EXPERIMENTAL DETERMINATION OF THE SPREADING COEFFICIENT*

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The spreading coefficient has been determined for three types of porous and one type of non-porous packings. On basis of these experiments the form, size and type of elements of the porous packing is not greatly affecting the value of the spreading coefficient. The found numerical value of the spreading coefficient for the porous packing has been verified by comparison of the theoretical distribution curve for a hypothetical ring source in the region of unlimited packing solved here with the experimental data..

In the preceding study[1] the method has been described for determination of the spreading coefficient in a randomly packed bed of porous catalyst. Here the spreading coefficient is determined for three types of porous and one type of nonporous packings. The found value of the spreading coefficient D is then used for calculation of liquid distribuiton for the ring source in an unlimited packing *i.e.* in the flow region where the liquid distribution is not yet affected by the wall.

THEORETICAL

Theoretical relations used for determination of the spreading coefficient are given in the paper[1]. In calculations of the distribution function for the ring source and unlimited packing the equation by Cihla and Schmidt[2] has been solved for an axially symmetric cylindrical system

$$\frac{\partial f(r, z)}{\partial z} = D\left[\frac{\partial^2 f(r, z)}{\partial r^2} + \frac{1}{r}\frac{\partial f(r, z)}{\partial r}\right] \tag{1}$$

with initial and boundary conditions

$$f(r, z)_{r=a} = 0\,, \tag{1a}$$

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$$f(r, z)_{z=0} = K\ \delta(r - r_1)\,, \tag{1b}$$

$$f(r, z)_{r\to\infty} = 0\,, \tag{1c}$$

$$\left(\frac{\partial f(r, z)}{\partial r}\right)_{r=0} = 0\,. \tag{1d}$$

By the usual method of separation of variables and by application of boundary and initial conditions (*1a – d*) the particular integral is obtained

$$f(r, z) = \sum_{n=1}^{\infty} A_n\, J_0(Rq_n) \exp\left(-\, q_n^2 T\right), \tag{2}$$

where

$$A_n = \frac{2}{a^2\, J_1^2(q_n)} \int_0^a K\, \delta(r - r_1)\, J_0(Rq_n)\, dr\,, \tag{3}$$

$$K = Q/(2\pi r_1)\,. \tag{4}$$

By application of both equations (*3*) and (*4*) and under the assumption of the hypothetical ring source (the ring area is negligible in comparison with the reactor area) relation describing the liquid distribution can be obtained

$$\frac{f(r, z)}{f_0} = \sum_{n=1}^{\infty} \frac{J_0(R_1 q_n)\, J_0(Rq_n)}{J_1^2(q_n)} \exp\left(-q_n^2 T\right) \tag{5}$$

where q_n are the roots of equation $J_0(q_n) = 0$.

TABLE I

Parameters of Packings Used

Symbol	Type	Surface area $m^2\,g^{-1}$	Porosity %	Size mm	Equivalent diameter[a] mm	d_k/d_p	Free volume
A	Nickel on Kieselguhr, tablets	195	61	9·0 × 7·2	8·8	28·4	0·37
B	Nickel on Alumina, tablets	152		4·7 × 4·5	5·3	47·2	0·34
C	Kieselguhr carrier, pellets	2·4	65	5·8 × 7·0	7·0	35·7	0·36
D	Glass spheres, litographical	—	—	9·8	—	25·5	0·36

[a] Equivalent diameter calculated according to Hobler[3] ($d_{eq} = 1{\cdot}241\ (V_p)^{1/3}$.

EXPERIMENTAL

The distribution function has been determined experimentally in an apparatus described earlier[1]. The ring source had a radius of a circle 0·04 m in which were situated holes for the liquid inlet. In conformity with the required initial wetting density three sources of liquid were used differing in the number and size of the inlet holes.

The same experimental procedure has been used as in the study[1]. Water was the wetting liquid, the used types of packings are given in Table I. For the given initial wetting density and the bed height in total five measurements were made in the steady state. Scattering of the found liquid flows in individual sections from which samples were withdrawn was controlled by the Dixon test of extreme deviations[4] and the unsatisfactory values were eliminated prior to further evaluation.

RESULTS

Values of the spreading coefficients determined by the modified Tour-Lerman's relation according to the paper[1] are given for all types of the studied packing in Table II. It results that the average values in the interval of the initially chosen wetting densities do not principally differ for individual types of porous packings. Thus it can be assumed that the geometry of the element and the type of the porous packing is not much affecting the value of the spreading coefficient. With the non-porous packing (glass spheres) is the found value of the coefficient D approximately by 20% lower. It is numerically identical with the spreading coefficient found by Staněk[5] for this type of packing.

General validity of the numerical value of the spreading coefficient of a porous packing has been verified by comparing the theoretical distribution curve as calculated from Eq. (5) for the ring source with the experimental points. The value of the spreading coefficient substituted into this equation has been the average of the found

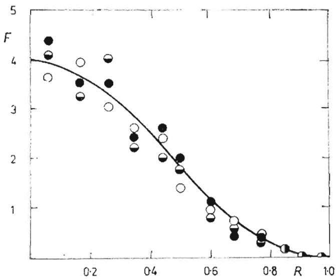

FIG. 1

Comparison of Theoretical Distribution Curve for Ring Source, Calculated According to Eq. (5), with Experimental Points

$z = 0·2$ m, dimensionless wetting density $F = f/f_0$; Packings: ○ A, ◒ B, ● C, ◑ common value.

TABLE II

Spreading Coefficients $D/m/$for Various Packings

f_0	Type of packing			
$m^3\ m^{-2}\ h^{-1}$	A	B	C	D
1	0·0019	0·0016	0·0020	0·0013
3	0·0020	0·0016	0·0018	0·0015
7	0·0022	0·0020	0·0020	0·0014
11	0·0020	0·0016	0·0019	0·0014
15	0·0018	0·0019	0·0015	0·0015
Mean	*0·0020*	*0·0018*	*0·0018*	*0·0014*

values for porous packings A, B and C. The distribution function for the height of the porous packing, when the assumption of an unlimited packing holds, is given in Fig. 1. It is obvious from this figure that the experimental points fit the calculated curve relatively well. As the same results have been obtained by evaluation of more than 5000 experimental data, it can be said that determination of the spreading coefficient D by use of the modified Tour–Lerman's relation is appropriate. Validity of the given solution for liquid distribution in the region of unlimited packing at wetting by a ring source has been proved as well.

List of Symbols, see paper[1].

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