Vorsana™

RADIAL COUNTERFLOW SOLUTIONS

Vorsana Gas Scrubber

Continuous Carbon Capture and Flue Gas Scrubbing

The Vorsana™ Gas Scrubber is a version of the McCutchen Processor™ used for the continuous separation of gaseous components, including mechanical carbon capture and scrubbing of flue gas. This device centrifugally separates a gas mixture using a network of vortices created using high shear between axially fed counter-rotating disks. It makes use of the fact that polluting gases happen to be heavier, by molecular weight, than non-polluting gases.

For flue gas, such as from coal plants, the lighter gases, such as oxygen, nitrogen, and water vapor, are drawn in to the axis of the Scrubber and safely vented to the atmosphere, while heavier gases, including carbon dioxide, sulfur dioxide, and other pollutants such as fly ash, are spun out and captured in a shrouding tank. The stripping away of the nitrogen ballast and concentration of the carbon dioxide from a high-volume flue gas stream enables a more effective carbon capture and sequestration strategy. It also isolates concentrates the other heavier pollutant gases, such as NOx and SOx, ozone, and VOCs, which can be separated and treated by a further cascade of Scrubbers.

The Scrubber can also be used to purify and separate other gas mixtures, such as natural gas scrubbing, where the desired light fraction is methane and the unwanted heavy fractions include carbon dioxide, hydrogen sulfide, water, particulates, mercury, and mercaptans. The Scrubber can also be used for cement plants, sulfuric acid factories, medical waste incineration, industrial boilers, paper factories, steel mills, ships, and other industrial facilities.

In the Scrubber, the gaseous feed is continuous at the axis of rotation, and divergent heavy and light fraction streams emerge. Long residence time for mixing and separation is provided by a shrouding tank about the periphery of the disks, which collects heavy fractions and impedes centrifugal outward flow of the feed while the disks shear the feed between them. The shrouding tank also causes back pressure, driving a radially inward flow of light fractions through the vortex cores to an axial suction pump at the axis of rotation. Effective bulk porosity is created by the shear and the vortices in combination with back pressure, in what might be called a dynamic membrane, where only the lighter components can get through to the axis.

Each disk acts as a centrifugal pump, and against each disk is an adherent boundary layer being advected radially outward in centrifugal flow. Between the counter-rotating boundary layers is a shear layer where turbulent vortices form at many scales. The fluid dynamics classification is open von Karman swirling flow - open signifies that there is continuous mass flow in and out between the disks. All vortices, whatever their rotation, have a radial alignment and communicate through a fractal tree network of low pressure gradients feeding into an axial pump, which sucks the light fractions through the vortex cores radially inward to make an inward-flowing sink flow. So the turbulence is anisotropic – organized, not chaotic.

Each microscopic turbulent vortex acts as a centrifugal separator, such that heavy fractions spin out of the shear layer into the boundary layers while light fractions collect at the vortex cores. The G force for separation is high because the vortex radii are small and for each rotation of the impellers, the small radius vortices rotate many times, with the vortex-wall interaction acting to squeeze and accelerate the rotation of the vortices. The separation effects of the radial structure of vortices is organized, because suction from the axial pump, together with the vortex-wall interaction, forces a continuous sink flow to the axis of rotation and thereby sustains the coherence of the vortex structure and collects the separation effects of the organized turbulence.

