Paste 2026 – AB Fourie, M Horta, M Oliveira & S Wilson (eds)

doi:10.36487/ACG_repo/2655_42

AURUM membrane squeeze technology: optimising tailings filtration in filter presses

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Abstract

The increasing demand for efficient and sustainable tailings management has intensified the need for robust dry-stacking filtration technologies capable of delivering low cake moisture content at high throughput and reduced operational cost. The LENSER AURUM membrane for filter plates represents a significant advancement in filter press technology, combining the advantages of traditional squeezing materials such as polypropylene (PP), thermoplastic elastomer (TPE), and ethylene propylene diene monomer (EPDM) rubber into a single, high-performance solution. The test work shows that AURUM delivers exceptional abrasion resistance and superior flexing durability, addressing the primary failure modes of conventional membranes. With up to 3 times faster inflation kinetics compared to standard materials, AURUM enables accelerated dewatering cycles, directly enhancing throughput. This paper presents comparative test performance data and outlines the integration of AURUM into existing filter press systems. Within the scope of mining applications, the integration is exemplified using an iron ore tailings filtration plant. The modular design supports seamless retrofitting, while the extended lifetime and reduced maintenance requirements contribute to lower opex and improved sustainability metrics.

Keywords: *filtration, diaphragm, membrane filter press, filter plate*

1 Introduction

Membrane filter presses are used in many industrial dewatering processes. They are an advancement of the traditional recessed plate filter press and enable mechanical compression of the filter cake by inflating an elastic membrane, also known as a diaphragm. They have the following benefits:

- Taking all applications into account, membrane squeezing reduces the final cake moisture content by approximately 1–20% depending on the compressibility of the particles (Ripperger et al. 2013).
- The use of squeezing shortens the overall cycle time and increases throughput (Anlauf 2019).
- Squeezing results in a more homogeneous cake and facilitates cake post-treatment like washing and cake air blow drying (Rushton et al. 1996; Metso Outotec 2021).

Furthermore, as shown in Figure 1, the key factors influencing the squeezing are the process parameters, primarily the filtration pressure and the squeeze pressure, as well as the interaction between the respective kinetics and equilibrium conditions (Fränkle & Bragin 2025). In tailings filtration, improvements in residual moisture levels are highly dependent on the characteristics of the particles. Incompressible tailings lie in the low single-digit percentage range, while an increasing fines content enhances the effect of the squeezing stage. Additionally, membrane application improves cake air blowing by creating a more homogeneous filter cake.

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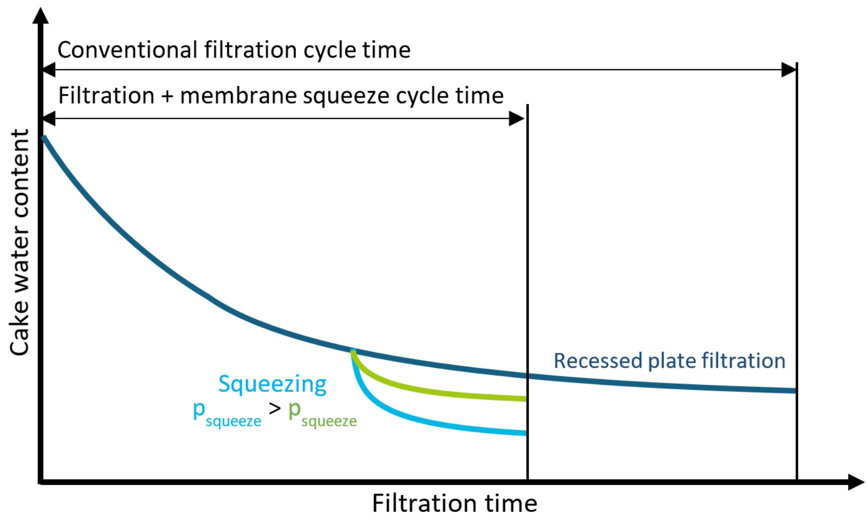

