CHAPTER IV

EXPERIMENTAL

GENERAL

For the purpose of this study, the simulation model was solved by numerical approximation. The approximation and calculation used some raw data from this experiment. These datas were the measuring of temperature - time profiles during vulcanization. During tire curing, thermocouples were located within the green tire. The data recorder was used to record the green tire temperature profile during the whole curing cycle. All of data were used to calculate the thermal diffusivity for heat transfer process. This value was empirical value.

Anyhow, the constant value for heat transfer equation can be calculated from data of instrumentation. So that, the second part of this experiment, tread rubber compound were determined thermophysical properties. Thermal analyser were used to measure the properties. These properties included density and specification , heat of material.

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And then all of data from instrumentation were calculated for thermal diffisivity and conductivity. These values were called the calculation value.

In this experiment was separated in two main parts as follows :-

1. Temperature distribution by thermocouple in real time
2. Thermophysical properties of tread compound determination

These properties were - density

- specific heat

The details of the experiments and work instruction are shown.

TEMPERATURE DISTRIBUTION BY THERMOCOUPLES IN REAL TIME

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The experimental was direct measurement of temperature change in green tire. Thermocouple wires were located at the study positions as follows. :

1.) Under tread position.

2.) Mould surface position.

3.) Bladder surface position.

EQUIPMENT :

1. Thermocouple wire Type "T". (Copper - Constantan) temperature range -200 °C to 400 °C
2. Hybrid recorder "Yokogawa HR 2400"

Laboratory application was temperature change versus time interval recording.

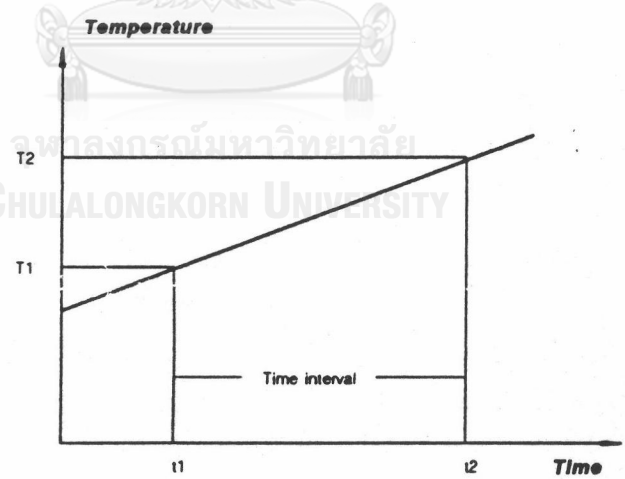

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Figure 4.1 Shows temperature change versus time interval recording

INSTRUCTION :

a.) The observed green tire was constructed by, to open tread splice for sinking thermocenple wires at under tread position. To ensure that wire was a perfect fit in the green tire and resplice.

b.) For mould surface or tread surface and inner liner position, to stick thermocouple wires by tape.

c.) After wiring, to mark the position by identification on thermocouple wires.

d.) Green tires were brought to curing press (curing machine) and constructed thermocouple wires from inside the mould.

e.) To clamp the wire with input terminal block of the recorder.

f.) To start curing process and record temperature chage versus time interval (min.). Let this step is initial condition.

g.) After tire curing process finnished, eject cured tire from the mould.

h.) To make sure the thermocouple wires still fit in the observed position by cut tire visual inspection.

i.) Data collection.

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THERMOPHYSICAL PROPERTIES OF TREAD COMPOUND DETERMINATION

1. DENSITY VERSUS TEMPERATURE MEASUREMENT

The initial density of tread compound was measured by submersion in Zinc chloride solution. The density of the tread compound changed with temperature during tire curing process was simulated and measured by thermomechanical analyser, (TMA.). The heating rate during this test was 2 °C/min. The probe followed the changing in volumn and its movement was recorded as a displacement on a chart recorder via a high-sensitivity amplifier.

EQUIPMENT AND ACCESSORY :

The measuring equipment and accessory for use in this application was separated into three part, Thermomechanical analyser, (TMA.). The Dilatometer accessory and personal computer workstation. All of these parts were component of the **PERKIN-ELMER 7 Series** Thermal Analysis System.

The Dilatometer accessory permited the convenient determination of volumetric changes of rubber compound as a function of temperature.

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Accessory consists of the following parts.

- Dilatometer barrel and plunger.
- Filling medium (filler) , Alumina (Al_2O_3)

INSTRUCTION :

The determination of volumetric thermal expansion as follows :

a.) Weight the sample and placed in it the Dilatometer accessory barrel. Filling medium (Al_2O_3) should completly surround the sample.

b.) Place sufficient Alumina in the barrel to fill the cell up to the hole in the barrel.

c.) Place the plunger in the barrel with the cutout in the plunger facing the hole. (see Fig. 4.1)

d.) Rotate the plunger so that the cutout in the plunger will not be encountered by the hole in the barrel when the sample expands.

e.) Place the Dilatometer accessory on the sample tube platform of the TMA. and lower the slightly positive loaded probe onto the Dilatometer plunger. Raise the TMA furnace.

