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APPENDIX

A. CALCULATION OF EMPIRICAL THERMAL CONDUCTIVITY

From the empirical thermal diffusivity (D-Emp.) could be calculated the empirical thermal conductivity (K-Emp.) by this equation below ;

$$D = K/\rho Cp \qquad (A-1)$$

This value was represented quantity of heat flux transport through the tire. This experiment, the changing of tread compound properties during tire curing process were simulated to measure by thermal analyser. Those measurings were specific heat and density change with temperature. (see Fig. A.1 and A.2) The details of calculation shown in table 5.6 and 5.7. The empirical value had some correlation with temperature. But the literatures presented, thermal conductivity was calculated from overall range of temperature during curing process. This work also, calculating had been done based on vulcanizing temperature 125-150 °C. It found that the value as follows.

- For ideal boundary condition : 0.24 - 0.26 W/m.°C.

- For actual boundary condition : 1.25 - 1.36 W/m.°C.

Curve 1: TMA in Expansion
File info: uvsam   Thu Feb 23 15: 36: 25 1995
Sample Height: 13.101   mm
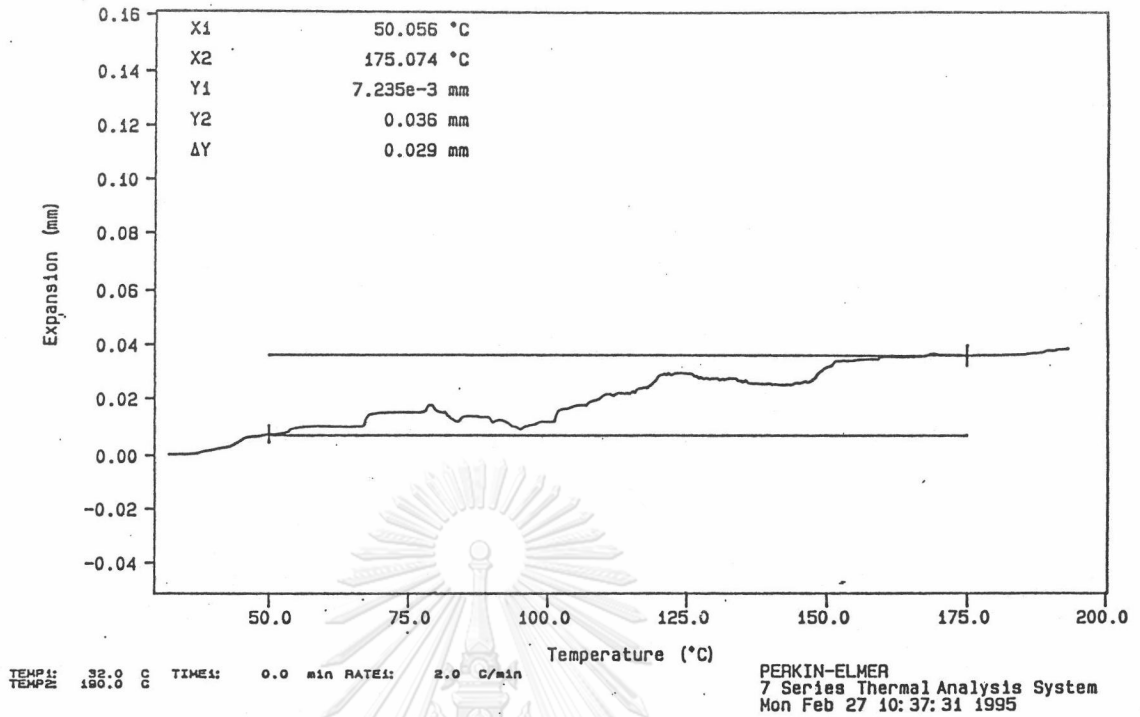non-vulcanisated sample
    (Subtracted)

X1	50.056 °C
X2	175.074 °C
Y1	7.235e-3 mm
Y2	0.036 mm
ΔY	0.029 mm

TEMP1: 32.0 C   TIME1:   0.0 min RATE1:   2.0 C/min

PERKIN-ELMER
7 Series Thermal Analysis System
Mon Feb 27 10: 37: 31 1995

Figure A.1 The expansion of tread compound during tire curing
                ; Simulation by TMA.