Figure 1 Schematic illustration of cake water content in recessed chamber and membrane filter press operation

Typically, membrane plates and standard plates are alternately installed in the filter press, referred to as a mixed pack. There are various designs of membrane filter plates, examples of which are shown in Figure 2. In the case of welded membrane plates, 2 so-called membrane halves are welded onto a carrier plate. The 2 illustrated types mainly differ in the shape of the resulting filter cake. The welded membrane plate shown on the right allows for the formation of a cake with nearly uniform thickness across the entire chamber height, which facilitates post-treatment steps such as washing or air blowing. Additionally, there are plates with replaceable membranes. These can be designed so that either the entire membrane halves are replaceable, or only the inflatable inner part, while the sealing edge remains part of the carrier plate.

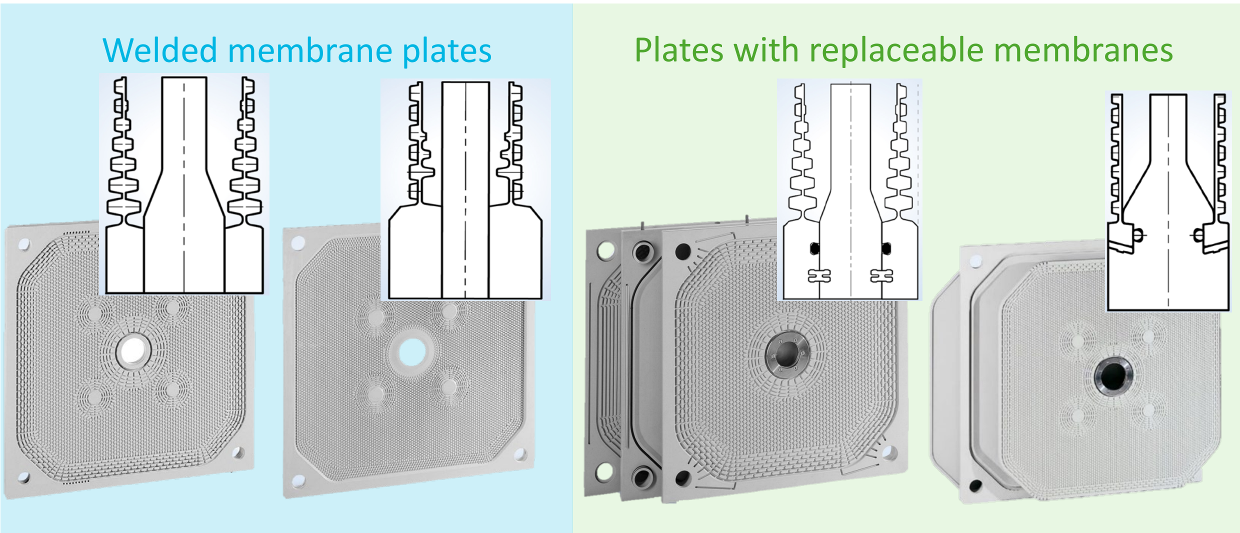

Figure 2 Different types of welded and replaceable membrane filter plates

Which type of membrane plate delivers the best performance depends heavily on the specific separation task and the materials used.

The primary characteristic of membranes is their flexibility and ability to withstand a high number of movement cycles which can be referred to as flexing durability. Over the decades, several materials have become established in the market: polypropylene (PP) which is also the standard material for recessed plates and carrier plates, thermoplastic elastomers (TPE), e.g. blends of PP and rubber, and fully rubber e.g. ethylene propylene diene monomer (EPDM) membranes. Membranes that cannot be welded to the PP carrier plate, such as rubber ones, are necessarily designed as replaceable versions.

