invent®
umwelt und verfahrenstechnik

CYBERFLOW®-Accelerator

Energy-efficient generation of horizontal flows in circulation basins
for biological wastewater treatment

Content

Water needs responsibility

Water is the basis and the source of all life. However, the pollution of our waters is reaching more ominous proportions, making purification and provision of water one of the most important ecological tasks of our time. Since the early 1990s **INVENT** Umwelt- und Verfahrenstechnik AG has developed, produced and sold innovative equipment, systems and processes for the efficient water purification and treatment. Our persistent dedication and efficient products contribute to the preservation of water quality on a global scale

Find out more at
www.invent-uv.com

Leaders in mixing and aeration

CYBERFLOW®, the INVENT Accelerator

The **CYBERFLOW®**-Accelerator is a revolutionary advancement over conventional flow generators. It has been specially developed and optimized for the most energy efficient generation of horizontal flows in applications such as biological wastewater circulation in donut, racetrack or carrousel type basins. Extensive research and development have led to efficiency improvements of up to 30% over traditional flow generators, regardless of the application.

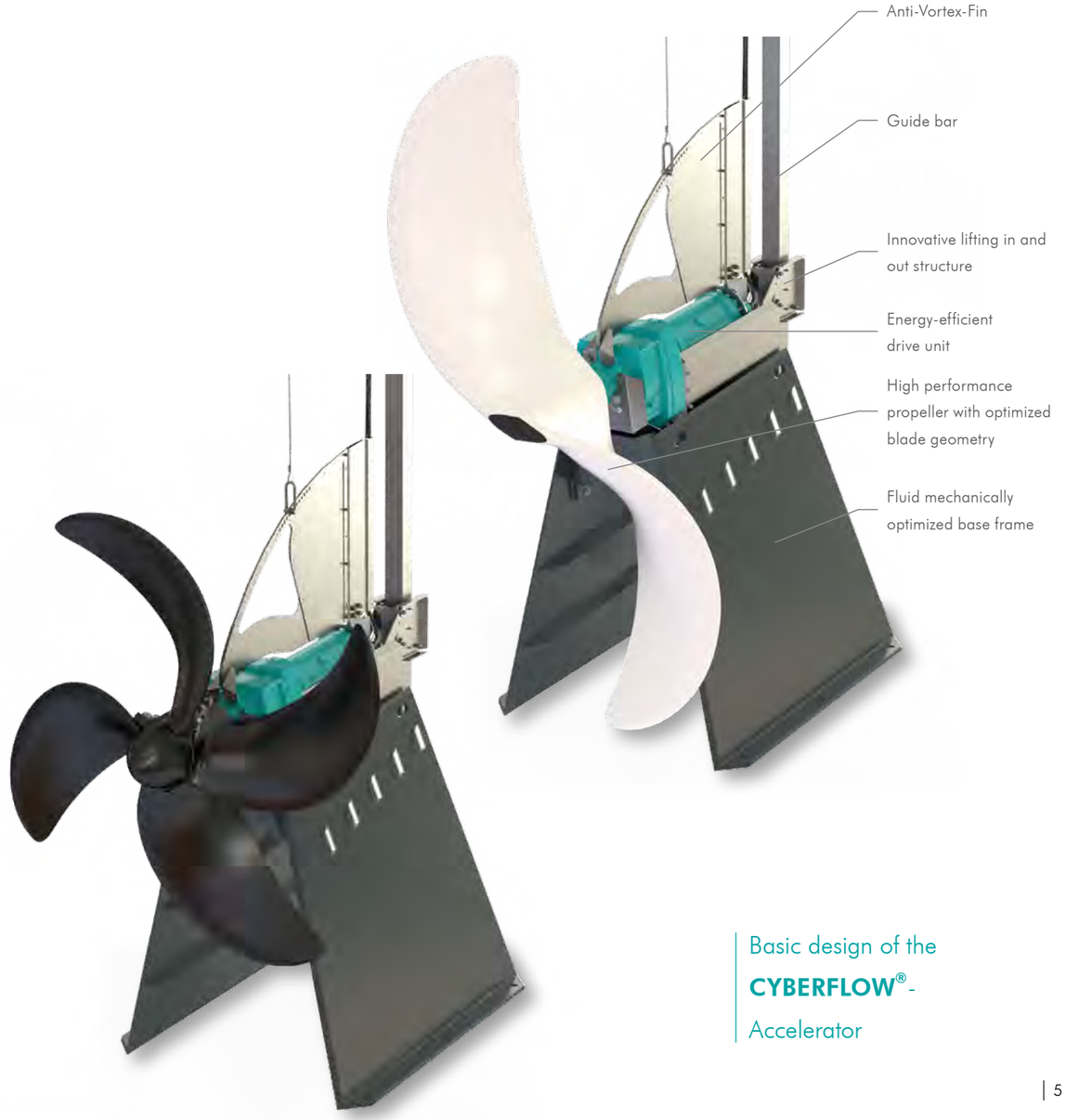
Optimization approach
This is made possible by a holistic, fluid mechanical optimization approach, which considers not only on the propeller design, but the interaction of the flow with the entire machine.

