

High-efficiency reject and process water treatment

How advanced hydrocyclone technology contributes to fiber recovery, process stability, and sustainable paper production

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INTRODUCTION:

Rising raw material costs, increasing quality requirements, and growing pressure to reduce environmental impact are driving continuous optimization across the pulp and paper industry. At the same time, paper producers are confronted with increasingly complex raw material streams, higher levels of contamination, increasing numbers of grade changes, and tighter process windows. These challenges demand separation technologies that go beyond conventional solutions in terms of efficiency, selectivity, adaptivity, and operational stability.



Figure 1: High-G-Combi Line | 40 m³/h | Fine Reject Treatment.

Hydrocyclones have been an integral part cornerstone [LB1.1] of pulp stock cleaning and process water treatment for decades. However, traditional designs often reach their limits when faced with modern reject compositions, fine contaminants, and the need to minimize fiber losses while maintaining low energy

consumption. In many applications, the trade-off between separation efficiency and fiber recovery remains a persistent issue.

ECOFARIO has developed the next-generation hydrocyclone technology—referred to as the High-G-Separator—that addresses these challenges through optimized flow patterns, defined flow reversal, and high centrifugal

forces. This article provides an overview of the underlying technology and outlines the different areas within the paper mills where ECOFARIO systems are applied, ranging from stock preparation and approach flow systems to reject treatment, white water circuits, process water purification, and wastewater treatment.

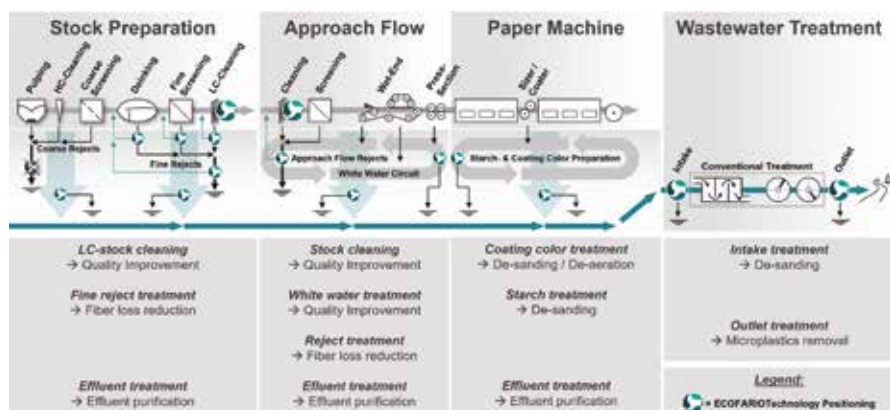


Figure 2: ECOFARIO - Technology Positioning | Paper Industry

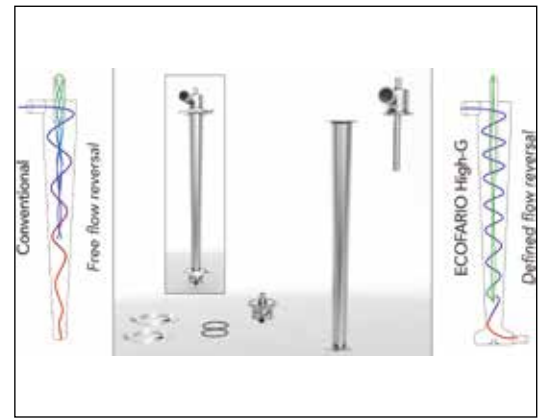


Figure 3: Flow Pattern Improvement | ECOFARIO vs. Conventional Cyclone Design.

The Challenge of Fiber Losses and Contaminant Removal

Fiber losses represent a significant economic and ecological burden in paper production. Even small percentages of fiber discharged with rejects or effluents can translate into substantial raw material losses over time. At the same time, contaminants such as stickies, waxes, plastics, sand, fillers, and fine dirt particles increasingly affect process stability, product quality, and machine runnability. [LB1.1] In order to remove these contaminants, hydrocyclones are implemented, while their use always goes along with additional fiber losses, which relatively increases with the removal resistance of the specific contaminant.

Conventional low-consistency hydrocyclones often rely on free flow reversal and partially controlled velocity profiles as separation mechanisms. While effective for coarse separation tasks, their selectivity is limited when dealing with consistencies above 1,5%, high degrees of contamination, fine contaminants, or combined reject streams. Consequently, high required reject dilution rates, fiber thickening, and elevated specific energy consumption are common side effects.

