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ANNEXES

ANNEX I

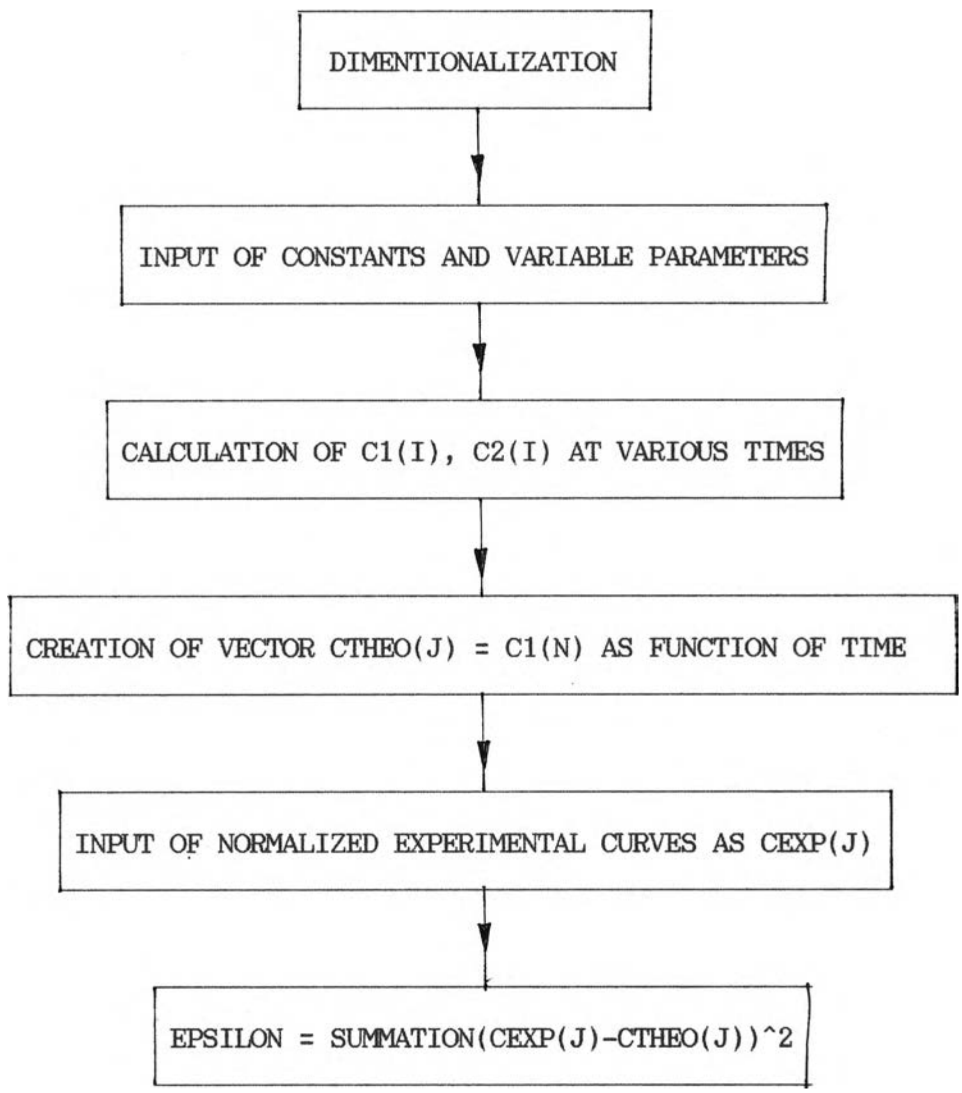
THE OPTIMIZATION PROGRAM

The following is the flow diagram and the actual computer program for the optimization written in BASIC for use on a microcomputer. What the program does is as follows, it reads in a normalized set of points obtained from an experimental tracer response curve, comprising for example of 67 points; the program then continues by reading in values of certain parameters and then generates using the theoretical model a set of points corresponding to a theoretical curve also on the same number of points which is again normalized; the program finally sums the square of the difference between both normalized curves and obtains the criteria Epsilon of the optimization.

Then by varying the values of the parameters which we add into the theoretical model it is possible to obtain different values of the criteria. And the smallest criteria indicates the best fit between theory and experiment. This optimization is best accomplished manually if done on a microcomputer for this type of problem.

To be presented below is the flow diagram of the computer program followed by one version of the computer program written in BASIC.