Figure 3 presents the properties of common membrane materials in the form of a radar chart. EPDM membranes exhibit a significantly higher permissible inflation speed compared to TPE and PP. This is due to the embrittlement of the plastic when subjected to rapid stress. In terms of resistance to abrasion, EPDM also outperforms both TPE and, even more drastically, PP. The same applies to flexing durability. When additional properties such as aging resistance are considered, the assessment shifts: TPE and PP demonstrate significantly superior long-term performance compared to EPDM. While there are no significant differences in permissible process temperatures, the same applies to chemical resistance. In this area as well, TPE and PP are the preferred materials. These assessments serve as a general guideline; the membrane material should always be selected based on the specific process parameters and suspension characteristics.

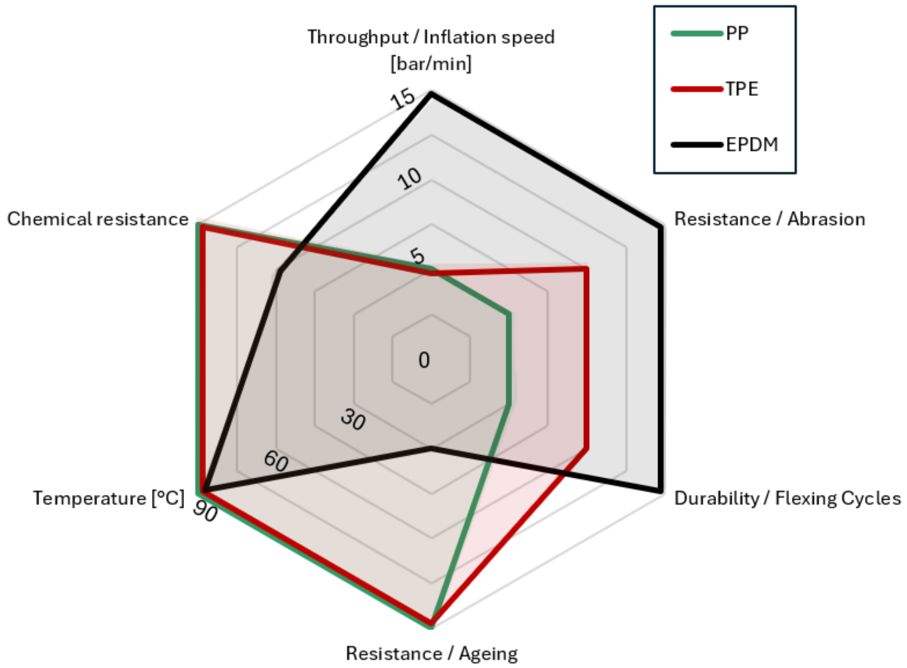

Figure 3 Comparison of the properties of various common membrane materials

The corresponding typical damage patterns are shown in Figure 4. Abrasion in the area of the membrane's filtrate outlets as well as in the sealing zones leading to the corner port of the carrier plate is illustrated in Figure 4a. Figures 4b and 4c depict stress in the hinge area, where the membrane experiences its greatest flexing: manifesting as cracks on the front side facing the filter cake, and as stress-whitening on the rear side. Depending on the load type, the situation may be the opposite for the front and back sides. Figure 4d illustrates the aging effects observed in the rubber material.

