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RADIANT-INTERCHANGE CONFIGURATION FACTORS FOR FINITE RIGHT CIRCULAR CYLINDER TO RECTANGULAR PLANES

J. A. WIEBELT* and S. Y. RUO†
Oklahoma State University

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Abstract—The solution of many practical thermal radiation problems require knowledge of the configuration factor for right circular cylinders to rectangular planes. Results from lengthy numerical calculations are presented in this paper in the form of graphs. These values were obtained by use of the contour integration method using a digital computer to carry out the numerical work. Accuracy of the final presented values are presumed to be within ±5 per cent of the correct value.

INTRODUCTION

THE solution of practical thermal radiation problems frequently depends on the availability of interchange configuration factors. Hamilton and Morgan [1] have presented the interchange configuration factors for many practical geometries One important group of geometries which were not presented are the cases of finite length right circular cylinders radiating to rectangular planes. The purpose of this paper is to present the results of lengthy numerical integrations required to obtain these configuration factors.

METHOD

Since the analysis for the configuration factors of interest is not feasible by ordinary integration techniques, the factors were determined by the method of contour integration [2, 3]. Basically the cylindrical surface was divided into sub-areas, the number varying from twenty-five to 100, and the local configuration factor from each sub-area to the plane evaluated. The local configuration factors, as a resulting system, were summed over the surface. This procedure is somewhat analogous to ordinary integration, but, of course, is not as accurate. Since the number of calculations involved was too large to handle by desk calculations, an IBM-650 was used to obtain the final values.

In the evaluation of local configuration factors by the contour integration method described in Moon's [2] text, the values of vectors must be obtained from trignometric functions of angles. These vector quantities depend on the local horizon for the case described in this paper [3]. Since the local horizon must be obtained by the solution of a set of linear algebraic equations, the angular values will depend on the accuracy of the linear system solution. Unfortunately, these values are affected by the truncation or round off procedures used by electronic computers. When a large number of such calculations are required the errors, although very small for an individual calculation, carry over and in certain cases will cause significant errors. The effect of these errors was noticed in the results in several cases. When the number of sub-areas used in the evaluation is increased, the results should approach the answers obtained by analytical evaluation. In order to check this, a geometry involving a cylinder and plane with L/D ratio very large was examined. This case should

* Member ASME, ARS, is at the present an Associate Professor of the School of Mechanical Engineering at Oklahoma State University.

† At the present a Graduate Assistant in the School of Mechanical Engineering at Oklahoma State University, Stillwater, Oklahoma.

approach the result presented by Hamilton and Morgan for the infinitely long cylinder to plane. In several cases it was found that the results were less accurate when a large number of sub-areas were used. An attempt was made to determine the number of sub-areas which should be used to obtain the most accurate answer, but this did not result in a consistent system. For this reason certain personal judgment was exercised in obtaining the final results and it is felt that the individual configuration factor may have an error as large as ±5 per cent.

DESCRIPTION OF THE RESULTS

In order to obtain the most usable form, the results are described in terms of the diameter of the cylinder. The various ratios used in Figs. 2, 3, 4, 5, 6 and 7 are defined in Fig. 1. In every case, one edge of the rectangle is a line parallel to the axis of the cylinder and the rectangular plane is located such that it is normal to the plane formed by this edge of the rectangle and the axis of the cylinder. This geometry permits the evaluation of several other related geometries by the use of flux algebra as explained in [1].

The dashed lines plotted in Figs. 2, 3, 4, 5, 6 and 7 are extrapolations to the infinite cylinder values as given in [2].

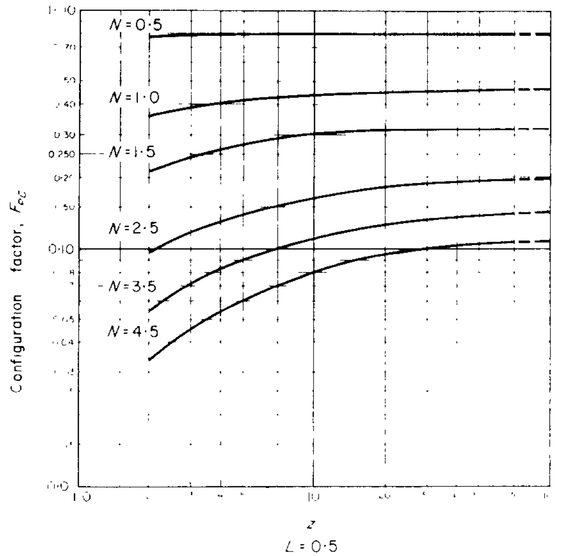

FIG. 2. Configuration factor curves for the plane to cylinder geometry. (Also for Figs. 3–7.)

