

Influence of Installation Orientation and Cone Angle on Pressure Drop and Filtration Efficiency of Conical Strainers

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ABSTRACT - Cone strainers are very important in oil and gas pipeline systems because they prevent particles from entering the system and damaging pumps, compressors, and other critical equipment. This study experimentally examines the effects of cone angle, installation orientation, and open area ratio (OAR) on pressure drop (ΔP) and filtration efficiency (η) in conical filters. Four setups were examined with cone angles of 74° and 81° and hole diameters of 4 mm and 6 mm, at flow rates between 15 to 30 m³/hour. The results reveal that the 81° configuration (OAR = 38%) with unidirectional installation has the lowest pressure drop (1,250–2,500 Pa) and a filtration efficiency of over 92%, making it ideal for energy-efficient use. Conversely, the 74° cone can capture more particles (>93%) but experiences higher pressure loss (up to 9,500 Pa), making it suitable for applications requiring very stringent filtering. Installing the counter-current way was shown to increase turbulence and lower efficiency by up to 20%, which demonstrates the importance of the correct installation orientation for maintaining hydrodynamic stability and filtering effectiveness. These results highlight the critical need to optimise cone geometry and OAR to strike a balance between energy efficiency, hydraulic stability, and filtering performance. For pre-filtration and equipment protection in oil and gas systems, the optimal setup is an 81° angle, a 6 mm hole, a 38% OAR, and unidirectional flow. This configuration can contribute to smoother operations, energy savings, and reduced maintenance requirements.

Keywords: conical strainer, pressure drop, filtration efficiency, cone angle, orientation, open area ratio (OAR).

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INTRODUCTION

Conical strainers are commonly utilised in oil and gas piping systems to safeguard equipment from particulates that may impair performance. In line with this, Makmur (2021) highlighted that filter media characteristics and suspended solids concentration strongly affect the filtration resistance and plugging index in injection-water systems, emphasising the critical role of filter geometry and media configuration in maintaining hydraulic stability in oil and gas operations. Field measurements by Rosmayati et al. (2015) indicate that particulate size and concentration at gas refuelling stations strongly determine the need for dehydration units and filtration to prevent plugging; these findings support the need to characterise particles when designing strainers for oil and gas systems.

Mahajan & Maurya (2020) substantiated the strainer function utilising CFD, albeit the concentration on T-type strainers constrains direct applicability to conical geometries. Jin et al. (2025) demonstrated that the apex angle and configuration of conical microarray chips influence fluid interaction and collection efficiency, providing insights for strainer design. Shaikh et al. (2024); Mehta. (2024); Kenyon (2020) further illustrated that cone angles influence surface pressure distributions, yielding insights into flow prediction. Likewise et al. (2023) demonstrated a significant correlation between flow rate and pressure drop, emphasising the need for efficiency in filtration systems. Even with these contributions, there is still not much direct research on conical strainers. Sakamoto et al. (2022); Leloko et al. (2021) investigated installation positions in related systems, and Saksena & Lakhera (2022) explored taper angles in turbulent flow; nevertheless, neither study addressed filtration efficiency in conical strainers. Park et al. (2020) correlated pressure drop with filtering effectiveness in particulate filters; Kamiński et al. (2022) investigated multilayer filter dynamics; Chen et al. (2023) analysed cone angles in rock fragmentation; and Jin et al. (2025) evaluated fog collecting utilising conical chips. These studies offer valuable comparisons but exhibit a distinct deficiency concerning cone angle and installation orientation in conical strainers.

Experimental evidence further emphasises the importance of geometry. Tulloh & Purwoko (2024) showed that filter size significantly affects the service life of diesel filters, highlighting geometric parameters as critical to performance. Rakhimov and

Valiev (2023) demonstrated that Experimental data highlights the importance of geometry. Tulloh & Purwoko (2024) showed that filter size significantly affects the longevity of diesel filters, highlighting geometric attributes as crucial to performance. Rakhimov & Valiev (2023) demonstrated in Hele-Shaw cells that fluid-particle interactions increase pressure drop, while Masuda et al. (2021) found that conical Taylor-Couette flows enhance mixing depending on geometry. Saksena & Lakhera (2022) established a correlation between the taper and curvature of a cone and pressure losses in spiral tubes. The results indicate that geometry and orientation strongly influence fluid dynamics and efficiency; however, this is frequently not observed with conical strainers.

Filtration efficiency studies reinforce this view. Zhou et al. (2021) found that increased fiber alignment reduces efficiency in fibrous filters, while Kahane-Rapport et al. (2025) showed that the orientation of biological filter lobes significantly affects performance. Sahel et al. (2021) demonstrated that baffle orientation in membrane tubes enhances efficiency by altering flow dynamics, and Huang et al. (2022) showed that porous foam orientation improves particle capture. These results confirm that geometry and orientation strongly govern filtration, yet research directly addressing conical strainers is still lacking.

One of the most critical geometric parameters influencing the performance of strainers is the open area ratio (OAR), which represents the ratio between the total open (perforated) area and the total cross-sectional area of the flow passage, Sotoodeh (2019); Peng et al. (2023); Śmierciew et al. (2021). Higher OAR generally reduces pressure losses due to lower flow resistance, but it may also decrease filtration efficiency by allowing more contaminants to pass through the strainer surface. Conversely, a lower OAR improves particle retention but increases pressure drop, leading to greater energy losses within the system. Previous studies have shown that optimising the OAR is essential to balance hydraulic efficiency and filtration performance in industrial filtration systems, Altzibar et al. (2013); Gao et al. (2019); Sotoodeh (2019). Therefore, in this study, the OAR is treated as a key design and analytical parameter, as it directly governs both the flow behaviour and the overall efficiency of the conical strainer under various geometrical and operational conditions.

Efficient filtration is essential in oil and gas pipelines to prevent particulate contamination that can impair pumps, compressors, and heat exchangers. While previous studies have shown that geometry, porosity (OAR), and orientation affect pressure drop and filtration efficiency, the combined influence of cone angle and installation direction in conical strainers remains poorly understood. This study addresses this gap by experimentally quantifying their effects on hydrodynamic losses and filtration performance, providing both theoretical insight and practical guidance to enhance energy efficiency and operational reliability in industrial filtration systems, Kamiński et al. (2022); Yuan et al. (2023).

METHODOLOGY

Experimental study

This study uses an experimental methodology to investigate the influence of installation orientation and cone angle on the hydrodynamic performance and filtration effectiveness of a cone filter. By using modular testing equipment that allows for safe changes in cone shape and flow direction. This approach ensures that testing is conducted in a safe environment. Pressure gages are installed before and after the filter to monitor the instantaneous pressure drop (ΔP). Particle concentration is also measured to see how effectively the filter is performing (η). The experimental design follows the testing conducted by Qiao et al. (2022), which emphasized the need for careful monitoring of flow parameters and accurate pressure measurements across various flow regimes. This research method utilises an experimental study approach with 4 conical strainers having different parameters. The test was carried out by installing the strainer in two different directions, namely with the cone facing the direction of the fluid flow, as shown in Figure 1a, and the cone facing the opposite direction of the fluid flow, as shown in Figure 1b.

Figure 1 shows two installation directions for a cone filter in a piping system: (a) in the same direction as the fluid flow, (b) in the opposite direction to the fluid flow. In this study, both installation directions will be tested to understand how flow direction and cone shape significantly affect the hydrodynamic performance and filtration efficiency of the filter. This is done to determine the differences between installation orientations, as previous studies (Qiao et al., 2022; Zhang et al., 2021) have shown that flow alignment and geometric symmetry have a significant impact on pressure distribution, turbulence intensity, and the effectiveness of the filtration system in capturing particles.

After the system was run, the flow rate was adjusted with a ball valve at variations of 15, 20, 25, and 30 m³/h. The flow rate was measured using a rotameter, and the pressure drop was recorded from the readings of two pressure gauges installed before (upstream) and after (downstream) the strainer. The dirt that escaped from the conical strainer was collected and weighed again.

Conical strainer

Conical strainer consists of several main parameters, namely the strainer diameter (D_p), (length (L), material thickness (t), hole diameter (d), cone angle (θ), distance between holes (pitch), The hole pattern used in this design is a staggered type with an angle between rows of 60°, which allows holes to be arranged crisscrossing so that the density of holes per unit area becomes higher. A study conducted by Xu et al. (2021) highlights that an optimised angle can minimise pressure loss while maximising flow efficiency. Their findings indicate that an angle of approximately 80° to 85° results in an efficient transition with minimal energy loss. Research indicates that a sharper transition (smaller cone angle) can increase turbulence, leading to increased friction and, consequently, a higher-pressure drop by Tambe et al. (2024); Al-Karooshi

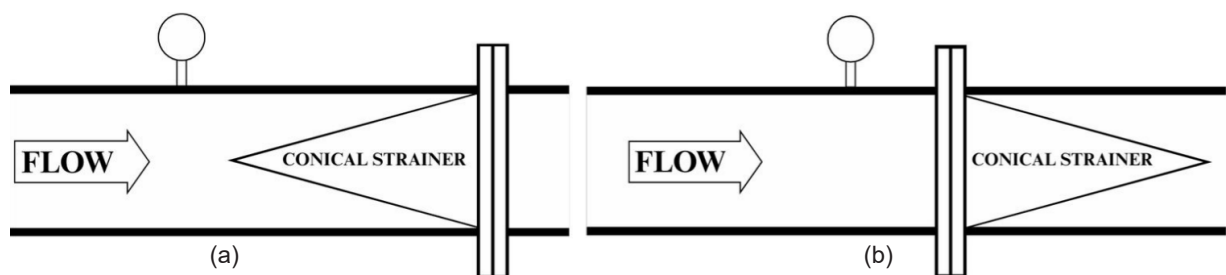


Figure 1. Installation of the cone strainer (a) in the direction, (b) opposite of fluid flow.