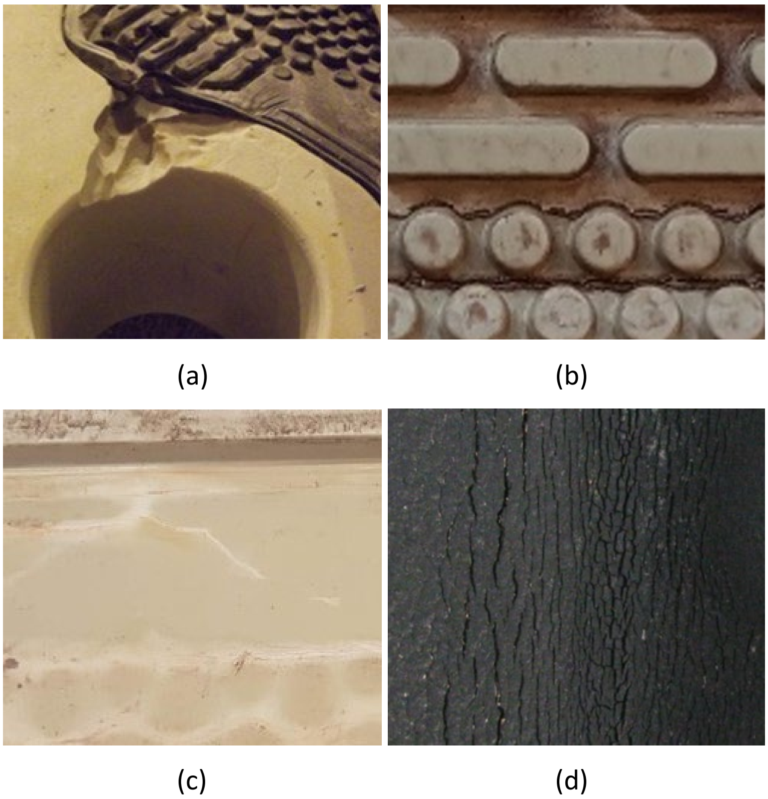

Figure 4 Typical membrane damage patterns caused by (a) abrasion, (b) and (c) flexing, and (d) aging

Another important aspect to consider with rubber-based materials is that their production relies on a vulcanisation reaction. Compared to reaction-based processes, thermal forming methods offer better control and reproducibility. With the development of new materials, like the LENSER AURUM, it is now possible to combine the advantages of various standard materials and their manufacturing processes to achieve optimal properties for use in mining operations. Corresponding replaceable membranes are thermally formed and exhibit high inflation speeds, outstanding resistance to abrasion and flexing, and minimal signs of aging. Figure 5 presents the properties of AURUM in addition to the common membrane materials.

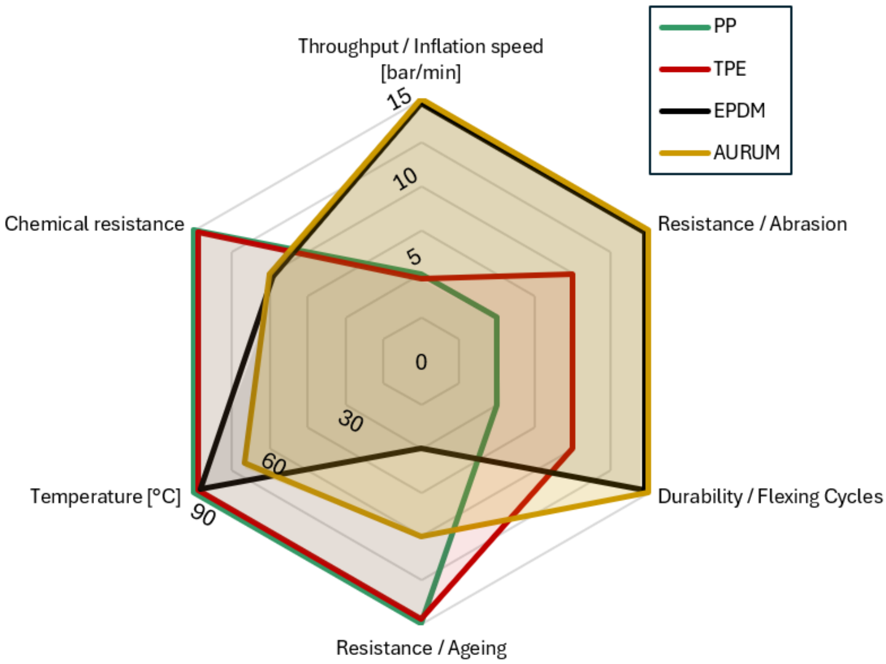

Figure 5 Material properties of LENSER AURUM membranes

The process-related added value and reduction of opex are disproportionally higher than the increased capex compared to the other materials. This material also differs visually, as shown in Figure 6. It is transparent with a golden hue, which allows for better visual inspection of the condition of the membrane and the carrier plate. As an example, a membrane plate in the 1,500 × 1,500 mm size with 4 integrated stay bosses is shown; however, the material can be used across all formats.