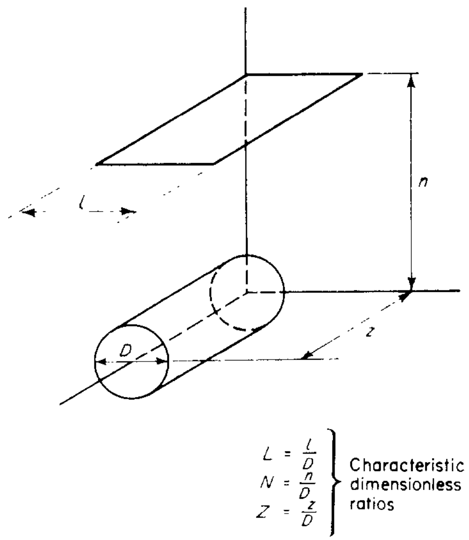

FIG. 1. Geometric description for configuration factors.

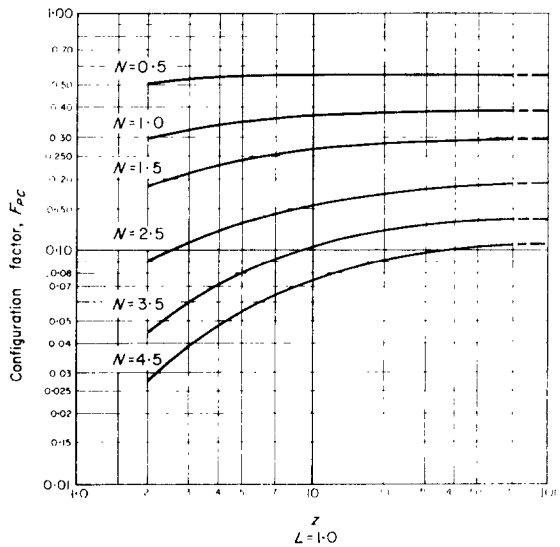

FIG. 3.

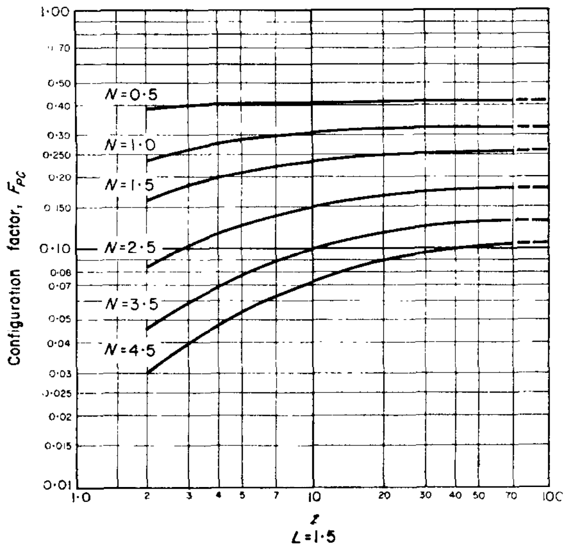

FIG. 4.

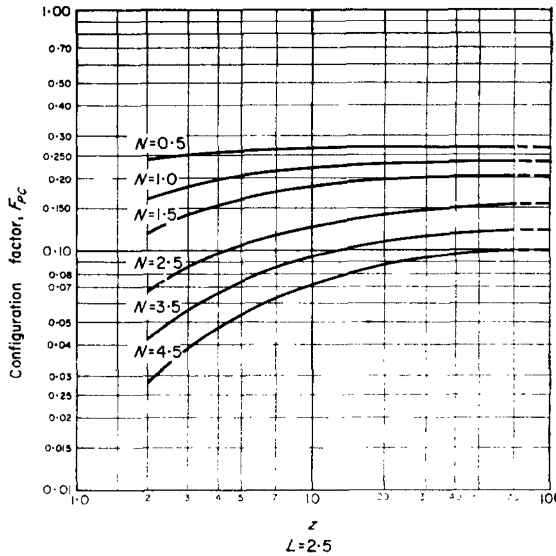

FIG. 5.

