# Chapter IV

## EXPERIMENTAL RESULTS

The experimental results are divided into two parts. The first part deals with results using water as an evaporating liquid. The second part deals with results using sucrose solution as an evaporating liquid.

### 4.1 Experimental Results Using Water as an Evaporating Liquid

#### 4.1.1 The Heated wall Temperature of the Evaporating Body

Effects of feed rate and steam inlet temperature on the wall temperature of the heated tube were studied. Temperature of the wall measured at the mid-section of the 1 ft tube are shown in Fig 4.1 and 4.2. It has been observed that there is no variation of wall temperature with feed rate. However, the wall temperature is varied directly with steam inlet temperature. It may be taken therefore that the wall temperature is 2.25$^{o}$F. lower than the steam inlet temperature.

#### 4.1.2 The Vapor Phase Temperature Along the Heated Tube

Four series of measurements were made to ensure that the vapor phase temperature measured at the mid-

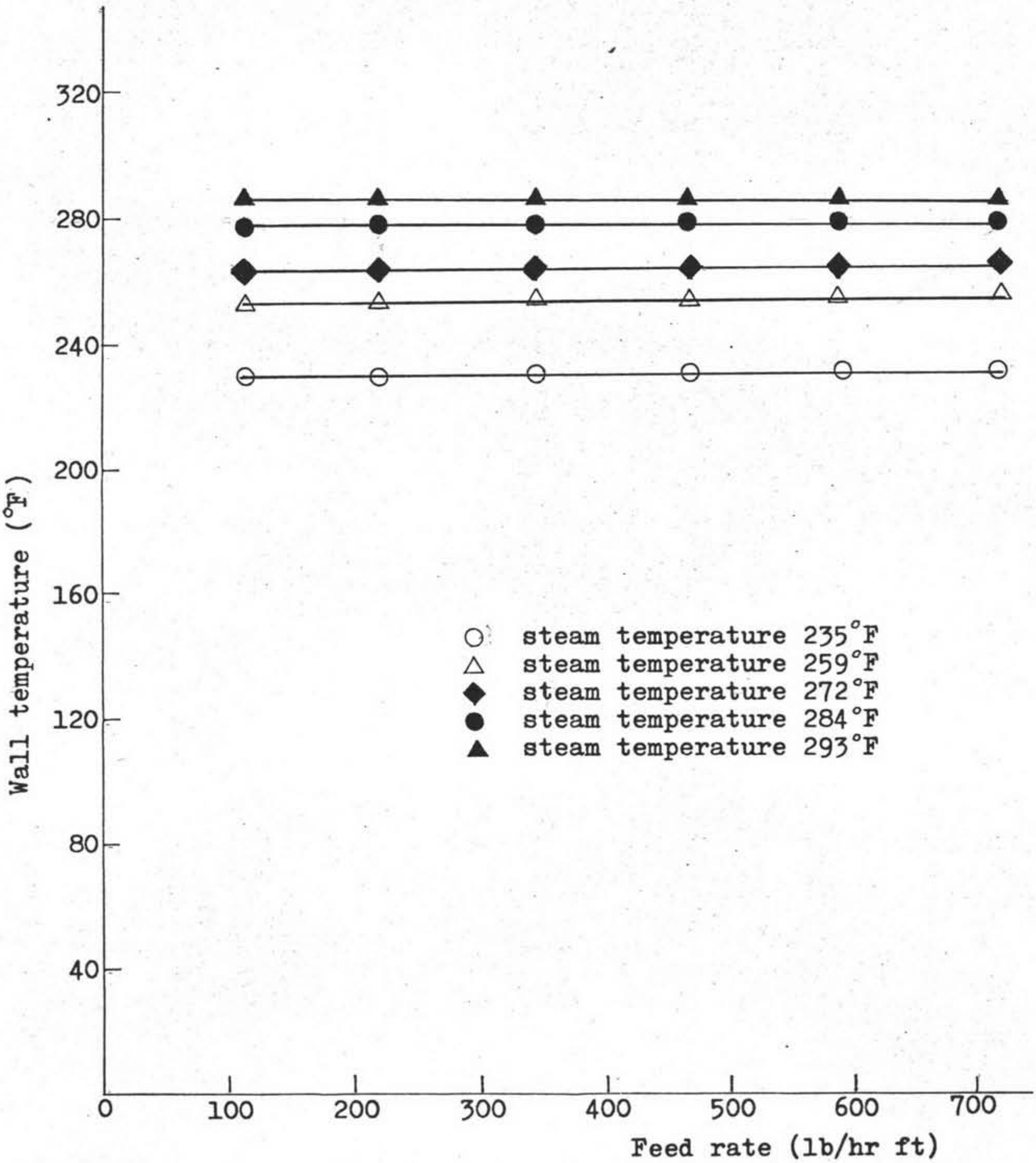


Fig. 4.1 Variation of wall temperature with feed rate

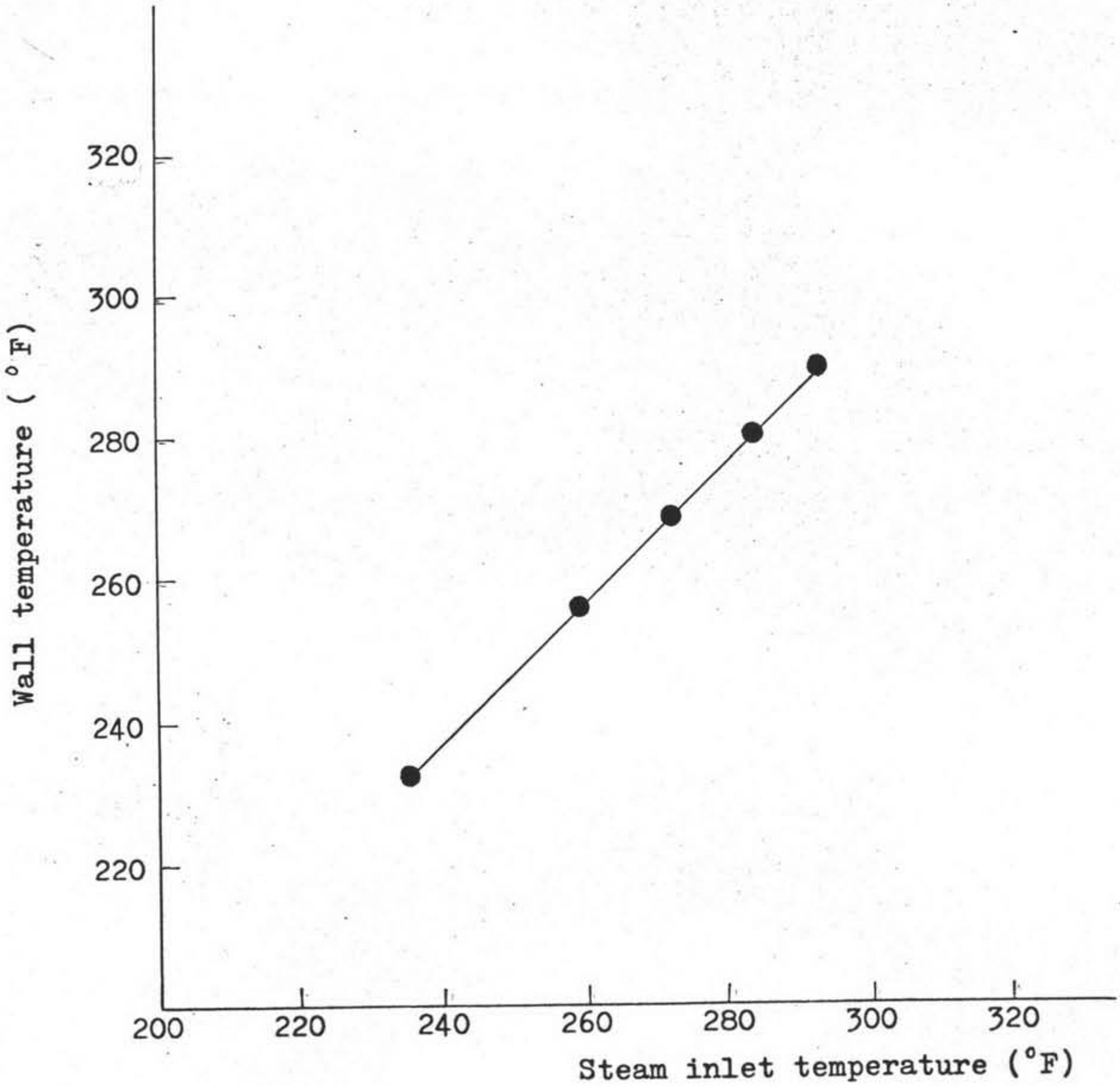


Fig.4.2 Variation of wall temperature with steam temperature

section might represent a temperature at any position along the axis of the heated tube. Temperatures measured at 1-inch interval along the axis, using a thermocouple held in a small glass tube and placed centrally inside the heated tube, are shown in Fig 4.3 for a 1-ft tube. There seems to be some variations of temperature from the lower end up to about 4 inches; this was observed only for a steam temperature of 258$^{o}$F. For a steam temperature of 272$^{o}$F, the variation might be considered as negligible.

Similarly, temperatures in the vapor phase along the axis of the 2-ft tube were measured; the results are shown in Fig 4.4. There seems to be no variation at all for the two cases of steam temperatures used.

### 4.1.3 The Film Heat Transfer Coefficient

In order to investigate whether the efficiency of the evaporator can be improved by film technique, and to study the effects of feed rate; feed temperature; temperature of heating surface and length of heated tube on the evaporation, the mean film heat transfer coefficient are calculated and compared.