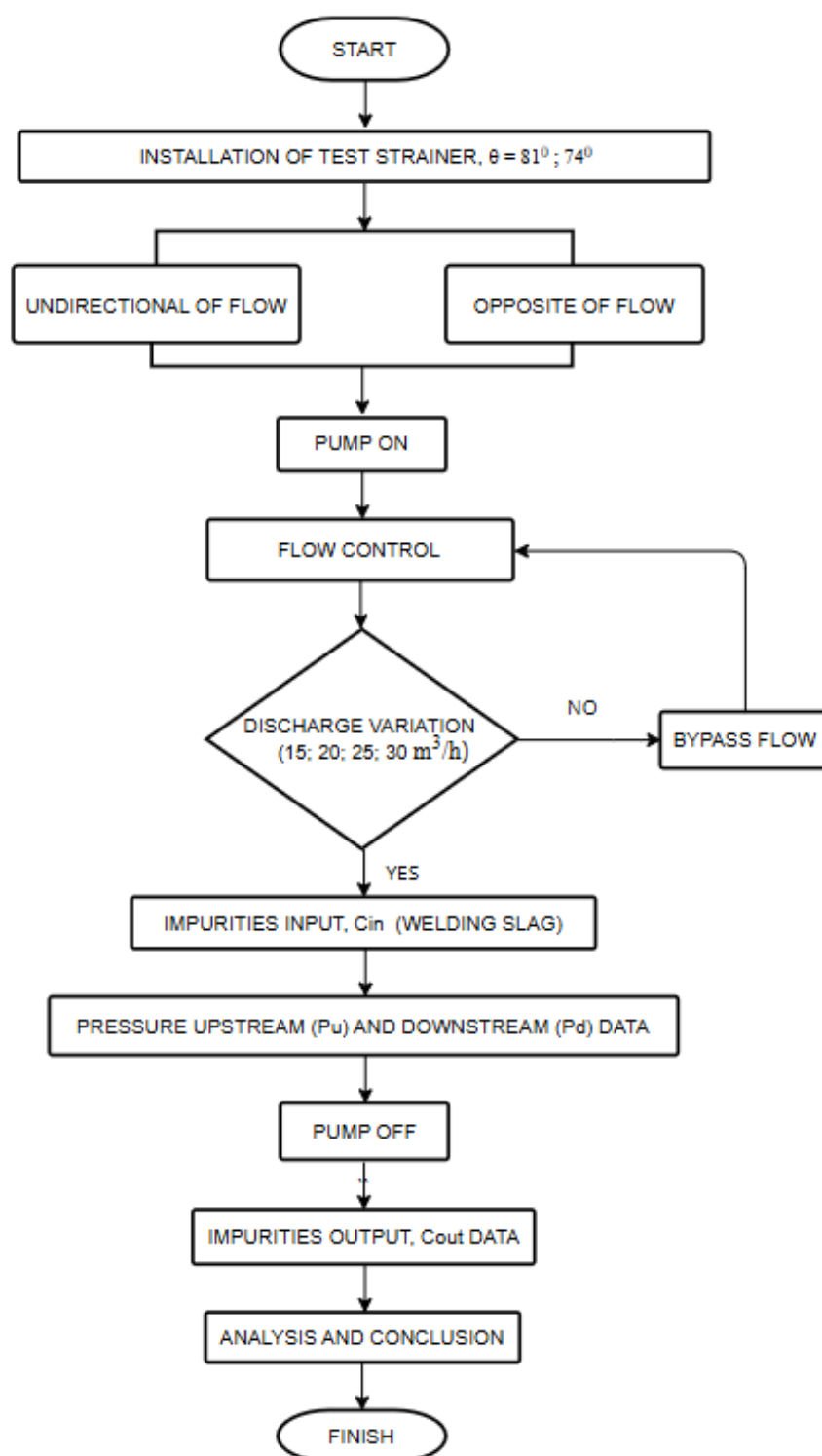


Figure 2. Workflow of experiments.

et al. (2023); Owen et al. (2022). In this study, cone angles of 81° and 74° will be compared with the influence of several other parameters mentioned at the beginning of this paragraph. To prove the statement in previous research, which states that a cone angle of 81° produces a lower pressure drop, Rianto et al. (2025) and an angle smaller than 75° has a less-than-optimal ability to reduce pressure, Carlomagno et al. (2012). so that the test results can provide empirical evidence related to the effect of a smaller cone angle on flow characteristics and pressure drop.

Experimental setup

Figure 4 is the design of the piping system used as a test device when taking data. This test device is an application carried out is the selection of pipe size and material, connection construction, and testing.

Pressure drop (ΔP)

Pressure drop is the pressure difference between

$$\Delta p = P_u - P_d \tag{1}$$

the upstream and downstream sides of a barrier element in a fluid flow system, such as a strainer. In this study, four staggered type strainers with cone angles of 81° and 74° were used, each having a variation in hole diameter of 4 mm and 6. Pressure drop can be calculated using the following equation.

Filtration efficiency (η)

Filtration efficiency is the ability of a filter element, such as a conical strainer, to hold solid particles so that they are not carried away by the fluid flow to the downstream side. The efficiency value is calculated based on the ratio of the mass of

Table 1. Experimental parameters and fluid properties

Property	Symbol	Value	Unit	Description
Density	ρ	997	kg/m^3	Fluid density of water at 25 °C
Viscosity	μ	0.00089	$Pa \cdot S$	Water viscosity at 25°C
Temperature	T	25	°C	Ambient test temperature Controlled by a valve and measured using a rotameter
Flow Rate	Q	15–30	m^3/h	Based on the calculated Reynolds number
Type of Flow	Re	Turbulent	—	$Re > 4000$
Pressure Gauge	—	0 – 0.1	bar	Level of accuracy, C.L. 2.5 (±2.5% FS) EN 837-1
Rotameter	—	12 – 60	m^3/h	Level of accuracy, ±2% FS (±1.2 m³/h) ISO 10790:2015

Table 2. Parameter variation of the strainer

No	Type Hole	D_p (mm)	t (mm)	L (mm)	θ (°)	d (mm)	Pitch (mm)	OAR (%)
1	Staggered	83	0.8	270	81	4	7	29
2						6	9	38
3				140	74	4	7	25
4						6	9	34