This approach focuses on optimizing all aspects fo the design and application including

- installation location
- installation position
- flow direction
- upstream flow
- downstream flow
- design of the base construction

In addition to the propeller design, these items play an important role in the overall level of efficiency of a horizontal flow generator.

INVENT has studied these topics in depth and as a result created an exceptionally energy-efficient product for biological wastewater treatment.



Basic design of the **CYBERFLOW®**-Accelerator

The Task Definition

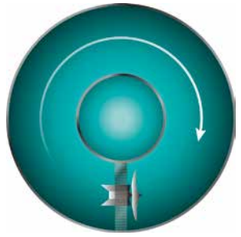
In recirculation applications, horizontal flow generators for racetrack basins move the wastewater horizontally in a circuit and at the same time prevent sedimentation of activated sludge flocs. The most common forms of recirculation basins are:

- Race Track Basins
- Donut Basins
- Carrousel Basins

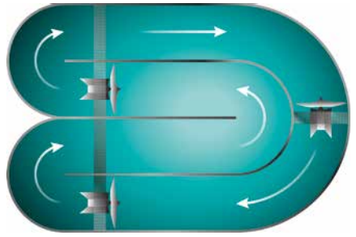
From the process engineering point of view, good quality mixing requires the following:

- Maintaining activated sludge flocs in suspension.
- Turbulence on the surface of the water should be avoided in order to minimize the transfer of oxygen from the air.
- Backflows should be prevented.
- Distributing the activated sludge flocs as evenly as possible throughout the entire basin (homogenization).
- The mixer should limit forces that result in floc shear.

Race Track Basins



Donut Basins



Carrousel Basins

CYBERFLOW®-Accelerator in a municipal wwtp in Bulgaria

The following points are important in the development of a horizontal flow accelerator:

- Should be positioned close to the floor in a favorable position and alignment providing energy at the bottom of the tank where it is needed to prevent solids deposition and backflows.
- Should have a large diameter and run at low speeds to minimize energy consumption and shear forces.
- When multiple flow generators are installed, they should rotate in different directions to prevent energy losses.
- The flow generator should have an undisturbed upstream flow and a non-rotating downstream flow.
- The base frame should have a small cross-section, a low flow resistance and it should streamline the flow.

From the mechanical engineering point of view, it is important to achieve a design which is reliable, robust, durable, and allows for long maintenance intervalls.

