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SC Filter Cleaning Mechanisms: A Review

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***Abstract*: Self-cleaning filters were developed to tackle multiple problems plaguing the conventional filters used in industries. Long maintenance hours, process equipment's downtime and increased annual cost to name a few. Theses filters were so effective that along with providing permanent solution to the aforementioned problems, some products were able to achieve break even in as less as three months. Some of the systems do not need round the clock supervision and can perform their function without human intervention. One can now choose a SCF from plethora of options available in the market, with every product being different form the other. This paper reviews numerous filter media cleaning mechanisms. Points like feasibility, annual cost, maintenance and supervision hours, and availability in the market, benefits and limitations are addressed.**

***Keywords*: Filter media, scrapper, self-cleaning filter**

1. Introduction

As the size of the manufacturing establishments swelled to cater to the growing demand. Keeping the industry up and running round the clock became a necessity. In such scenario the conventional filtration system that uses a filter media (surface filter media or depth filter media) was found to be plagued with a lot of problems like increased annual cost due to frequent replacements of disposable filters or bursting of bags collecting the dirt. After the advent of self-cleaning filter every sector of the industry that needed filtration of any kind for any type of fluids has recorded considerable fall in the process machinery downtime during the filter maintenance as well as the annual cost incurred by the company to keep the filters up and running.

Following are the benefits of self-cleaning filter to state a few:

Self-cleaning requires no regular maintenance. The necessary maintenance while using filters is that one needs to regularly open up the filter and clean the filter media. This maintenance work is automated in SCFs which makes it possible to function without any human supervision.

- Self-cleaning assures optimal filtration efficiency. As the cleaning process in the filter is automated consistency in the functioning of the filter is assured.
- Self-cleaning reduces energy cost.
- As filter media accumulates suspended contaminants, the pressure drop across the filter increases and flow rate decreases. The filter consumes the same power, but does less work.
- Self-cleaning extends media life, (five to ten years typical).
- The necessary disciplined, routine maintenance required for manual filters is the exception, not the rule. As a consequence, the filter media overloads with contaminants and thereafter, backwashing is less effective in removing accumulated solids. Manual cleaning or media replacement is required to remove the accumulated sludge.
- Self-cleaning is cost effective.

Among the few customers that choose manual filters, it is not uncommon for us to receive an inquiry within a year after the sale, asking the cost to retrofit the filter from manual to self-cleaning. The retrofit fit cost is more than the initial incremental cost for self-cleaning.

The cleaning of the screen is thought of as a simple matter of reversing the flow through the pipe. This method worked for stopping the solid particles. However, drawbacks do exist. Solids build-up (caking) occurs very quickly. Pressure drop across the screen is high. Cleaning of the screen can be ineffective and required large amounts of wasted water for backwashing. Backwash interrupts the main flow. Manual cleaning of the screen is often required.

The need for a better way of cleaning the screen was recognized. Many mechanisms were developed to cater to this problem. This paper takes a review of those mechanisms describing the pros and cons of each mechanism. The mechanisms discussed in the paper are some of the commercially available products as well as some that are in experimental stage.

2. Mechanisms for filter cleaning

A. Using spark discharge in produced water

This mechanism attempted to keep the filter surface clean using HV spark discharges. When a HV spark discharge is created between two submerged electrodes in water, a thermal plasma channel is formed, producing intense shockwaves and other plasma products (UV radiation, strong electric fields, focal areas of high temperature over 2000 K, various reactive species like OH, O, O_2, O_3, HO_2, H_2O_2, NO, NO_2 and charged particles) which are useful in the water treatment. Fig 1 and fig 2 shows the schematic of the filter using HV spark electrodes used for the experiment and damage caused to the filter due to cathodic hotspot [1].

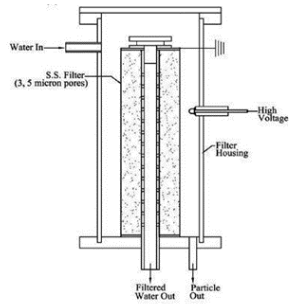

Fig. 1. Schematic of the filter using HV spark electrodes [1].

Fig. 2. Filter damage due to cathodic hotspot [1].