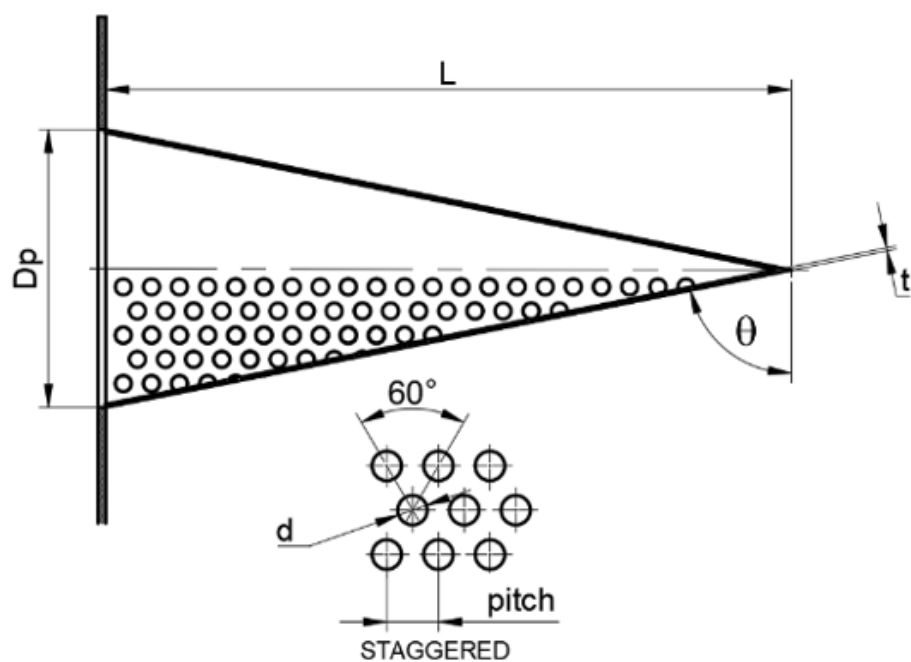


Figure 3. Conical strainer specification

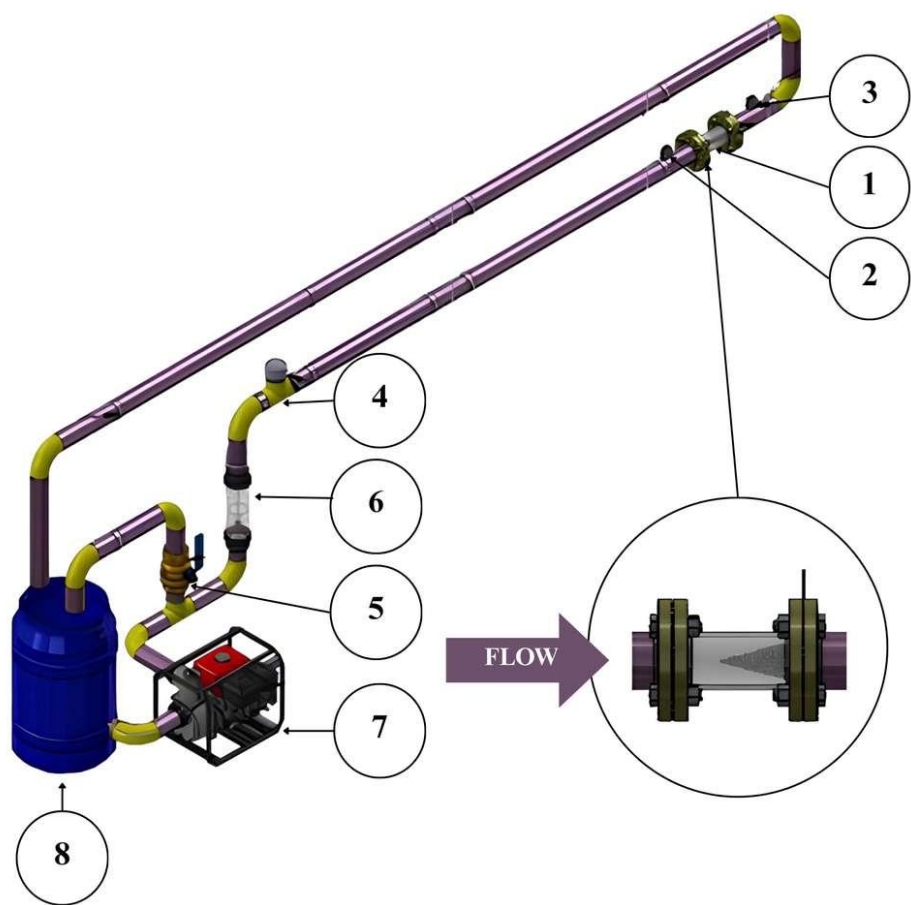


Figure 4. Test device



Figure 5. Test strainer

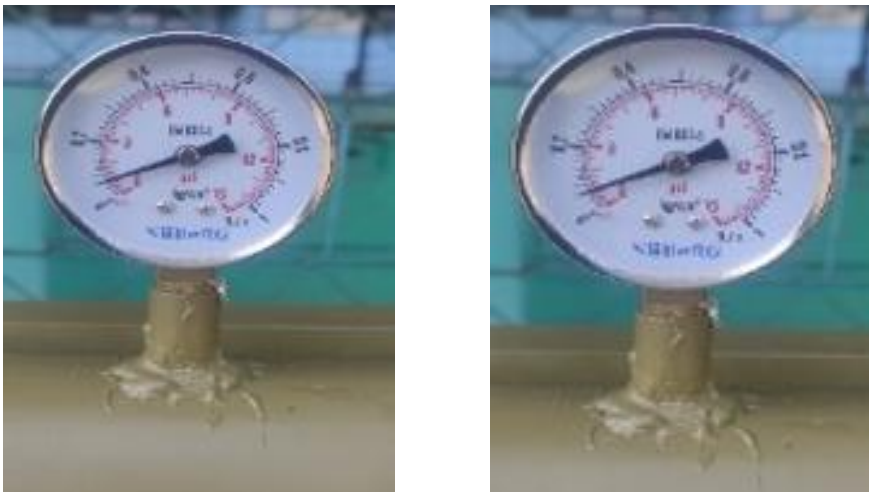


Figure 6. Pressure (a) upstream (b) downstream

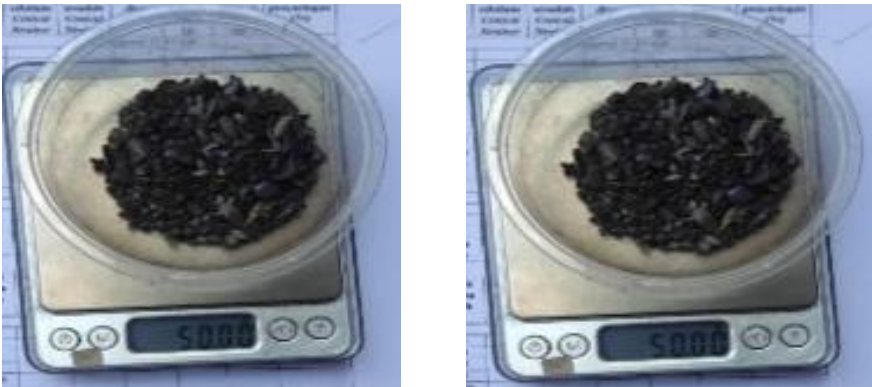


Figure 7. Impurities (a) in (b) out the strainer

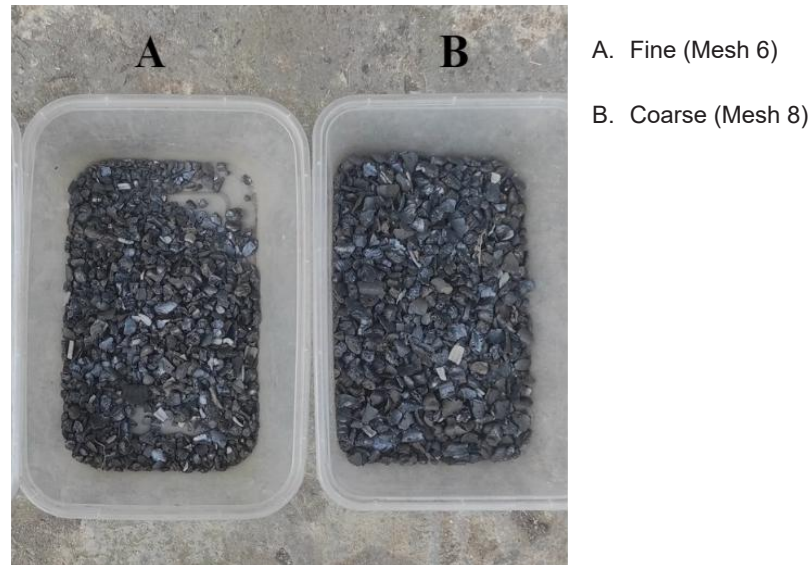


Figure 8. Impurities size

Table 3. Pressure drop and efficiency of conical strainer 81° hole diameter 4 mm (OAR 29%).

Installation undirection of fluid flow						
Flowrate (m ³ /h)	C_{in} (gr)	P_u (Pascal)	P_d (Pascal)	ΔP (Pascal)	C_{out} (gr)	η (%)
15	50	2500	1250	1250	1.73	96.54
20	50	3750	1250	2500	3.64	92.72
25	50	5000	2500	2500	3.06	93.88
30	50	7500	2500	5000	1.05	97.9
Installation opposite of fluid flow						
15	50	2500	0	2500	2.02	95.96
20	50	3750	1250	2500	3.63	92.74
25	50	5000	2500	2500	4.20	91.6
30	50	7500	2500	5000	5.89	88.22

dirt entering to the mass of dirt leaving the system. Efficiency can be calculated using the following Equation 2 (Bolshak et al., 2023).

$$\eta = \frac{C_{in} - C_{out}}{C_{in}} \times 100 \% \quad (2)$$

Impurities

The Impurities used in this study were welding slag (teck welding residue), commonly composed of metallic oxides such as FeO, SiO₂, MnO, and Al₂O₃, originating from the solidified flux and metal droplets during the welding process. The average particle density was approximately 3.2 g/cm³ (Liu

et al., 2024) , with an irregular shape and granular texture. Prior to testing, the slag particles were sieved using mesh sizes 6 and 8 to classify them into coarse and fine particle groups, ensuring uniformity and repeatability of the contaminant feed in the filtration experiments. Each data collection for the weight of the pollutant fed was 50 grams.

RESULT AND DISCUSSION

Performance of 81° conical strainers.