The Solution

The **CYBERFLOW®**-Accelerator is the first horizontal mixer for race-track basins which has been consistently designed and optimized based on fluid mechanical considerations. This has led to a revolutionary overall design as described in detail:

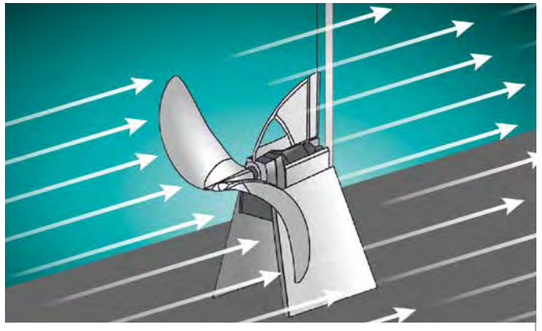
Flow direction
Conventional flow generators possess a direction of flow where the upstream flow is on the drive side. As a result, a turbulent and swirled flow hits the propeller and consequently results in high efficiency losses for the entire unit.

The high-performance propeller of the **CYBERFLOW®**-Accelerator is hit by a completly undisturbed upstream flow, thereby achieving much higher flow speeds with less energy input than conventional flow generators because efficiency losses due to disturbed upstream flows are avoided completely.

Vortex-free downstream flow
Rotating propellers always generate not only axial velocities, but radial and tangential velocities as well. However, only the axial component of the velocity contributes to accelerating the fluid in the horizontal direction. The other components produce ineffective vortices which cause energy dissipation, resulting in severe efficiency losses.

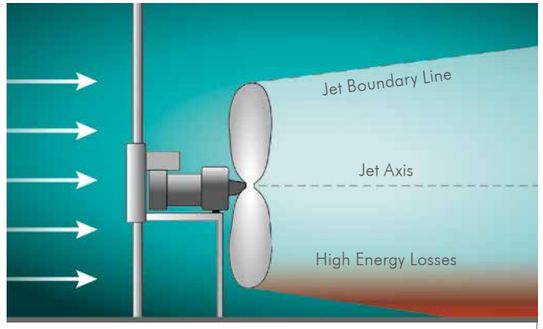
The integral fluid mechanical design of the **CYBERFLOW®**-Accelerator incorporates a socalled “anti-vortex” base frame design which streamlines the flow and takes out the vortex induced by the propeller movement. This effect is supported by the additional “anti-vortex” fin on the back of the power train resulting in energy recovery by converting radial and tangential velocity components into actual axial flow. With this intelligent design, it is possible for the first time to recover energy which is otherwise lost into energy dissipation. This design feature makes a considerable difference and severely contributes to the high energy efficiency of the entire machine.

High-loss high-vortex flow induced by conventional horizontal flow generators

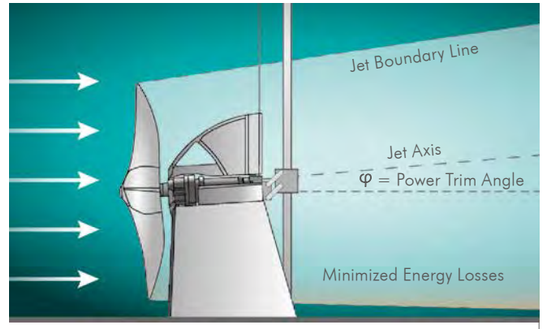


Efficient vortex free flow pattern

INVENT Power Trim Technology®
Conventional horizontal flow generators take the word “horizontal” literally and the drive shaft of the propeller is parallelly aligned to the floor. As a result, they do indeed pump horizontally. On the contrary, it is more efficient to angle the drive shaft slightly so that the flow is aligned slightly upwards. This can greatly reduce friction – and therefore prevent energy-losses at the bottom of the tank. We call this alignment of the flow, which we chose depending on the application at hand, **INVENT Power Trim Technology®** and this design optimization alone improves efficiency by up to 10 %.

