tent $\bar{U}_1$ and $\bar{U}_4$ respectively are obtained as a function of the dimensionless drying time N_{Fo} and the percentage differences $[(\bar{U}_1-\bar{U}_4)/\bar{U}_1]$ 100 per cent are plotted as a function of N_{Fo} with N_{Lu_L} as parameter where "V" indicates the beginning of the falling rate period.

It is evident in Fig. 4 that the "intermittent" procedure improves the efficiency even during the first interval of the falling rate period. This is particularly true for materials exhibiting small values of N_{Lu_L}, i.e. for porous solids which are difficult to dry. It has been shown previously [1] that the moisture content profiles corresponding to small N_{Lu_L} has a much steeper profile towards the surface. Therefore, at the end of each constant rate period, the remaining average moisture content, $\bar{U}$, is larger for small values of N_{Lu_L}. Consequently, the amount that can be removed during additional constant rate period is also larger. However, it should also point out that such a steep moisture content profile toward the surface may also be resulted by intensified external transfer processes or by additional means of heat supply. Therefore, one may conclude that such an "intermittent" process will be especially feasible for any drying processes whereby the duration of the constant rate period is severely shortened either by intensifying the external transfer processes or by additional heat supply to the drying material. Furthermore, the general agreement between the results of experimental observation reported in literature and the prediction of the parameter study presented here, may be looked upon as a partial verification of the theoretical model for the drying process.

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HEAT-TRANSFER REGIMES IN VERTICAL, PLANE-WALLED, AIR-FILLED CAVITIES

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NOMENCLATURE

- Cp, specific heat of air at atmospheric pressure;
- d, thickness of the air layer;
- g, local acceleration due to gravity;
- Gr, Grashof number based on d ($\equiv g/\beta\Delta T d^3 \rho^2/\mu^2$);
- h, height of the fluid layer;
- hd, aspect ratio;
- k, thermal conductivity of air;
- Pr, Prandtl number $\left(\equiv \frac{\mu Cp}{k}\right)$;
- Ra, Rayleigh number ($\equiv Gr.Pr$).

Greek symbols

- β, coefficient of thermal expansion of the air;
- ρ, density of the air at atmospheric pressure;
- μ, dynamic viscosity of the air;
- ΔT, temperature difference across the air layer of thickness d.

INTRODUCTION

FREE CONVECTIVE flow phenomena in plane, enclosed, vertical air layers at atmospheric pressure are of a complex nature. Three regimes of heat transfer can be distinguished within vertical cavities for the laminar flow region of Grashof number and these have been termed the conduction, the transition and the boundary-layer regimes respectively.

In the conduction regime heat is transferred predominantly by gaseous conduction and the temperature gradients are linear except near the top and bottom of the cavities. In the transition regime convective flow becomes significant and the temperature profiles across the air layer are no longer linear. However, the boundary layers on the hot and cold walls merge with one another and gaseous conduction remains the dominant heat-transfer mechanism. The boundary layer regime is characterized by separate thermal boundary layers on the hot and relatively cold walls and the temperature profiles exhibit steep gradients at the walls with a zero or inverted slope within the core region. Consequently convection rather than gaseous conduction is the predominant mechanism of heat transfer.

LIMITS OF THE REGIMES

Eckert and Carlson [1] proposed that the delineation of the three regimes could be obtained from relationships of the form:

$$Gr = f(h/d). \tag{1}$$

A limit for the conduction regime has been derived theoretically by Batchelor [2] to be:

$$Gr = 695(h/d). \tag{2}$$

It is debatable, however, whether the limits of the flow regimes are dependent upon the aspect ratio (h/d), and no conclusive evidence has yet been offered to support this contention. For fluids of various Prandtl numbers (> 1), MacGregor and Emery [3] found that the flow regimes were characterised by the Rayleigh number. Moreover, it has been stated by de Graaf and Van der Held [4] that the aspect ratio has only a minor effect in controlling the flow conditions. Hence Brooks and Probert [5, 6] conducted an interferometric investigation on air layer widths of 0·635, 1·27