The results of the test show the pressure values on the upstream and downstream sides of the strainer for each design variation tested. The pressure

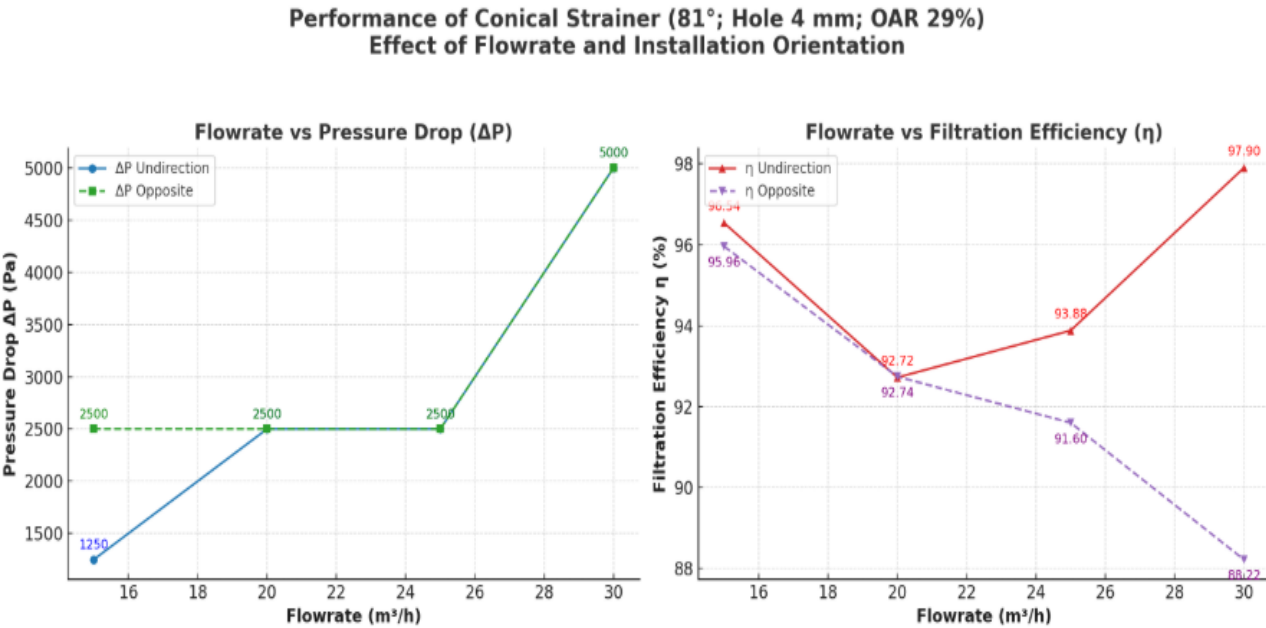


Figure 9. Graph of pressure drop and filtration efficiency of conical strainer angle 81, hole 4 mm

Table 4. Pressure drop and efficiency of conical strainer 81° hole diameter 6 mm (OAR 38%).

Installation undirection of fluid flow						
Flowrate (m³/h)	C _{in} (gr)	P _u (Pascal)	P _d (Pascal)	ΔP (Pascal)	C _{out} (gr)	η (%)
15	50	2500	1250	1250	2.52	94.96
20	50	2500	1250	1250	3.56	92.88
25	50	5000	2500	2500	3.42	93.16
30	50	5000	2500	2500	2.72	94.56

Installation opposite of fluid flow						
15	50	3750	2500	1250	9.39	81.22
20	50	3750	2500	1250	9.12	81.76
25	50	5000	2500	2500	9.44	81.12
30	50	7500	3750	3750	10.37	79.26

difference illustrates the ΔP value, which is further analysed to evaluate the effect of strainer design on pressure drop. And the dirt that escapes is analysed as the filtration efficiency that can be achieved by the strainer.

Pressure drops and filtration efficiency of 4mm hole (OAR 29%)

This study confirms that both flowrate and installation orientation strongly affect the hydraulic and filtration performance of conical strainers. Under proper alignment, the pressure drops (ΔP) increased moderately from 1250 Pa at 15 m³/h to 5000 Pa at 30 m³/h, while maintaining high filtration efficiency (>92%), reflecting a favourable balance between

energy use and particle retention. In contrast, opposite installation consistently produced higher ΔP and reduced efficiency, declining to 88.22% at 30 m³/h due to turbulence and recirculation. These results are consistent with prior studies emphasising the role of flow orientation in minimising hydraulic resistance and ensuring stable performance (Min et al., 2024; Divi et al., 2018). From an industrial perspective, the findings underscore that correct installation and cone geometry selection are critical to achieving energy efficiency, reduced pump loads, and reliable protection of downstream equipment, making them key design parameters in oil and gas filtration systems.

**Performance of Conical Strainer (81°; Hole 6 mm; OAR 38%)
Effect of Flowrate and Installation Orientation**

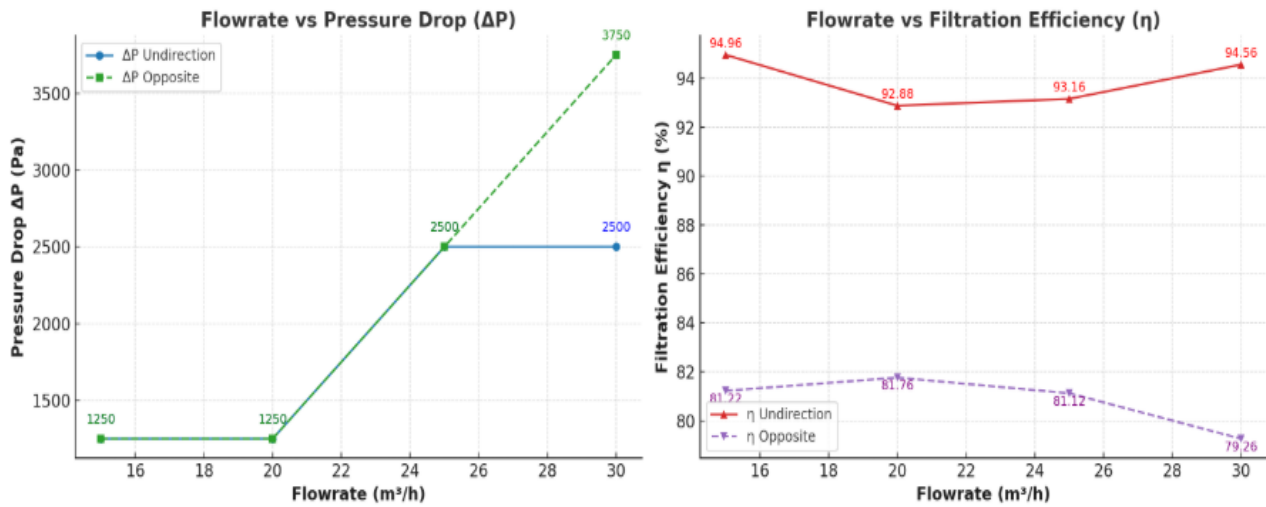


Figure 10. Graph of pressure drop and filtration efficiency of conical strainer angle 81, hole 6 mm

Pressure drops and filtration efficiency of 6mm hole (OAR 38%).

The performance test of the 81° conical strainer (6 mm, OAR 38%) shows that the direction of flow has a big effect on its hydraulic and filtration properties. When installed in one direction, the pressure drop (ΔP) stays low and steady (1250–2500 Pa), and the filtration efficiency (η) is over 92%, which means that the flow is smooth and there is little energy loss. In contrast, counter-flow installation raises ΔP to 3750 Pa and lowers η to 79.26% because of turbulence and recirculation at the cone surface. These results show that appropriate alignment is necessary to keep hydraulic stability and excellent filtration efficiency. This conclusion is consistent with the findings of Min et al. (2024), Samsudin et al. (2023), and Divi et al. (2018), who similarly noted that optimised flow orientation and geometry substantially diminish hydrodynamic losses while maintaining filtration performance, which are critical factors for improving energy efficiency and operational reliability in industrial filtration systems.

The way the 81° conical strainer works hydraulically depends on the balance between the flow inertia and the pressure recovery over its surface. When installed in one direction, the fluid streamlines follow the cone shape smoothly, which leads to a uniform velocity distribution, low shear, and minimum turbulence. These conditions improve filtration effectiveness and keep the pressure drop (ΔP) low.

Detailed flow behaviour while installing counter-flow.

The 81° conical strainer (6 mm, OAR 38%) doesn't work well for hydraulic and filtration when installed in counter-flow because the flow separates and recirculation zones occur around the inner cone surface. When the approaching jet hits the concave wall, the flow suddenly expands, functioning like a diffuser that creates a strong negative pressure gradient that pushes the boundary layer away. This separation creates slow-moving vortices around the base of the cone that have high turbulent kinetic energy (TKE) and flow that goes in the opposite direction, which makes viscous and pressure losses bigger. The backflow changes the paths of particles and breaks up the flow of streamline, which traps low-inertia particles in vortex cores or brings them back into the main flow. This makes them spend less time on the filtration surface. This means that the area that can be effectively filtered gets smaller, and the flow that goes around the filter becomes more important. This leads to a big decline in efficiency ($\eta = 79.26\%$).

