Thus no strain is induced into the component, which at a later stage possibly would have to be removed by thermal finishing treatment in order to guarantee dimensional stability.

Also, this avoids burrs or similar process-related inaccuracies of the edges on the apertures and mechanical finishing treatment is not necessary. As for filters, where the filter cake has to be stripped off, the contact surface needs to be free from burrs. This is also true for contact with supporting structures, which may lead to undercuts or cavities where undesired particles and bacteria could deposit (Fig. 3).

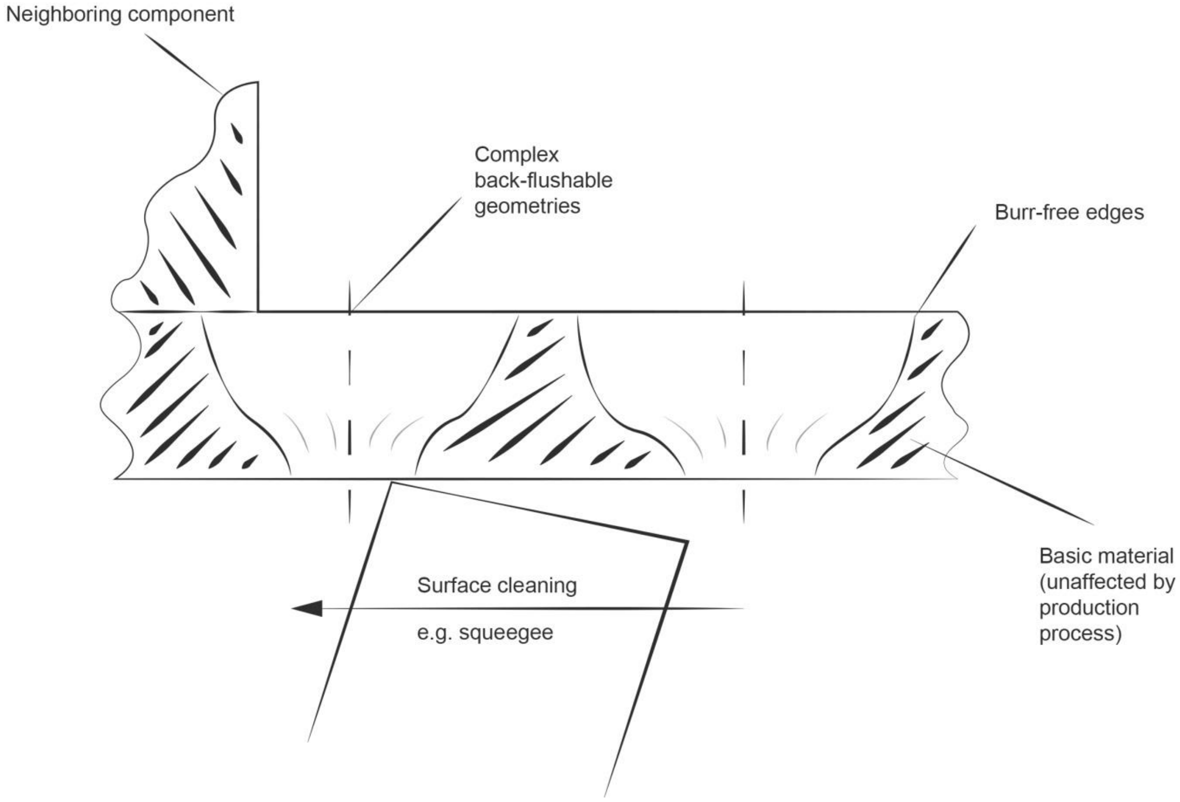

Fig. 3: General advantages of chemical etching

One of the biggest advantages of photo chemical etching technology is that irrespective of the structure complexity, productivity is consistently high. Due to parallel, tool-free processing of the complete component surface in the etching bath, the most complex structures can be realized at the same rate as single individual structures, e.g. circular apertures (Fig. 4). As chemical etching is a stressless production technique, the basic material can be extremely decimated i.e., a significant part of the metal surface can be opened up. Thus etching technology can still be applied where metal cutting and stamping technique meet their boundaries.