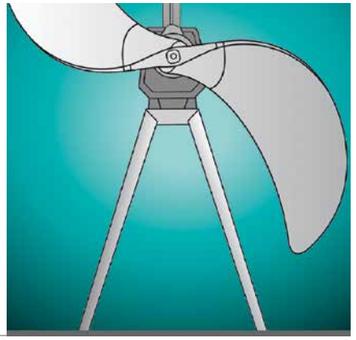


Flow induced by conventional horizontal flow generator



INVENT Power Trim Technology®

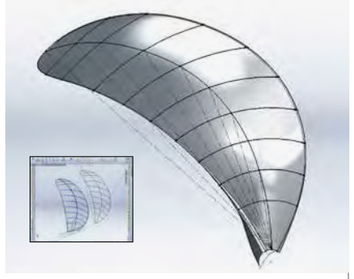
Fluid-mechanically optimized base frame
In the design of the base frame, the **CYBERFLOW®**-Accelerator eliminates the use of standard rectangular tubes with unnecessarily high cw-values completely. Only rigid cast metal structures with a small cross-section, minimized surface and small cw-values are used. This made it possible to create the base frame with the most streamlined design in the market.



Fluid-mechanically optimized base frame

Propeller design

Propellers for flow generators of the first generation were derived mostly from agricultural applications. The design largely neglected any fluid mechanical considerations. The large number of adopted products used second generation propeller designs, which followed or copied the design of ship propellers.



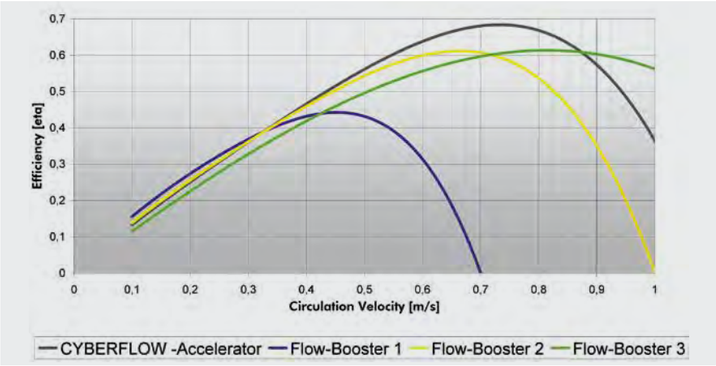
Innovative propeller design

Although this was a step in the right direction, it was still far away from the application in biological wastewater treatment. Ship propellers are designed for maximum thrust and do not have to whirl up sludge flocs or prevent sedimentation. In mixing application in wastewater treatment, the thrust does not play any decisive role. It is far more important to create a directional flow with few losses in a given reactor (activated sludge basin) with as little energy input as possible.

The **CYBERFLOW®**-Accelerator introduces a third-generation propeller design. Its specific shape was developed and optimized in the **INVENT** flow laboratories in Erlangen, Germany using state-of-research facilities, measuring technology and simulation methods specifically for use in activated sludge basins in wastewater treatment. This resulted in a smooth and efficient propeller geometry.

A further aim was to find a robust, durable, light and flexible, structural mechanical design. The result was a propeller structure made of glass- and carbon fibre-reinforced plastic in a sandwich design which can be used even in the most heavyduty municipal and industrial applications.

In result, the **INVENT** propeller design is superior to all conventional propeller designs in the market, irrespective of the number of blades used in the comparison propellers. **INVENT** uses an especially well-balanced two-or four blade design, depending on the application.

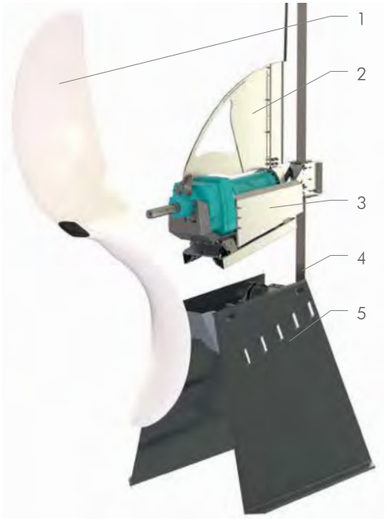


Efficiencies of various propeller geometries depending on the advance coefficient