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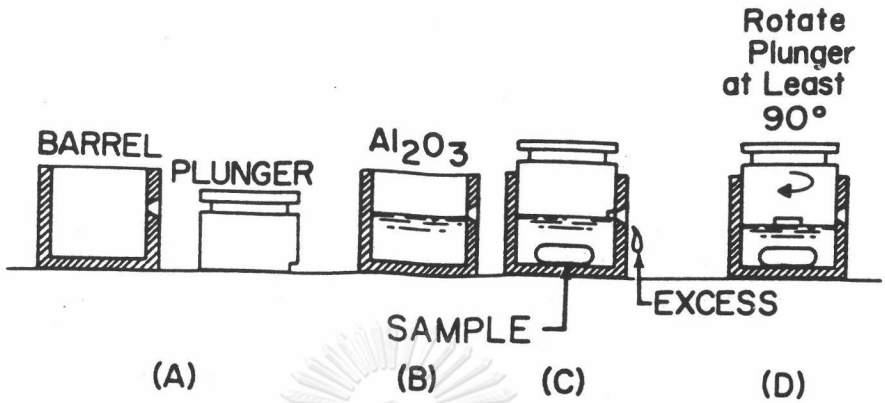

Figure 4.2 Operating with the Dilatometer accessory

The expansion of the Alumina (although very small) must be subtracted from the total expansion for maximum accuracy. To do this , the filled accessory must be weighted (just before placing the accessory in the TMA.) , and the previously determined weights of the dry cell and of the sample must be subtracted. The amount of expansion due to the Alumina must be determined, that is the expansion run for the identical amount of Alumina used in the sample run, but without the sample, must be determined.

The results obtained should appear as shown in figure 4.2

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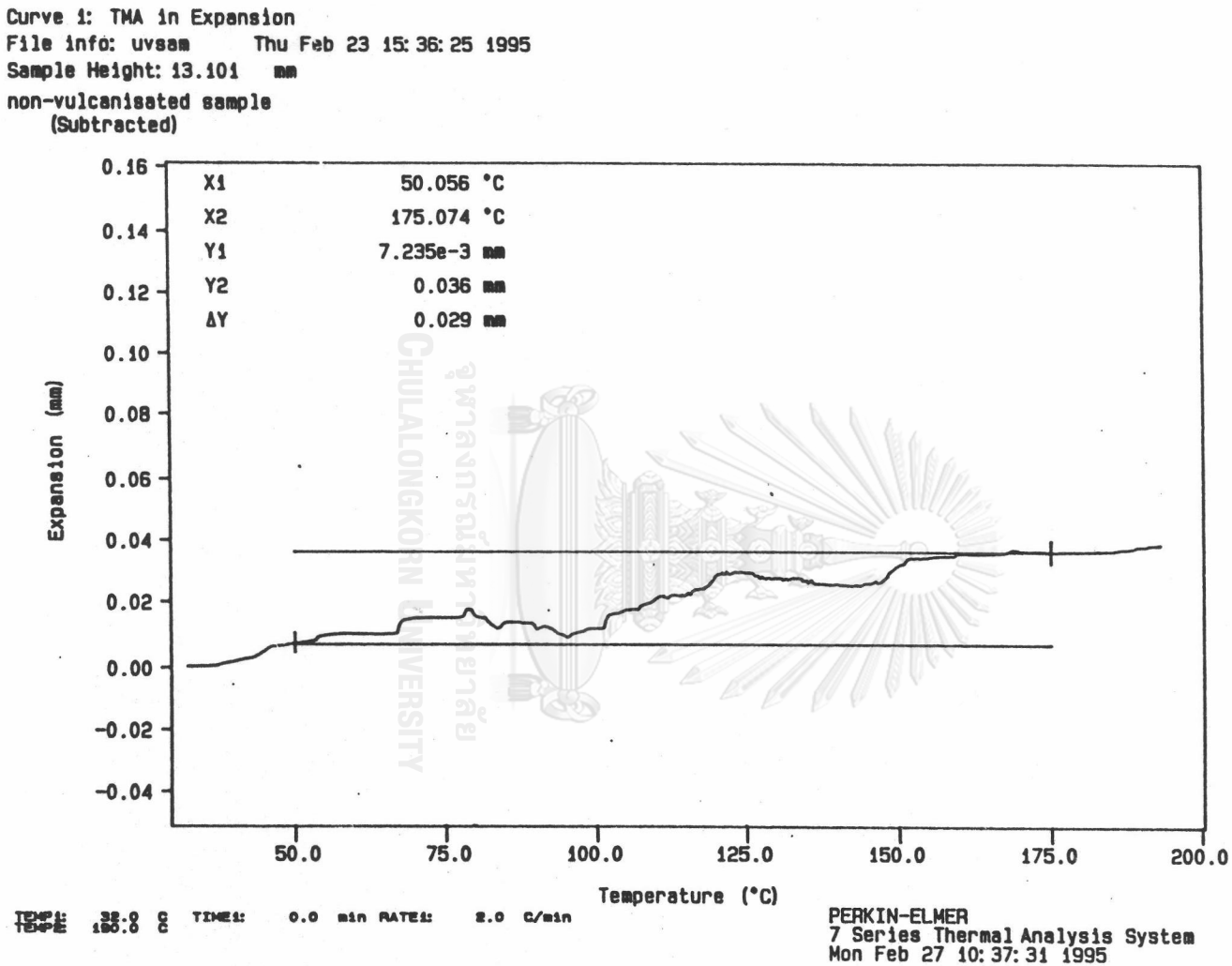

Figure 4.3 The results of expansion versus temperature change recording from TMA.