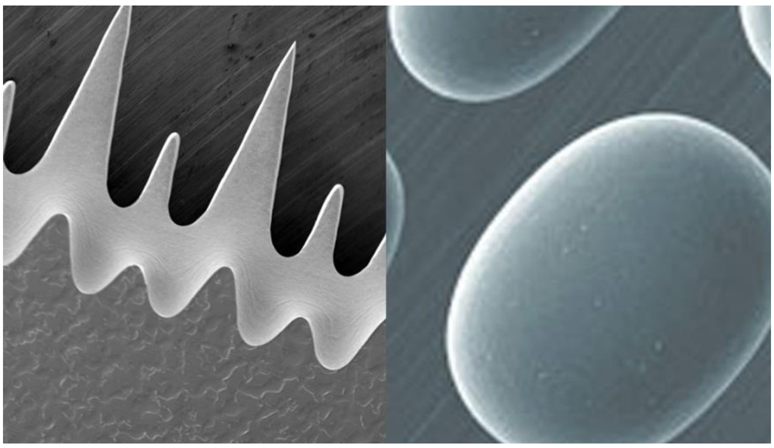

Fig. 4: Geometries produced by photo chemical etching at consistent productivity

As chemical etching technique uses a fluid to remove the metal, straight or orthogonal walls and/or edges cannot be created in the third dimension, i.e. into the depth of the component. Especially after perforation of the metal strip from both sides, chemical etching results in washing and rounding effects. But this apparent disadvantage in chemical degradation may turn into an advantage if easily back-flushable shapes need to be created within the filters (Fig. 5). Conically shaped apertures can easily be created and also be positioned inclined into the material by parallel offsetting the front side and back side structure. Thus the structure array in the element can be adapted to specific geometrical positions or fluid dynamic conditions.

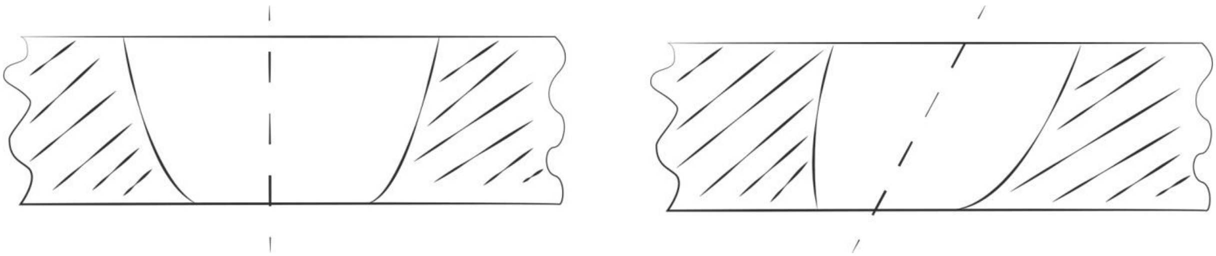

Fig. 5: Variants of back-flushable shapes

It is also possible to vary the dimensions of apertures in the material over the complete surface of a component to realize specific flow conditions or changes in filter efficiency within a defined area (Fig. 6). This effect is especially interesting in diffuser technique and is difficult to realize with an even aperture distribution as present in tissues and nonwoven materials.

