

# Flotation technology



One Source

Superior Metallurgy & Higher Availability

# FLSmidth Flotation Technology

**FLSmidth has assembled un-paralleled flotation resources and is fully invested in leading edge flotation research to give our customers the best flotation solutions now and in the future.**



Below is a photo of the largest flotation installation in the world consisting of 66 250m<sup>3</sup> Wemco Flotation Machines located in Mexico



FLSmidth is the leader in flotation technology with sound metallurgical design principles anchored in the world's most efficient designs. We have integrated the expertise of three world leaders with the addition of Dorr-Oliver and Wemco to create the ultimate flotation technology for process specific solutions.

The two most significant factors impacting a flotation plant's financial performance are metallurgical recovery and flotation cell availability. FLSmidth flotation machines excel in both of these important criteria.

### **Versatile Solutions**

FLSmidth is the only company to offer you both self aspirated and forced air flotation machines. This allows optimum utilization of the best cell technology based on the process requirements.

### **Devoted Support**

FLSmidth is fully invested in supporting and improving flotation solutions for our customers. We have regional process engineers located globally to offer customers regional support. We offer unparalleled process support and flotation experience.

### **Leader in Flotation Research Worldwide**

FLSmidth brings together mechanical, process, and metallurgical engineers to form a complete and well rounded flotation team. FLSmidth strives constantly to improve our flotation technology by funding fundamental research and leveraging world class scientists in key disciplines. Our fully staffed Research and Development team works in conjunction with research institutions to stay current with the latest developments and innovations in flotation.

FLSmidth brings our team together in a major new Technology Center located in Salt Lake City where we are applying leading edge tools and skills to flotation development.

Dawson Metallurgical Laboratory adds to the expertise of the FLSmidth team. With this additional metallurgical testing expertise, FLSmidth is able to provide unprecedented flotation expertise for every application.

(Top) FLSmidth's state-of-the-art Technology Center  
(Bottom) FLSmidth metallurgist performing a flotation concentration test in one of the many labs in our Technology Center



# WEMCO® Flotation Machines

**WEMCO® Flotation Machines have the largest installed base of any flotation Machine around the world.**



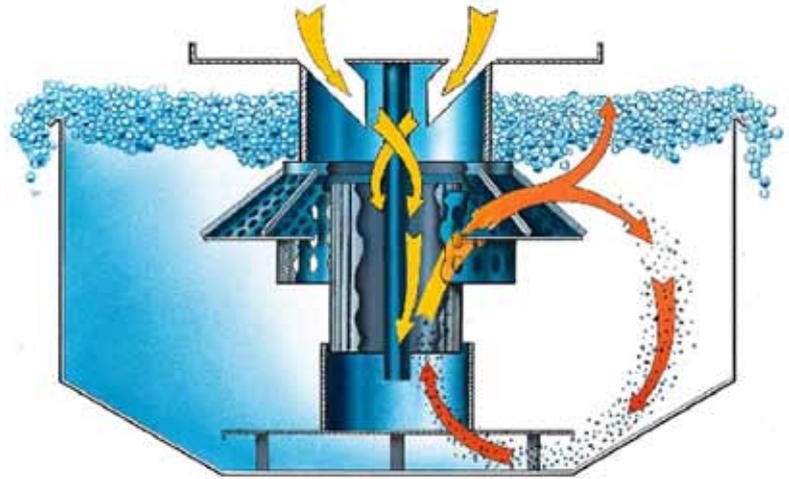
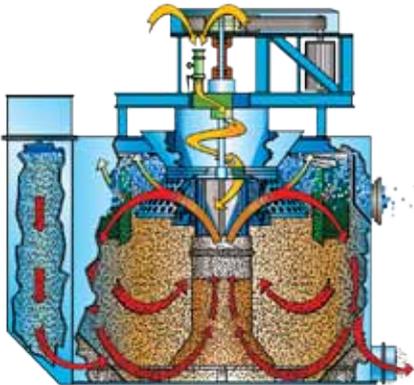
250m<sup>3</sup> Wemco Cells installed in a Copper plant in Mexico



## Wemco Flotation

The self aspirating Wemco flotation technology, whether incorporated into the original 1+1™ Flotation Machine design or newer generation SmartCell™ Flotation Cell combines ease of operation with improved metallurgical performance. The Wemco rotor is positioned higher in the flotation tank resulting in the following advantages:

- Shorter froth travel distance for improved coarse particle recovery
- Reduced maintenance and greater availability
  - » Rotor is positioned near the top of the cell resulting in less wear
  - » Reversing and inverting rotor extends life
  - » Mechanisms can be changed without shutting down or draining the row of cells
- No blower and associated air piping is required.