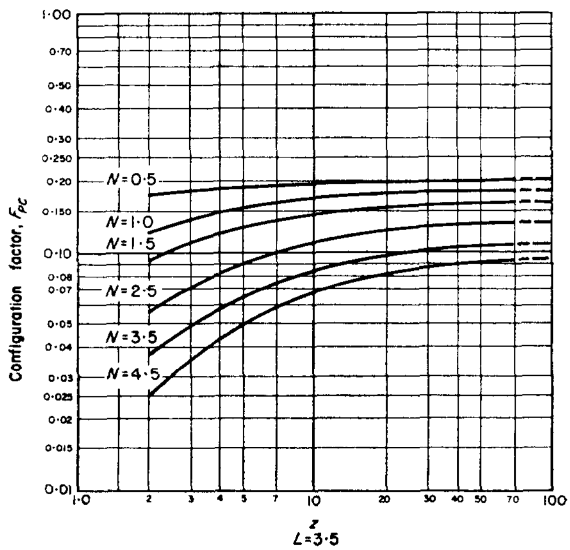

FIG. 6.

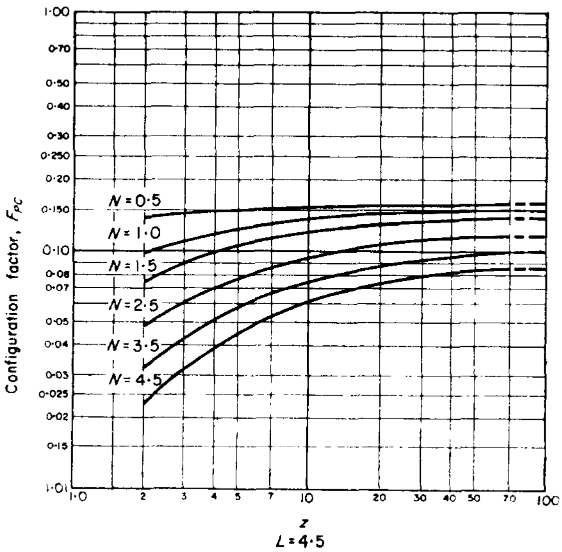

FIG. 7.

REFERENCES

1. D. C. HAMILTON and W. R. MORGAN, Radiant interchange configuration factors. NACA Technical Note 2836 (1952).
2. P. MOON, *The Scientific Basis of Illuminating Engineering*. McGraw-Hill, New York (1931).
3. R. DE BASTOS, Computation of radiation configuration factors by contour integration. M.S. Thesis, Oklahoma State University, Stillwater, Oklahoma (1961).

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Résumé—La solution des problèmes pratiques de rayonnement thermique nécessite la connaissance du facteur de forme pour des cylindres circulaires rayonnant sur des plans rectangulaires. Les résultats obtenus à partir de très longs calculs numériques sont présentés dans cet article sous forme graphique. Ces valeurs ont été obtenues par une méthode d'intégration graphique et on a utilisé une machine à calculer électronique pour les calculs numériques. On suppose que les valeurs présentées sont à $\pm 5\%$ de la valeur exacte.

Zusammenfassung—Die Lösung vieler praktischer Probleme des thermischen Strahlungsaustausches erfordert die Kenntnis des Anordnungsfaktors für gerade Kreiszylinder zu rechteckigen Ebenen. Ergebnisse langwieriger numerischer Rechnungen sind in Form von Diagrammen angegeben. Die Werte wurden nach der Kontur-Integrationsmethode auf einem Digitalrechner erhalten. Die Genauigkeit der endgültigen Werte beläuft sich auf etwa $\pm 5\%$

Аннотация—Решение практических задач теплоизлучения требует знания коэффициента формы прямых круговых цилиндров и прямоугольных плоскостей при их взаимном излучении. В данной статье результаты громоздких вычислений представлены в виде графиков. Эти значения получены с помощью метода контурного интегрирования. Численные расчёты производились на цифровых вычислительных машинах. Точность приведенных данных составляет $\pm$ 5%.