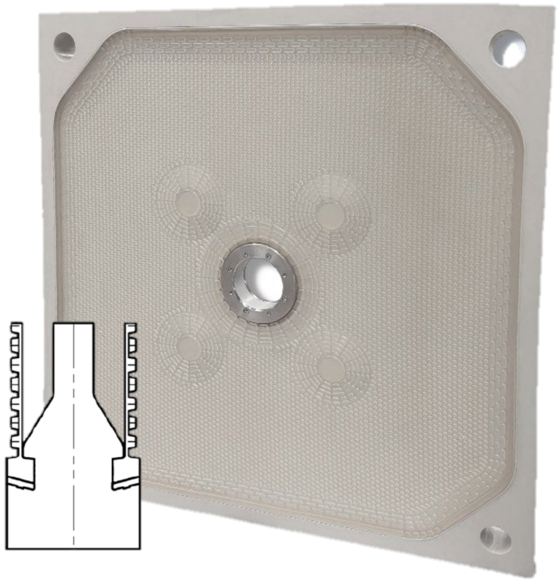

Figure 6 Membrane filter plate with replaceable LENSER AURUM membrane (plate size 1,500 × 1,500 mm)

In tailings filtration, both chamber and membrane filter presses are used, with the latter being especially suitable for difficult-to-filter slurries with high clay content. Furthermore, a post-treatment step known as desaturation, commonly referred to as an air blow, is applied to sufficiently reduce the residual moisture in the filter cake in accordance with geotechnical requirements (Fränkle 2024). In principle, membranes facilitate this drying step and, depending on the feed composition, also increase the throughput of the filter press. However, membranes are considered to be a wear part (Wisdom et al. 2020) and increase opex besides higher capex. Wear-promoting characteristics in tailings filtration, such as abrasive particles and high cycle frequencies, exacerbate the problem. The LENSER AURUM membrane is engineered as an exchangeable diaphragm for filter press plates with prolonged lifetime, designed to maximise flexing durability, abrasion resistance, and inflation performance. By integrating the advantageous properties of PP, TPE, and EPDM, AURUM provides a robust alternative to traditional membranes, suitable for demanding mining applications. The membrane is available in various formats and sizes, supporting both new installations and retrofitting of existing mining presses.

2 Experimental set-up and methodology

Basic abrasion tests were carried out by sandblasting various membrane materials and steel as a reference material. In addition, durability was evaluated by performing 8,000 flexing cycles in a membrane plate set-up test-rig in comparison to PP.

Comparative laboratory-scale filtration tests were conducted using a standardised kaolin–water suspension (20 vol.% solids) to evaluate filtration performance. Compared with tailings, kaolin exhibits a lower D_{50} and is more difficult to filter because of the fine particles. The resulting filter cake is also more compressible. These characteristics amplify the effectiveness of membrane squeezing. Tests were performed on a 470 × 470 mm size filter press with multifile PP filter cloths, equipped with either PP or AURUM membranes. The filter press was instrumented with LENSER i-Plate sensors for live filter cake moisture measurement, a feed pressure and a squeeze pressure sensor. A moisture-analysing balance was used for the LENSER i-Plate calibration regarding the kaolin suspension.

The test plan included:

- filtration pressure: 8 bar
- membrane squeeze pressure: 12 bar
- inflation rates: 3 bar/min (PP membrane) versus 9 bar/min (AURUM membrane).

The set-up of the test press and a filter cake is shown in Figure 7. The plate pack consists of a head plate, an intermediate plate, and an end plate resulting in 2 filtration chambers. The intermediate plate is designed as a membrane plate, while the end plate is configured as an i-Plate with moisture sensor.