Li et al. (2021) and Park et al. (2020) found that diffuser-induced separation in conical geometries makes turbulence and pressure changes worse, which makes the system less stable and the flow less uniform. This behaviour is in line with those studies. In the same way, Samsudin et al. (2023) found that reverse-flow arrangements make turbulent energy

**Performance Comparison of Conical Strainer 81° (Unidirectional Flow)
Hole Diameter 4 mm vs 6 mm**

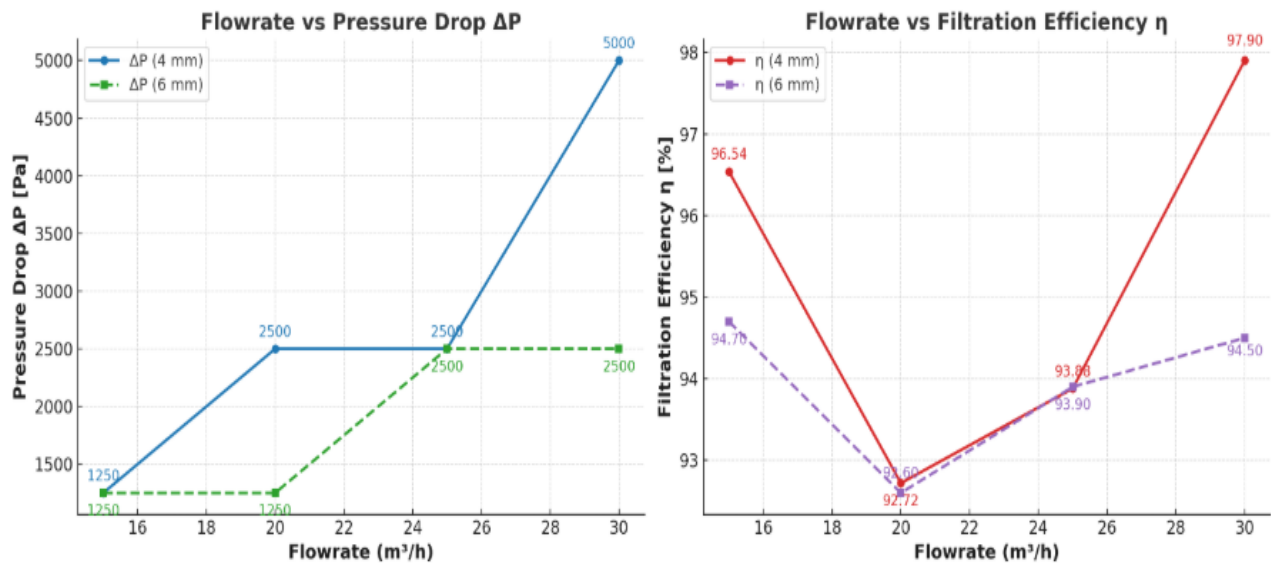


Figure 11. Comparison chart of 4 (OAR 29%) and 6 mm (OAR 38%) holes.

Table 5. Pressure drop and efficiency conical strainer 74° hole diameter 4 mm (OAR 25%)

Installation undirection of fluid flow						
Flowrate (m³/h)	C_{in} (gr)	P_u (Pascal)	P_d (Pascal)	ΔP (Pascal)	C_{out} (gr)	η (%)
15	50	3750	0	3750	2.17	95.66
20	50	5000	0	5000	1.72	96.56
25	50	7500	2500	5000	3.2	93.6
30	50	11000	2500	8500	2.96	94.08
Installation opposite of fluid flow						
15	50	5000	0	5000	1.79	96.42
20	50	6250	1250	5000	3.53	92.94
25	50	7500	1250	6250	2.95	94.1
30	50	12000	2500	9500	4.49	91.02

dissipation and recirculation stronger, which raises ΔP and lowers separation performance. From a fluid physics point of view, the counterflow arrangement turns what should be a pressure recovery zone into a high-loss recirculation cavity, where the difference in momentum between inertial and viscous forces speeds up energy loss. So, not only does geometric misalignment make hydraulic resistance higher, it also makes filtering less effective. This shows how important it is to optimise flow orientation and cone shape to make filtration systems for industrial use that are energy efficient and reliable.

OAR 29% vs 38% (unidirectional flow).

The 4 mm (OAR 29%) and 6 mm (OAR 38%) conical strainers show a clear trade-off between pressure drop and filtering effectiveness when used with unidirectional flow. The 4 mm strainer has a greater ΔP (up to 5000 Pa) because it has a smaller perforation area and stronger wall shear. However, it still filters well ($\eta = 97.9\%$) because the streamlines are stable, and it catches particles well. The 6 mm strainer, on the other hand, has lower hydraulic resistance ($\Delta P = 1250\text{--}2500$ Pa) and smoother flow transitions, although η drops somewhat ($\approx 93\text{--}94\%$) because of flow bypass and less surface interaction.

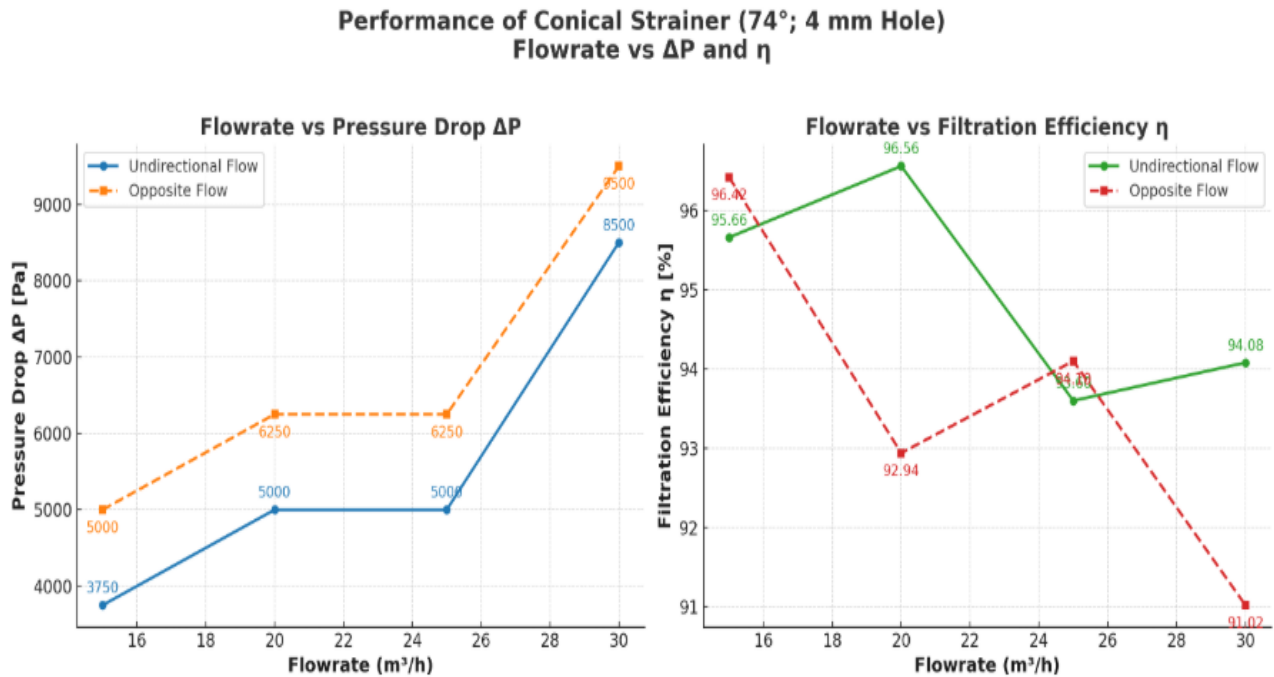


Figure 12. Graph of pressure drop and filtration efficiency of conical strainer angle 74, hole 4mm

This discrepancy is caused by the way viscous drag and inertial momentum work together near the holes. A smaller OAR makes it easier for the boundary layer to stick to the surface and reduces recirculation. A bigger OAR, on the other hand, encourages flow dominated by inertia, which lowers ΔP but makes capture less effective. Researchers have seen similar flow filtration interactions in porous media and conical filter geometries. When the porosity goes up, the pressure losses go down, but the separation accuracy goes down (Kamiński et al., 2022; Yuan et al., 2023; Park et al., 2020). Samsudin et al. (2023) also point out that the right flow direction and perforation ratio can lower turbulence and make the whole system use less energy. The 4 mm strainer is best for precise filtering because it keeps a lot of particles and keeps the flow stable. The 6 mm strainer, on the other hand, is best for energy-efficient pre-filtration because it has less resistance.

Performance of 74° conical strainers.

Pressure drops and filtration efficiency of a 4mm hole (OAR 25%).

The results for the 74° conical strainer with a 4 mm hole show that both the flow rate and the way it is installed have a significant impact on the hydraulic and filtration performance. In the

unidirectional arrangement, the pressure drop (ΔP) increased with the flow rate, rising from 3750 Pa at 15 m³/h to 8500 Pa at 30 m³/h. This indicated predictable flow resistance at higher flow rates through the narrow cone section. Despite this surge, the filtration efficiency (η) remained between 93% and 96%, demonstrating that proper flow alignment improves particle interception and maintains stable flow distribution in the porous medium. Conversely, when the flow was in the opposite direction, pressure losses were consistently higher, reaching a maximum of 9500 Pa at 30 m³/h, while η gradually decreased to 91%. This degradation is caused by localised turbulence and reverse recirculation near the strainer wall. These processes prevent particles from settling evenly and allow some of them to pass through. These findings align with other studies by Min et al. (2024), Mahajan et al. (2020), and Sotoodeh (2019), all of which demonstrated that inappropriate orientation and blockage-induced flow distortion could lead to increased pressure drop and less stable filtration. Overall, the results confirm that the best hydraulic performance of conical strainers depends on both the shape and alignment of the cone to find the right balance between energy efficiency and contaminant removal. This is important for improving designs and making accurate predictions in CFD-FEA modeling of filtration systems.

Pressure drops and filtration efficiency of 6mm hole (OAR 34%).

