

Global warming and its consequential change in worldwide climate is one of the greatest challenges for contemporary society. Excessive emissions of greenhouse gases, especially carbon dioxide, are the major factor causing climate change, which is progressing at increasing rate. One of the proposed approaches toward limiting CO<sub>2</sub> emissions is carbon capture (CC) technology, the point of which is to remove carbon dioxide out of flue gases in order to prevent them from entering the Earth's atmosphere. The usual approach to CC is gas-liquid absorption.

The most widespread technology for absorption process is the use of column contactors. In a typical absorption column the liquid is pumped to the top of the apparatus, where it is sprayed onto a packing or trays, and the compressed air is introduced at the bottom. Gravitational downward flow of the liquid and upward flow of the gas caused by the pressure gradient cause the both phases to contact in counter-current, facilitating the mass transfer from the gas toward the liquid. Although simple in both construction and operation, the column contactors are however far from optimal for mass-transfer processes. The major bottleneck of column processes is the aforementioned gravitational flow of the liquid phase, which limits the column capacity, as increasing the liquid throughput in the column over the operational limit causes accumulation of the liquid and therefore flooding of the column.

Since gravitational acceleration cannot be changed, the only way to overcome that bottleneck is to use a different type of force causing the liquid flow. Such "artificial gravity" has been known and utilized for generations in the form of centrifuges. Centrifugal fields can create force orders of magnitude higher than gravity. This approach has been used in the concept of rotating packed bed (RPB) technology, in which the gas contacts the liquid in counter-current in an annular internal, rotating at a very high speed.

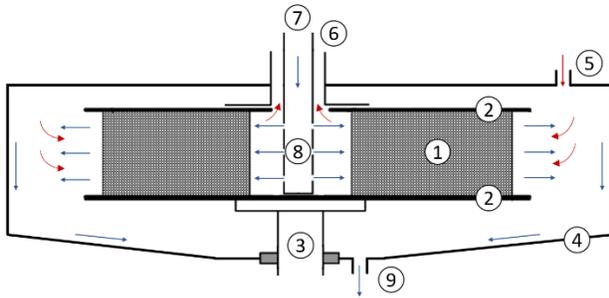


Figure on the left shows a schematic of a typical RPB unit, consisting of an internal (1) between two rotor plates (2) fixed to a rotating shaft (3) within a stationary casing (4), with specified gas inlet (5) and outlet (6), as well as liquid inlet (7), distributor (8) and outlet (9). The denser phase, i.e. liquid, is sprayed in the eye of the rotor from a liquid distributor such as a set of nozzles, and flows outwards through the internal, eventually colliding with the casing and flowing down to the liquid outlet.

The compressed gas phase is introduced perpendicularly into the casing and flows through the internal counter-currently to the liquid phase due to pressure gradient, and eventually escapes through the outlet in the eye of the rotor. This approach allows for a significant increase in absorption efficiency in a very compact geometry due to increased capacity in a very compact geometry and very intense micro-mixing.

Despite RPB being known for several decades, it is still a very young technology, not yet realized in its full potential. Most of the publicly available information regarding RPB operation is exploratory, and there is still much to learn and improve. Additionally, most of the in-depth analyses of RPB operation are concerned with specific zones of phase flows, and don't focus on the overall, holistic picture.

The significance of this project is three-fold. First of all, it will provide comprehensive three-dimensional computational fluid dynamics (CFD) simulation of the whole apparatus. Secondly, with a thorough visual study system, we will formulate a reliable mass transfer model in the cavity zone. Finally, the project will explore several hypotheses regarding the improvement of mass transfer in an RPB, i.e.: a) use of alternative primary liquid distributors in the eye of the rotor, b) use of a secondary liquid distributor outside the rotor for better mass transfer area beyond the internal, c) changes in the casing geometry for more efficient mass transfer and liquid residence time. Each step of the project will be validated by experimental data gathered from RPB units owned by both research institutes, with system comprising CO<sub>2</sub> as the absorbed gas and aqueous solutions of tertiary amine as the solvent. We believe that this project will significantly improve the RPB processes with new technological solutions, and will provide a universal tool for modeling and simulation of different types of RPBs, regardless of their technological application.