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BONDINGS FOR TUBULAR SOLAR COLLECTORS *

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1 Introduction

Designing of flat plate solar collector is very important for the purpose of heat collection. Selection of the fins and tubes for good conduction and convection of heat are irregular and arbitrary. Usually fins and tubes are bonded in different ways -such as M.I.T. clamping, wiring, bonding and bondless system. Selection of fins and position of the tubes by bonding or bondless system for efficient collector is vital for the design of the system. The four models used for this study are considered from Duffie and Beckman (1974) and (1980). They are - tubes bonded above the absorber plate, tubes bonded under the absorber plate, tubes in-line with the absorber plate and bondless tubes in-line with the absorber plate.

Usually galvanized irontubes are bonded for good thermal contact to facilitate better transfer of heat. Here consideration is made for copper or aluminium panels with GI tubes.

2 Collector systems

Four different models of constructing collectors are taken from Duffie and Beckman(1974) and (1980) as follows -

First Model- (Fig.1a)- the plate efficiency factor is given by

$$F_p = \frac{1}{WU_L \left[\frac{1}{\pi d h_c} + \frac{m_t}{\pi d k_t} + \frac{1}{C_b} + \frac{1}{U_L[b+F(W-b)]} \right]} \tag{1}$$

Second Model-(Fig.1b) for this

$$F_p = \frac{1}{WU_L \left[\frac{1}{\pi d h_c} + \frac{1}{C_b} + \frac{1}{U_L[d+F(W-d)]} \right]} \tag{2}$$

Third Model -(Fig.1c)-for this

$$F_p = \frac{1}{\frac{WU_L}{\pi d h_c} + \frac{1}{\frac{b}{W} + \frac{1}{WU_L\left[\frac{1}{C_b} + \frac{1}{U_L(F(W-b)} + \frac{m_t}{\pi d k_t}\right]}}} \tag{3}$$

Fourth Model -(Fig.1d)-for this

$$F_p = \frac{1}{WU_L \left[\frac{1}{\pi d h_c} + \frac{m_t}{\pi d k_t} + \frac{1}{U_L[b+F(W-b)]} \right]} \tag{4}$$

3 Numerical Computation

The efficiency and energy gained from flat solar collector are computed for different sets of parameters for single glazing.The parameters are taken as: $U_L = 4.8\,W/m^2 -^\circ C$, $W = 0.1\,m$, $m_p = 0.00055\,m$, $d = 0.0127\,m$, $m_t = 0.001\,m$, $G = 0.001\,Kg/sec$, $C_b = 20\,W/m^\circ C$, $h_c = 396\,W/m^2 -^\circ C$, (circular tube), $k_t = 63\,W/m -^\circ C$ (G.I.), $k_p = 211\,W/m -^\circ C$ (Aluminium); $385\,W/m -^\circ C$ (copper), $C_p = 4190\,J/kg -^\circ C$, and $A_c = 1.0\,m^2$.

The tube spacing is taken as 0.025m to 0.2m, tube diameter as 0.0125m to 0.05m, overall heat loss co-efficient as 2.0 W/m ^{2}-$^\circ C$ to 10.0 W/m ^{2}-$^\circ C$, fluid flow rate as 0.001 kg/sec to 0.1 Kg/sec, the bond conductance as 5 W/m- $^\circ C$ to 50 W/m-°C, heat transfer coefficient as 300 W/m^2-$^\circ C$ to 550W/m ^{2}-$^\circ C$, tube thickness as 0.00050 to 0.002m and plate thickness as 0.00038 to 0.0009m.

4 Analysis of the graphs

Fig.2 shows that the minimum fin width is better for good heat transfer. Heat gained by the bondless fin and tube model is the best among the four models. Fig.3 shows that heat removal factor increases with the increase in the tube diameter. Fig.4 shows that the overall heat loss is much less for the bondless model and heat loss minimizes the thermal stress. Fig.5 shows that the greater fluid flow increases the factors for all the models. Fig.6 shows that the heat removal efficiency factor is greater for larger heat transfer.

Overall study of this paper shows that the combination of copper as fin and GI tube is better than the combination of aluminium fin and GI tube.

