LAMINAR DISPERSION IN HELICALLY COILED TUBES

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CERTIFICATE

This is to certify that the thesis entitled,'LAMINAR DISPERSION IN HELICALLY COILED TUBES' being submitted by Mr. Alok Kumar Saxena to the Indian Institute of Technology, Delhi for the award of the degree of 'Doctor of Philosophy' is a record of the bonafied research work carried out by him. Mr. Alok Kumar Saxena worked under my guidence for the submission of this thesis which to my knowledge has reached to requisite standard.

The thesis or any part thereof has not been submitted to any other university or institution for the award of any degree or diploma.

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ABSTRACT

Complex flow behaviour of fluids, flowing through coiled tubes, has been drawing the attention of engineers for the last few decades. The reason for this is the mixing in cross-sectional plane causing an increase in heat transfer coefficients hence making it a better heat transfer equipment and causing a reduction in axial dispersion which improves the performance of flow reactors as compared to straight tubes.

The magnitude of axial dispersion belongs to basic problems in designing flow reactors for chemical reactions. This aspect has been theoretically as well as experimentally investigated[1-6,48-53] for Newtonian laminar flow in coiled tubes of circular cross-section. Despite of considerable amount of literature on axial dispersion in coiled tubes, there are various helical flow situations which are yet to be investigated. In the present study axial dispersion in some of such flow situations has been reported.

Experimental results on laminar dispersion in non-Newtonian helical flow reveal a reduced axial dispersion over that in straight tubes and dispersion data have been successfully correlated with N_{Re}, N_{sc} and λ.

RTDs for diffusion free laminar flow of non-Newtonian (power law) fluids through coiled tubes, have been numerically

computed. Narrowing of RTD with increase in pseudoplasticity of the flowing fluid has been observed and a good agreement between theoretical and experimental results is found.

Effects of torsion and cross-sectional ellipticity on diffusion free RTD in helical coils are investigated by numerically computing RTDs in such cases. Nauman's[3] model for diffusion free RTD was fitted to the numerically computed RTDs and model parameters are correlated with torosity (T) and cross-sectional ellipticity (α).

A new parameter 'orientation of cross-sectional plane with the direction of centrifugal-force' in case of helical flow through tubes of non-circular cross-section has been identified and its effect on RTD has been investigated by carrying out step response experiments in coiled tubes of square cross-section. It is found that coiled tubes of square cross-section results in a higher axial dispersion as compared to circular cross-section tubes. An appropriate condition under which Taylor's dispersion model holds for helical flow in tubes of square cross-section is also provided.

A critical review of the theoretical and experimental results on axial dispersion in coiled tubes reveal that though coiling of tubes results in a substantial amount of reduction in axial dispersion, it is attainable only at very high values of Dean number. It, in turn, results in a higher initial and operating costs of flow reactors. To over come such problems a new coiled configuration is introduced in the present study. Superiority of the proposed device has been established on the basis of its performance substantially closer to ideal plug flow, low initial and operating costs, compactness and ease of fabrication.

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