Experimental obtention of power consumption for helical ribbon impellers using highly viscous liquids

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Abstract

Historically, most of the correlations for power consumption, heat transfer and impeller flow in mixing processes have an empirical nature. It was only recently that the behavior prediction of stirred vessels has been given more emphasis with computational fluid dynamics (CFD). Even so, the simulation of many agitated systems cannot be obtained with CFD, such as kLa obtention in bioreactors, so that experimental results in agitated tanks are still of great importance for the study of stirred vessels. Improvements in computing and other areas have made the experimental methods increasingly sophisticated, but experimental results for stirred tanks remain restricted to older studies, such as Nagata *(Mixing – Principles and Applications, Kodansha Scientific Books, 1975)* and Oldshue's *(Fluid Mixing Technology, Chemical Engineering – McGraw-Hill, 1st edition, 1983)*. Publications with new results are scarce because most impeller manufacturers have often no interest in spreading their experimental data. This paper presents more recent data than those available in the literature, with regard to power consumption in laminar flow agitators.

Nowadays, close-clearance impellers, like anchor type and helical ribbon impellers, have been widely used in many industrial applications that involve highly viscous fluids, so that there are much interest in obtaining experimental data for these impellers. Another objective of this work is to share experiences with CFD researchers that have experimental results in laminar flow agitation, since very few results are published for this range of Reynolds number.

Tests were performed with helical ribbon, flat blade and pitched blade impellers, using corn syrup diluted in water as mixing fluid. From these tests, it was possible to make log-log plots of power number x Reynolds number, in order to get the power curve of the impellers tested in laminar flow.

The obtained graphs show a linear profile in low Reynolds number (laminar flow zone), what is consistent with expected results. One of these plots can be seen down below:

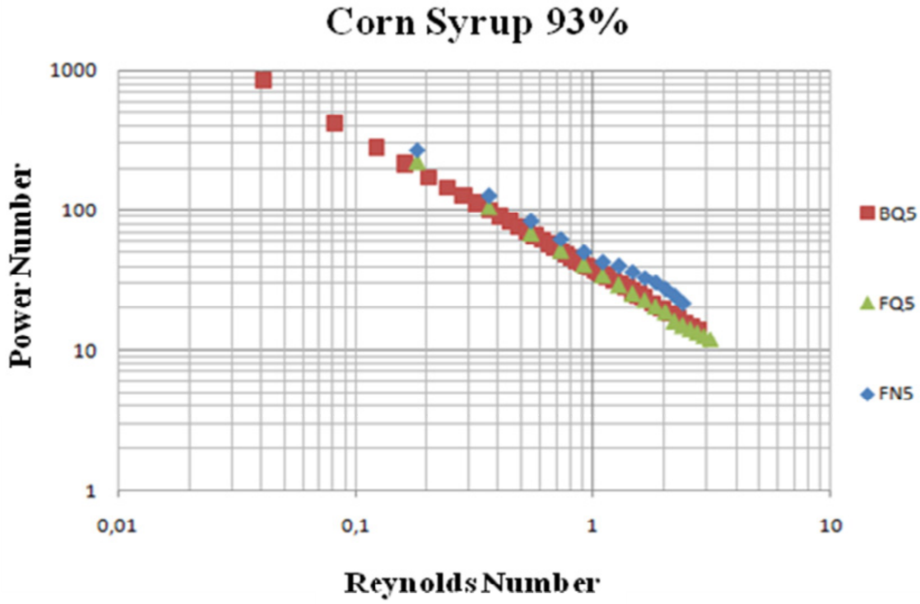

Figure 1 - Power Number x Reynolds Number plot for three different impellers, using 93% corn syrup - 7% water

There are many published papers about experiments in agitation pilot plants with helical ribbon impellers, but most of them are from years or decades ago, so that one of the objectives of this study is to provide more recent data on this subject. Bourne et al., in 1969 *(Trans. Instn. Chem. Engrs., v.47 p.263-270)*; Hall and coworkers, in 1970 *(Trans. Instn. Chem. Engrs., v.48 p.201-208)*; Carreau et al., in 1993 *(AIChE Journal, v.39 n.9 p.1421-1430)*; and Wang and coworkers, in 1999 *(Chemical Engineering Science, v.55 p.2339-2342)*, conducted studies on power consumption of helical ribbon impellers in experimental stirred vessels, obtaining and making available power number x Reynolds number log-log graphs. These plots can be compared with those obtained in this work, taking into account the limitations due to differences in geometry of impellers used.

Hall et al., in 1970 *(Trans. Instn. Chem. Engrs., v.48 p.201-208*), also made a survey of results obtained in previous articles by other researchers. These data can be useful to be compared with the results acquired in this work. (Supported by FAPESP)

keywords: mixing, helical ribbon impeller, viscous fluids, agitation pilot plant, power number, Reynolds number, stirred vessels, close-clearance impeller, laminar flow

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