The 74° conical strainer with a 6 mm opening worked better for filtering and hydraulics when the flow direction and rate changed. The pressure drops (ΔP) in the unidirectional setup went up progressively from 2500 Pa at 15–20 m³/h to 5000 Pa at 30 m³/h. This shows that the hydrodynamic resistance stayed the same when the flow was oriented. Even though ΔP went up, the filtration efficiency (η) stayed rather high, between 91% and 96%. This suggests that a bigger pore diameter keeps pressure stable and captures particles better. On the other hand, the other

installation had greater ΔP values, reaching 5250 Pa, although efficiency dropped drastically to 79.92% at 30 m³/h. This significant decrease shows that flow reversal creates internal vortices and backflow zones, which help particles bypass and make capture less uniform. The patterns we saw support the findings of Min et al. (2024), Mahajan et al. (2020), and Sotoodeh (2019), who showed that the shape of the filter and the direction of the flow are both important factors in improving filtering efficiency and reducing hydraulic losses. The findings collectively affirm that the correct alignment of conical strainers is crucial for attaining energy-efficient operation and enduring filtration reliability in industrial flow systems.

Table 6. Pressure drop and efficiency conical strainer 74° hole diameter 6 mm (OAR 34%)

Installation undirection of fluid flow						
Flowrate (m ³ /h)	C_{in} (gr)	P_u (Pascal)	P_d (Pascal)	ΔP (Pascal)	C_{out} (gr)	η (%)
15	50	2500	0	2500	2.03	95.94
20	50	5000	2500	2500	4.34	91.32
25	50	5000	1250	3750	3.18	93.64
30	50	7500	2500	5000	3.95	92.10

Installation opposite of fluid flow						
15	50	3750	0	3750	6.28	87.44
20	50	5000	0	5000	9.11	81.78
25	50	6500	1250	5250	9.53	80.94
30	50	7500	2500	5000	10.04	79.92

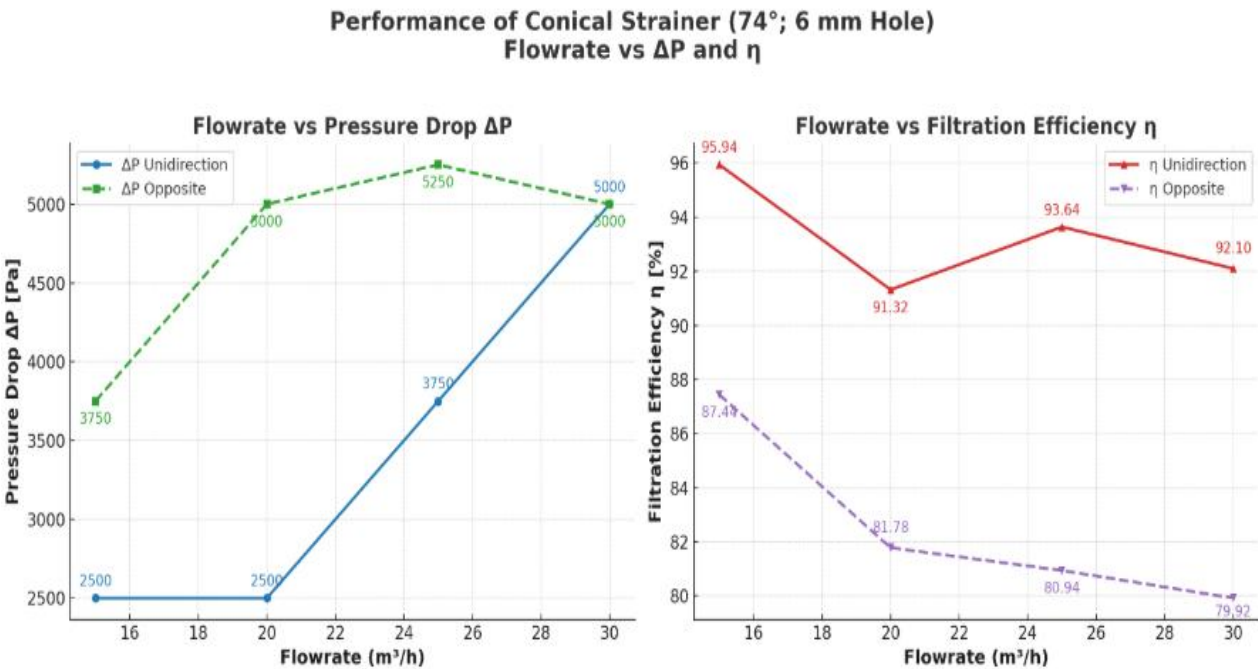
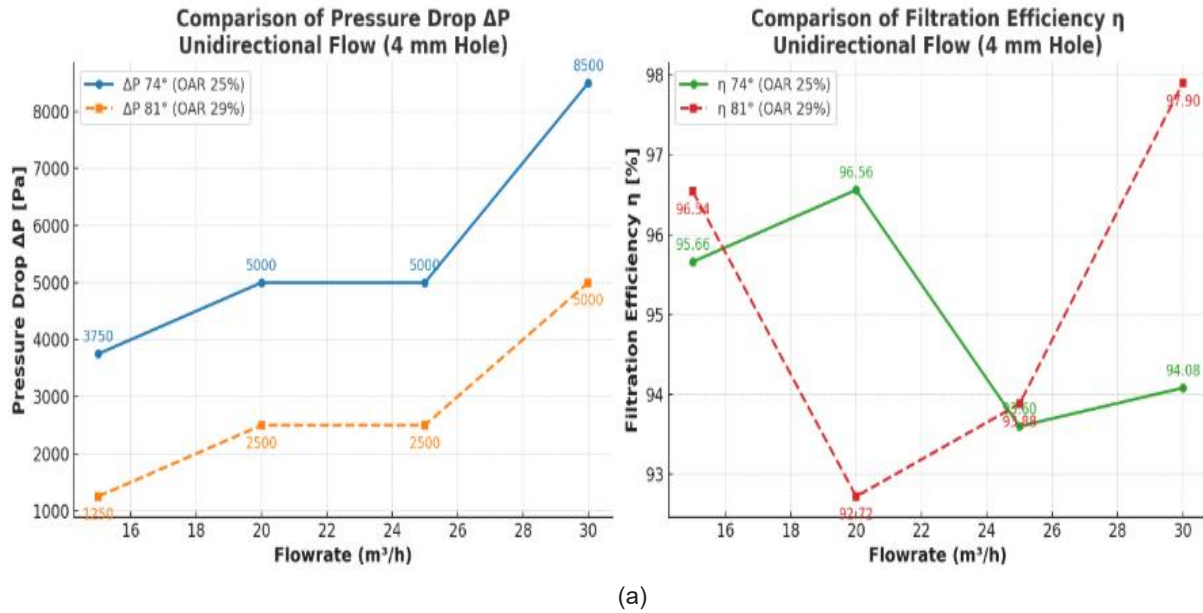


Figure 13. Graph of pressure drop and filtration efficiency of conical strainer angle 74, hole 6mm

**Performance of conical strainer $\theta = 81^\circ$ vs 74°
(unidirectional flow)**

**Performance Comparison of Conical Strainer (4 mm Hole)
Cone Angle 74° vs 81° under Unidirectional Flow**



**Performance Comparison of Conical Strainer (6 mm Hole)
Cone Angle 74° vs 81° under Unidirectional Flow**

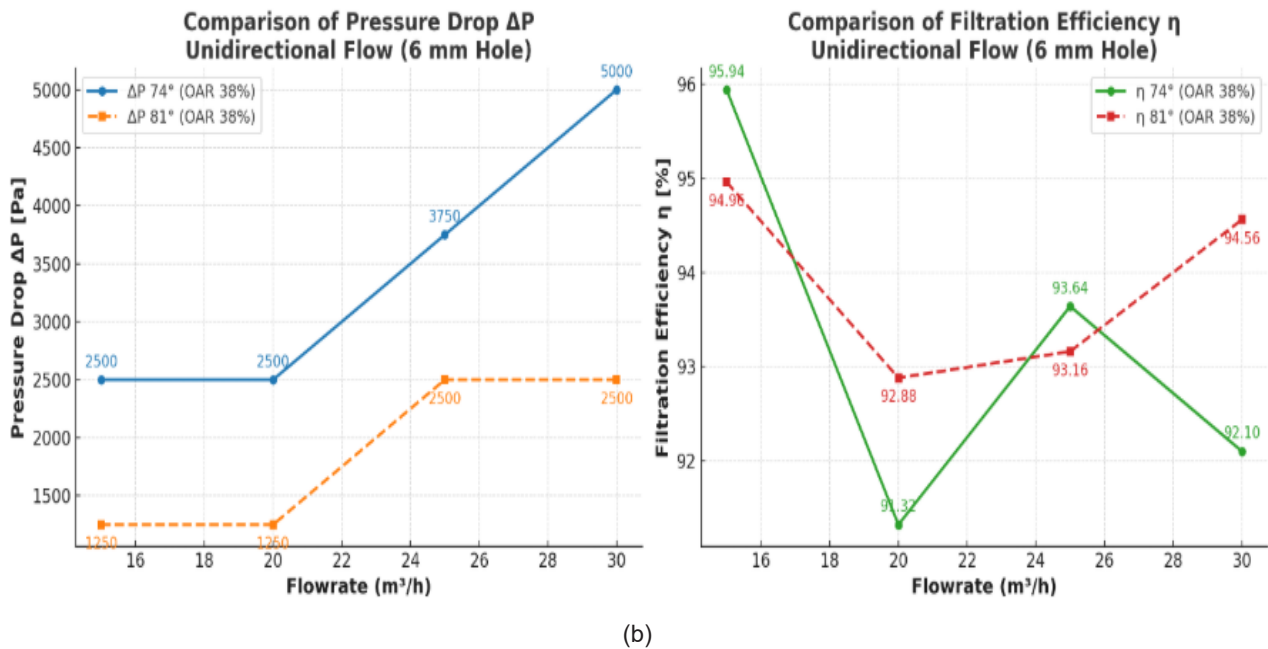


Figure 14. Comparison of the performance of conical strainer 810 and 740 (a) 4mm holes, (b) 6mm holes.