B. Using filtered liquid for backwashing

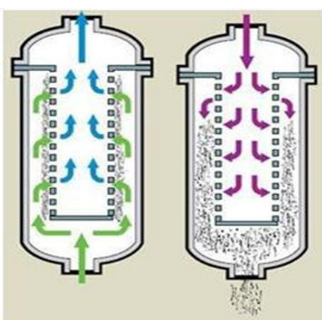

Fig. 3. Schematic showing the regular and backwashing cycle of Eaton AFC, AFR & F-Series filters

This method makes use of the filtered liquid to clean the filter surface by reversing the flow of the fluid when a preset value of pressure drop across the filter media is reached. This method is employed by tubular backwashing filters by Eaton. Process liquid flows into the housing inlet at its base and passes across the filter media from the outside inward. Because of this flow path, contaminants collect on the outside of the filter element slowly forming a cake, removing smaller particles. During backwash, triggered by time or pressure differential, a valve switches one station's flow from the inlet header to the drain header and the direction of the flow is reversed in the filter tube, dislodging contaminants from the media surface. The source of the cleaning fluid may be a diversion of process fluids (internal backwashing) or an external source (external backwashing). Contaminants and the fluids used for cleaning are expelled through the drain header at the base of the unit. Once backwashing is complete, the flow is reversed again and normal filtration resumes. Fig 3 shows the working principle of the filter based on backwash type self-cleaning [2], [7].

C. Ultrasonic cleaning

This method made use of ultrasonic vibrations as an additional cleaning step in the filtration process under submerged, large-scale conditions. The filtration consisted of usual forward flow of the fluid through the filter media, but prior to backwashing the filter media was exposed to ultrasonic vibrations that would help dislodge stubborn dirt that stuck to the filter media and cannot be cleaned using backwashing alone. Ultrasonic equipment (Hieschler Ultrasonics GmbH) was used, consisting of a generator (UIP 500), a transducer (UIP 500) and an ultrasonic horn (BS2d40spec) with an effective length of 200 mm. The ultrasonic horn produced longitudinal mechanical vibrations (by a reverse piezoelectric effect) with a frequency of 25 kHz. The output power was 500 W.

Fig. 4 and fig. 5 presents results using different sonication frequencies (25, 40, 80, 120 kHz) at different exposure times (1, 5 and 10 min). It is obvious that the lower the frequency, the higher the cleaning efficiency. In other words, 120 kHz leads only to 10% opening of the pores after 1 min sonication whereas using 25 kHz resulted in 95% opening of pores. By increasing the exposure time to 10 min, only 60% of the pores are cleaned using 120 kHz. Bubbles cannot grow to a sufficient size using higher frequencies (>80 kHz) and therefore sludge particles will not detach as easily from the cake layer as with lower frequencies [3].

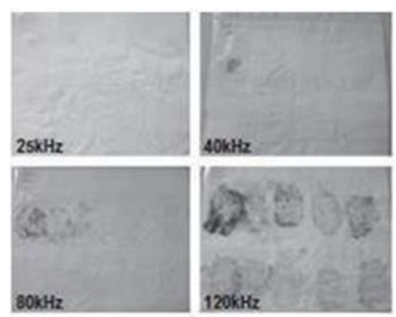

Fig. 4. Images of mesh samples treated under different sonication frequencies [3]

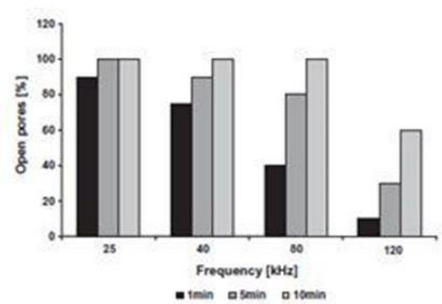

Fig. 5. Open pores at different sonication frequencies and different exposure times [3]

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D. Using scrappers and cleaning discs

In this method to clean the filter after it is loaded, a cleaning element (SS brush, Teflon discs etc.) rotates/slides over the entire length of the filter media scraping the dirt off the filter media. Figure 5 shows one such filter is the DCF filter from Eaton. Eaton's directly coupled filters are based on a simple concept: Cylindrical stainless steel housing contains a filter screen; unfiltered liquids enter the inlet; solids are deposited on the interior surface of the filtration screen; and filtered fluid exits at the outlet. When the media requires cleaning (based on time, differential pressure, or manual selection), a spring loaded cleaning disc travels down and up, wiping the media clean of concentrated solids in both strokes. Once the debris is removed from the slotted screen, the cleaning disc directs the contaminant to the bottom of the housing and out of the flow path. This cleaning process happens while the filter remains in service, thereby maintaining process efficiency and dramatically reducing loss of valuable product [4]-[7].