The expansion occuring in the sample during a temperature increase (T_1-T_2) can be obtained this equation.

EQUATION :

Equation for the amount of sample of sample expansion or contraction in going from temperature T_1 to temperature T_2

$$dV = \pi d^2/4 \, (dl_2 - dl_1)$$

Where ; d is the diameter of plunger and $(dl_2 - dl_1)$ is the change in probe position due to sample expansion going from temperature T_2 to T_1

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2. SPECIFIC HEAT VERSUS TEMPERATURE MEASUREMENT

EQUIPMENT AND ACCESSORY :

During this work the specific heat change with the temperature profile of rubber compound were measured by a Differential Scanning Calorimetery (DSC) and the accessory is personal computer workstation. These equipments are components of the PERKIN - ELMER 7 Series Thermal Analysis System.

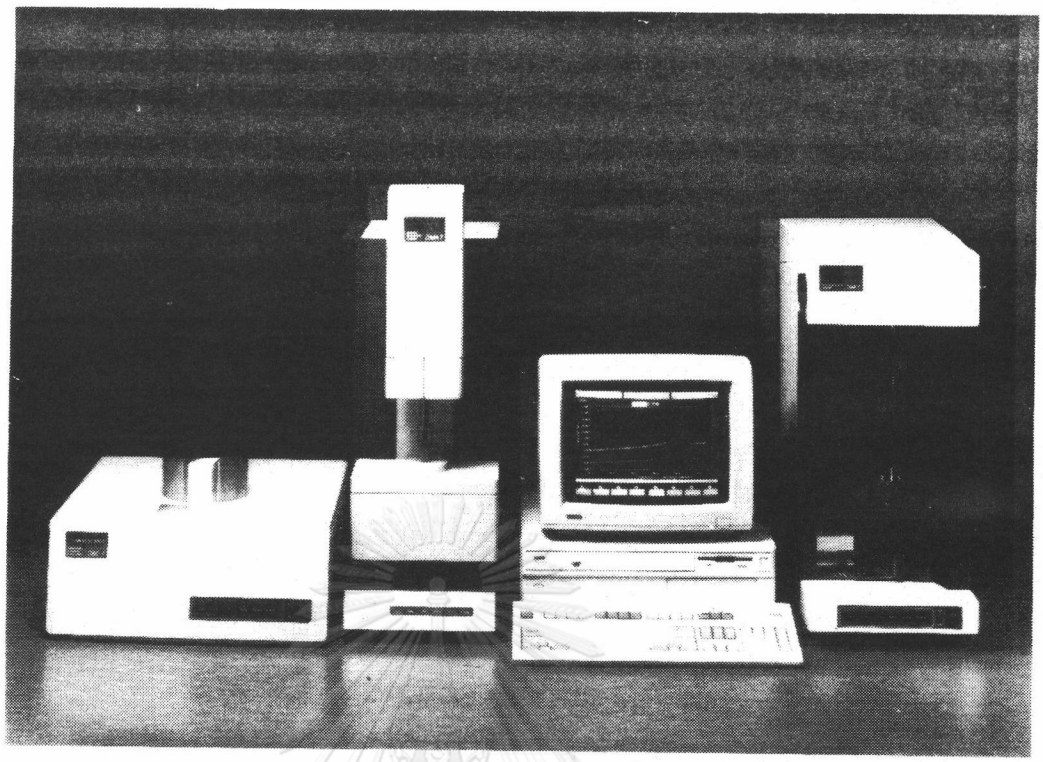

Figure 4.4 PERKIN - ELMER 7 SERIES : THERMAL ANALYSIS SYSTEM

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INSTRUCTION :

a.) Weight the sample in order of mg. and place in the specimen pan.

b.) The sample and specimen pan were covered by cover pan and took to the specimen plunger to cut offed and compact them.

c.) Programming temperature scanning are as following ;

Step 1. - To raise the temperature from 30 C to 50 C using scanning rate 10 C per minute.

Step 2. - Isothermal at temperature 50 C, maintain time 2 minutes.

Step 3. - To raise the temperature again from 50 C to 200 C due to heating rate 10 C per minute.

Step 4. - Isothermal again at temperature 200 C , time 2 minutes.

Step 5. - Shut down.

d.) Take emply pan (specimen pan) to platform of DSC. and running baseline at the same temperature programming.

e.) Take the sample to platform of DSC. and determined. Using the same temperature programming. The results obtained appear as the heat flow (mW,or mJ/s.) versus temperature change and the heat flow of sample had to substracted by the heat flow of baseline.

f.) Using computer to calculate specific heat.

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