Structure and Material Selection

The Design

The **CYBERFLOW®**-Accelerator consists of the following main components:



1 Propeller with optimized blade geometry
2 Anti-Vortex-Fin
3 Energy-efficient drive unit
4 Innovative lifting in and out structure
5 Fluid mechanically optimized base frame

The Propeller

The propeller of the **CYBERFLOW®**-Accelerator has been developed and optimized with the help of state-of-research fluid mechanical methods which were applied to the flow in racetrack basins. This resulted in a smooth and efficient propeller geometry. A further aim was to find a robust, durable, light and flexible, structural mechanical design. The result was a propeller structure made of glass- and carbon fibre-reinforced plastic in a sandwich design which can be used even in the most heavyduty municipal and industrial applications.

Power train

The **CYBERFLOW®**-Accelerator power train in turn consists of

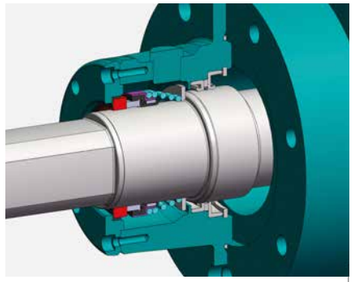
- a specially developed corrosionfree **INVENT** shaft-hub connection
- the gear-reduced drive unit with **INVENT** mechanical seal package
- the “high-efficiency” electric motor

The special **INVENT** shaft-hub connection ensures smooth and even transmission of torque to the propeller hub with low local surface pressures.

INVENT shaft-hub connection

The gearreducer is used for an efficient reduction of the electric motor drive speed. It is designed as a multi-stage helical gearbox with reinforced bearings in order to exceed calculated service life times of 100,000 hours. The sealing of the gearbox towards the outside is realized by a mechanical seal with oil reservoir.

The "high-efficiency" electric motor consists of a fully enclosed, watertight three-phase asynchronous motor with an efficiency rating of IE 3 or higher.

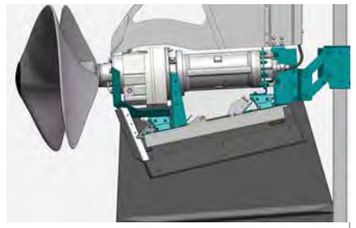


INVENT mechanical seal

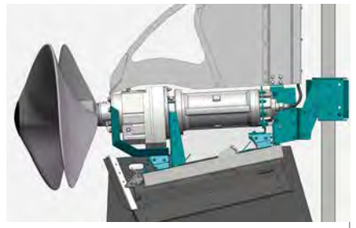
Lift-out and guide construction
The lift-out and guide construction is based on a stainless steel guide bar, which allows for securely lifting out the **CYBERFLOW®**-Accelerator, but also to engage it securely in the base frame again by reversing the process.

Anti-Vortex-Fin Technology®
The "Anti-Vortex-Fin" is attached to the top of the drive unit. It is made from corrosion-resistant stainless steel and is used to streamline the flow and recovers energy from the vortex in the wake of the propeller blade.

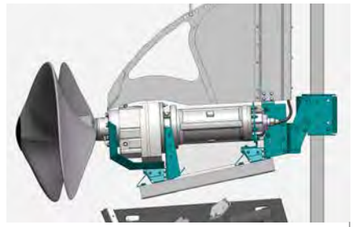
Base frame
The base frame is used to securely anchor the **CYBERFLOW®**-Accelerator to the floor and to streamline the flow during operation. It is an integral part of the overall design.