## Wemco® SmartCell™ Flotation Machines

Wemco self aspirating flotation technology has been the industry standard for decades. It has been updated, adapted, and refined into the SmartCell to meet the demands of modern, large scale concentrators. The SmartCell features large, cylindrically shaped tanks with special design features that improve mixing and achieve unmatched hydrodynamics and tank utilization. Since its introduction in 1996, most of the major mineral concentrators have selected the SmartCell to ensure high recovery and ease of operation.

FLSmidth Research and Development efforts have designed the SmartCell to exceed our mineral processing customer's expectations by using special design features:

- Streamlined hybrid draft tube to optimize slurry pumping
- Beveled tank bottom to eliminate stagnant zones and improve particle suspension
- Tank Baffles to stabilize froth surface and enhance mixing
- Radial Launderers to improve froth removal and increase recoveries

The Wemco SmartCell Flotation machine is available in sizes up to 500m<sup>3</sup> to accommodate the largest mining operations in the world.

## Wemco 1+1™ Flotation Machines

In applications with lower tonnage throughput, traditional rectangular shaped tanks may be the most economical selection. For these applications FLSmidth offers Wemco 1+1™ self aspirating technology.

- The Wemco 1+1™ Flotation Machine, at more than 50,000 units, has the greatest installation base of any flotation cell in the world.
- Beveled tank bottom for better coarse particle suspension
- Self supporting tank bottom for ease of installation.
- Sizes ranging from lab scale to 85m<sup>3</sup> are available.
- Also available as the InertGas™ design for use in copper/moly separation resulting in lower reagent consumption and eliminating the need for Nitrogen supply.

# Dorr-Oliver® Flotation Cells

**While excellent as an “all around flexible” flotation machine the Dorrr-Oliver design is well suited for fine particle recovery with multiple high energy contacts and high bubble surface area flux.**



160m<sup>3</sup> Dorrr-Oliver flotation Cells in a South African Platinum Group Metals Plant.



### Increased Fine Particle Recovery

The Dorr-Oliver Flotation Mechanism is the most energy efficient, technically advanced, forced air flotation machine on the market. It has been specifically designed to maximize fine particle recovery. The Dorr-Oliver streamlined, high efficiency rotor is a very powerful pump that works together with the stator to generate and define an energy intensive zone in the bottom of the cell. This ensures effective solids suspension and the ability to restart in even the most difficult of applications. The well defined turbulence zone at the bottom of the cell results in multiple passes of unattached particles through the highest energy dissipation area of the cell where fine particles are driven into contact with the air bubbles. The stator design, in addition to providing good separation of the zones in the cell also serves to redirect the rotor jet uniformly across the tank to allow the maximum amount of air to be dispersed into the cell without disturbing the surface. Air dispersion capabilities of the Dorr-Oliver cell exceed all competitive forced air designs. Maximizing the air dispersion capability is an important consideration for fine particle recovery.

### Improved Froth Handling and High Concentrate Grade

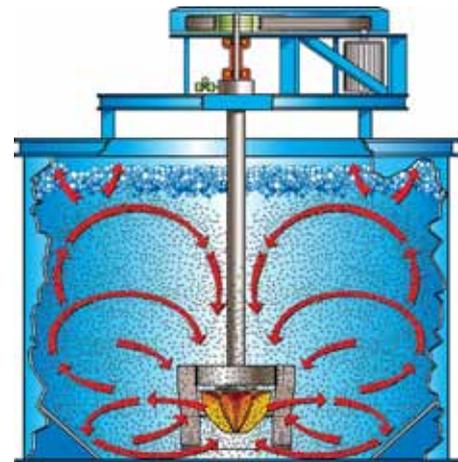
By containing the intense circulation energy at the bottom of the cell the upper zones of the cell remain quiescent to maximize recovery of marginally attached coarse particles and minimize entrainment. The Dorr-Oliver Cell is an exceptional design for cleaner duty.

Dorr-Oliver tank cells are equipped with a uniquely designed high efficiency radial launder system that accelerates the removal of froth as it reaches the surface. Bubble-particle aggregates travel vertically through the froth lattice in essentially plug flow while upgrading. The high efficiency radial launder is shaped to receive the froth uniformly from the cell surface as well as from the typically heavy loaded area near the center of a forced air machine. On passing over the lip the froth is accelerated to the perimeter of the cell. Rarely is launder water a requirement with this unique design.