As mills move toward higher recovery rates, closed water circuits, and more demanding quality targets, separation systems must deliver:

- High contaminant removal efficiency
- Minimal fiber thickening and fiber loss
- Low specific energy consumption
- Stable operation over a wide consistency range
- Reliable separation over a wide flow range

ECOFARIO High-G-Technology: Design Principles

The ECOFARIO High-G-Technology is based on a fundamentally optimized hydrocyclone design. The key difference compared to conventional units lies in the defined flow reversal and the precise control of tangential, axial, and radial velocity components.

Optimized Flow Patterns

Computational and experimental analyses have shown that homogeneous flow velocities and stable flow patterns are critical for effective separation. The High-G design minimizes turbulence zones and avoids uncontrolled flow reversal, resulting in:

- Higher effective centrifugal (G) forces
- Improved selectivity between fibers and contaminants
- Reduced clogging tendency
- No resulting need for reject- or cone dilution

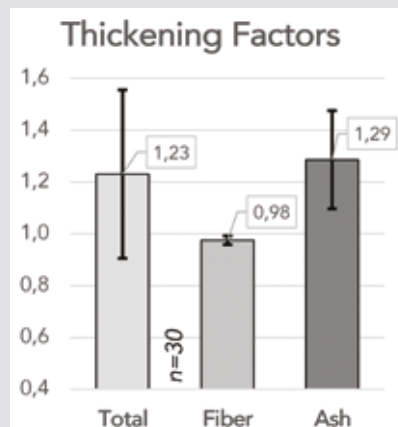
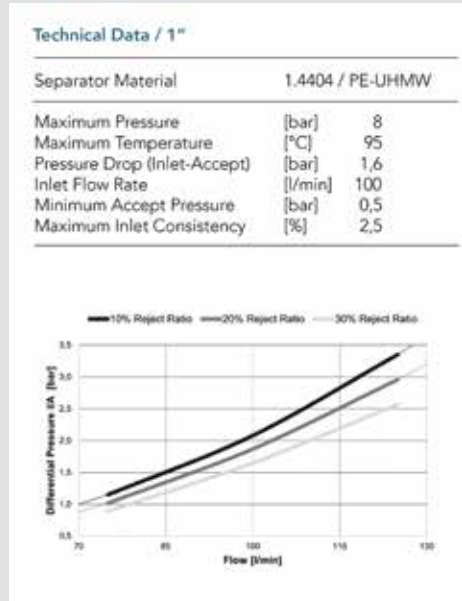


Figure 4: (Above) ECOFARIO Thickening Factors.

Figure 5: (Right) ECOFARIO | Differential Pressures High-G- Heavy Line 1".



Minimal Fiber Thickening

A central objective of the High-G-Technology is to keep fibers in suspension while selectively removing heavy and light contaminants. This leads to very low fiber thickening in the reject stream, which is particularly important for reject treatment applications where fiber recovery is a primary goal.

Energy-Efficient Operation

Due to optimized hydraulics and reduced pressure losses, ECOFARIO systems operate with exceptionally low specific energy consumption. In all applications, no additional cone or reject dilution is required, further reducing energy and water demand.

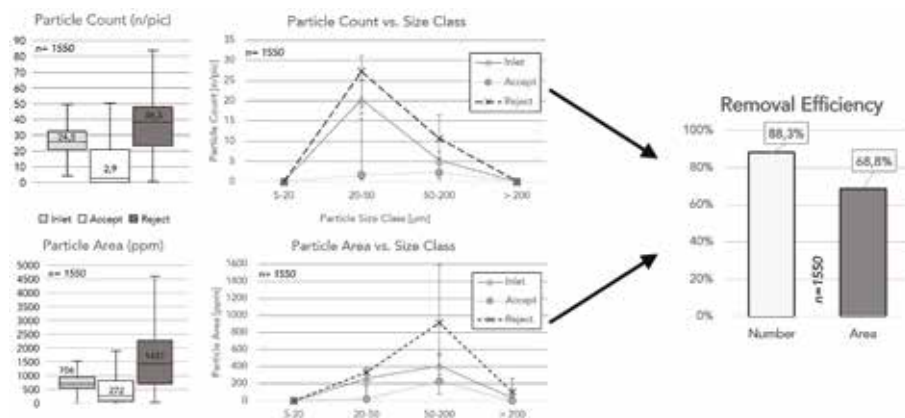


Figure 6: ECOFARIO | Dirt Spec Removal Efficiency | Approach Flow.