5 Nomenclature

A_c=collector area,m^2; C_b=bond conductance,$W/m -^\circ C$; C_p= specific heat of fluid,$J/Kg -^\circ C$; d=inner tube diameter,m; F_p=plate efficiency factor; F_R=heat removal factor; G=flow rate of fluid Kg/ sec ; h_c=heat transfer coefficient,$W/m^2 -^\circ C$; k_p=plate conduc tivity,$W/m -^\circ C$; k_t=tube conductivity,$W/m -^\circ C$; m_p=plate thickness,m; m_t=tube thickness,m; U_L=over all heat loss coefficient, $W/m^2 -^\circ C$;

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6 References

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Duffie, J.A. and Beckman, W.A. (1980). Solar Engineering Thermal Processes, John Wiley, New York.

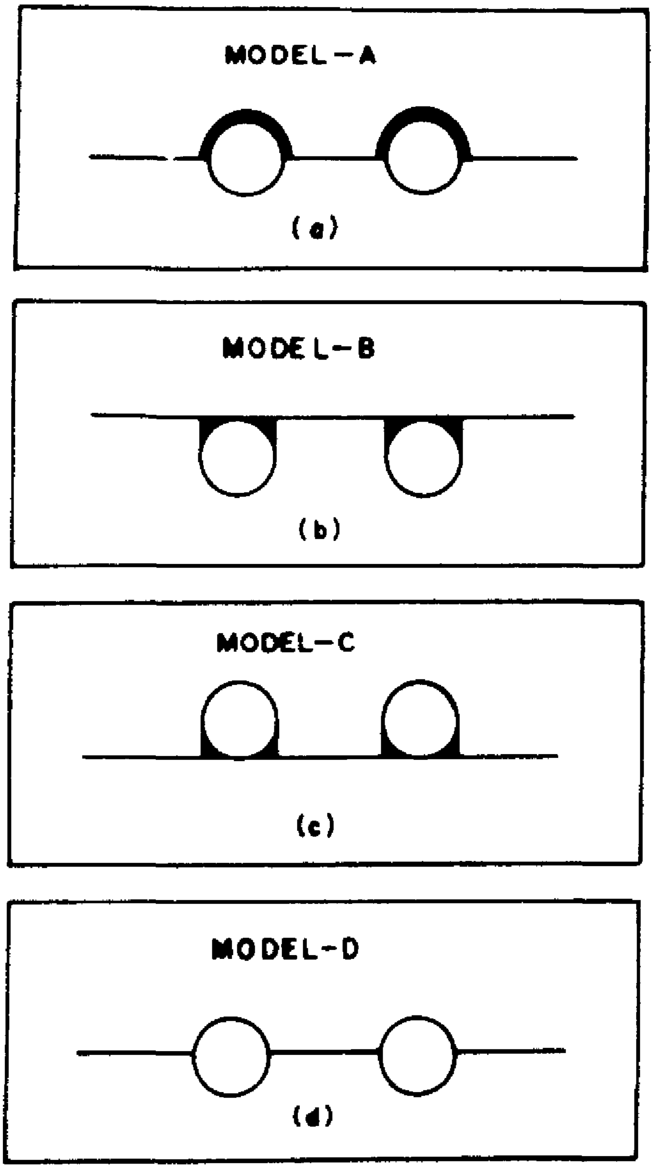

Fig.1. COLLECTOR CONFIGURATION.

