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ABSTRACT BOOK

Posters

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TOP-COVERED UNBAFFLED STIRRED TANKS: EXPERIMENTS AND NUMERICAL SIMULATIONS

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Abstract:
Stirred tanks are widely employed in a large number of process industries. A correct design and operation of these systems is often crucial for the economical profitability of the process. In recent years many research efforts have been devoted to the seldom employed unbaffled stirred vessels. Although unbaffled tanks may exhibit poorer mixing rates than baffled vessels, they may show significant advantages in a number of applications: crystallization, bioremediation, biotechnology, ore industry, etc. Therefore, a better knowledge of the features of the flow field that characterizes these apparatuses is important for assessing the applications for which advantageous overcome drawbacks.
In this work Computational Fluid Dynamics was employed to predict the flow field of an unbaffled stirred tank from steady to turbulent conditions. The tank was stirred by a standard six-bladed Rushton turbine and provided with a top-cover to prevent the central air vortex formation. A corresponding baffled tank was also simulated in order to compare the flow fields of the two systems.
Both transient and steady state simulations were carried out. For the case of the unbaffled vessel a reference frame moving with the impeller was adopted. The well-known Multiple Reference Frame was employed for the baffled tank to account for the impeller-to-baffle relative rotation.
A grid dependence analysis was performed both in terms of local and global quantities of the flow field. A structured grid of about 4 million computational cells was found to be sufficient to provide results practically unaffected by any grid dependence.
The transient simulations exhibited velocity profiles perfectly steady up to the a Reynolds number equal to 150 thus implying that the flow field is still laminar, despite the significant departure of the relevant power number (Np) values from the well-known viscous inverse proportionality law. In particular the flow fields was creepy up to Re=3.5. The transient and the steady state simulations were found to provide identical results. Different turbulent models were employed to simulate the unbaffled system under turbulent conditions: in particular, for the first time the k-w SST model was employed to predict local and global quantities in a top-covered unbaffled stirred tank. The Np values predicted were found to be in a very good agreement with purposely collected experimental data. The flow fields exhibited by the two tanks were very similar under steady conditions thus confirming both our experiments and those by Rushton (1950).

Reference 1: Rushton, J.H., Costich, E.W., Everett, H.J., Power characteristics of mixing impellers, part II. Chemical Engineering Process, 46 (9) (1950) 467-476.
Reference 2 :
Reference 3 :
Reference 4 :

Highlight 1: CFD was employed to predict the flow field of unbaffled tanks from steady to turbulence
Highlight 2: The transient and the steady state simulations were found to provide identical results
Highlight 3: The Np values predicted were found to be in very good agreement with experimental data