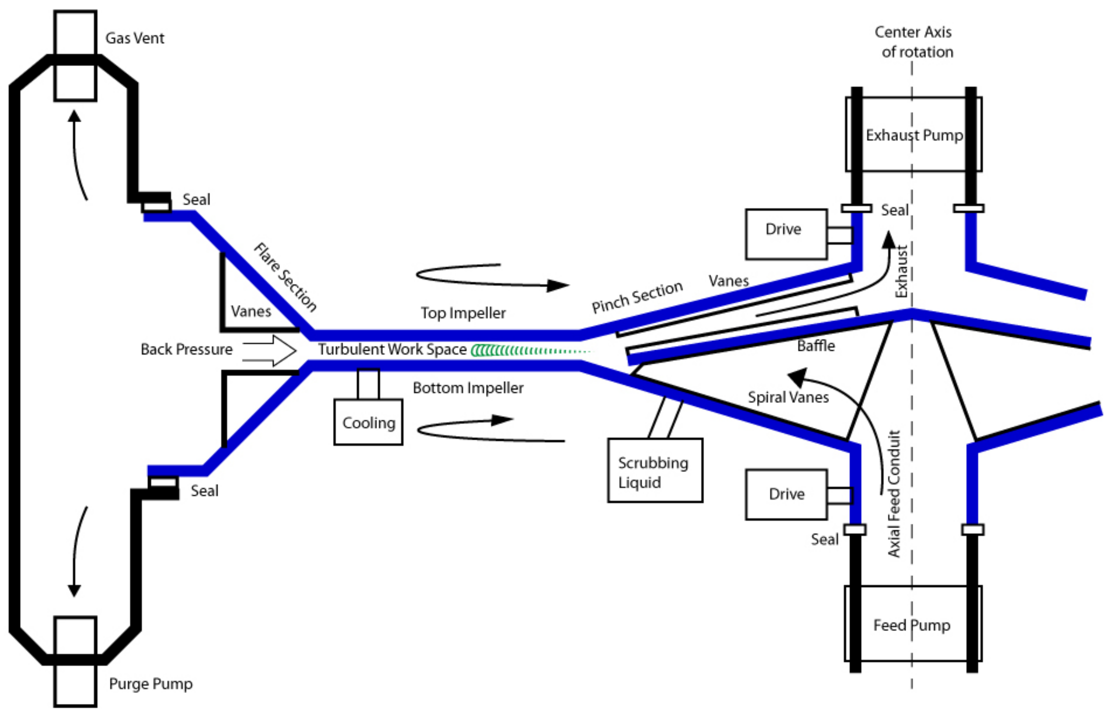
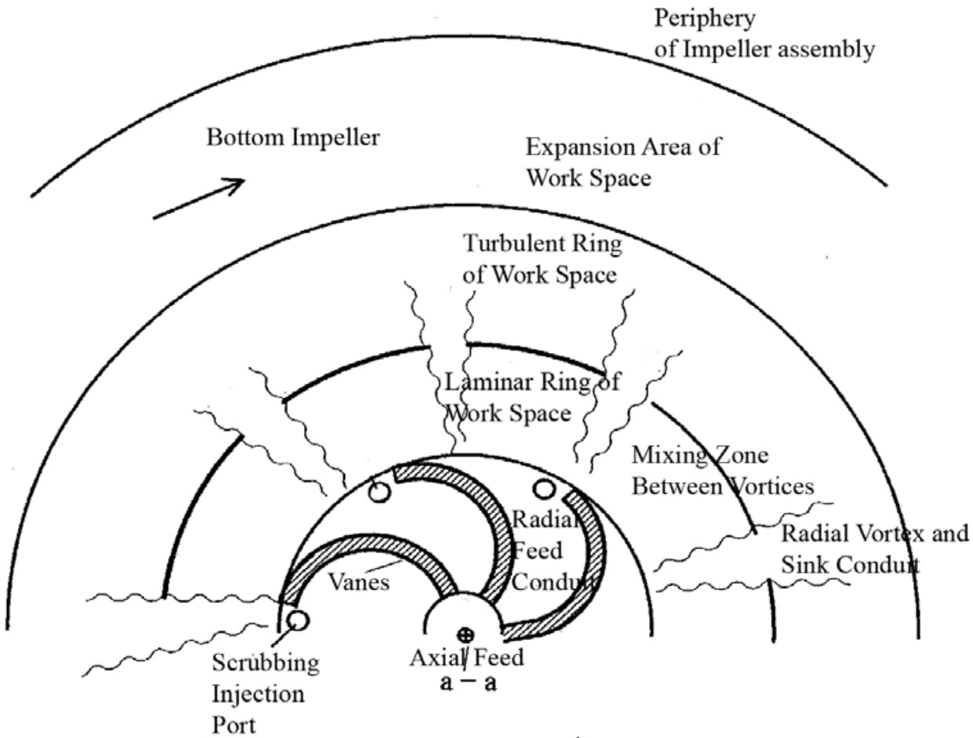


Figure 1 is a cross section of one half of the Vorsana Gas Scrubber showing counter-rotating centrifugal impellers for carbon capture and scrubbing. The axial feed emerges from underneath a baffle attached to the bottom impeller by spiral vanes, which push the feed outward into the workspace and toward the shrouding tank on the left side. The buildup of pressure in the tank causes back pressure, which slows the outward feed flow and forces the light fractions inward through the vortex cores, in combination with suction from the axial exhaust pump. The heavier fractions, meanwhile, are spun outward by their weight from the vortex cores, and concentrate in the shrouding tank. Gases such as carbon dioxide are extracted from the top of the tank, while liquids and solids such as scrubbing liquid or fly ash are extracted from the bottom.

Figure 2 shows a top view of half the work space shown in Fig. 1, with the top impeller and baffle invisible, showing an array of co-rotating radial vortices between the impellers, a turbulent ring, and mixing zones between the radial vortices and the impellers.



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