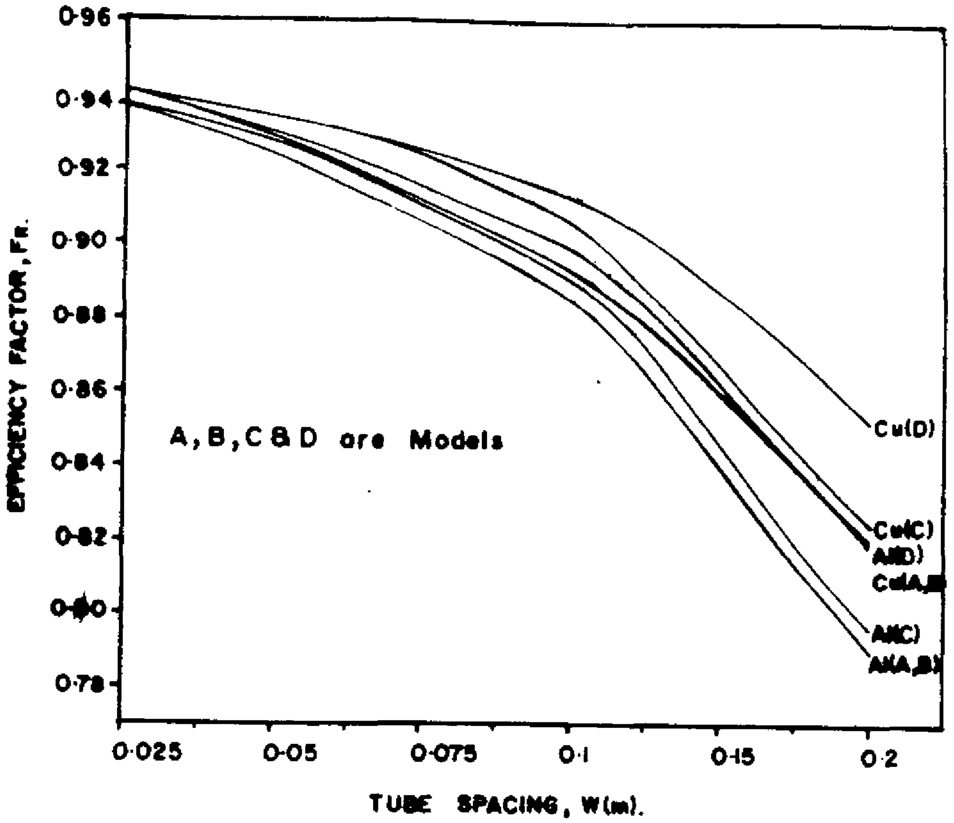

Fig.2 F_R V_S W FOR UNEQUAL TUBE SPACING.