- Well defined quiescence zone reduces entrainment and gives stable froth
- Concentrate grade is maximized.
- High efficiency radial launder maximizes froth recovery and reduces coarse particle drop back.
- Froth transport is optimized.

(Top) Dorr-Oliver Cell Flow Diagram

Dorr-Oliver Cells are available from our smallest rectangular cells 10-100ft<sup>3</sup> through U-Tanks designs from 150 to 1550ft<sup>3</sup> and across the tank cell sizes from 5m<sup>3</sup> to 350m<sup>3</sup>. Specific cell type, sizes and arrangements are recommended based the application requirements



# SuperCell<sup>®</sup> Flotation Cells

**FLSmidth is the world leader in large cell technology with the greatest installed capacity of any flotation manufacturer**



(Above) 350m<sup>3</sup> SuperCell installed with a Dorr-Oliver mechanism in a copper installation in the USA.

(Below) 300m<sup>3</sup> SuperCells with Wemco mechanisms installed in a Copper plant in Chile.



FLSmidth is pioneering the way for large cell technology with the largest operating cells on the market today. From our first 250m<sup>3</sup> cells installed in 2003 to now with up to 350m<sup>3</sup> designs and 300m<sup>3</sup> cells being installed around the world. The 350m<sup>3</sup> SuperCell™ flotation cell is the largest operating flotation cell in the world with proven performance in hydrodynamics, metallurgy, and mechanical reliability.

FLSmidth has the largest installed based of large cells around the world. Over 50 of the 300m<sup>3</sup> SuperCells have been sold and over 100 of the 250m<sup>3</sup> cells have been installed.

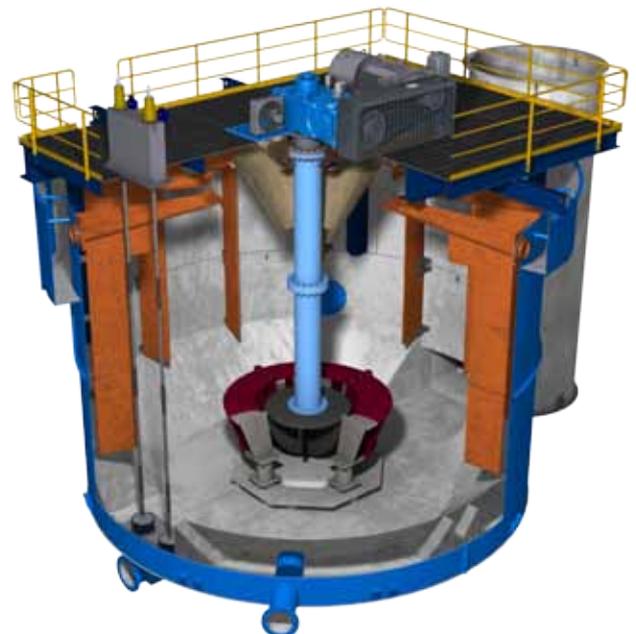
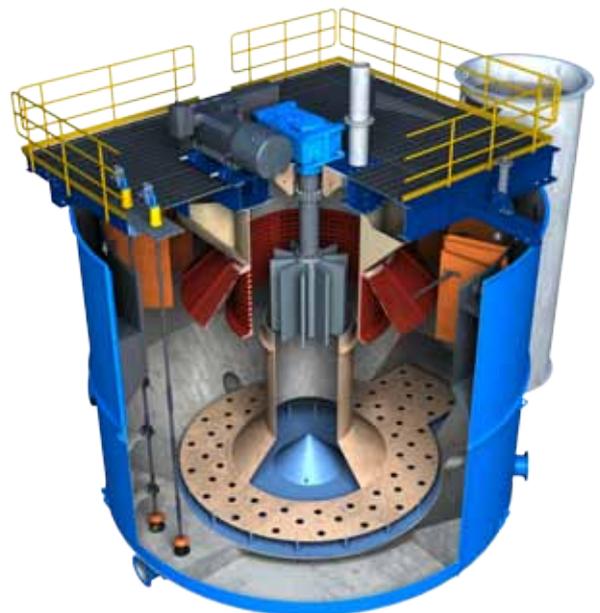
The SuperCell Flotation Cells are proven to reduce operating and installation costs as a result of the economies of scale and a reduced foot print with fewer control points. Scale up was completed using validated CFD models with comprehensive metallurgical testing at full scale. There is no degradation of metallurgical performance with the SuperCell.