Curve 1: DSC
File info: tu5   Wed Mar 8 11: 09: 34 1995
Sample Weight: 5.120   mg
unvulcanize

1 unvulcanize: tu5
    Heat Flow (mW)   s: 1+3

2 baseline: base22mar
    Heat Flow (mW)   s: 1+3

3 unvulcanize: tu5
    Specific Heat (J/g°C)   s: 1+3

TEMP1: 50.0 C   TIME1: 1:0 min RATE1:   10.0 C/min
TEMP2: 200.0 C   TIME2: 1:0 min

PERKIN-ELMER
7 Series Thermal Analysis System
Wed Mar 8 11: 18: 24 1995
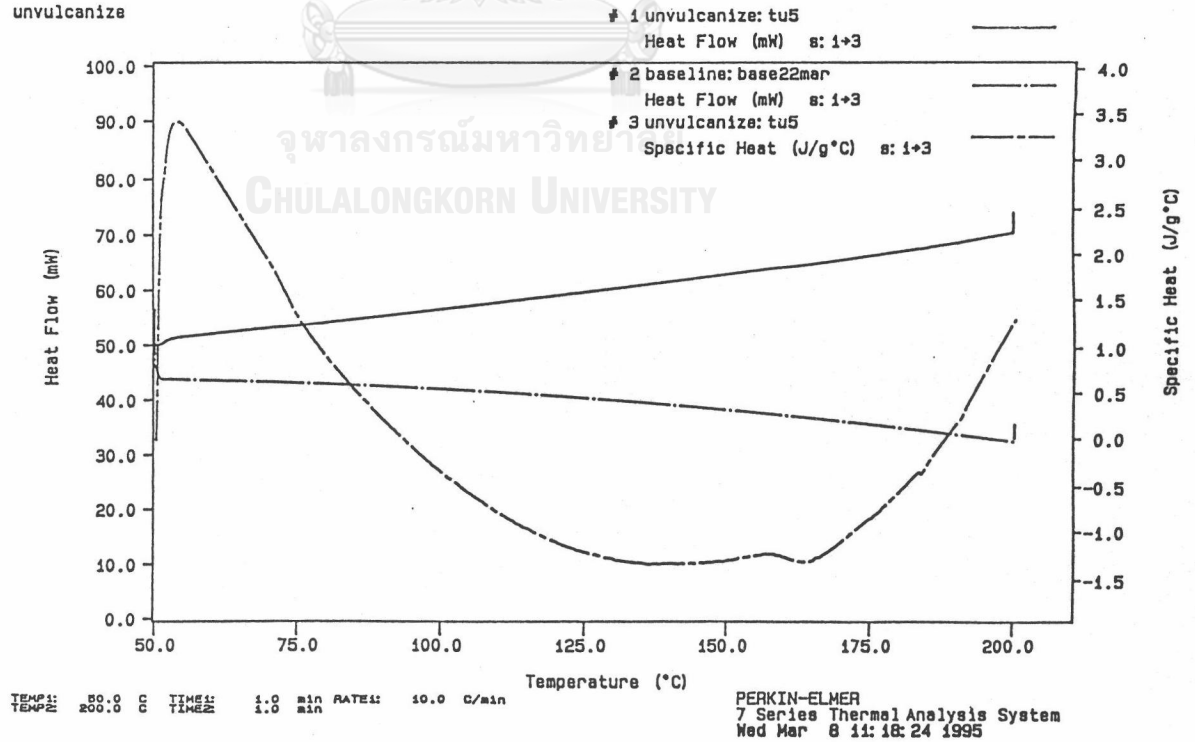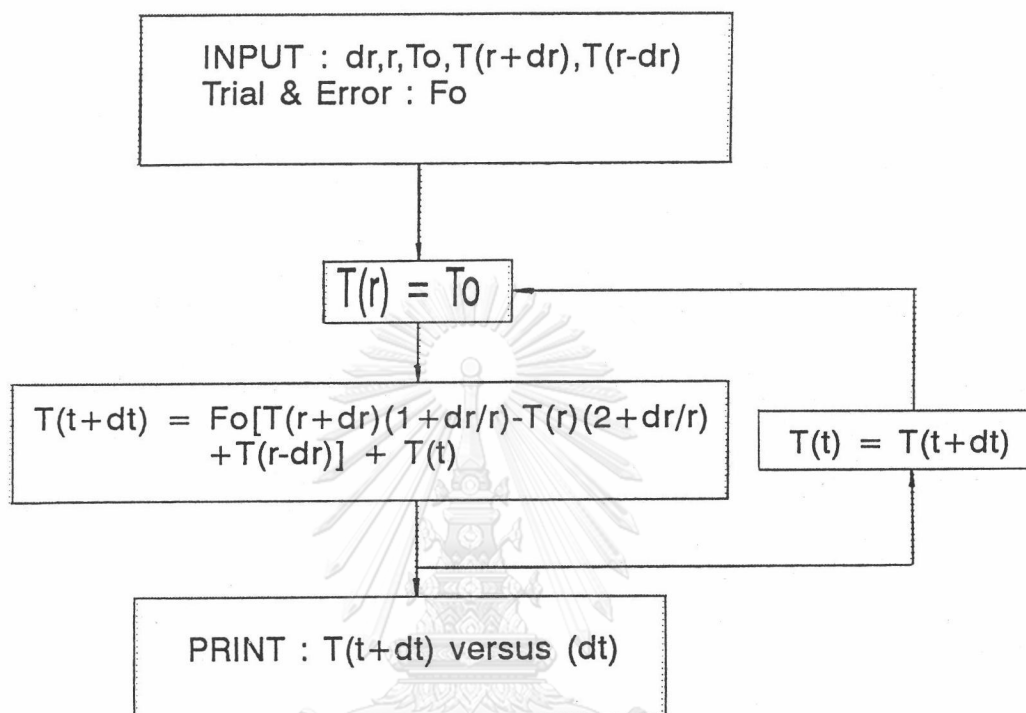
Figure A.2 The specific heat versus temperature profile