Fig. 6. Eaton DCF filter.1) Filter housing, 2) Filter media, 3) Inlet, 4) Outlet, 5) Cleaning disc, 6) Debris 7) Drain outlet [4].

Fig. 7. Teflon cleaning disc [4]

E. Using cleaning nozzles/jets

This method makes use of pressure energy to clean the filter media by opening a small portion of the filter media to the atmosphere thereby reversing the flow, taking the debris with it. Tekleen filters force water to backwash in a concentrated spot. The self- cleaning filters work on water line pressure alone without external power. Fig 8 shows a filter with an additional pipe and a valve. When the valve is opened to the atmosphere, water flows out of the pipe. Since the end of the pipe is in a close proximity to the screen, part of the water entering the pipe will come from the opposite (clean) side of the screen. High water velocity or point suction washes the dirt off the screen without interrupting the main flow. Furthermore, the whole screen will be cleaned by moving the pipe over the entire screen area. In fact, Tekleen's dirt collector spins and cleans using water line pressure alone.

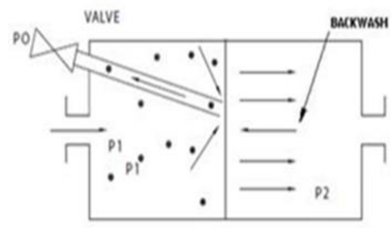

Fig 8. Schematic of forsta filter showing suction nozzle and valve [12]

Similar to the models using positive pressure to clean the filter some companies opted to develop negative pressure to draw the debris from the filter media. Fig 9 shows one such filter is Forsta 180 series, which makes use of a flush valve and set of nozzles to suck the debris away from the filter media [9]-[12]. Along with the suction nozzles [12].

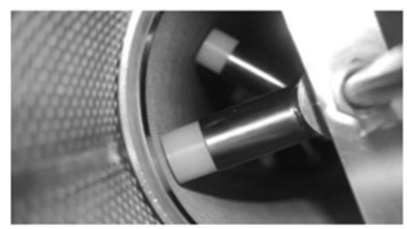

Fig. 9. Image showing inside of the Forsta filter

3. Comparative analysis different cleaning mechanisms

Various cleaning mechanisms described above were compared on the basis of different parameters and conclusions were drawn regarding the suitability of different mechanisms for different situations present in the industry. Table 1 shows the parameters according to which the mechanisms were compared.

4. Conclusion

There are various other self-cleaning methods that are not discussed in this paper. Those methods are more or less inversions of one of the above stated ones. Every method has its own set of benefits and limitations. The working liquid for every method above was water, some methods like the ultrasound and spark discharge type are suitable for water only, and it cannot be used for viscous fluids like paints or heterogeneous liquids like paper pulp or slurries. For such fluids and many other self-cleaning using a scrapper is the best suitable option. It is very suitable in terms of the capacity as well because these filters can be manufactured according to the client's requirements.

Table 1
Comparison of various self-cleaning methods

S. No.	Parameters	Spark discharge	Backwash/reverse flow	Ultrasound	Scraper	Cleaning nozzles/jets
1	Energy	Electrical energy	Kinetic energy of flowing liquid	Acoustical energy	Mechanical energy	pressure energy (+ve/-ve)
2	Cleaning mechanism	Shock waves created by HV spark discharges along with other by products used for cleaning	Reversing the flow through filter to dislodge the dirt accumulated	Ultrasound used as additional cleaning step after chemical cleaning.	Scrapers made of plastic used to scrape the dirt loaded in the filter media	Pressure (+ve/-ve) used to blow/suck the dirt away from the filter media
3	Complexity	Very high	Minimum	Very high	Minimum	Medium
4	Supervision & maintenance	Required for spark generation apparatus	Supervision not required, annual maintenance only.	Required for ultrasound generating apparatus	Supervision not required, annual maintenance only.	Minor supervision required, and annual maintenance.
5	Cost	Highest due to sophisticated electronics	Minimum	Highest due to sophisticated electronics	Minimum	Medium
6	Operator skill	Highly skilled operator required	Unskilled operator also can operate	Highly skilled operator required	Unskilled operator also can operate	Skilled operator required
7	Environment	Clean environment required for the electronics	Not effect of environment	Clean environment required for the electronics	Not effect of environment	Not effect of environment
8	Status of product	In research stage	Commercial products available	In research stage	Commercial products available	Commercial products available

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