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MODELLING OF A HOMOGENEITY DISTURBANCE OF AIR/CO_2 MIXTURE BY MEANS OF ACOUSTIC WAVE

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Studies of the thermoacoustic wave (Remiorz et al. 2010 and Rulik et al. 2011) have shown that, in certain conditions, the wave can be used in the gas separation process. The aim of this study is to investigate the possibility of using the thermoacoustic wave in CO_2 separation processes. It should be treated as preliminary research for further, more detailed, analyses. In particular, the aim of this study is to start a numerical model of the separation process, and its parametric analyses. The performer tentative calculations are original and are not based on the other calculations presented in literature.

The numerical model of carbon dioxide separation was developed with the use of a Computational Fluid Dynamics commercial code Ansys-CFX. The scheme of the model is presented in Fig. 1. Both for the lateral and the top as well as bottom areas, boundary conditions were assumed as symmetry. Therefore, the model does not take account of the impact of the walls and the friction related to it on the behaviour of the acoustic wave.

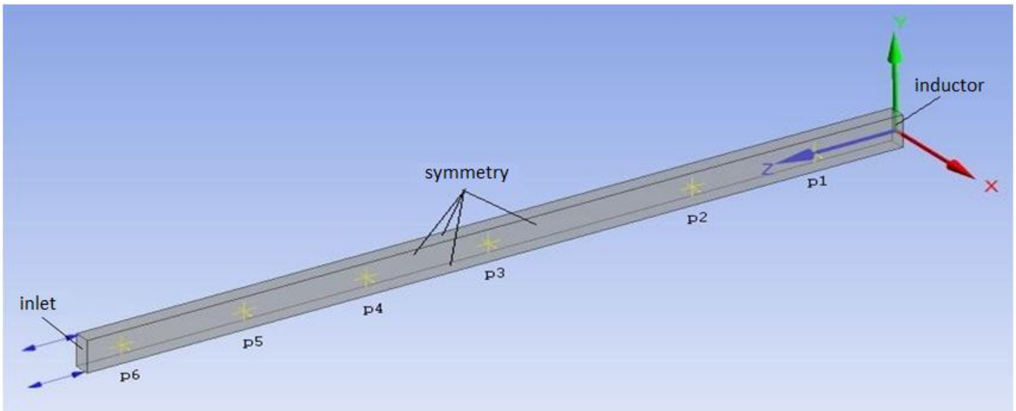

Fig. 1 View of the tube adopted for the calculations. Rectangular tube with dimensions: 20x50x1000mm.

The numerical analysis shows that if in a rectangular tube filled with a mixture of air and CO_2 an acoustic wave with an appropriately selected frequency is generated, due to the effect of the wave a slow-changing process of the separation of the gases occurs. The process has a lasting nature with respect to the running acoustic wave, i.e. subsequent wave cycles do not disturb the process, but they intensify it. This is shown in Fig. 2. At instant t=0s the whole tube is filled with a homogenous mixture of air and CO_2. After time t=0.6s, places appear with an increased concentration of CO_2, and after time t=1.2s the lasting inhomogeneity is already clearly visible.

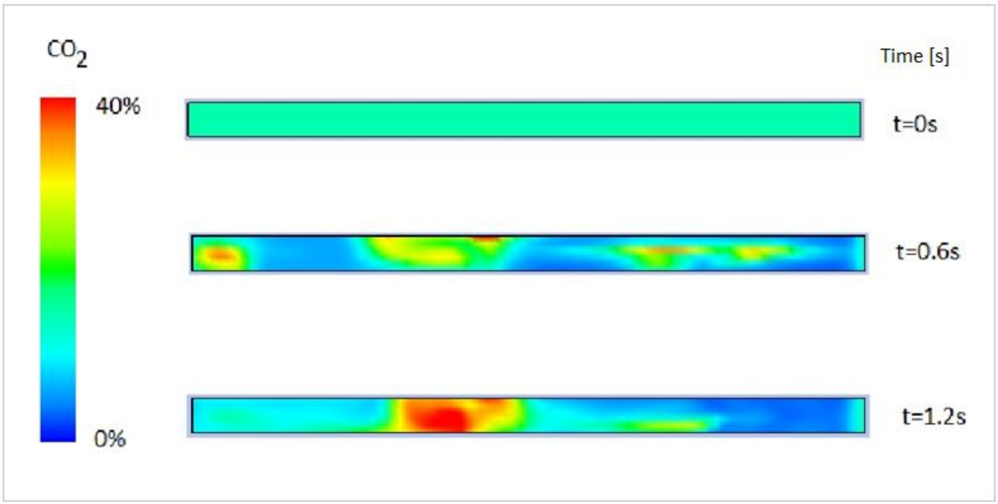

Fig. 2. CO_2 separation. Image of the modelled tube at subsequent time instances: t-0s, t=0.6s, t=1.2s. The red colour denotes places of CO_2 concentration.

In the numerical model the separation process did occur and it is intense. However, the obtained result has to be verified by laboratory tests.

The homogeneity disturbance had a lasting character with respect to the subsequent oscillation cycles in the tube. The observed phenomenon was not qualitatively affected by parameters such as the numerical mesh size, the adopted time step or the pressure in the tube. The separation could be observed regardless of the values of adopted parameters, within the set limits, of course. At the same time, the values adopted for the modelling had an impact on the level and time of separation, which was the case for space and time discretisation in particular. The presented results need experimental verification, which is the subject of further studies.

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