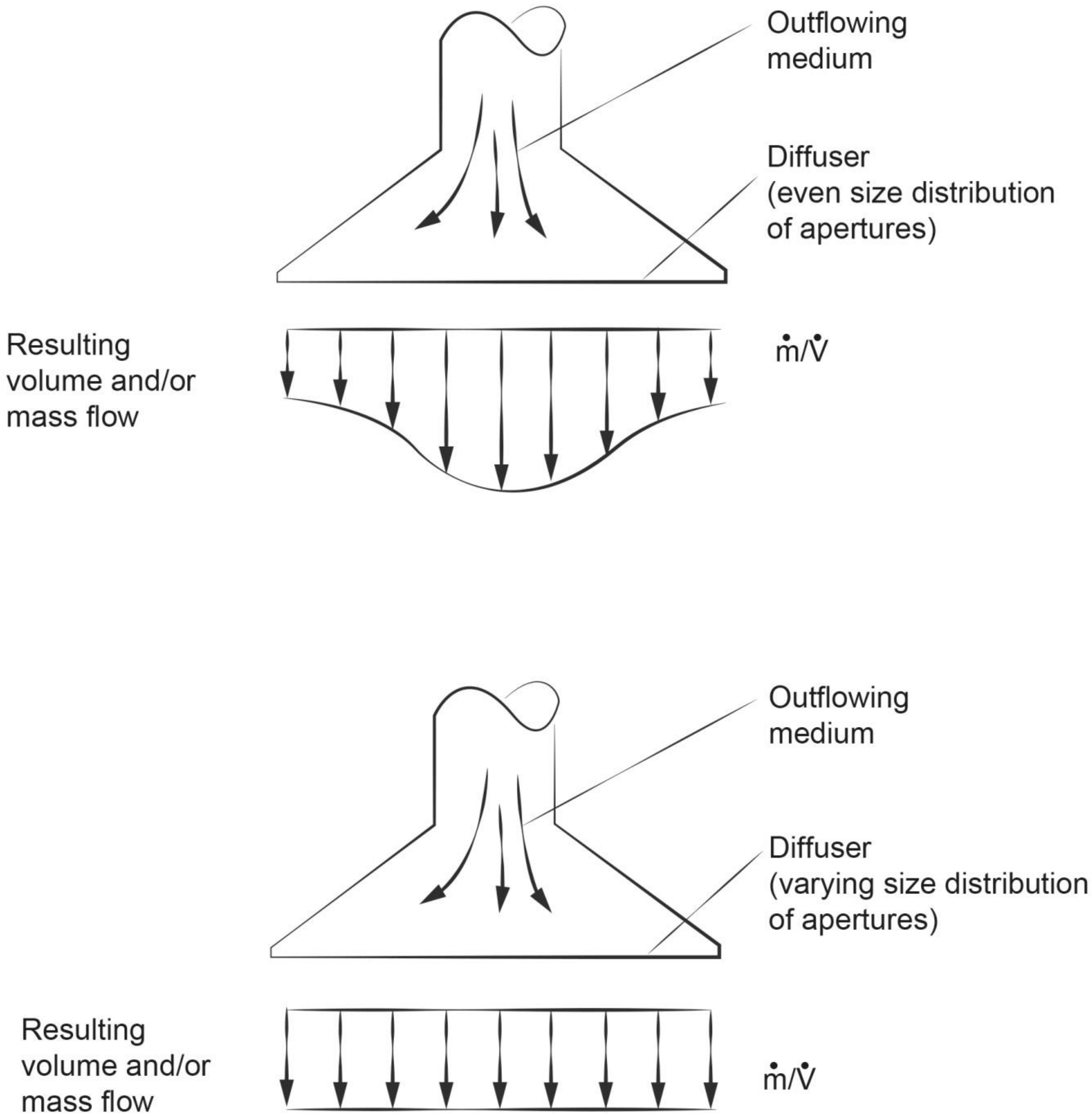

Fig. 6: Compensation of flow effects by varying the aperture shape or size

Due to the fact that in the front and back of a component different geometries can be pushed ahead, further variations are possible, which are not mentioned in detail in this paper. It is, e.g. possible to etch a channel into the back of a component which only comes into contact with the front-side filter structure at defined areas thus possibly creating micro channels or media reservoirs. There are almost no limits set to the fantasy of the design engineer.

Especially interesting is the combination of different layers of sheets which have undergone photo chemical etching and have been pressed together into a single unit. To this point only filter, separator and diffuser apertures were described which were driven into the material orthogonally to the metal surface as seen in conventional sieves. Stacked etched metal components offer an even greater variety of design possibilities (Fig. 7).

As can be seen in the below illustration, filter effect is not only achieved by an etched aperture but is the result of etching the metal surface (so called **half etch**) and is additionally limited by the surface of the stacked neighboring component. This way manifold geometries of apertures and outer geometries of stacked filters can be generated thus taking into account individual installation conditions and space allowances.