The findings comparing the performance of conical sieves with angles of 74° and 81° reveal that changes in Open Area Ratio (OAR) have a big effect on filtration efficiency and hydrodynamic resistance. The 74° sieve with a lesser OAR (25%) made a larger pressure drop (ΔP) of up to 9500 Pa with a hole diameter of 4 mm. The 81° sieve (OAR 29%) only reached about 5000 Pa. This rise in ΔP shows that the flow constriction and energy dissipation were stronger, but the filtration efficiency stayed above 94%, which means that the system could still collect particles well even though the pressure loss was higher. When the hole width was enlarged to 6 mm (OAR 38%), ΔP dropped sharply (<5000 Pa) in both configurations, showing that the flow was more open and the energy use was better. However, a bigger OAR made it a little harder for particles to get through since it weakened the flow constriction effect, as seen by changes in efficiency ($\eta = 92\text{--}95\%$). The 81° shape works well because it has a good balance between low ΔP and constant η . The 74° shape, on the other hand, captures particles better but needs more energy. These results align with the findings of Min et al. (2024) and Mahajan et al. (2020), which validate that augmenting the OAR improves hydraulic efficiency while perhaps diminishing particle capture density. Sotoodeh (2019), on the other hand, stresses how important it is to find the right balance between

the cone shape and the OAR for the best design. In general, raising the OAR has been demonstrated to lower ΔP and make the system more energy efficient. However, it needs to be fine-tuned to keep the filtering system working reliably.

Performance summary of comparison by cone angle, hole size, orientation and OAR.

Recommendation for industry.

The results recommend using a conical strainer with a cone angle of 81° and a hole diameter of 6 mm (OAR = 38%) in the flow direction (unidirectional orientation) for oil and gas pipeline systems where flow, pressure stability, and pollution control are all very important. This layout cuts down on pressure loss by 25% to 40% compared to smaller or misaligned setups, while still keeping filtration efficiency at 92%. This setup makes sure that hydrodynamics stays stable in large-scale filtration networks like compressor protection, condensate return, or hydrocarbon pre-filter. It also uses less energy to pump and needs less maintenance. Also, combining this shape with optimal flow conditioning inlets or gentle diffuser transitions can help reduce flow separation even more and make the service life longer, which is in line with industry goals for energy-efficient and reliable operation. Recent developments in computational modeling also contribute to understanding fluid-

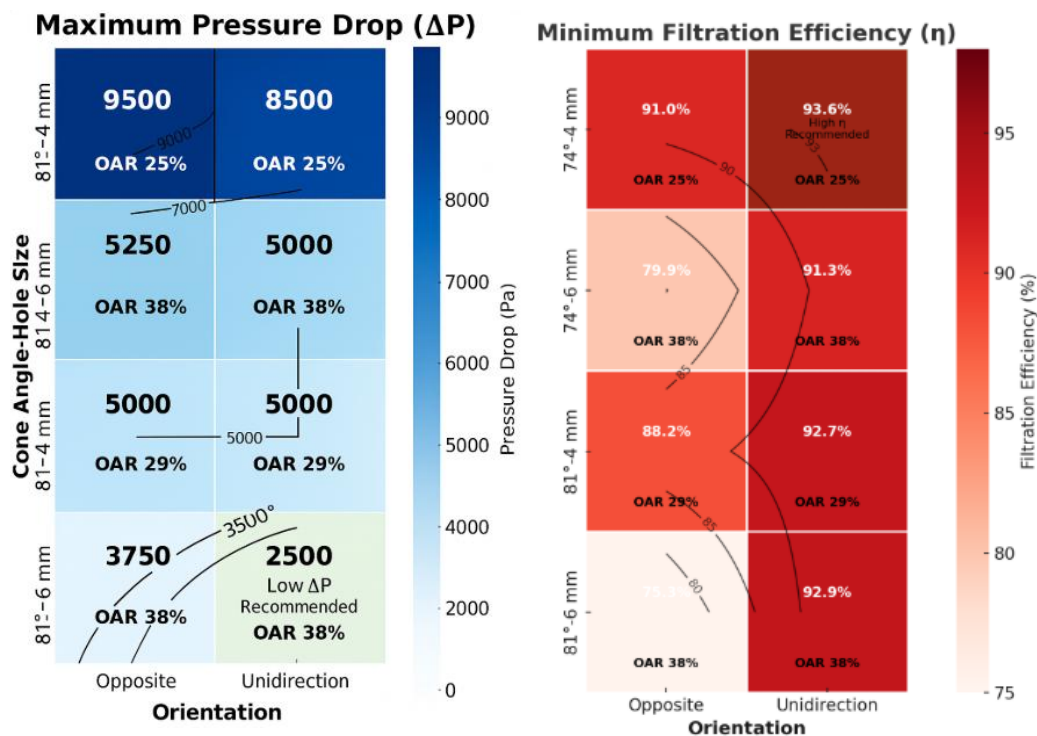


Figure 15. Performance map of conical strainers: influence of geometry and orientation on maximum ΔP and minimum η

solid interactions in porous media. Adrianto et al. (2025) successfully applied backpropagation neural networks to predict gas flow behaviour through complex porous structures, demonstrating that artificial intelligence can complement experimental and CFD methods in evaluating flow resistance and pressure distribution in filtration systems.

CONCLUSION

This study shows through experiments that the shape of the cone and the way it is installed are the most important factors that affect how well cone strainers work in oil and gas pipeline systems. The configuration with a cone angle of 81° , a hole diameter of 6 mm (OAR = 38%), and unidirectional installation gives the best results with the least pressure drop (1,250–2,500 Pa) and a filtration efficiency of more than 92%. This means that it strikes the best balance between energy efficiency and particle capture ability. The 74° cone, on the other hand, has a bigger pressure drop (up to 9,500 Pa) but better filtration capabilities, making it perfect for situations where strict filtering is needed. Installing it against the flow direction, on the other hand, generates a lot of turbulence, recirculation zones, and a drop in efficiency. This shows how important it is to put it in the right direction to keep flow stability and system performance.

To make filtering systems work better, last longer, and use less energy, it's vital to optimise the cone angle, open area ratio (OAR), and flow direction. The best setup for pre-filtration and equipment protection in oil and gas pipeline systems is an 81° angle, 6 mm holes, 38% OAR, and unidirectional flow direction. This setup can lower pressure loss, cut down on maintenance costs, and support efficient and long-lasting operations.

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GLOSSARY OF TERMS

Symbol	Defenition	Unit
ΔP	Pressure Drop	Pascal
η	Effeciency	%
θ	Cone Angle	°
OAR	Open Area Ratio	%
P_u	Pressure Upstream	Pascal
P_d	Pressure Downstream	Pascal
C_{in}	Pollutant In	gr
C_{out}	Pollutant Out	gr

REFERENCES

- Makmur, T. (2021). Influence of activated carbon on total suspended solids and relative plugging index of injection water from X-oilfield. *Scientific Contributions Oil and Gas*, 36(3), 771–779. <https://doi.org/10.29017/SCOG.36.3.771>.
- Rosmayati, L., Andriani, Y., & Pringgasta, N. (2015). *Kajian Pendukung Revisi Kadar Air Dan Partikulat Dalam Spesifikasi Compressed Natural Gas (Cng) Untuk Kendaraan Bermotor*. *Lembaran publikasi minyak dan gas bumi*, 49(3), 255–262. <https://doi.org/10.29017/LPMGB.49.3.1201>.
- Mahajan, G., & Maurya, R. S. (2020). Development of an efficient t-type strainer with its performance evaluation. *Journal of thermal engineering*, 6(6), 420–433. <https://doi.org/10.18186/thermal.836499>.
- Jin, S., Dong, S., Ye, G., Guo, R., Wei, Z., & Guo, Y. (2025). Research on the influence of conical micro array chip parameters on fog water collection. *Journal of Micromechanics and Microengineering*, 35(2), 025014. <https://doi.org/10.1088/1361-6439/ada97.f>
- Shaikh, J. S., Pathan, K. A., & Khan, S. A. (2024). Numerical Simulation of Surface Pressure and Temperature Distribution Along a Cone at Supersonic Mach Numbers Using CFD. *Journal of Advanced Research in Numerical Heat Transfer*, 28, 1–26. <https://doi.org/10.37934/arnht.28.1.126>.
- Mehta, R. (2023). Numerical simulation of flow field over a sharp-tipped double cone at high speed. *joast*, 37–44. <https://doi.org/10.61653/joast.v67i1.2015.295>.