#### 4.1.3.1 Effect of feed rate on film heat transfer coefficient ($h_m$)

Six values of feed rate at 15.8, 29.7, 46.2, 62.0, 78.7 and 95.0 lb/hr were used and its Reynolds Number

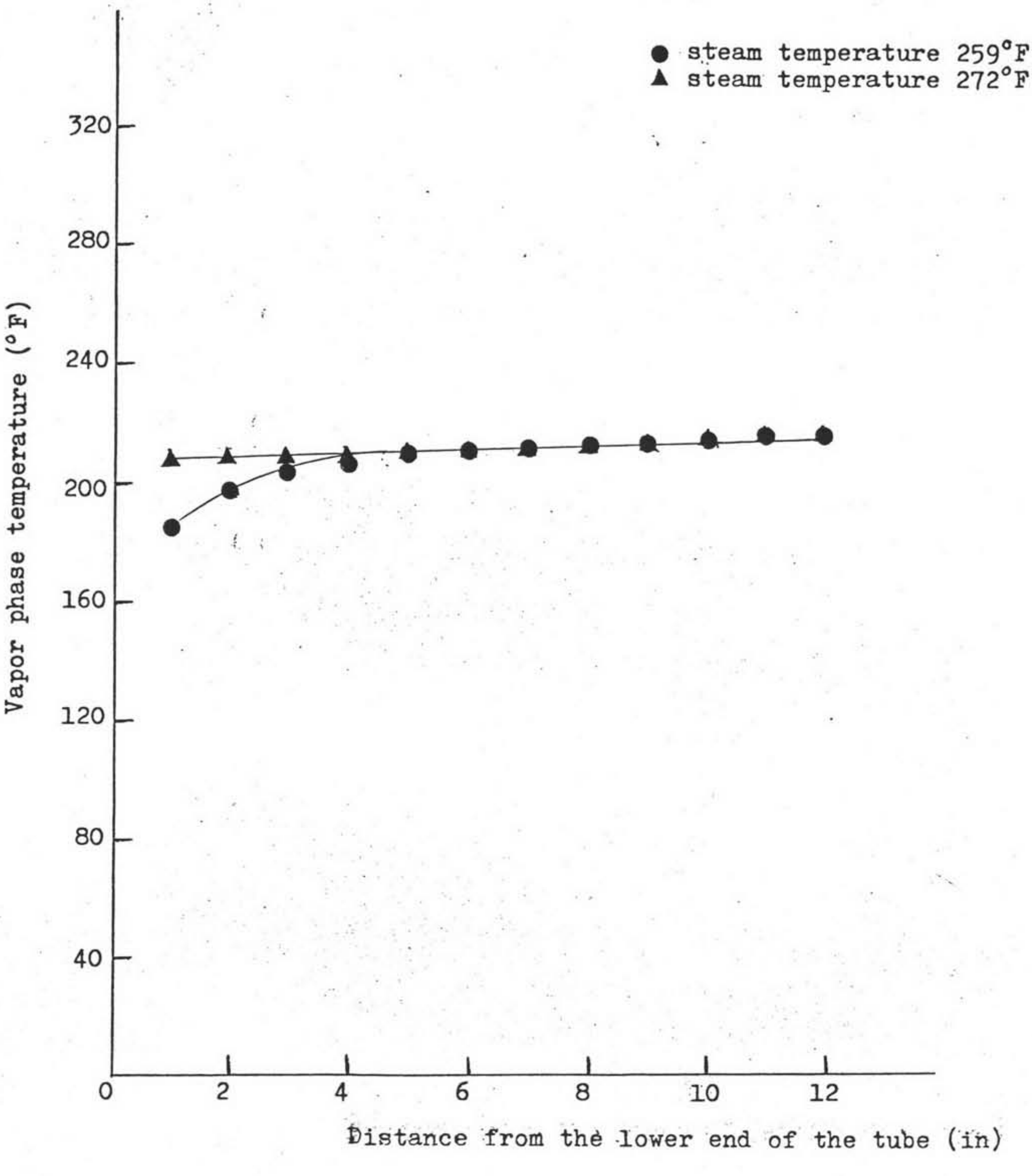


Fig. 4.3 Variation of vapor temperature along 1-ft tube

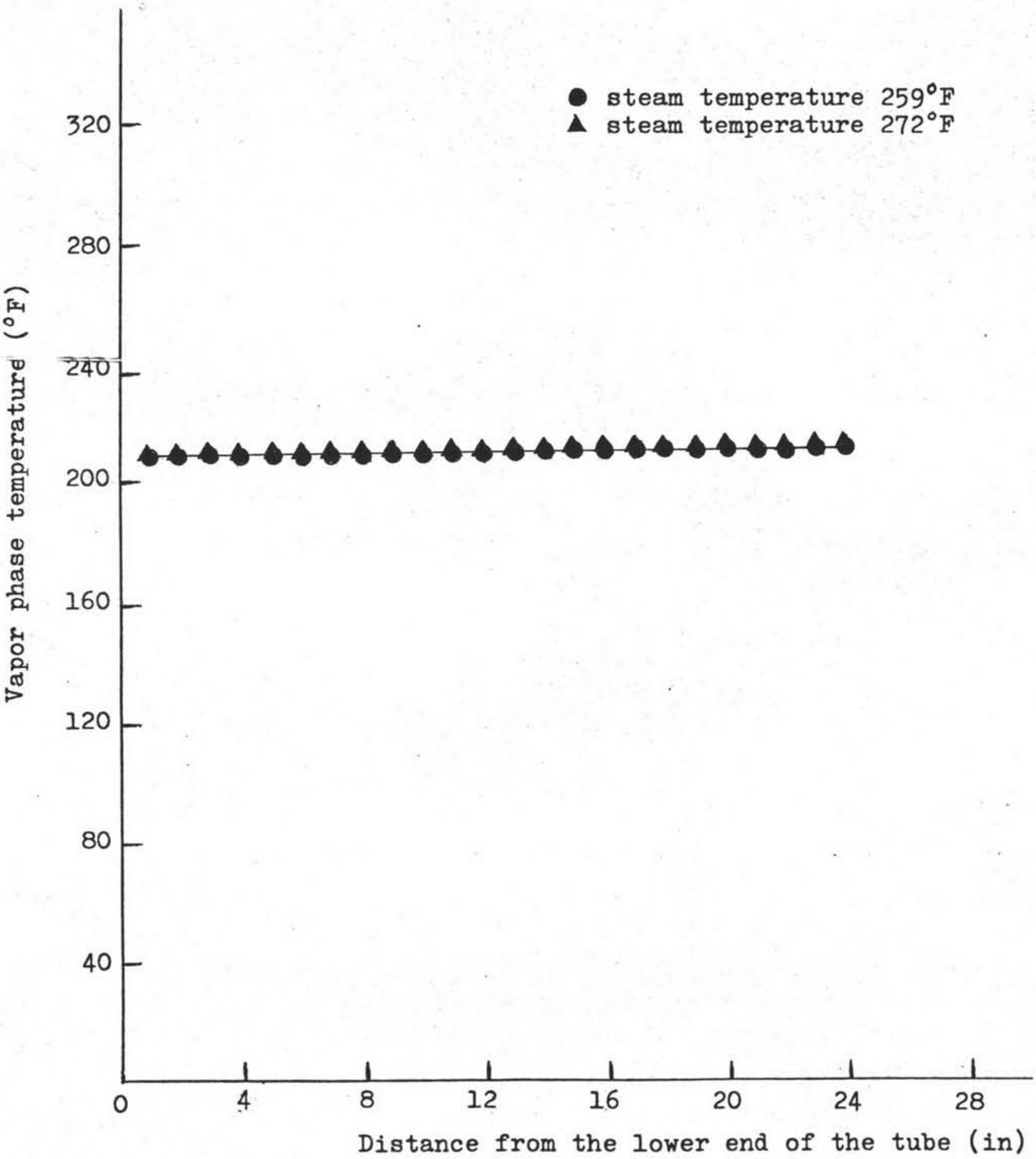


Fig. 4.4 Variation of vapor temperature along 2-ft tube

were calculated and plotted with $h_m\left(\frac{\mu^2}{\rho^2 gk^3}\right)^{1/3}$ as shown in Fig 4.5. It was observed that $h_m$ decreased up to Re of $1.2 \times 10^3$ and then continue to increase with Re. At Re $2.5 \times 10^3$, $h_m$ sharply drop again.

4.1.3.2 Effect of feed temperature on $h_m$

Effect of feed temperature on $h_m$ were studied; results are shown in Fig 4.6. It has been observed that $h_m$ decreased with feed temperature.

4.1.3.3 Effect of steam inlet temperature on $h_m$

Five values of steam inlet temperature 235, 259, 272, 284 and 293$^\circ$F were used. The results are shown in Fig 4.7a. It was observed that at steam temperature between 235 and 259$^\circ$F. $h_m$ decreased with increasing steam temperature. Above steam temperature 259$^\circ$F, $h_m$ increase sharply; and levelled off at steam temperature higher than 280$^\circ$F.

4.1.3.4 Effect of length of heated tube on $h_m$

Both 1 and 2 ft tubes were used, and operated at feed rate 46.2 lb/hr and feed temperature of 93$^\circ$F. The results are shown in Fig 4.7b. It was observed that $h_m$ of a 2-ft tube appeared to be slightly higher than that of a-1-ft tube.