SuperCell benefits include:

- Reduced foot print
- Reduced installation cost
- Easier implementation of sophisticated process control
- Equal or better metallurgy
- Proven performance in hydrodynamics, metallurgy, and mechanical reliability

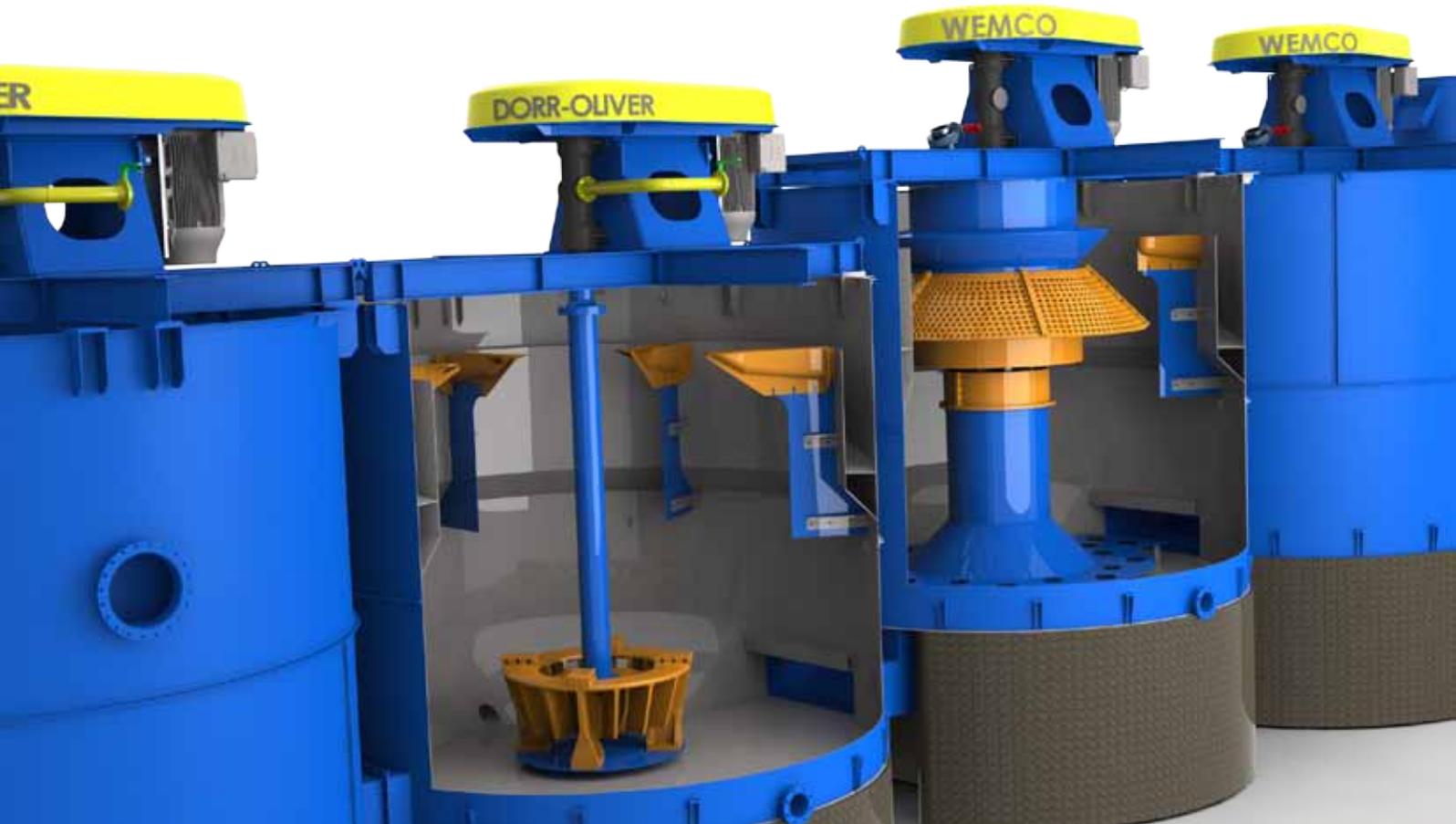
FLSmidth SuperCells use a universal tank that can be fitted with either the Wemco® self aspirated or Dorr-Oliver® forced air designs. This allows SuperCells to be installed as roughers, cleaners and scavengers depending on the requirements of your application.