                for tread compound ; Measured by DSC.

B. Sample calculation by computer aided
Calculation flow chart

```
┌─────────────────────────────────────────┐
│ INPUT : dr,r,To,T(r+dr),T(r-dr)          │
│ Trial & Error : Fo                       │
└─────────────────────────────────────────┘
                    │
                    ▼
              ┌──────────┐
              │ T(r) = To │◄──────────────────┐
              └──────────┘                     │
                    │                          │
                    ▼                          │
┌─────────────────────────────────────┐  ┌──────────────┐
│ T(t+dt) = Fo[T(r+dr)(1+dr/r)-T(r)(2+dr/r) │ T(t) = T(t+dt) │
│         +T(r-dr)] + T(t)             │  └──────────────┘
└─────────────────────────────────────┘      ▲
                    │                          │
                    ▼                          │
┌─────────────────────────────────────┐      │
│ PRINT : T(t+dt) versus (dt)          │──────┘
└─────────────────────────────────────┘
```

From this flow chart, the calculation had been done on computer by using *LOTUS 123* application. Input data for calculation are including ;

- Initial and boundary condition : To , T(r+∆r) ,T(r-∆r)

- Time interval : ∆t

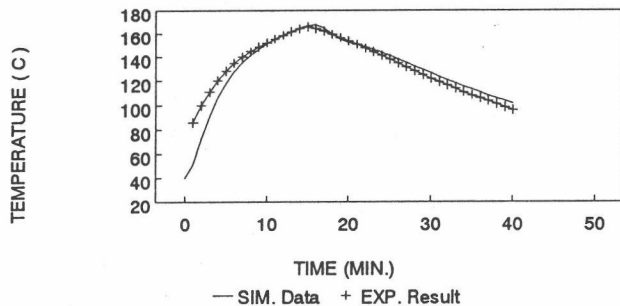- Dimension for specified under tread position : ∆r ,r

- Trial and Error : Fo

The running results are shown at next page.