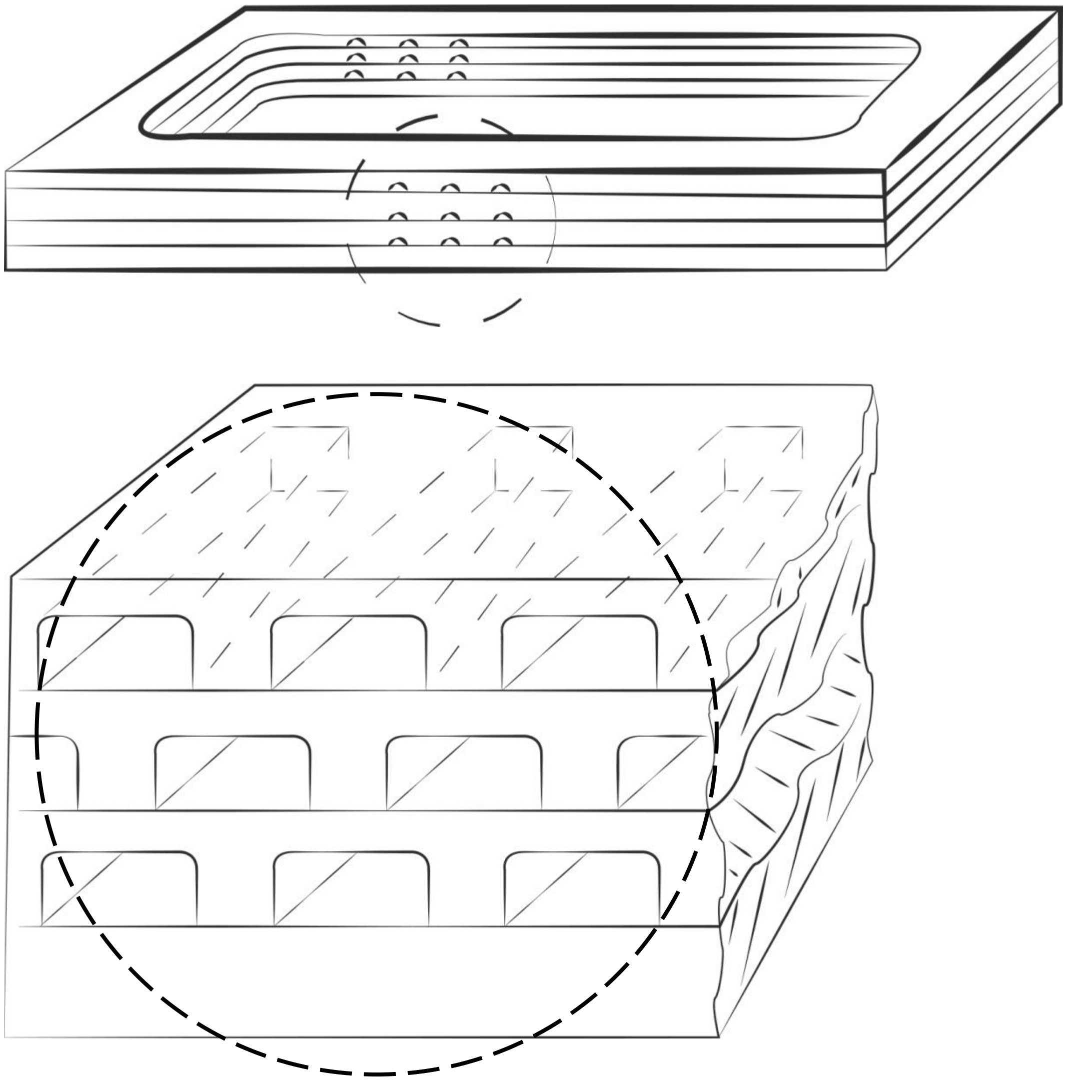

Fig. 7: Stacked filter element with central discharge of filtrate

By stacking and pressing of a large number of these components stable three dimensional filter systems can be created - operating and backwashing under enormous pressures (extreme lifetimes).

Also, components produced by photo chemical etching technique can be provided with fixtures and reference drillings during the first manufacturing step without any loss in productivity. The complexity of the individual component needs only to be reproducible as a lithographic template.

5. Summary

Metal filters, sieves/separators and diffusers are complex components calling for comprehensive technical manufacturing standards. Mainly for economical reasons the use of fabric and nonwovens has established for these components. But these meet their boundaries for metallic function elements exposed to high levels of stress, because they are also extremely limited in the scope of design and in the creation of undercut-free geometries. From a manufacturing point of view it is quite a challenge to insert a vast number of apertures having different geometries into metal in a cost-effective manner.

Metal etching offers a great design freedom for flat components which is especially true for filters, sieves and diffusers especially when a large number of apertures with equal or varying geometries is required. This technology generates further added-value due to the specific process characteristics as post-treatment may not be necessary. As for stacked components, photo chemical etching offers a large variety of design possibilities to the engineer.

Interlinked, continuous etching technology increases the added-value already achieved by chemical etching and increases this factor by a high process stability and a higher economic efficiency. Especially if taking into account the advantages of **photo chemical etching** technology at a very early stage in the development cycle, a great benefit can be derived from this application or makes this application altogether possible.

MICROMETAL GmbH has specialized in the production of high numbers of precision metal components using photo chemical etching technology. We would be pleased to act as your development consultant, if one of the aforementioned advantages might be of interest for your applications.

Autor

Dipl.Ing.(FH) Michael Sillmann
Managing Director micrometal GmbH
Michael.Sillmann@micrometal.de

micrometal excellence in etching

Renkenrunsstrasse 24
79379 Muellheim/Baden

Tel.: +49-(0)-7631-93688-0
Fax: +49-(0)-7631-93688-109
http://www.micrometal.de/text/1/en/home.html