(Top) SuperCell™ Flotation Cell with a WEMCO mechanism  
(Bottom) SuperCell™ Flotation Cell with a Dorr-Oliver mechanism



# Mixed Rows™ & Mixed Circuits™

**By combining Wemco® self aspirated and Dorr-Oliver® forced air cells in the same plant FLSmidth can exploit their unique characteristics to maximize circuit and row performance.**



## FLSmidth Mixed Rows™ & Mixed Circuits™

In the past, mineral producers had to choose between mechanical flotation systems that naturally ingest ambient air and others that require a blower. FLSmidth is in the unique position to exploit the inherent and unique advantages of both the Wemco® self aspirated and Dorr-Oliver® forced air technologies. These two types of machines can be used in different parts of the flotation circuit forming a Mixed Circuit™ or in a single row forming a Mixed Row™.

### Mixed Circuits™:

#### Wemco for Recovery & Dorr-Oliver for Cleaners

The Wemco design with its agitator near the top of the tank maximizes coarse particle recovery since transport distance of the fragile bubble particle aggregate is minimized. The Wemco mechanism is also not exposed to the damaging effects of tramp material (ball chips etc) that are inevitable in rougher circuits due to upsets. The Wemco cell is a true workhorse for rougher, rougher scavenger and cleaner scavenger applications. The Dorr-Oliver design with its rotor/stator at the bottom of the tank is well suited for maximizing air dispersion and focusing energy dissipation, conditions which drive fine particle flotation. The fine particles can survive the higher transport distances inherent in this design. This distance also serves to promote upgrading making the Dorr-Oliver machine ideally suited for cleaner applications. Air control and higher range of froth depth with the Dorr-Oliver design also are beneficial in the cleaner application. The FLSmidth Mixed Circuit™ is an exceptional and unique flotation solution to optimize your flotation plant performance.

### Mixed Rows™: Maximizing recovery by combining Wemco and Dorr-Oliver Mechanisms in the Same Row

The Mixed Row is an extension of the Mixed Circuit concept. By combining the inherently different designs in the same row it is possible to exploit their unique advantages further to maximize recovery. There are several strategies which have been employed in several plants around the world. These are tailored to the particular application and can offer greatest flexibility for optimized recovery.

### The Universal Tank

On large cells (100m<sup>3</sup> and larger), we have developed a "Universal Tank" that can accommodate either the Wemco induced-air cell or the Dorr-Oliver forced-air cell and are interchangeable to provide flexibility for future ore changes or other considerations.

By supplying customized solutions to its mineral processing partners, FLSmidth maintains its global industry leadership in the supply of flotation technology with over 53,000 flotation cells delivered to date.

(Top) 160m<sup>3</sup> Wemco and Dorr-Oliver Cells in a mixed circuit configuration in a PGM installation in South Africa.  
(Below) Interchangeable Wemco and Dorr-Oliver Mechanisms that can be placed in Mixed Rows or Mixed Circuits