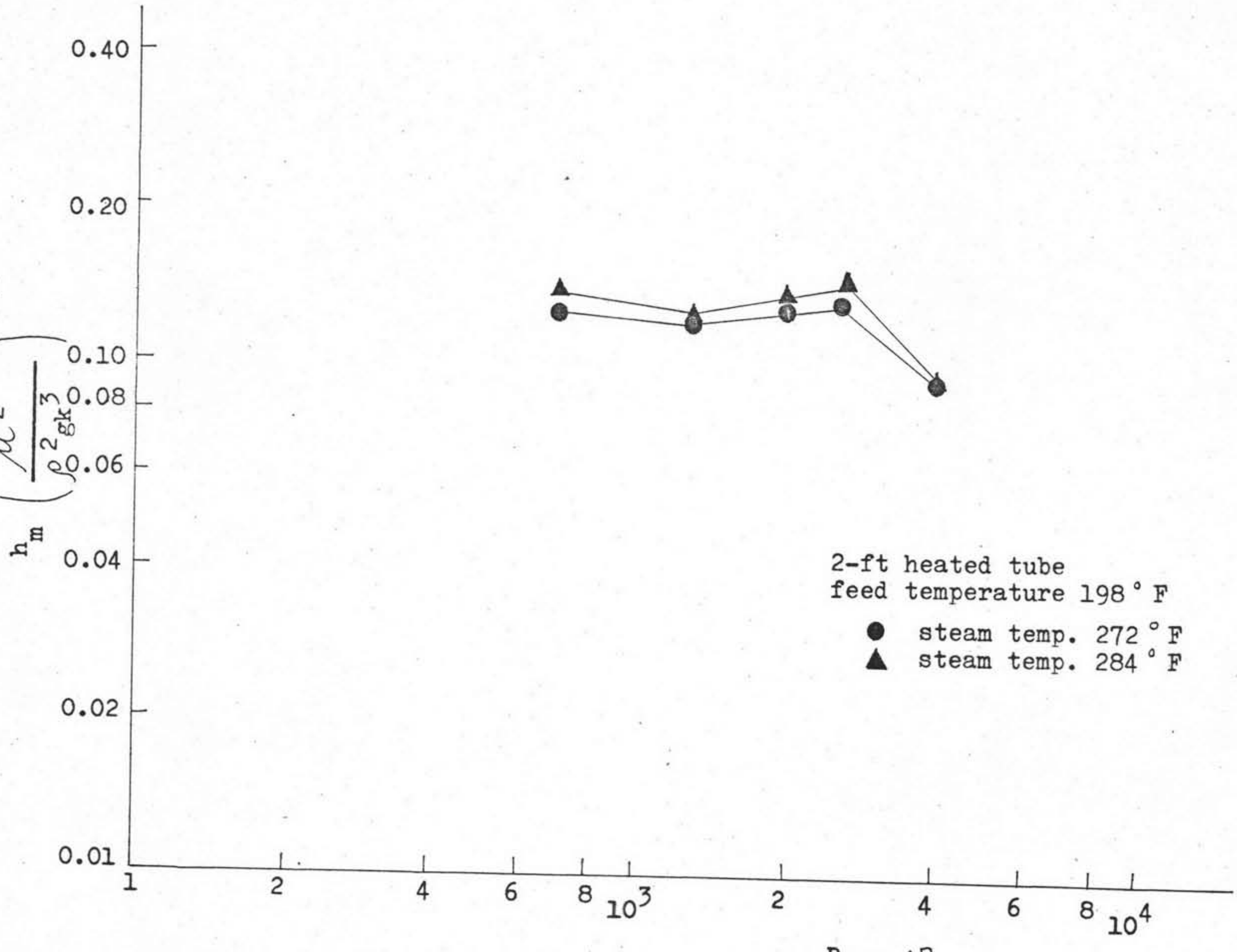


Fig.4.5 Variation of $h_m \left(\frac{\mu^2}{\rho^2 g k^3}\right)^{1/3}$ with Re

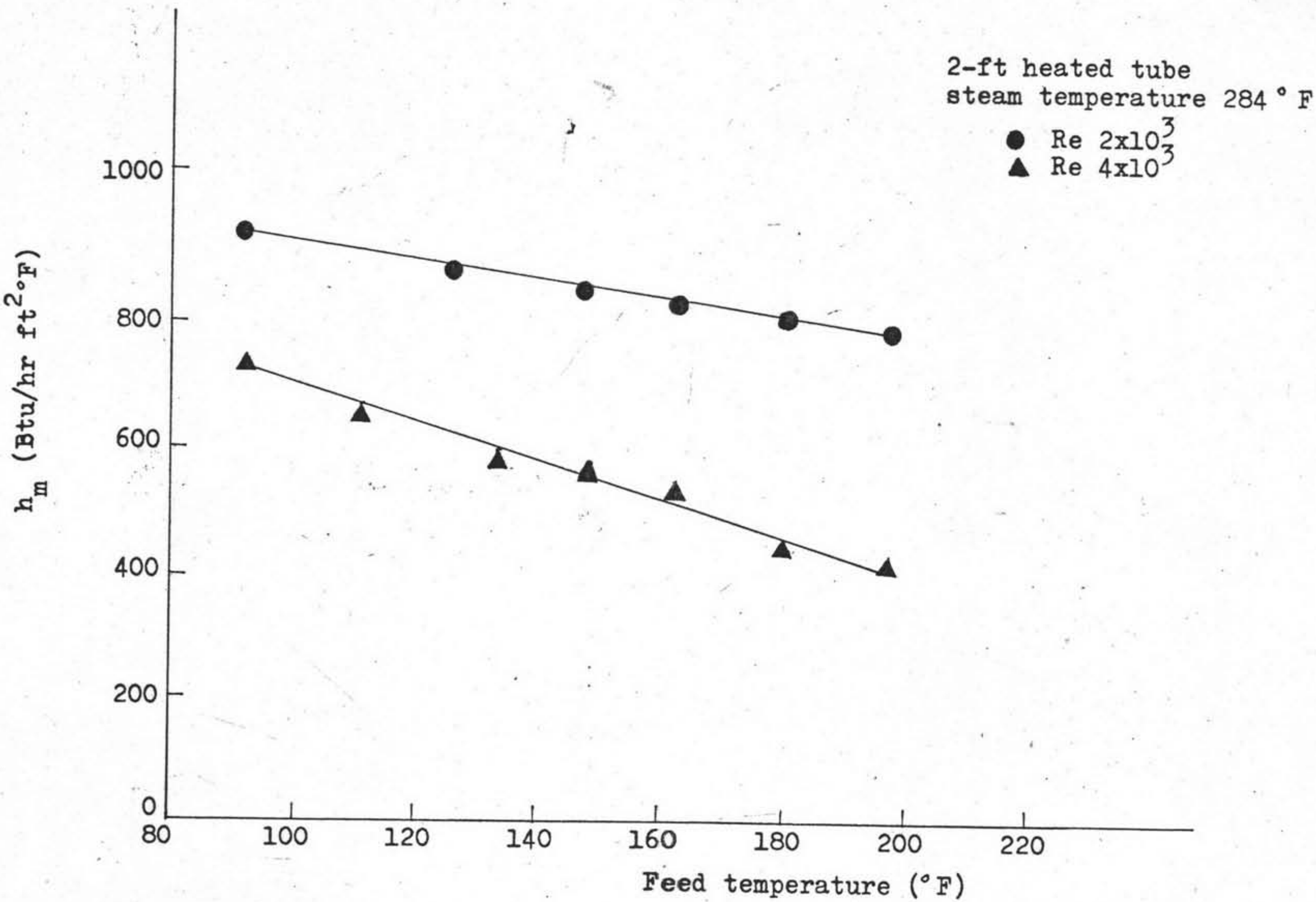


Fig.4.6 Variation of $h_m$ with feed temperature

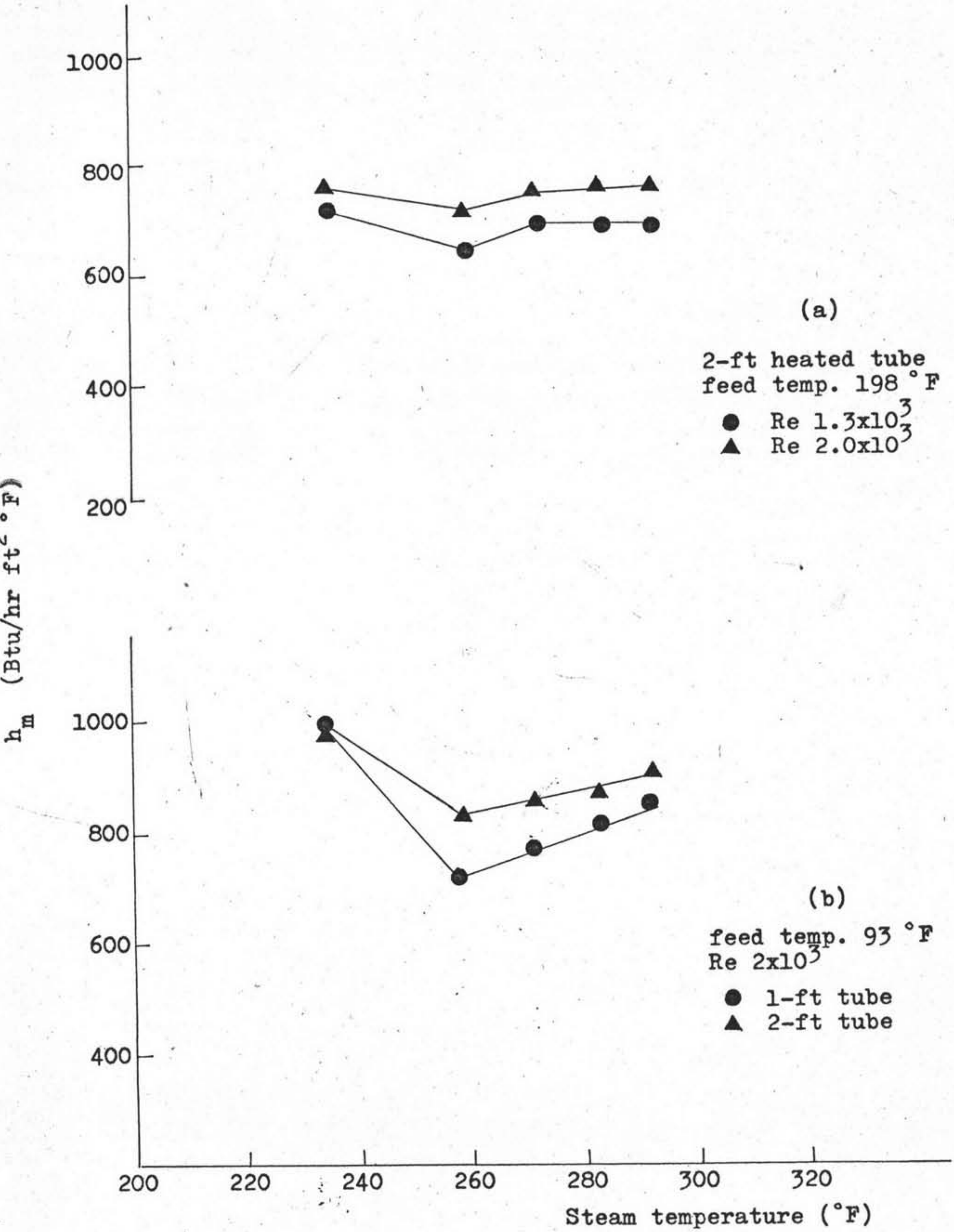


Fig.4.7 Variation of $h_m$ with steam temperature

## 4.2 Experimental Results Using Sucrose Solution as an Evaporating Liquid

### 4.2.1 Viscosity of Sucrose Solutions

Viscosities of various concentration of sucrose solution were determined by Oswald viscometer. The temperature, for viscosity determinations, was varied from 30–70$^{\circ}$C. Results are shown in Table B.1 in appendix B and plotted in Fig 4.8.

### 4.2.2 Effect of Viscosity on Film Heat Transfer Coefficient

To study effect of viscosity on film evaporation, sucrose solutions of 0-15 Brix were used. The results are shown in Table D-7 and plotted in Fig 4.9.