Figure 7 Filter press (size 470 × 470 mm) with 2 chambers including an AURUM membrane plate and a LENSER i-Plate with moisture sensor

3 Results and discussion

In addition to fundamental and application-specific material tests and subsequent laboratory experiments using kaolin, the integration into existing filter press installations as well as the optimisation potential regarding tailings filtration are evaluated in this section.

3.1 Material testing

The results of the sandblasting study on test specimens made from various membrane and steel reference material are shown in Figure 8. Like EPDM, AURUM offers a clear advantage over thermoplastic elastomers, as well as PP. The material loss relative to volume is approximately twice as high for TPE and almost 4 times as high for PP. The abrasion of steel is an order of magnitude higher.

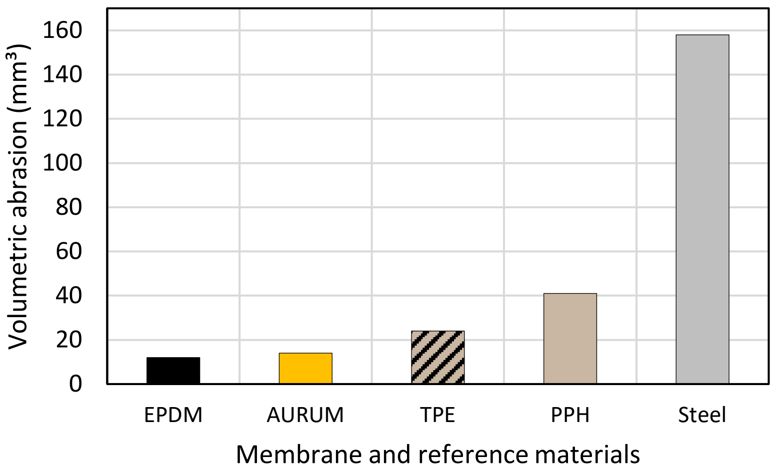

Figure 8 Volumetric abrasion of specimens from various materials during sandblasting tests

The bending test specimens of the AURUM membrane withstand 1,000,000 flexing cycles in water at 20°C. This demonstrates the fundamental suitability of this material for use as a diaphragm for membrane filter plates. In addition, application-specific tests were carried out using a set-up that simulates the stresses acting on a membrane. After 8,000 simulated cycles in water heated to 70 °C, AURUM membranes showed no deterioration, whereas PP already exhibited whitish discoloration at the bending areas. From this, a longer flexing durability of the AURUM membrane can be inferred.

3.2 Filtration and membrane-squeezing testing

Figure 9 shows live moisture and pressure monitoring of a kaolin filtration with PP membrane squeezing using the LENSER i-Plate moisture sensor and additional pressure sensors. During the filling phase, a peak in the cake-water content curve can be observed as soon as the liquid level rises in front of the sensor. Shortly afterwards, the chambers of the filter press are completely filled, and cake formation begins. During cake formation, the kaolin particles are retained on the filter cloth and the cake itself, creating a pressure drop that leads to a simultaneous rise in the feed pressure curve. The feed pressure increases up to the set maximum of 8 bar and then remains approximately constant. Meanwhile, the filter cakes on both sides of each chamber grow until they meet in the middle. Further filling of the press results in consolidation of the material in the chambers, while dewatering becomes progressively slower. After 4 minutes, equilibrium for this filtration pressure is nearly reached, and the cake moisture remains constant. After approximately 6 minutes and 30 seconds, the squeezing process was initiated, meaning compressed air was applied to the void between the PP carrier plate and the membrane, which then bulges. For the PP membrane, this occurred at a rate of about 3 bar per minute. Even during the filling of the cavity behind the flexible membrane, additional dewatering can be observed. This significantly reduces the water content of the kaolin filter cake by nearly 10%. The kinetics of squeezing are fast, and the equilibrium of dewatering for this squeezing pressure is reached after about 11 minutes total time. The fact that dewatering is almost completed at the same time as the set maximum pressure is reached indicates that the inflation rate of the membrane is the limiting factor of the throughput.