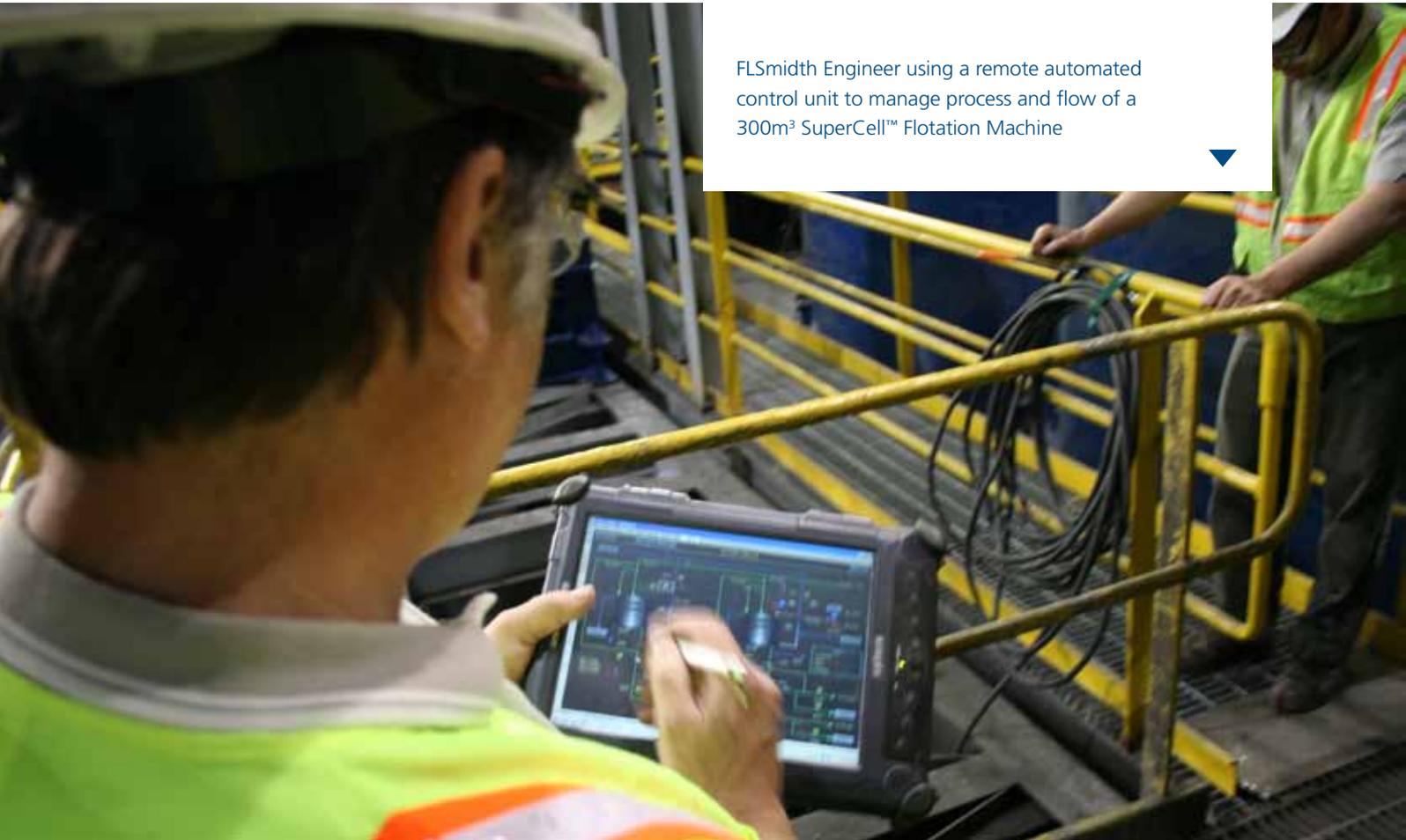


# Optimizing Flotation Control

**FLSmidth's advanced process control solution, ECS/ ProcessExpert, ensures that flotation cells perform better resulting in optimized plant performance for grade and recovery.**



FLSmidth Engineer using a remote automated control unit to manage process and flow of a 300m<sup>3</sup> SuperCell™ Flotation Machine



## Why Automate?

FLSmidth's ECS/ProcessExpert provides advanced process control and optimization for minerals plants, focusing on ensuring maximum efficiency and higher profitability. ECS/ProcessExpert stabilizes the flotation plant flow, and adjusts and maintains operational set points so that target performance is optimized and constantly achieved. FLSmidth's accumulated process knowledge as a technology leader in flotation forms the basis for a robust and reliable automated control solution.

## Optimizing flotation control

(Content on how ECS/ProcessExpert optimizes flotation needs to be developed) FLSmidth's ECS/ProcessExpert for Flotation Applications is built on process plant specific process strategies. The applications designed using MPC techniques supplemented with Fuzzy Logic manipulate actuators controlling pulp levels, pulp flows, aeration rates, and reagent additions. Complimented by advanced froth vision analysis instrumentation analyzing bubble size, froth texture, froth mobility and froth color, the ECS/ProcessExpert provides a complete solution for flotation control.

## Optimized using cutting-edge technology

Designed by process and automation experts specifically for normally aspirated and forced air flotation machinery in minerals applications, ECS/ProcessExpert leverages technologies and tools such as Model Predictive Control (MPC) and Fuzzy Logic to implement efficient advanced control solutions.

## Built for long-term success

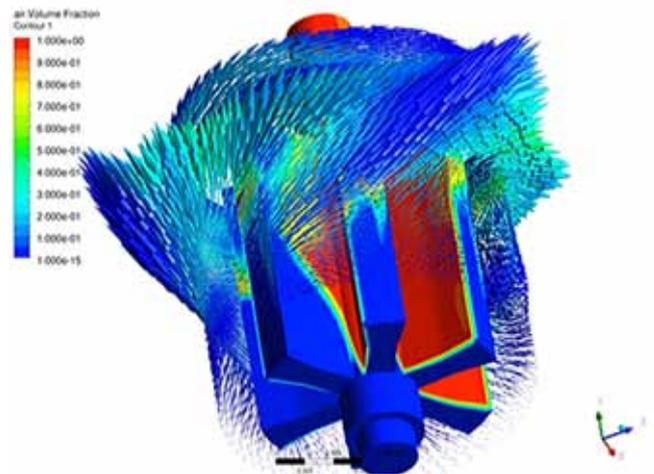
For advanced process control solutions to operate reliably and efficiently, it needs to be implemented correctly. FLSmidth follows a clearly defined implementation process designed to ensure a tailored solution that fit the individual process. We also understand that strong service support is necessary to ensure long-term and changing plant and ore conditions which is why FLSmidth maintains a full service program with a 24-hour hotline, remote troubleshooting and KPI monitoring to ensure that problems can be avoided or solved with minimum plant disruption.