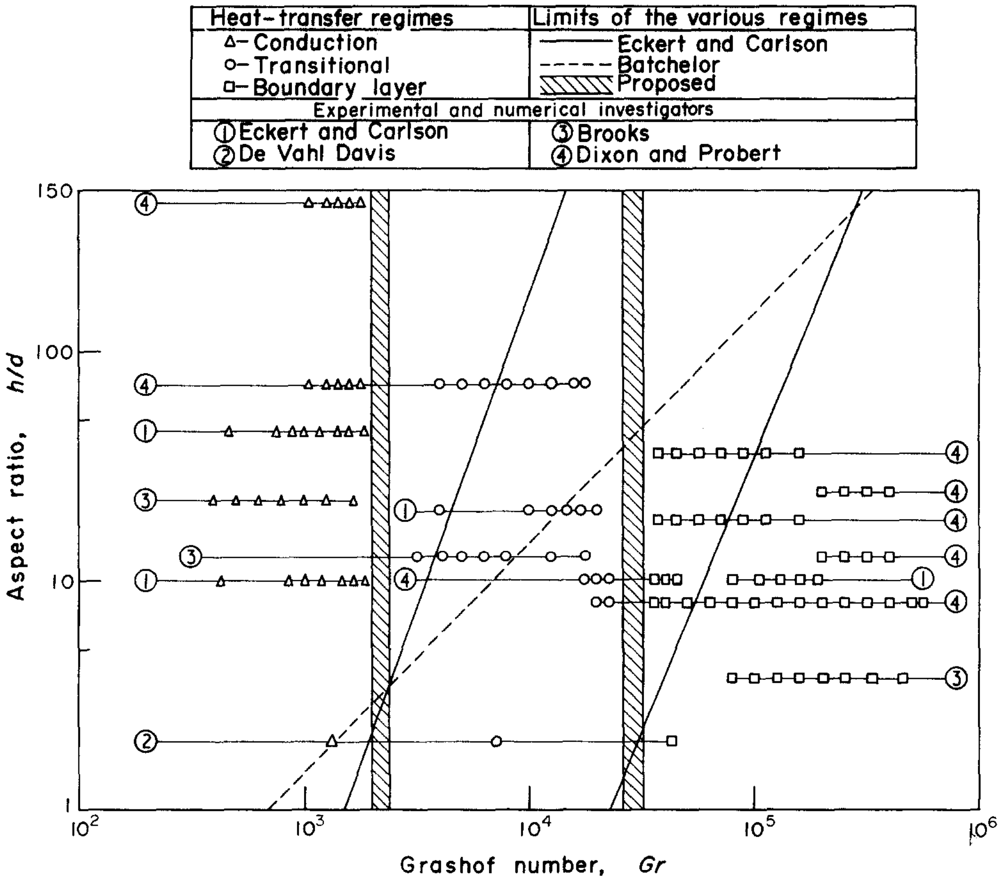

FIG. 1. Limits for the heat-transfer regimes for enclosed, plane walled, vertical layers.

and 3·81 cm with aspect ratios of 22·4, 11·2 and 3·73 respectively. The limits of the conduction and transition regimes for this study occurred at $Gr = 2{\cdot}2(\pm 0{\cdot}2) \times 10^3$ and $Gr = 2{\cdot}9(\pm 0{\cdot}3) \times 10^4$ respectively. Figure 1 illustrates the various limits for all the available results.

CONCLUSIONS

It can be seen from Fig. 1 that the limits of the regimes of heat transfer within vertical air layers can be identified solely in terms of the Grashof number and are independent of h. This implies that the cavity width d is the only geometric factor which determines the regimes, and therefore, it would appear that the Nusselt vs Grashof number relations should also be correlated on the width d rather than with respect to the aspect ratio (h/d).

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