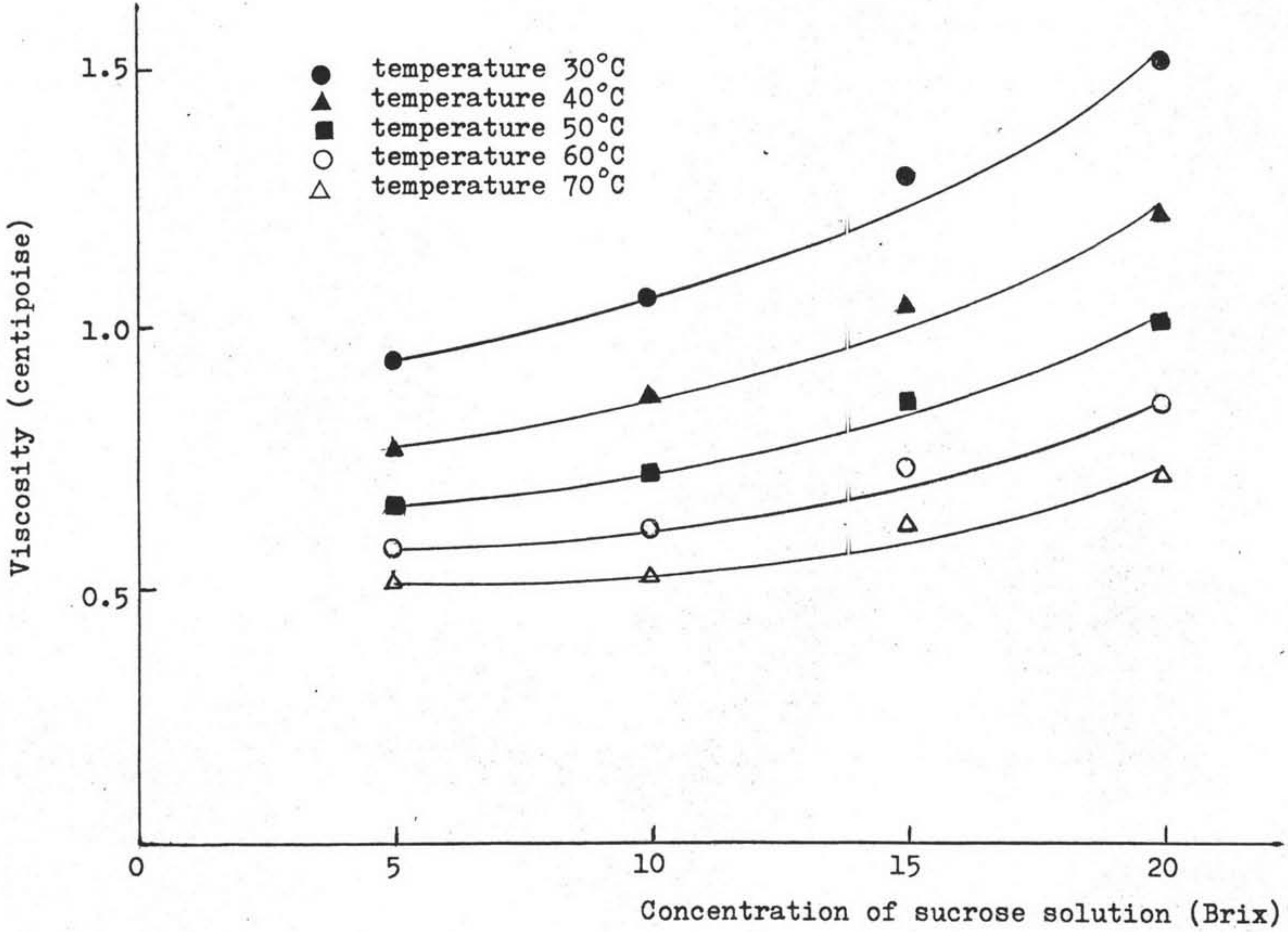


Fig. 4.8 Variation of viscosity of sucrose solution with concentration