For more information about ECS/ProcessExpert and FLSmidth's other automation solutions, please visit [www.flsmidth.com/automation](http://www.flsmidth.com/automation).

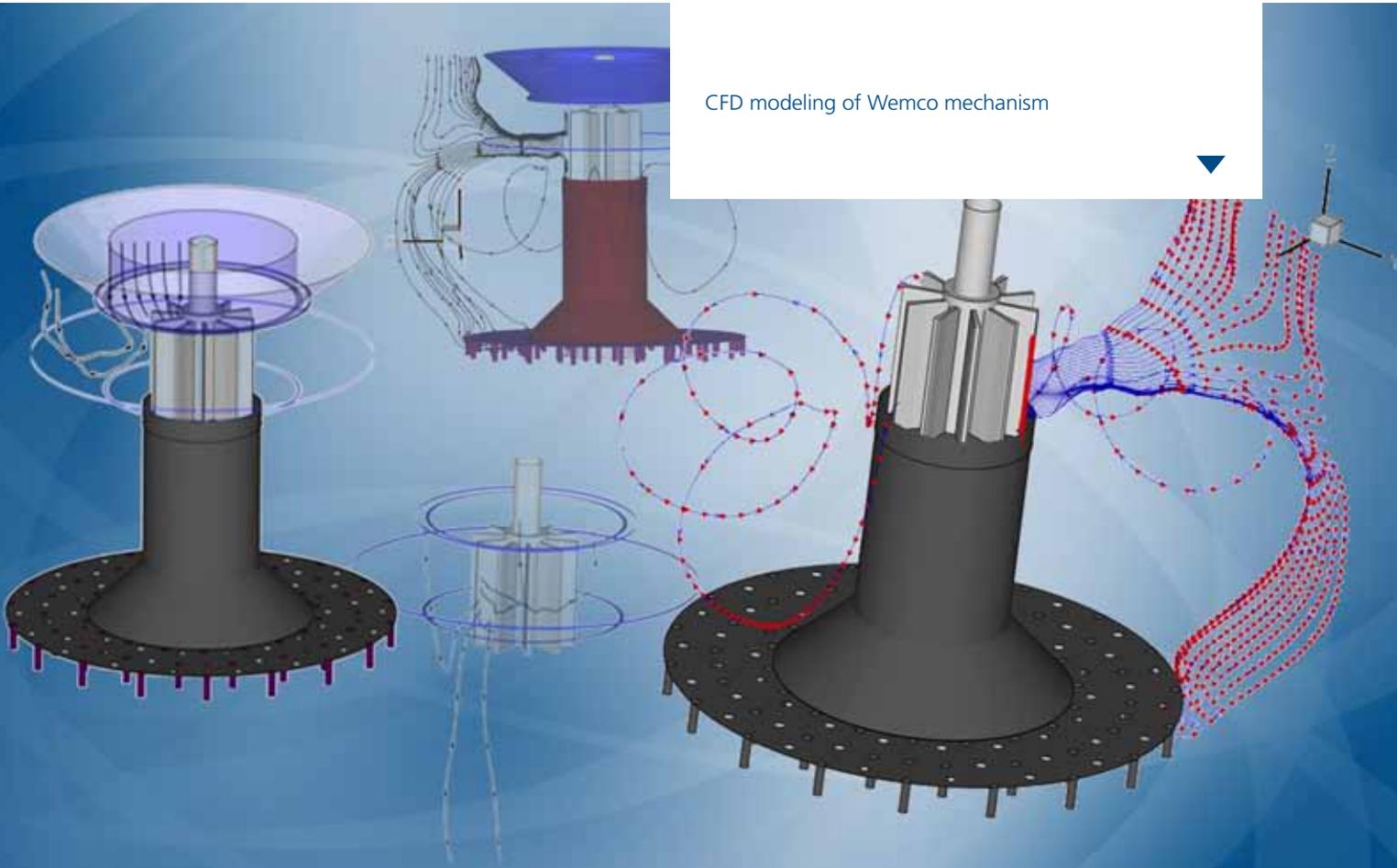


# Research & Development

**FLSmidth is devoted to advancing flotation with new and innovative methods and designs.**



CFD modeling of Wemco mechanism



FLSmidth is the only manufacturer that provides self induced and forced air types of full scale flotation equipment, which allows us to deliver the right flotation equipment to any mineral application. Although the Dorr-Oliver and Wemco flotation machines differ in their operational philosophy, the physics of the separation process is the same. The flotation cell's design is based on fundamental hydrodynamic and metallurgical principals.