- Kenyon, K. E. (2020). Cone rotating in a fluid. *Natural Science*, 12(01), 1-3. <https://doi.org/10.4236/ns.2020.121001>.
- Rakhimov, A. A., & Valiev, A. A. (2022). An experimental study of the ultrasound effect on the motion of glass spherules in Hele-Shaw cells. *Vestnik Tomskogo Gosudarstvennogo Universiteta. Matematika i Mekhanika*, (80), 117-132. <https://doi.org/10.17223/19988621/80/11>.
- Sakamoto, K., Goel, S., Funakoshi, A., Honda, T., & Nagao, K. (2022). Flow cytometry analysis of the subpopulations of mouse keratinocytes and skin immune cells. *STAR protocols*, 3(1), 101052. <https://doi.org/10.1016/j.xpro.2021.101052>.
- Lekoko, M. L., Olonijju, S. D., & Magalakwe, G. (2022). Analysis of pressure and heat distribution in a dilating or contracting filter chamber with two outlets using multivariate spectral quasilinearization method. *Heat Transfer*, 51(2), 1543-1567. <https://doi.org/10.1002/htj.22363>.
- Saksena, D. P., & Lakhera, V. J. (2022). Numerical study on pressure drop characteristics for turbulent flow in conical spiral tubes. *Engineering Research Express*, 4(3), 035023. <https://doi.org/10.1088/2631-8695/ac84c1>.
- Park, C., Johnston, A. S., & Kweon, H. (2020). Physical filtration efficiency analysis of a polyaniline hybrid composite filter with graphite oxide for particulate matter 2.5. *Journal of Applied Polymer Science*, 137(38), 49149. <https://doi.org/10.1002/app.49149>.
- Kamiński, M., Gac, J. M., Sobiech, P., Kozikowski, P., Jakubiak, S., & Jankowski, T. (2022). Filtration of submicron soot particles, oil droplets, and their mixtures on single-and multi-layer fibrous filters. *Aerosol and Air Quality Research*, 22(3), 210258. <https://doi.org/10.4209/aaqr.210258>.
- Chen, S., Jin, X., Hu, R., Liu, F., & Hu, Z. (2023). Investigation on the Rock-Fragmentation Process of Conical-Shaped TBM Cutterhead in Extremely Hard Rock Ground. *Stavební obzor-Civil Engineering Journal*, 32(3), 409-425. <https://doi.org/10.14311/cej.2023.03.0031>.
- Tulloh, S. H., & Purwoko, P. (2024). Pengaruh Penggunaan Filter pada Strainer Terhadap Usia Pakai Filter Bahan Bakar Mesin Diesel 6374 CC. *Jurnal Teknik Mesin, Industri, Elektro dan Informatika*, 3(2), 146-158. <https://doi.org/10.55606/jtmei.v3i2.3793>.
- Masuda, H., Iyota, H., & Ohmura, N. (2021). Global Convection Characteristics of Conical Taylor-Couette Flow with Shear-Thinning Fluids. *Chemical Engineering & Technology*, 44(11), 2049-2055. <https://doi.org/10.1002/ceat.202100236>.
- Zhou, M., Fan, Q., Quan, Z., Zhang, H., Wang, L., Qin, X., ... & Yu, J. (2021). Mass production of polyacrylonitrile sub-micron fibrous webs with different aligned degrees via free surface electrospinning for air purification. *Textile Research Journal*, 92(15-16), 2731-2741. <https://doi.org/10.1177/00405175211010688>.
- Kahane-Rapport, S. R., Teeple, J., Liao, J. C., Paig-Tran, E. W. M., & Strother, J. A. (2025). Filter feeding in devil rays is highly sensitive to morphology. *Proceedings B*, 292(2039), 20242037. <https://doi.org/10.1098/rspb.2024.2037>.
- Sahel, D., Boudaoud, W., Ameer, H., & Alem, K. (2021). Numerical Investigation of the Effect of Blower Baffles on the Performance of Membrane Tubes for Water Treatment. *Acta Mechanica Slovaca*, 25(1), 34-40. <https://doi.org/10.21496/ams.2021.006>.
- Huang, P., Wu, F., Su, Y., Luo, H., Lan, X., Lee, P. C., & Zheng, W. (2022). Supercritical CO₂ foaming of open-cell polypropylene/ethylene propylene diene monomer composite foams with oriented cellular structures for water treatment. *Journal of Applied Polymer Science*, 139(43), e53068. <https://doi.org/10.1002/app.53068>.
- Sotoodeh, K. (2019). Handling the pressure drop in strainers. *Marine Systems & Ocean Technology*, 14(4), 220-226. <https://doi.org/10.1007/s40868-019-00063-2>.
- Peng, Y., Mao, H., Liu, Z., & Wei, C. (2023). Simulation Study on Geometric Parameters Influencing the Flow Coefficient of Perforated Plate. *Buildings*, 13(3). <https://doi.org/10.3390/buildings13030804>.
- Śmierciew, K., Butrymowicz, D., Karwacki, J., & Gagan, J. (2021). Numerical prediction of homogeneity of gas flow through perforated

- plates. *Processes*, 9(10), 1770. <https://doi.org/10.3390/pr9101770>.
- Altzibar, H., Lopez, G., Bilbao, J., & Olazar, M. (2013). Effect of draft tube geometry on pressure drop in draft tube conical spouted beds. *The Canadian Journal of Chemical Engineering*, 91(11), 1865-1870. <https://doi.org/10.1002/cjce.21913>.
- Gao, Q., Ding, L., & Huang, D. (2019). Experimental and numerical study on loss characteristics of main steam valve strainer in steam turbine. *Applied Thermal Engineering*, 147, 935-942. <https://doi.org/10.1016/j.applthermaleng.2018.07.031>.
- Yuan, J., Gao, S., Zhu, D., Sun, S., Zhuang, D., & Liu, C. (2023). Effect of installing a screen filter in front of and behind a pump on filtering performance in a microirrigation system. *Irrigation and Drainage*, 72(2), 303-316. <https://doi.org/10.1002/ird.2792>.
- Qiao, S., Li, J., Ren, J., & Kim, S. (2022). Experimental Investigation on Effects of Flow Orientation on Interfacial Structure of Air–Water Two-Phase Flow. *Coatings*, 13(1), 5. <https://doi.org/10.3390/coatings13010005>.
- Xu, T., Zhao, H., Wang, M., & Qi, J. (2021). Numerical study of thermal-hydraulic performance of a new spiral Z-type PCHE for supercritical CO₂ Brayton cycle. *Energies*, 14(15), 4417. <https://doi.org/10.3390/en14154417>.
- Tambe, S., Kato, K., & Hussain, Z. (2024). Görtler-number-based scaling of boundary-layer transition on rotating cones in axial inflow. *Journal of Fluid Mechanics*, 987, R3. <https://doi.org/10.1017/jfm.2024.379>.
- Al-Karooshi, M. A., Chahrour, K. M., Khalil, W. H., & Al-Damook, A. (2024). Numerical investigation of hydrothermal performance over perforated conical pin heat sinks. *Heat Transfer*, 53(2), 666-687. <https://doi.org/10.1002/htj.22969>.
- Owen, S., Taremi, F., & Uddin, M. (2022). Effect of inflow conditions on transonic turbine airfoil limit loading. *Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy*, 236(5), 794-807. <https://doi.org/10.1177/09576509211059935>.
- Rianto, R., Akhyan, A., Novison, R., Zaira, J. Y., & Haiqal, M. (2025). Studi Numerik Penurunan Tekanan (ΔP) Akibat Perubahan Sudut (θ), Tipe Lubang dan Open Rasio Area (OAR) Pada Strainer. 05(01), 82–92.
- Carlomagno, M., Rossin, S., Delvecchio, M., & Anichini, A. (2012, June). Experimental and numerical validation of conical strainer fluid/structural performance model. In *Turbo Expo: Power for Land, Sea, and Air* (Vol. 44724, pp. 155-171). American Society of Mechanical Engineers. <https://doi.org/10.1115/gt2012-69751>.
- Liu, X., Zhang, C., Yu, H., Qian, G., Zheng, X., Zhou, H., ... & Zhong, Y. (2024). Research on the properties of Steel Slag with different Preparation processes. *Materials*, 17(7), 1555. <https://doi.org/10.3390/ma17071555>.
- Min, I., Choi, J., Kim, G., & Jo, H. (2024). CFD Analysis of the Pressure Drop Caused by the Screen Blockage Rate in a Membrane Strainer. *Processes*, 12(4), 831. <https://doi.org/10.3390/pr12040831>.
- Divi, R., Strother, J., & Paig-Tran, E. (2018). Manta rays feed using ricochet separation, a novel nonclogging filtration mechanism. *Science Advances*, 4(9). <https://doi.org/10.1126/sciadv.aat9533>.
- Samsudin, A. H., Hambali, N., Abdullah, M., & Ismail, N. D. (2023). The Analysis of Fluid Flow on Different Kapok Filter Orientations using Computer Fluid Dynamics. *Journal of Applied Engineering Design and Simulation*, 3(2), 38-48. <https://doi.org/10.24191/jaeds.v3i2.63>.
- Sotoodeh, K. (2019). Handling the pressure drop in strainers. *Marine Systems & Ocean Technology*, 14(4), 220-226. <https://doi.org/10.1007/s40868-019-00063-2>.
- Adrianto, A., Syihab, Z., Marhaendrajana, T., & Sutopo, S. (2025). Backpropagation neural networks for solving gas flow equations in porous media. *Scientific Contributions Oil and Gas*, 48(3), 31-40. <https://doi.org/10.11591/ijai.v14.i5.pp3744-3756>.