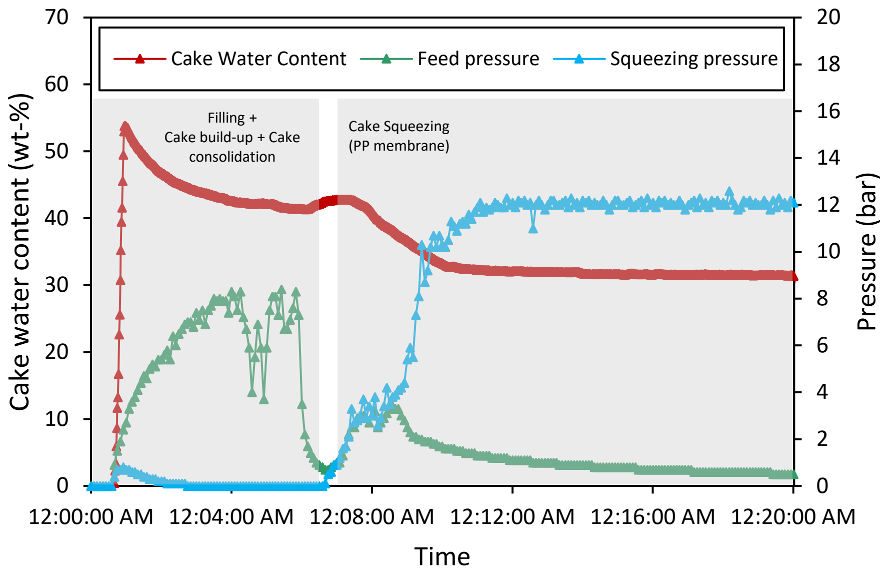

Figure 9 Kaolin filtration cycle data obtained from a laboratory filter press (470 × 470 mm) with polypropylene membrane squeezing

In comparison, the use of an AURUM membrane is additionally shown in Figure 10, zoomed in on the squeezing period. It is evident that the faster application of compressed air with approximately 9 instead of 3 bar/min to the membrane has a direct impact on the duration of the squeezing dewatering process. Similar to the PP membrane, additional dewatering by squeezing starts shortly after the membrane pressure is increasing and the equilibrium of this sub-step is nearly reached once the maximum pressing pressure is achieved. Using the AURUM membrane, however, this occurs after approximately 9 minutes instead of 11 minutes total process time, while the result of the solid–liquid separation remains identical.

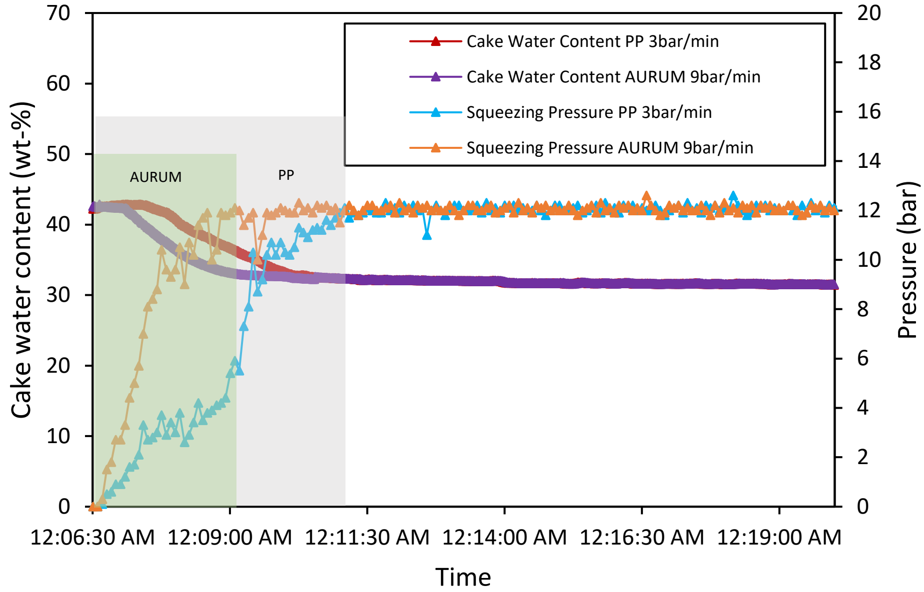

Figure 10 Comparison of the filter cake squeezing using a polypropylene and an AURUM membrane