Each type of flotation cell has unique hydrodynamic characteristics, which can all be characterized by the same set of dimensionless quantities. Which include Reynolds number, Power number, Froude number and Air Flow Number. Historically, these dimensionless numbers have been used to quantify both the hydrodynamic characteristic of the equipment and scale-up the flotation cells from  $0.1\text{m}^3$  to  $500\text{m}^3$ .

Over the past several years, FLSmidth has augmented this approach by implementing the use of fundamental first principles. This approach to machine development and circuit design permits FLSmidth to continuously improve our core product line and partner with the minerals producer to design and optimize their flotation circuit.

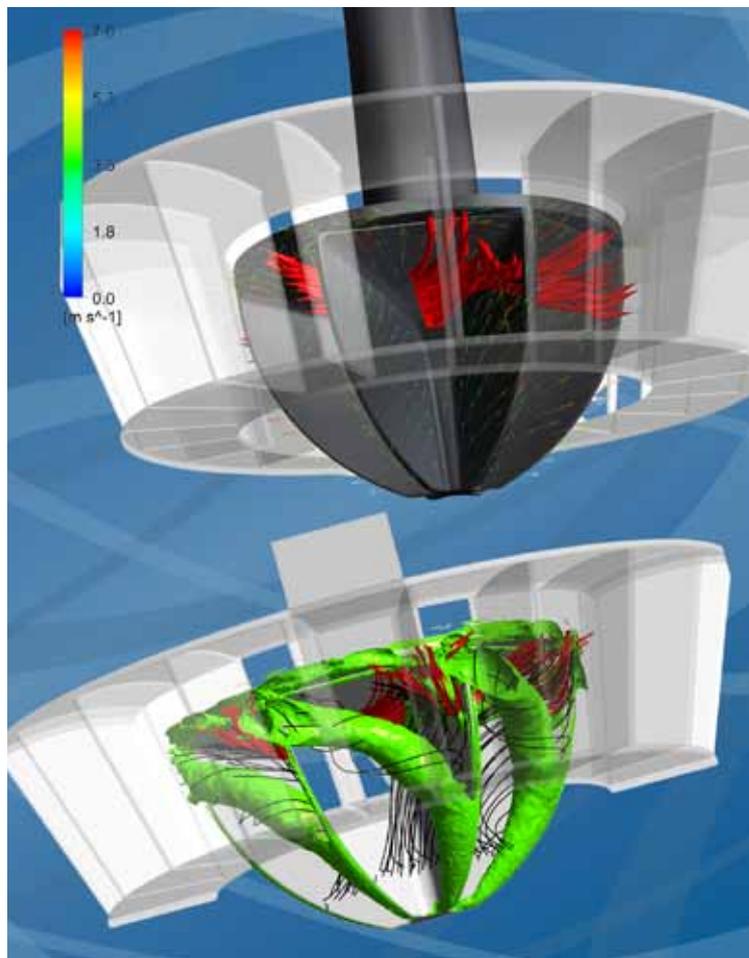
To effectively execute this philosophy, FLSmidth has a cooperative agreement with a consortium of seven universities with the mandate to conduct both fundamental and applied research in mineral processing technologies. The synergy developed with this collaborative research, has lead to, and will continue to provide, a better fundamental understanding of the flotation process and machine hydrodynamic parameters which influence that process.

To fully appreciate this work, one must realize that most flotation models developed in the past were empirical, with no predictive or diagnostic capabilities. The present work includes CFD models validated with pilot and production flotation equipment; empirical hydrodynamic models based on decades of FLSmidth flotation equipment design, and surface chemistry parameters and first principle turbulent flow models. Innovative instrumentation and analytical techniques have also been developed to determine the location of bubble particle contact and detachment.

Utilizing this approach, we are able to make incremental improvements on existing equipment designs and effectively scale-up our equipment, as demonstrated with the successful implementation of the SuperCell™ Flotation Cells.

(Top) FLSmidth engineer performing strain gage analysis on a Wemco 250 cubic meter shaft.

(Bottom) CFD 3D model of Dorr-Oliver rotor and stator interface



One Source

**Minerals Processing  
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