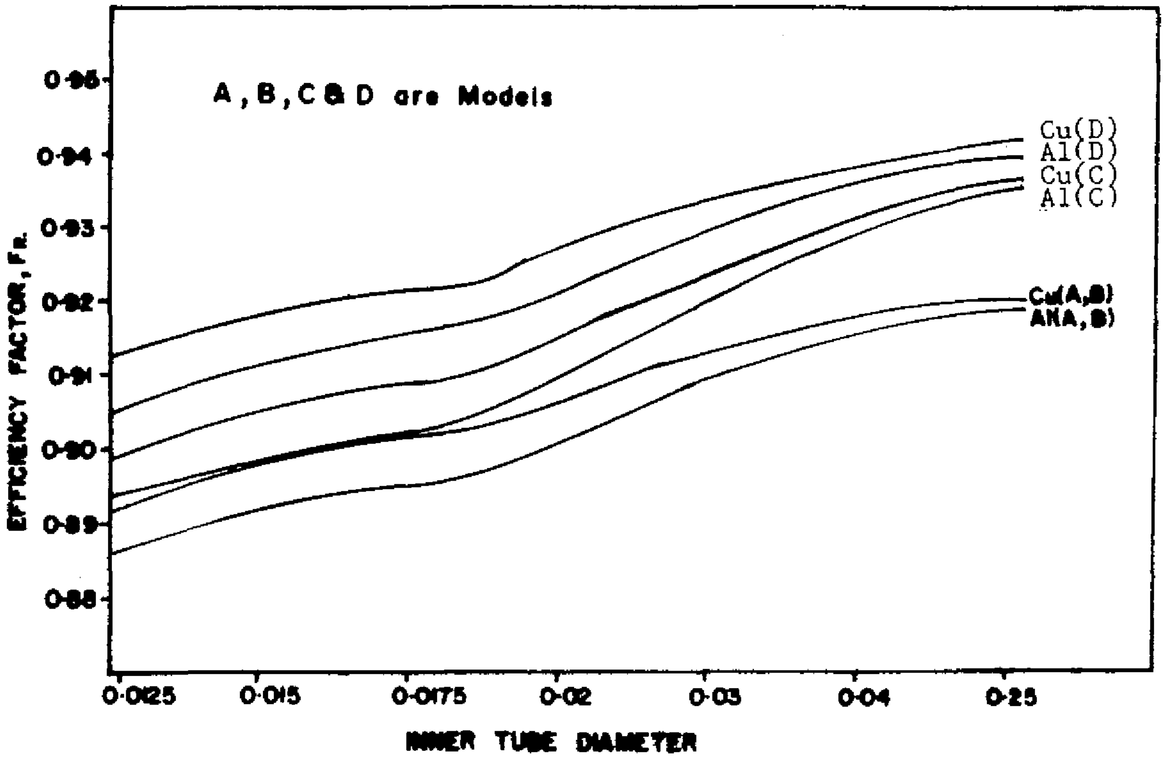

Fig. 3 $F_R V_S$ D FOR UNEQUAL INNER TUBE DIAMETER

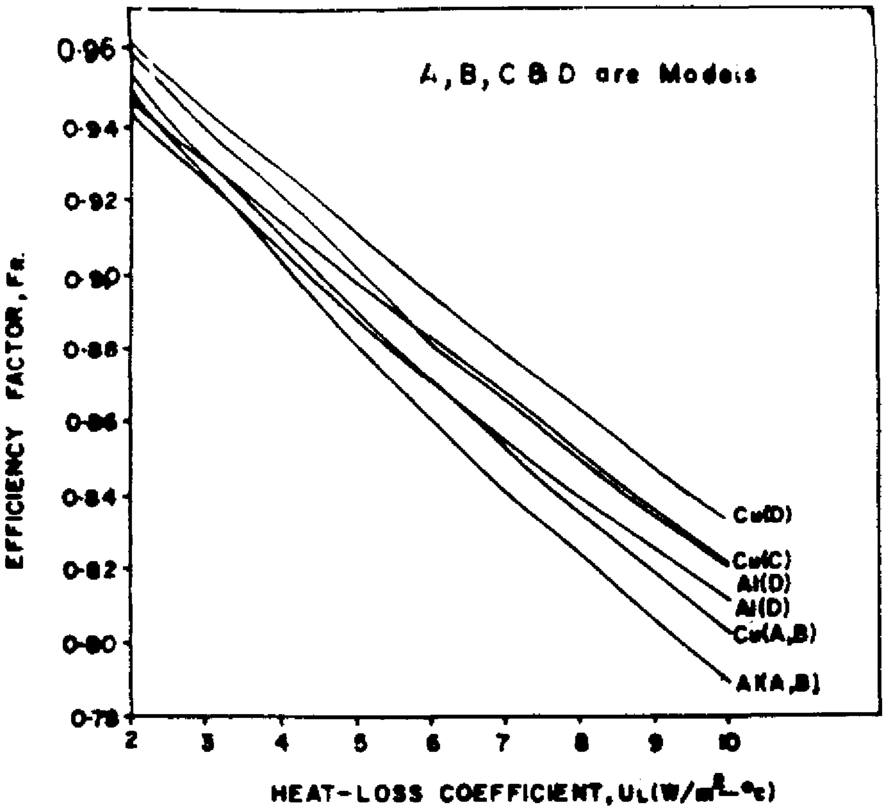

Fig.4. F_R Vs U FOR UNEQUAL HEAT LOSS COEFFICIENT

