COMMUNICATIONS TO THE EDITOR

Agitation of Non-Newtonian Fluids

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This paper is a comment on several statements concerning the prior art in the paper, "Power Requirements and Blend Times in the Agitation of Pseudoplastic Fluids," by E. S. Godleski and J. C. Smith, which appeared on page 617 of the November, 1962, issue of the *A.I.Ch.E. Journal.*

The authors' introduction states that no prior art paper has considered power requirements in non-Newtonian fluids which deviate from the power-law (that is, fluids which possess a nonconstant flow behavior index), and two of their three conclusions center on their stated extension of prior-art correlations to include such materials. However, the fluids used by Metzner, Feehs, Lopez-Ramos, Otto, and Tuthill (reference *4* of the Godleski-Smith paper) were frequently not power law materials. The legends of Figures 2 and 6 show, for example, the ranges covered in these instances. Similar data for the other figures are available in the published theses to which reference is given in the paper by Metzner, et al. When it is noted that changes in flow behavior index become irrelevant in any event as the index approaches unity (the indirect method used to estimate mean shear rates in a mixer in both of these papers breaks down as the fluid approaches Newtonian behavior) and the actual changes given by Godleski and Smith are compared to those in the earlier work by Metzner, et al., one sees that the deviation from power law behavior was about the same in both instances although a greater variety of fluids was used in the earlier work. Thus, while this portion of the Godleski—Smith paper presents clearly useful results, these results appear to be of the nature of an independent verification of other work published earlier.

In the second portion of their paper, a discussion of mixing or blending times, comparisons are made to the earlier paper of Norwood and Metzner (reference *7* of the Godleski-Smith paper). Godleski and Smith state that the earlier work on Newtonian fluids predicted mixing or blending times which were ten to fifty times smaller than their measured values in non-Newtonian systems. While some difference might well be expected, these appear to be surprisingly large. Inspection of their complete data, kindly supplied by Professor Smith during our correspondence, do reveal appreciable differences but these are greatest near those conditions under which Norwood and Metzner suggest the occurrence of a sharp discontinuity in the non-Newtonian case. For example, at a T/D ratio of approximately 3.0, Norwood and Metzner suggest that the non-Newtonian mixing times would approach infinity below a Reynolds number of about 270. This is just the behavior experienced by Godleski and Smith except that the critical Reynolds numbers range from approximately 500 to 1,000 instead of the value previously estimated. Unfortunately, no data appear to be available in either study to assess the differences or similarities between the mixing rates in Newtonian and non-Newtonian systems under conditions well removed from the transition point, below which the non-Newtonian mixing rates approach zero because of incomplete fluid turnover in the vessel.

The author does not wish to suggest strongly that the Norwood-Metzner correlation for mixing rates in Newtonian fluids be applied to non-Newtonians. As in the original paper by Metzner, et al. this can only be suggested as a rough and temporary expedient until some actual mixing-rate data are available for non-Newtonian systems. It is concluded, however, that under conditions of good mixing the differences may not be as large as in the transition region in which the Godleski-Smith data were obtained.

Reradiation to Furnace Tubes. Effect of Tube-to-Wall Clearance

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One of the most common radiant heat transfer problems in engineering calculations is the design of tubular industrial furnaces such as oil heaters, cracking furnaces, and steam boilers. Heat sinks in these furnaces are in the form of rows of tubes supported along the walls. A high temperature body of gas, either with or without suspended solid particles, constitutes the heat source.

Radiant fluxes to the sinks may be conceived of as being made up of two parts: direct radiation from the source and reradiation from the wall behind the tube rows.

The geometry of this radiating system is conveniently handled through conversion to a radiation system between two parallel planes. Hottel (*1*) evaluated factors of comparison between the real system and an idealized two-parallel-plane system. This factor of comparison, also called *effectiveness factor of tube rows* (*2*), was presented as a function of the ratio of tube-center spacing to tube diameter. Along with other cases, curves were given for a single row of tubes and double rows of staggered tubes. The results are widely used and contained in textbooks on heat transfer (*2, 3*).