Lower



Attach



Lock

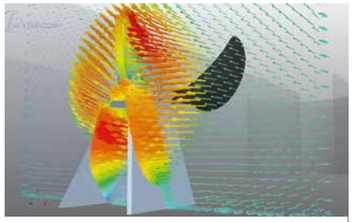
Plant Support

Assembly, maintenance, operation and service
The **CYBERFLOW®**-Accelerator is delivered in easy to assemble units. As a result, assembly is reduced to a few tasks, which any trained professional can perform without difficulty. **INVENT** offers trained personel to assist with all assembly, maintenance and service work worldwide.

Maintaining a **CYBERFLOW®**-Accelerator in a municipal wwtp in Germany

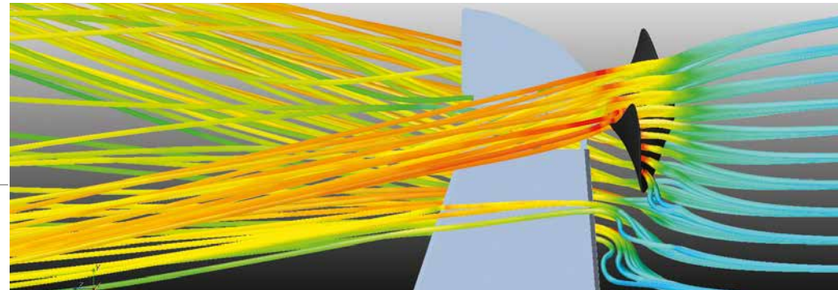
Layout and design
If the characteristic variables, such as generated velocity field and physical data of the activated sludge medium are known, the layout and design of horizontal flow generators is straightforward. All that is required is the application of an equilibrium consideration between the particle settling velocity and the buoyancy forces induced by the flow velocity in the basin. This produces a relationship between the minimum bottom velocity and particle size and density.

Using this simple approach, which **INVENT** successfully developed and introduced in the early 1990s, and has been using it ever since, it is possible to determine the number of flow accelerators, the rotational speed and the power consumption. A great advantage of this direct design is the fact that it is possible to achieve desired results without any virtual auxiliary factors such as thrust. This considerably increases the reliability of the layout and design.



Detailed CFD[1]-simulation of the flow close to the propeller

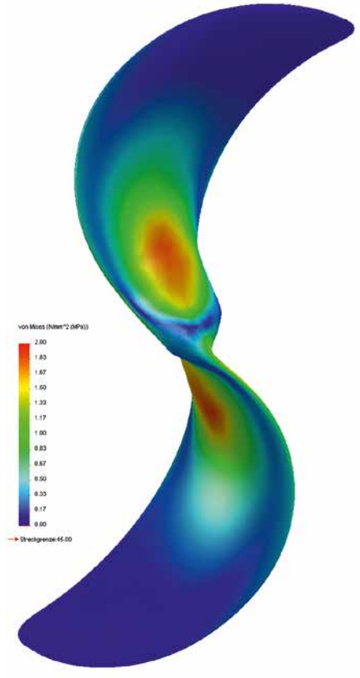
[1] CFD: Computational Fluid Dynamics



Streamlines of **CYBERFLOW®**-Accelerator

The **INVENT** Fluid Mechanical Laboratory

INVENT maintains a fully equipped fluid mechanical laboratory, pilot scale plants, and large scale test facilities at its headquarters in Erlangen in Germany. This enables **INVENT** to carry out all research and development work in-house with its own team of fluid mechanical specialists.



FEM[1] studies on propeller blade

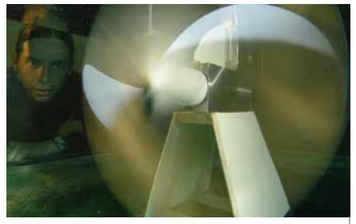
In the laboratory, the most modern flow measurement technologies and model plants are available. **INVENT** developments always follow basic fluid mechanical considerations, which are analytically formulated and brought into shape by state of the art 3D CAD systems. Modern rapid prototype machines are used for the production of models which are then examined in our laboratories to be able to validate the CFD[2] simulations which are executed in parallel to optimize the product for its task. With these processes, technologies and models we achieve excellent results within a very short development time.

