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Pressure drop in pulsed extraction columns with internals of discs and doughnuts

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ABSTRACT

A study on the pressure drop in pulsed extraction columns with internals of immobile discs and rings, usually called Discs and Doughnuts Columns (DDC) is carried out. The local pressure at a desired level of the column is obtained by resolving of turbulent flow model based on Reynolds equations coupled with k–ε model of turbulence. Consequently, the pressure drop for a column stage or for a unit of column length is determined. The results are used for development of correlations for determination of pressure drop as a function of plate free area, interplate distance and pulsation parameters – amplitude and frequency. Good correspondence to experimental data is observed. The developed quantitative relations are useful for non-experimental numerical optimization of stage geometry in view of lesser energy consumption.

Keywords: Pressure drop; Pulsed flow; Discs and doughnuts column

1. Introduction

Pulsed extraction columns with internals of discs and rings (usually called Discs and Doughnuts Columns – DDC) have revealed themselves as promising devices for extraction processes in liquid–liquid media. They are used in different area, mainly spent nuclear fuel recycling (Movsowitz et al., 2001; Cocaud et al., 2004), hydrometallurgy (Buchalter et al., 2002; Kleinberger, 2001; Mason et al., 2003), non-metal extraction (Martin, 1987; Prat et al., 2006; Van Delden et al., 2006). They have demonstrated good overall performance characteristics and recently are subject of intensive research (Bi et al., 2007; Bujalski et al., 2005; Jahya et al., 2005, 2009; Torab-Mostaedi et al., 2011; Wang et al., 2005, 2006; Wu et al., 2006).

1.1. *Apparatus description*

A principal scheme of a DDC apparatus is shown in Fig. 1.

Alternated internals of immobile discs and rings (doughnuts) are mounted in a vertical cylindrical apparatus body. They are placed horizontally and centered with respect to the column axis. A stage is formed by two rings and a disc between them. The outer edge of the rings is extended to the column wall. Two passages for the flow are formed – a central passage through the ring aperture and a peripheral passage through the annular aperture between the disc edge and column wall. A pulsing device is coupled to the column body, which induces reciprocal up and down movement of the fluids. The pulsation is characterized by its amplitude A and frequency f.

The column contains a number of equivalent stages. The geometry parameters of a stage are shown in Fig. 2.

D_c is the column diameter and the outer diameter of the ring; D_a is the inner diameter of the ring aperture; D_d is the disc diameter; H is the distance between two consecutive plates. The disc diameter is larger than the ring aperture in order to hamper a direct flow in axial direction.

Pressure drop is a basic parameter, which supplies information about the energy consumption associated to apparatus type and operational conditions, and is an important design parameter. Usually it is obtained experimentally by tests on pilot columns. The purpose of this study is to derive a correlation for numerical determination of pressure drop as a function of stage geometry and pulsation intensity, based on hydrodynamic description of a pulsed flow in DDC.

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