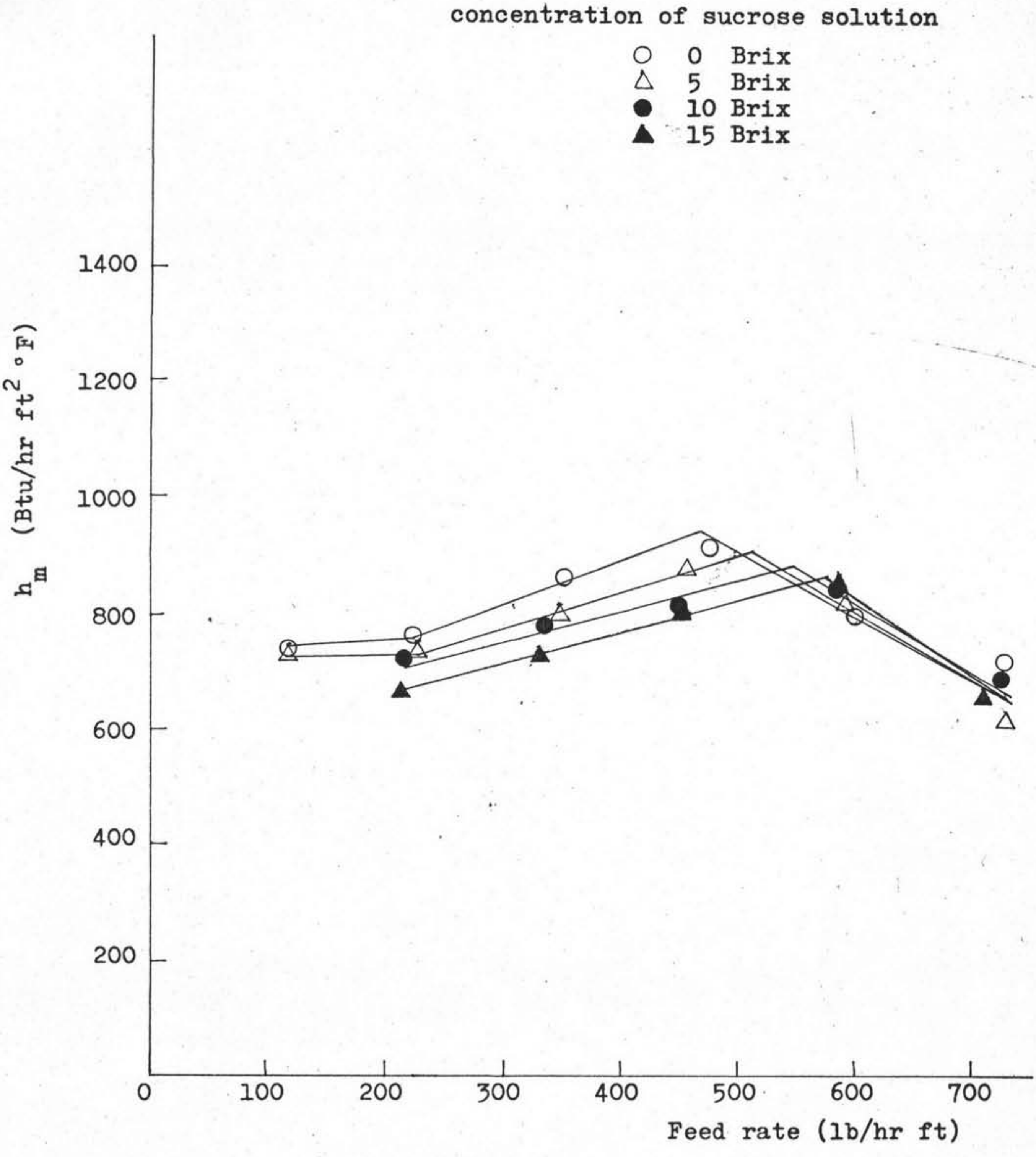


Fig.4.9 Variation of $h_m$ with feed rate and viscosity