For large scale tests **INVENT** maintains several test tanks and a test lagoon on its premises.

[1] FEM: Finite Element Method
[2] CFD: Computational Fluid Dynamics

INVENT large scale testing facility

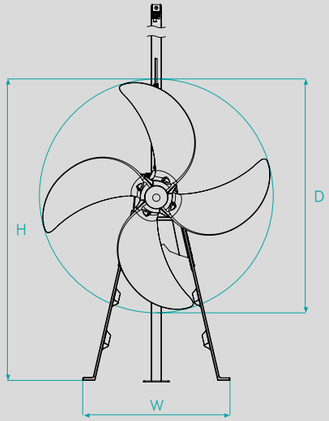
Rapid Prototyping in the **INVENT** laboratory

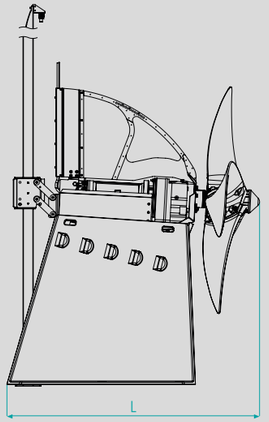


Flow measurements using a 3D-ultrasound-Dopplerprobe in local water channel

Technical Data

CYBERFLOW® TYPE	**GENERAL DATA**		**PROPELLER DATA**		**GEARBOX DATA**		**MOTOR DATA**	
	Length L Width W Height H	2.005 mm 1.142 mm 2.323 mm	Diameter D Rotational directions Material	1.800 mm cw/ccw[1] Polyurethan	Type No. of Steps Seal type	Helical gear 3 **INVENT** mechanical seal	Type No. of Poles Efficiency class	Three-Phase asynchronus Motor 4 IE3
CFM/1800-27-0.75	Total weight	997 kg	Rotational speed	27 upm		✓	Brake horsepower	0,75 kW
CFM/1800-30-1.1	Total weight	1.002 kg	Rotational speed	30 upm		✓	Brake horsepower	1,1 kW
CFM/1800-34-1.5	Total weight	1.002 kg	Rotational speed	34 upm		✓	Brake horsepower	1,5 kW
CFM/1800-39-2.2	Total weight	1.012 kg	Rotational speed	39 upm		✓	Brake horsepower	2,2 kW
CFM/1800-44-3.0	Total weight	1.017 kg	Rotational speed	44 upm		✓	Brake horsepower	3,0 kW
	Length L Width W Height H	2.005 mm 1.142 mm 2.673 mm	Diameter D Rotational directions Material	2.500 mm cw/ccw[1] FRP[2]	Type No. of Steps Seal type	Helical gear 3 **INVENT** mechanical seal	Type No. of Poles Efficiency class	Three-Phase asynchronus Motor 4 IE3
CFM/2500-24-1.1	Total weight	981 kg	Rotational speed	24 upm		✓	Brake horsepower	1,1 kW
CFM/2500-27-1.5	Total weight	981 kg	Rotational speed	27 upm		✓	Brake horsepower	1,5 kW
CFM/2500-30-2.2	Total weight	991 kg	Rotational speed	30 upm		✓	Brake horsepower	2,2 kW
CFM/2500-34-3.0	Total weight	996 kg	Rotational speed	34 upm		✓	Brake horsepower	3,0 kW
CFM/2500-39-4.0	Total weight	996 kg	Rotational speed	39 upm		✓	Brake horsepower	4,0 kW





Patent numbers

PCT/EP2008/001128
PCT/EP2008/001129
PCT/EP2013/055837
PCT/EP2013/055838
PCT/EP2013/055840
PCT/EP2013/055841
PCT/EP2020/061863

[1] cw: clockwise / ccw: counterclockwise
[2] FRP: Fiber Reinforced Plastic

Technical changes reserved

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Leaders in mixing and aeration

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