FLOW DIAGRAM



THE COMPUTER PROGRAM

```
10    DIM C1(50), C2(50)
20    DIM CA1(50), CA2(50)
30    DIM CTHEO(200), CEXP(200)
190   REM DETERMINATION OF EPSILON
200   K = 0
210   GOSUB 1000
220   EPS1 = EPSILON : PRINT "EPS1 ="; EPS1
225   LPRINT "K, D1, EPS1"
230   LPRINT  K, D1, EPS1
240   K = K+1
250   GOSUB 1000
255   EPS2 = EPSILON : PRINT "EPS2 ="; EPS2
260   LPRINT "K, D1, EPS2"
261   LPRINT  K, D1, EPS2
270   IF EPS1 > EPS2 THEN 300
280   IF ABS(EPS1 - EPS2) <= .001 THEN 400
290   IF K >= 50 THEN 400
300   EPS1 = EPS2
310   GOTO 240
400   END
1000  REM PROGRAM TRACER IN NON-FLOW SYSTEM
1010  REM N = L1/DZ, M = L2/DZ
1013 A2 = 170.8 : DZ = 2
1014 CONT = 1000
```

```
1015 INPUT "A1 ="; A1 : INPUT "DT ="; DT : INPUT "D1 ="; D1
1016 INPUT "D2 ="; D2 : INPUT "N ="; N : INPUT "M ="; M
1017 JMAX = 360/DT
1018 LPRINT "A1 ="; A1,"A2 =";A2, "DZ =";DZ, "DT =";DT
1019 LPRINT "D1 ="; D1, "D2 ="; D2, "N ="; N, "M ="; M
1020 LPRINT "CONT ="; CONT
1030 ALPHA = D1*DT/DZ^2
1040 BETA = D2*DT/DZ^2
1043 GAMMA = A1*D1/A2/D2
1045 DELTA = A1/A2
1050 J = 0 : Q = 1
1060 CA1(1) = CONT
1070 FOR I = 2 TO N : CA1(I) = 0 : NEXT I
1080 FOR K = 1 TO M : CA2(K) = 0 : NEXT K
1081 CTHEO(Q) = CA1(N)
1082 PRINT "CTHEO(Q) ="; CTHEO(Q)
1090 J = J + 1
1100 IF J > JMAX THEN 1530
1110 FOR I = 2 TO N - 1
1120 C1(I) = ALPHA*CA1(I+1)-2*ALPHA*CA1(I)+ALPHA*CA1(I-1)+CA1(I)
1130 NEXT
1140 C1(1) = [4*C1(2)-C1(3)]/3
1150 FOR K = 2 TO M - 1
1160 C2(K) = BETA*CA2(K+1)-2*BETA*CA2(K)+BETA*CA2(K-1)+CA2(K)
1170 NEXT
1180 C1(N) = [GAMMA*C1(N-1)+C2(2)]/(GAMMA+DELTA)
1190 C2(1) = DELTA*C1(N)
```

```
1200 C2(M) = C2(M-1)
1210 FOR I = 1 TO N : CA1(I) = C1(I) : NEXT I
1220 FOR K = 1 TO M : CA2(K) = C2(K) : NEXT K
1500 JSAMP = 12/DT
1503 JJJ = J : XJ = JJJ/JSAMP : JJ = INT(XJ)
1504 IF XJ = JJ THEN 1520
1515 IF J <= JMAX THEN 1090
1520 Q = Q + 1
1521 CTHEO(Q) = CA1(N)
1522 PRINT "CTHEO(Q) ="; CTHEO(Q)
1525 IF J <= JMAX THEN 1090
1530 REM CALCULATION OF EPSILON
1540 EPSILON = 0
1541 DATA
1542 DATA
1543 DATA
1565 FOR Q = 1 TO 31
1567 READ CEXP(Q)
1568 NEXT
1569 INPUT "CMAX ="; CMAX
1570 FOR Q = 1 TO 31
1571 EPSILON = EPSILON + (CEXP(Q) - CTHEO(Q)/CMAX)^2
1580 NEXT
1590 RESTORE
1591 PRINT "EPSILON ="; EPSILON
1600 LPRINT "EPSILON ="; EPSILON
1610 RETURN
```