Reject Treatment for OCC and DIP Plants

Reject treatment is a core application area for ECOFARIO systems, particularly in OCC and DIP plants where reject streams contain a complex mixture of fibers, plastics, stickies, fillers, and coarse contaminants.

Combined Treatment of Heavy and Light Rejects

The High-G-Combi Line enables the simultaneous treatment of heavy and light contaminants within a modular system

concept. By separating reject streams into defined heavy and light fractions, valuable fibers can be recovered efficiently.

Key benefits include:

- Significant reduction of fiber losses
- High thickening of contaminants with minimal fiber thickening
- Flexible integration into existing reject handling systems

Trials and industrial installations have shown fiber loss reduction potentials of more than 60 - 70%, depending on raw material composition and process configuration.

White Water Circuits

As mills move toward closed water circuits, the cleanliness of white water becomes increasingly important. Accumulation of fine particles and contaminants can negatively affect retention, drainage, formation, chemical efficiency, and product quality.

White Water Cleaning and Fiber Recovery

High-G separators are applied in white water circuits to:

- Remove fine suspended solids
- Recover fibers and fillers
- Improve overall water quality

The result is enhanced process stability, reduced fresh water consumption, and improved efficiency of chemical additives.

Starch and Coating Color Preparation

Starch and coating color systems are sensitive to contamination and sedimentation. Sand, agglomerates, and air inclusions can cause nozzle wear, coating defects, and quality issues.

Application Areas Across the Paper Mill

One of the key strengths of the ECOFARIO High-G-Technology is its versatility. The same core separator principle can be adapted to different process stages within the paper mill, each with specific separation objectives.

Stock Preparation

In stock preparation systems, the primary objectives are pulp cleanliness, stable operation, and protection of downstream equipment. The increasing use of recycled fibers introduces a wide range of contaminants that must be removed efficiently without excessive fiber loss.

LC Stock Cleaning and Fine Screening Support

High-G separators are used as:

- Tail stage cleaners in stock preparation lines
- Fine reject treatment units
- Supporting stages for existing screening systems

By selectively removing fine heavy and/or light contaminants, the High-G-Technology improves pulp quality and reduces the load on subsequent process stages.

Approach Flow Systems

The approach flow is one of the most sensitive areas in the paper mill. Even small variations in pulp cleanliness or consistency can directly affect sheet formation, paper or board quality, and machine stability.

Reduction of Fiber Losses in Tail Stages

In many mills, the final cleaner stages in the approach flow system generate rejects with relatively low contaminant content but still significant fiber concentration. Discharging these streams results in unnecessary fiber losses.

High-G separators can be integrated as:

- Tail stage cleaners
- Fiber recovery units for approach flow rejects

Field applications have demonstrated fiber recovery rates > 80% while maintaining effective contaminant separation, contributing to both economic savings and improved sustainability.

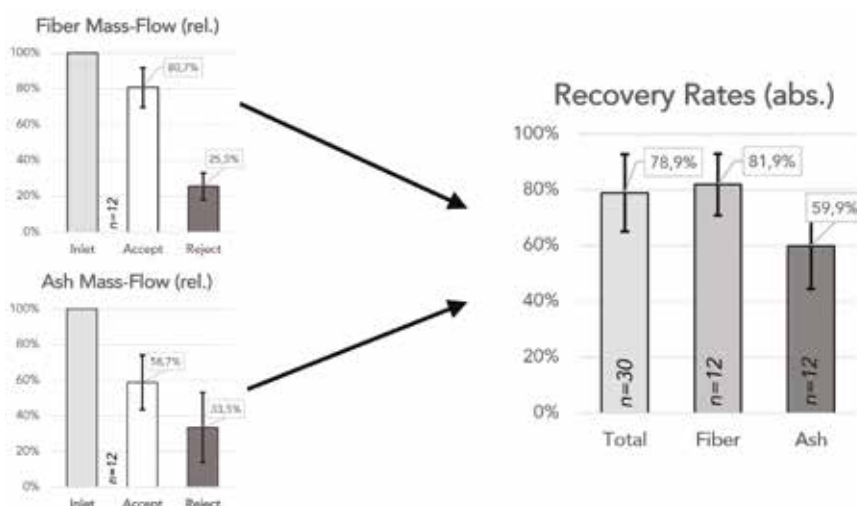


Figure 7: ECOFARIO | Fiber Recovery Efficiency.