T(r+dr)	T(r+dr)×(1+dr/r)	T(r)=T(t)	T(r)×(2+dr/r)	T(r−dr) = T(r+dr)			CURING TIME	
40.0	41.4	40.0	81.4	40.0	10.7	50.7	0.0	
75.3	77.9	50.7	103.2	65.7	21.5	72.2	1.0	85.8
95.5	98.8	72.2	146.8	76.7	18.8	90.9	2.0	99.7
110.5	114.3	90.9	185.0	93.0	15.1	106.1	3.0	110.9
122.2	126.4	106.1	215.7	106.9	12.1	118.1	4.0	120.4
130.8	135.3	118.1	240.3	118.3	9.5	127.6	5.0	128.4
137.8	142.5	127.6	259.6	127.7	7.6	135.2	6.0	135.0
143.6	148.5	135.2	275.1	135.3	6.4	141.6	7.0	140.3
148.3	153.4	141.6	288.1	141.9	5.2	146.9	8.0	144.9
152.3	157.5	146.9	298.8	147.3	4.5	151.4	9.0	148.9
155.8	161.1	151.4	307.9	152.0	3.9	155.2	10.0	152.3
159.1	164.6	155.2	315.8	156.0	3.6	158.8	11.0	155.6
162.0	167.6	158.8	323.1	159.8	3.3	162.1	12.0	158.7
164.3	169.9	162.1	329.7	163.3	2.7	164.8	13.0	161.7
166.3	172.0	164.8	335.2	166.2	2.3	167.0	14.0	164.3
168.0	173.8	167.0	339.8	168.6	0.6	167.6	15.0	166.1
167.9	173.7	167.6	341.0	167.5	−2.7	164.9	16.0	164.6
162.5	168.1	164.9	335.5	160.8	−5.0	159.9	17.0	162.3
156.2	161.6	159.9	325.3	155.4	−4.4	155.5	18.0	159.4
152.3	157.5	155.5	316.3	153.2	−2.8	152.7	19.0	156.6
150.3	155.5	152.7	310.6	152.1	−1.9	150.8	20.0	153.7
148.4	153.5	150.8	306.7	150.6	−2.0	148.8	21.0	150.8
146.3	151.3	148.8	302.7	148.5	−2.2	146.6	22.0	147.6
143.9	148.8	146.6	298.1	146.0	−2.6	144.0	23.0	144.6
141.4	146.3	144.0	292.9	143.1	−2.8	141.2	24.0	141.4
138.7	143.5	141.2	287.2	139.9	−2.9	138.3	25.0	138.0
135.9	140.6	138.3	281.3	136.8	−3.0	135.3	26.0	134.8
133.0	137.6	135.3	275.2	133.5	−3.0	132.3	27.0	131.5
130.2	134.7	132.3	269.0	130.4	−2.9	129.3	28.0	128.2
127.4	131.8	129.3	263.1	127.4	−2.9	126.4	29.0	125.0
124.7	129.0	126.4	257.2	124.4	−2.9	123.6	30.0	122.0
122.1	126.3	123.6	251.4	121.4	−2.8	120.8	31.0	119.0
119.4	123.5	120.8	245.8	118.5	−2.7	118.2	32.0	116.3
117.1	121.1	118.2	240.4	115.9	−2.5	115.6	33.0	113.8
114.7	118.6	115.6	235.2	113.2	−2.6	113.0	34.0	110.8
112.1	115.9	113.0	230.0	110.4	−2.6	110.5	35.0	108.1
109.8	113.6	110.5	224.8	107.9	−2.4	108.1	36.0	105.7
107.6	111.3	108.1	219.9	105.5	−2.3	105.8	37.0	103.4
105.4	109.0	105.8	215.3	103.2	−2.3	103.6	38.0	100.7
103.3	106.8	103.6	210.7	100.9	−2.1	101.5	39.0	98.2
101.2	104.7	101.5	206.4	98.8	−2.1	99.4	40.0	96.0
99.3	102.7	99.4	202.1	96.7	−1.9	97.4	41.0	93.9
97.5	100.8	97.4	198.2	94.8	−1.8	95.7	42.0	92.2
95.9	99.2	95.7	194.6	93.1	−1.1	94.5	43.0	
95.6	98.9	94.5	192.3	92.7	−0.2	94.4	44.0	
94.7	97.9	94.4	191.9	93.0	−1.2	93.2	45.0	
92.9	96.1	93.2	189.6	91.2		93.2	46.0	
	0.0	93.2	189.6	96.2		93.2	47.0	
						0.0	48.0	
						0.0	49.0	