3.3 Integration of AURUM into existing filter press systems

For a field test, 3 AURUM test elements (each consisting of one PP carrier and 2 membranes) were installed in March 2022 on a membrane filter press operating in a sand and gravel application. These replaced, on a 1:1 basis, 3 PP membrane plates in the so-called mixed pack, which consists of alternating recessed chamber intermediate and membrane plates. These AURUM plates are still in operation today and show no deterioration. The service life of the filter cloths is the same for PP and AURUM membranes. This demonstrates that individual AURUM plates can be integrated into existing packs.

Regarding general integration, it should be noted that, with the addition of the necessary peripheral equipment, it is in principle possible to convert a filter press into a membrane press. Furthermore, the modification of membrane presses using other squeezing technologies to AURUM diaphragms is feasible, provided the application meets the required technical conditions.

3.4 Iron ore tailings filtration optimisation approach

In the following, the optimisation potential of the AURUM membranes is evaluated based on operating conditions in an iron ore tailings filtration plant. For this application in Brazil, a filtration cycle time of 18–23 minutes and a total cycle time (start-to-start) of 31 minutes are assumed (Figure 11), referring to publicly accessible data (Gerards & Panholzer 2025).

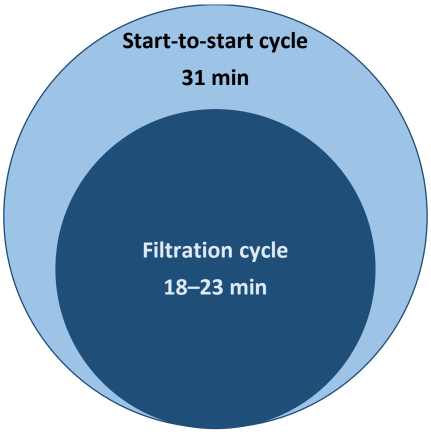

Figure 11 Schematic representation of the temporal composition of the iron ore tailings application

It is already a highly optimised process using 4 2.5 × 2.5m overhead filter presses. During operation, pressure is applied to the membrane for approximately 9 minutes, with inflation to 11 bar taking 3 minutes. Due to the optimised AURUM material, an inflation time of 1 minute could be targeted. This would correspond to a time saving of 2 minutes per cycle. Table 1 lists the resulting improvements for the 2 different time considerations. AURUM would result in an improvement of 6.5% in start-to-start cycle time.

Table 1 Time improvement for different time considerations of the iron ore tailing filtration

Time scale	Duration	Duration (AURUM)	Improvement
Filtration cycle	18–23 min	16–21 min	9–11%
Start-to-start cycle	31 min	29 min	6.5%

In addition to considering a single filtration cycle, further improvement is expected in the long term due to the longer durability and reduced maintenance for membrane plate exchange.

4 Conclusion

In conclusion, the AURUM Membrane Squeeze Technology marks a significant advancement in membrane filter press operation. This innovative technology combines the benefits of traditional squeezing materials like polypropylene, thermoplastic elastomer, and EPDM rubber into one high-performance solution. For example, the experimental results and theoretical estimation demonstrate the benefits of the fast membrane inflation rate. In combination with the additional advantages regarding abrasion resistance and superior flexing durability, the new diaphragm is able to optimise heavy duty applications like tailings filtration. Future research should explore the long-term operational stability and economic feasibility of the AURUM membrane squeeze technology in real-world industrial settings.

Acknowledgement

The authors would like to thank Johann Biegerl and Amberger Kaolinwerke Eduard Kick GmbH & Co. KG.

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