ANNEX II

THE LEAST SQUARE PROGRAM

The following two short programs are least square programs that are used to obtain a general line of the type y = Ax + B passing through a set of N data points and a general line of the type y = Ax passing through a set N data points.

```
10  REM LEAST SQUARE PROGRAM ON A POINTS, 2 DIMENSIONS
20  REM THIS PROGRAM CALCULATES THE COEFFICIENTS A, B IN
30  REM THE GENERAL STRAIGHT LINE EQUATION Y = AX + B PASSING
40  REM THROUGH  N  DATA POINTS WITH COORDINATES Xi,Yi.
50  REM A = [SUM(X)*SUM(Y)-N*SUM(X*Y)]/DENOM
60  REM B = [SUM(X)*SUM(X*Y)-SUM(Y)*SUM(X*Y)]/DENOM
70  REM DENOM = [SUM(X)]^2 - N*SUM(X*Y)
80  REM
90  INPUT "N =";N
100 DIM X(N), Y(N)
110 FOR I=1 TO N :INPUT"X(N) =";X(I) :NEXT I :PRINT"X'S ALL OK"
120 FOR I=1 TO N :INPUT"Y(N) =";Y(I) :NEXT I :PRINT"Y'S ALL OK"
121 LPRINT"N =";N :FOR I= TO N :LPRINT X(I),Y(I) : NEXT I
122 FOR I=1TO N:ZX=X(I):X(I)=LOG(ZX):ZY=Y(I):Y(I)=LOG(ZY):NEXT I
130 SUM=0 : FOR I=1 TO N : SUM=SUM+X(I) : NEXT I : SUMX = SUM
140 SUM=0 : FOR I=1 TO N : SUM=SUM+Y(I) : NEXT I : SUMY = SUM
150 SUM=0 :FOR I=1 TO N :SUM=SUM+X(I)*X(I): NEXT I: SUMXX=SUM
160 SUM=0 : FOR I=1 TO N;SUM=SUM+X(I)*Y(I):NEXT I :SUMXY=SUM
```

```
170 DENOM=SUMX*SUMX-N*SUMXX

180 A = (SUMX*SUMY-N*SUMXY)/DENOM : LPRINT A

190 B = ( SUMX*SUMXY-SUMY*SUMXX)/DENOM : LPRINT B

200 END
```

```
10  REM LEAST SQUARE PROGRAM ON N POINTS, 2 DIMENSIONS
20  REM THIS PROGRAM CALCULATES THE COEFFICIENT A IN THE
30  REM GENERAL STRAIGHT LINE EQUATION Y = AX PASSING THROUGH
40  REM N DATA POINTS COORDINATES Xi,Yi.
50  REM A = SUM(X*Y)/SUM(X*X)
60  INPUT "N =";N
70  DIM X(N),Y(N),AF(N),A1(N),H(N)
80  INPUT "B =";B
81  INPUT "C =";C
82 INPUT "D =";D
90  FOR I=1 TO N :READ Y(I) : NEXT I
91  DATA 1.52,1.78,1.9,3.65,4.02,4.8,8.9,13.6,18.2,1.57,1.5
92  DATA 1.55,1.75,2.24,2.7,1.3,17,18.4,.77,.9,.89,.95,2.19
93  DATA 2.45,10.4,12,12.2
100 FOR I=1 TO N : READ Y(I) : NEXT I
101 DATA .47,.53,.59,.87,.95,1.05,2.42,2.63,2.91,.47,.53,.59
102 DATA .87,.95,1.05,2.91,2.63,2.42,.47,.53,.59,.87,.95,1.05
103 DATA 2.42,2.63,2.91
110 FOR  I=1 TO N : READ A1(I) : NEXT I
111 DATA 78.54,78.54,78.54,44.18,44.18,44.18,15.9,15.9,15.9
112 DATA 78.54,78.54,78.54,44.18,44.18,44.18,15.9,15.9,15.9
113 DATA 78.54,78.54,78.54,44.18,44.18,44.18,15.9,15.9,15.9
120 FOR I=1 TO N : READ H(I) : NEXT I
121 DATA 6.25,6.25,6.25,6.25,6.25,6.25,6.25,6.25,6.25,3.75
122 DATA 3.75,3.75,3.75,3.75,3.75,3.75,3.75,3.75,2.5,2.5,2.5
123 DATA 2.5,2.5,2.5,2.5,2.5,2.5,2.5
130 FOR I=1 TO N : X(I)=AF(I)^B*A1(I)^C*H(I)^D : NEXT I
```

```
140 SUM=0 :FOR I=1 TO N:SUM=SUM+X(I)*Y(I) : NEXT I :SUMXY=SUM

150 SUM=0 :FOR I=1 TO N:SUM=SUM+X(I)*X(I) : NEXT I :SUMXX=SUM

160 A=SUMXY/SUMXX : LPRINT A

170 FOR I=1 TO N : LPRINT Y(I),X(I) : NEXT I

180 END
```

AUTOBIOGRAPHY

Sangnuan Hongsirinirachorn was born on April 9, 1958 in Bangkok, Thailand. She received her Bachelor of Science Degree in mical Engineering from Chulalongkorn University, Thailand, in 1980.