dr = 11.4 MM.   dr/r = 0.0343

r = 332.25 MM.

GRAPH SHOWN SIMULATION vs. EXPERIMENTAL
SPECIMEN : Tire No. # 1

— SIM. Data   + EXP. Result

Fo = 0.4175

บริษัท ยางสยาม จำกัด

STEELBELTED RADIAL TYRE PROCESS

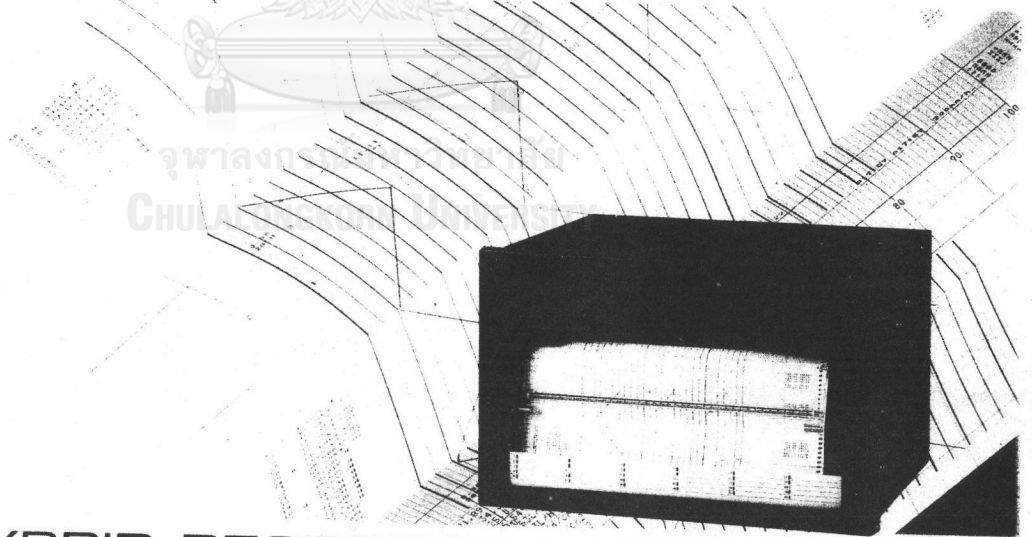กรรมวิธีการผลิตยางเรเดียลล้อเสริมเส้นใยเหล็ก