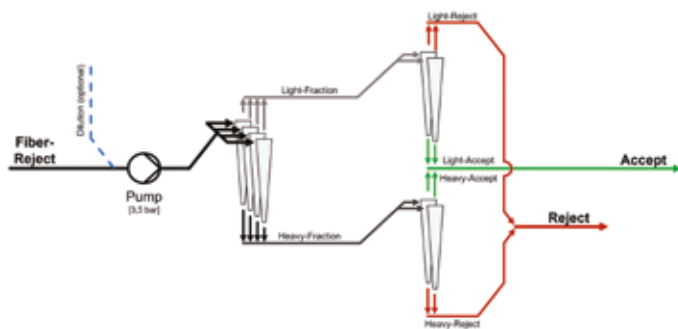


Figure 8: ECOFARIO | High-G Combi-Line Layout

De-Sanding and De-Aeration

ECOFARIO systems are used to:

- Remove sand and heavy particles from starch and coating color
- Improve suspension homogeneity
- Protect downstream equipment, such as roll covers or blades

The compact and modular design allows straightforward integration into existing preparation systems.

Wastewater and Effluent Treatment

Environmental regulations and sustainability targets require effective treatment of process effluents before discharge. At the same time, mills aim to recover valuable materials from wastewater streams wherever possible.

Microplastic and Particle Removal

High-G-Technology has proven effective in:

- Removing microplastic particles from effluents by over 85%
- Reducing suspended solids load
- Improving overall effluent quality

By combining fiber recovery with effluent purification, the technology contributes to both environmental compliance and resource efficiency.

Sustainability and Economic Impact

Beyond technical performance, sustainability and economic efficiency are central considerations for modern paper mills.

The ECOFARIO High-G-Technology contributes to sustainability through:

- Reduced raw material losses
- Lower specific energy consumption
- Decreased water usage
- Long component lifetimes and reduced maintenance

From an economic perspective, the recovery of fibers from reject and process water streams often results in attractive return-on-investment periods, even in applications with relatively low reject volumes.

Conclusion

The increasing complexity of raw materials, stricter quality requirements, and growing sustainability demands are reshaping separation tasks in the pulp and paper industry. Conventional hydrocyclone solutions are often no longer sufficient to meet these challenges without compromising fiber recovery or energy efficiency. ECOFARIO's High-G-Technology represents a significant advancement of the hydrocyclone principle. Through optimized flow patterns, defined flow reversal, and high selectivity, the technology enables efficient contaminant removal with minimal fiber losses across a wide range of applications.

From stock preparation and approach flow systems to reject treatment, white water circuits, additive preparation, and wastewater treatment, the High-G-Technology provides a versatile and future-oriented solution for modern paper production.

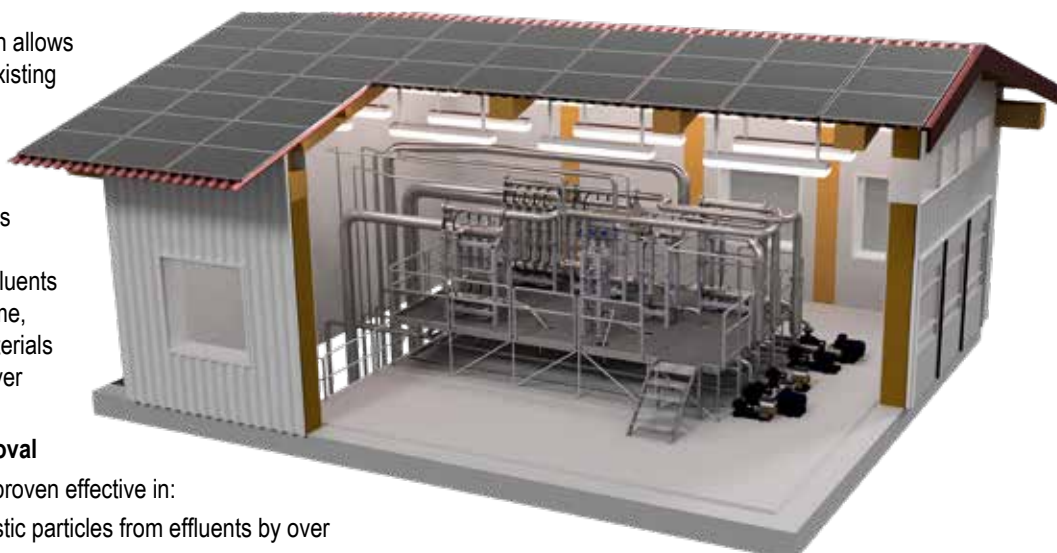


Figure 9: ECOFARIO | Microplastic Removal Plant | Wastewater.



Figure 10: The ECOFARIO | Team