CHAPTER III

LITERATURE REVIEWS

The heating and cooling of solids is known as "heat transfer in the unsteady state" since the temperature at any point within a body varies with both time and position. Where chemical reactions occur during the heating period, e.g., in the vulcanization of rubber, heat transfer is especially important since the rate of reaction increases rapidly with comparatively small changes in temperature. (D.A. Hills, 1970). A basic understanding of the principles involved can be gained by using simple conduction as a starting point. In the case of tire curing process is unsteady - state conduction, the basic Fourier's equation becomes a partial differential equation.

$$dT/dt = K/\rho C_p \, [(d^2T/dr^2) + 1/r(dT/dr) \qquad (3\text{-}1)$$

For the heat transfer in cylindrical system, the above equation usually referred to. It has been shown that for rubbers, and hence plastic except at melting transitions, the conductivity term is small and the above equation is adequate for most heat flow calculations. (Hands and Horsfall, 1977)

The expression $K/\rho Cp$ is called the "thermal diffusivity". D.A.Hills (1971) found that D or thermal diffusivity is independent of the temperature units, but is not necessary independent of the actual temperature. In the case of rubber, some comparatively attempts, Frumkin and Morris, (1944) to examine any variation in thermal diffusivity with temperature tended to show that the value for any compound became larger with increasing temperature, but false assumption invalidate the calculated results. Later work,Beatty and Armstrong. (1950), using simple unsteady-state methods found no significant change in the value of D over the range from room temperature to 135 C. Freeman and Lepetov. (1959,1962) report that the value of D decreases with increasing temperature. This has been attributed to the fact that the specific heat of rubbers increases considerably with rise in temperature. In most calculations,D.A. Hills (1971) conclude that an average value is usually employed over the normal range of curing temperatures. This is possible since any variations will be small compared to the accuracy of the figure chosen for calculation.

D.Hands and A.Hamilton (1988),presented the measurement of heat transfer in polymer that study on the thermal diffusivity and conductivity. The Value of thermal diffusivity and thermal conductivity are needed for heat flow calculations, for the determination of structure-property relationships, and for material selection and comparison. However, all aspects are hampered by a dearth of reliable data anything more than a superficial glance at the literature is apt to discourage the uninitiated. Hardly any thermal diffusivity data has been published, and the reported values of thermal conductivity show very large scatter. The present state of confusion can be seen, for example, in Figures 3.1 and 3.2, which show the reported thermal conductivity values for PVC and gum natural rubber. Not only to the values differ at some temperatures by more than 100 % , and in the case of rubber by almost 300 % ,but different trends are indicated throughout the temperature range.

Discrepancies of this size cannot be due to sample variations, and they give some indication of the experimental difficulties assocoated with thermal property measurements. (D.Hands and A.Hamilton, 1988.)

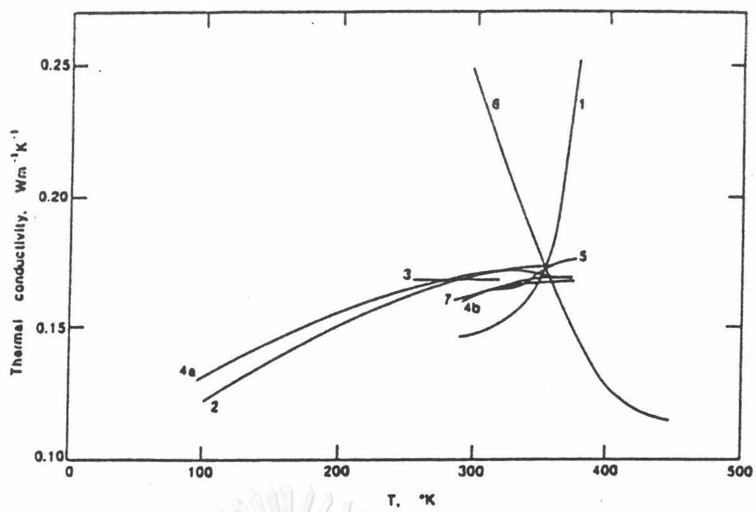

Figure 3.1 Literature values for the thermal conductivity of Polyvinyl chloride (D. Hands and A. Hamilton, 1988.)

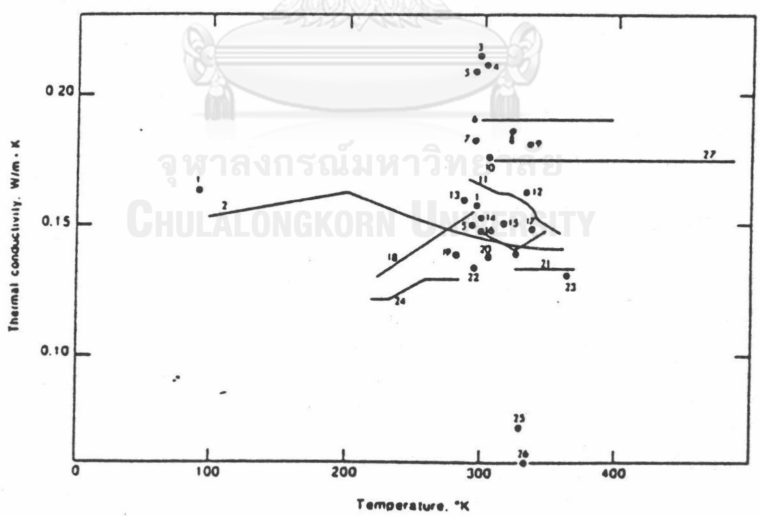

Figure 3.2 Literature values for the thermal conductivity of gum natural rubber (Carwile and Hoge,1966.);Curve 27 from (Hands and Horsfall, 1977.)

In 1987, Zhang and Ying Danyang. presented the simulation of time - temperature history and cure extent in rubber articles. A computer simulation program based on the finite element analytical was developed to calculate numerically 2-dimensional time - dependent temperature distribution and the extent of vulcanization in rubber articles with irregular geometries and different material sandwiches. In the program variable thermal properties, internal heat generations which depended on the temperature., vulcanization state during molding as well as during their cooling in air were considered. As a practical applied example, the temperature distribution history and the state of vulcanization at any point in tire during both molding cycle and cool down stages were calculated and compared with results of experimental work. A satisfactory agreement was obtained. The program successfully simulated the vulcanization cycle process of the rubber tire and any rubber articles. The program was used more widely and effectively to solve any 2-dimensional, unsteady-state heat conduction problems.