Appendix C.   FIGURE SHOWS STEELBELTED RADIAL TYRE PROCESS
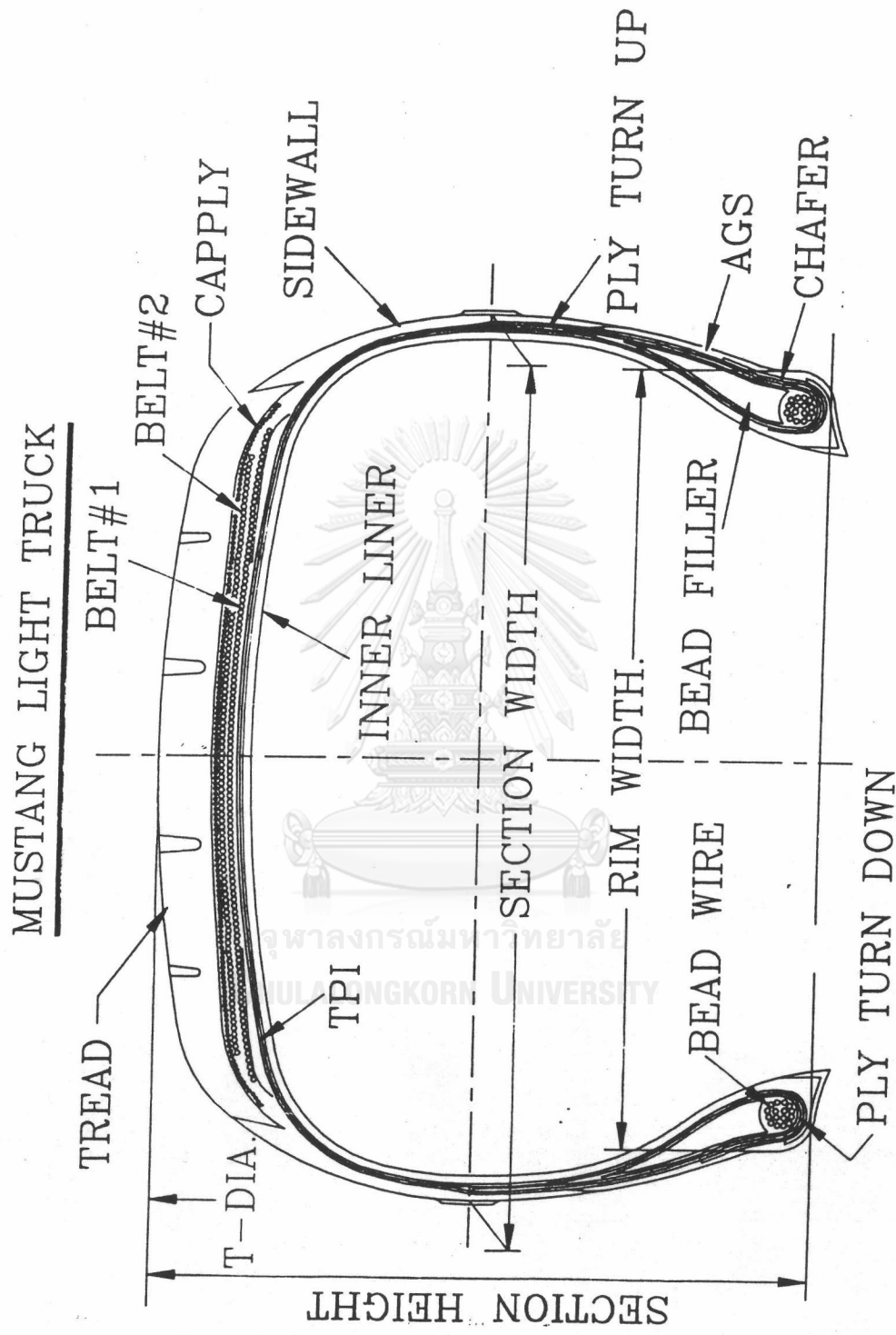
YOKOGAWA

High-speed scanning of 30 points/s
High-speed recording of 60 points/2 s
Ten-color analog traces

HYBRID RECORDER HR 2400

Appendix D. FIGURE SHOWS DATA RECORDER YOKOGAWA HR-2400

MUSTANG LIGHT TRUCK

TREAD
BELT#1
BELT#2
CAPPLY
SIDEWALL
PLY TURN UP
AGS
CHAFER
INNER LINER
SECTION WIDTH
RIM WIDTH.
BEAD FILLER
TPI
BEAD WIRE
PLY TURN DOWN
T-DIA.
SECTION HEIGHT

Appendix E. FIGURE SHOWS CROSS-SECTION TIRE OF LIGHT TRUCK RADIAL

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