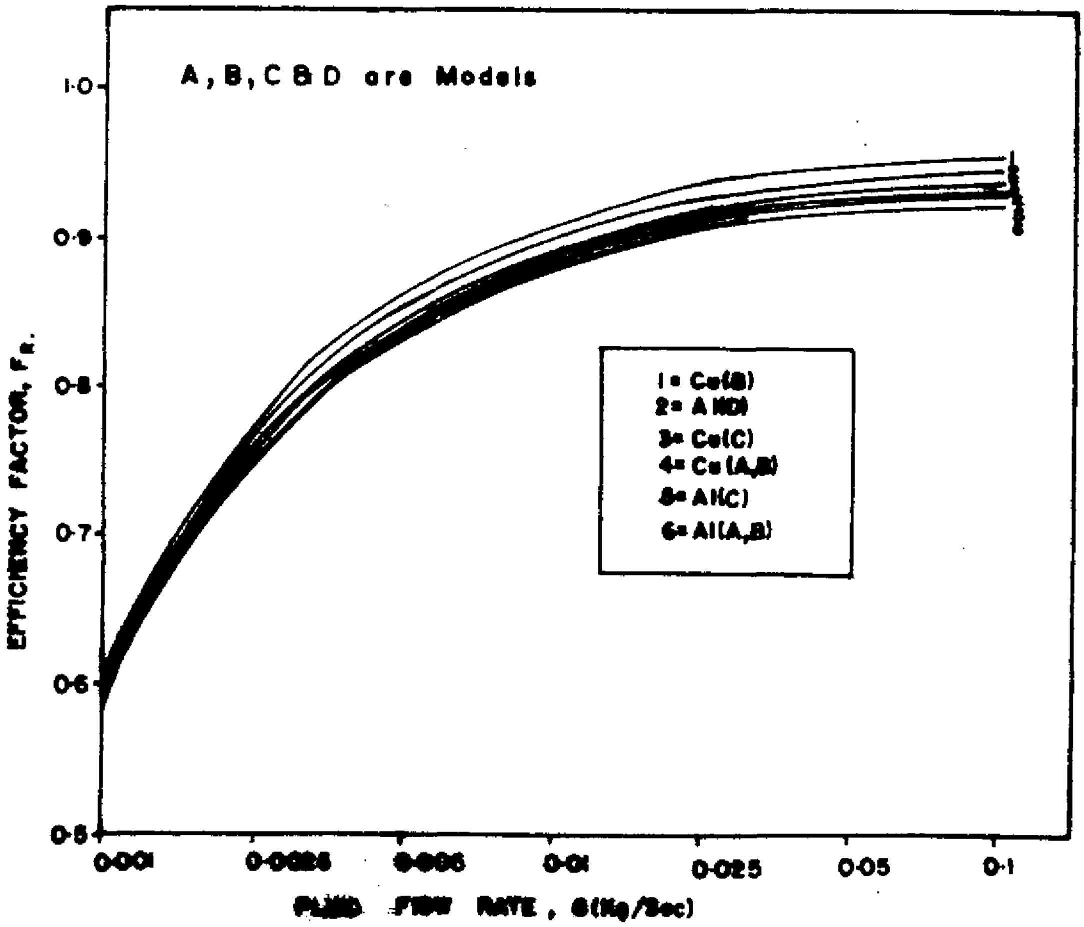

Fig.5 F_R Vs G FOR UNEQUAL FLUID FLOW RATE

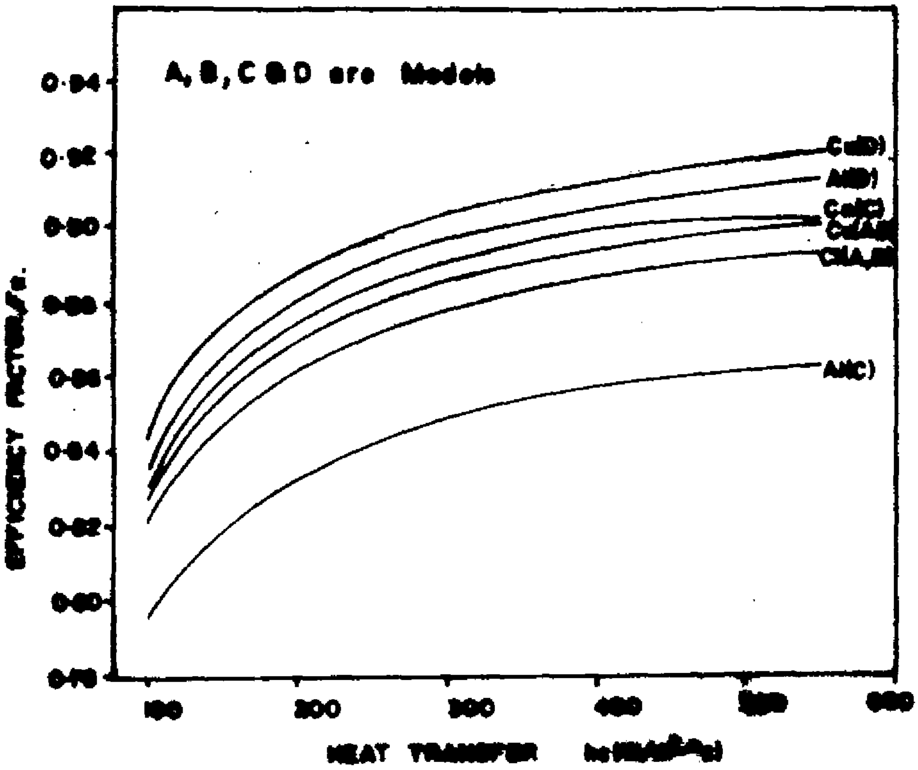

Fig.6 F_R Vs h_C FOR UNEQUAL HEAT TRANSFER