Radiation Efficiency of Elliptical Reflector-Photoreactors

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Hancil et al. (1972) recently published an analysis of the efficiency with which light energy is transmitted from a source to the surface of a photoreactor. The elliptical reflector-photoreactor was one of the configurations analyzed in their work. The authors compared theoretical and experimental efficiencies for several elliptical reflector-photoreactors and found that efficiencies were very low for their particular reactors and that the theoretical efficiency predicted was consistently larger than the corresponding experimental efficiency. The authors discussed some reasons why the second finding might be the case. Among these reasons were the inexact location of lamp and reactor along the foci of the reflector and nonuniform lamp energy distribution.

It is the purpose of this note to present some radiation efficiency data for elliptical reflector-photoreactors taken in our laboratory and compare them to the theoretical efficiencies predicted from the work of Hancil et al. It is important to note that the data reported here were taken under conditions where much larger efficiencies would be expected than in the cases reported by Hancil et al. The comparison of their theoretical results to experimental data can thus be extended to regions not covered in their original work.

The elliptical reflector-photoreactor apparatus and the chemical actinometer used in determining the absorbed radiation have been discussed previously by Ragonese and Williams (1971). An important modification of this apparatus was made by Zolner (1971) who also reported data which is presented in this note.

The efficiency data is given in Table 1 and compared with the theoretical efficiencies predicted from the work of Hancil et al. The light source in all cases was the General Electric G36T6, 36 watt, low pressure, mercury germicidal lamp. The light output and its spectral distribution were obtained from the manufacturer.

These data indicate that the theoretical efficiencies are consistently larger than the corresponding experimental efficiencies as was the case for Hancil et al. Measurements 5 and 6 by Zolner are particularly interesting since the experimental efficiencies differ markedly due to the use of different reactor tube diameters although the theory predicts that the efficiencies should be the same. In these experiments the reactor and lamp were positioned exactly at the reflector foci by the use of plexiglass covers at each end of the reflector. These covers were carefully drilled at the foci position to allow exact positioning of reactor and lamp. Furthermore, light baffles were positioned inside the reflector in order to utilize only the central two-thirds of the lamp where one would expect to find a uniform lamp energy distribution.

It appears that the reasons for this discrepancy are likely to be the assumption of a line source and sink to represent the lamp and reactor and the assumption of unity reflectance at the reflector surface. It is suggested that a refined theory of radiation efficiency would have to account for the finite size of lamp and reactor as well as possible reflectance at the reactor surface.

LITERATURE CITED

Hancil, V., V. Schorr, and J. M. Smith, "Radiation Efficiency of Photoreactors," *AIChE J.*, **18**, 43 (1972).

Ragonese, F. P., and J. A. Williams, "Application of Empirical Rate Expressions and Conservation Equations to Photoreactor Design." *ibid.*, **17**, 1352 (1971).

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TABLE 1. RADIATION EFFICIENCY OF ELLIPTICAL REFLECTOR PHOTOREACTORS

Experiment no.	Reflector reactor geometry $m \times 10^2$: Lamp length	Reactor length	Major axis of elliptical reflector	Reactor diam.	Radiation energy (keinsteins/s) $\times 10^9$: Lamp output	Absorbed energy	Efficiencies %: Exp'l.	Calc.*
1	91.44	15	25.4	1.3	33.07	1.533	4.63	14.30
2	91.44	50	25.4	1.3	33.07	5.333	16.13	46.33
3	91.44	40	25.4	1.3	33.07	4.183	12.65	37.53
4	91.44	40	25.4	2.0	33.07	4.966	15.02	37.53
5	61.44	40.64	25.4	1.5	22.22	4.256	19.15	48.08
6	61.44	40.64	25.4	2.5	22.22	6.187	27.84	48.08
7	61.44	61.44	25.4	2.5	22.22	8.455	38.05	66.85

* Equations (27) and (28), Hancil et al. (1972).