G e n e r a l A l g e b r a i c M o d e l i n g S y s t e m
C o m p i l a t i o n

```
 3
 4  positive variables x1,x2,x3,x4,x5,x6,x7;
 5  variables f,et,p,b,g,pro,feed,k ;
 6  equations profit,ethylene,propylene,butene,gasoil,procost,feedcost,ccap,
                                        pcap,ecap,prec,erec,thv;
 7
 8  profit.. f =e= pro - feed ;
 9  ethylene..et =e= 17.75*((.5*x1) +(.5*x5)+(.35*x2)+(.35*x6)+(.2*x3)
                                                  +(.25*x4));
10  propylene..p =e= 13.79*((0.01*x1)+(.01*X5)+(.15*x2)+(.15*x6)+(.15*x3)
                                                  +(.18*x4));
11  butene..b =e= 26.64*((.01*x1)+(.01*x5)+(.02*x2)+(.02*x6)+(.04*x3)+(.05*x4)
                                                  );
12  gasoil.. g =e= 9.93*((.01*x1)+(.01*x5)+(.07*x2)+(.07*x6)+(.25*x3)+(.3*x4))
                                                  ;
13  procost.. pro =e= et + p + b + g ;
14  feedcost.. feed =e= ((6.55*x1)+(9.73*x2)+(12.5*x3)+(10.14*x4));
15  ccap..((1.1*x1)+(.9*x2)+(.9*x3)+(1.0*x4)+(1.1*x5)+(.9*x6))=l=200000;
16  ecap..((0.5*x1)+(0.35*x2)+(0.25*x3)+(0.25*x4)+(0.5*x5)+(0.35*x6))
                                                  =l=(100000);
17  pcap.. ((.01*x1)+(.15*x2)+(.15*x3)+(.18*x4)+(.01*x5)+(.15*x6))=l=(20000);
18  erec..x5 =e= ((.4*x1)+(.4*x5)+(.06*x2)+(.06*x6)+(.04*x3)+(.05*x4));
19  prec.. x6 =e= ((.1*x2)+(.1*x6)+(.01*x3)+(.01*x4));
20  thv..20000000=e=((-6857*x1)+(364*x2)+(2032*x3)-(1145*x4)-(6857.6*x5)
                                        +(364*x6)+(21520*x7));
    Retrieve(cracking.dat)
    Retrieve(cracking.bas)
    Retrieve(cracking.exe)
    #include <stdio.h>
    #include <conio.h>
    #include<math.h>
    #define N 10
    #define NS 200
    int m,nc=8;
    double fun[N],dt[4],fs;
    double x=0.0;
    float f[N];
    void main(void)
    {

    int i,j;
```

```
double w[N],coilrate,h,length,l0[N],l1[N],l2[N],l3[N],dumf[N];
double pw[N],pf[N], sum,conv,z;
float temp,frate,ws;
void eval(void);
clrscr();

dt[0]=0.635; dt[1]=0.698; dt[2]=0.762; dt[3]=0.826;

for(i=1;i<=nc;i++)
{ w[i]=0; f[i]=0; }

printf("Enter feedrate in kg/hr per zone \n");
scanf("%f",&frate);
coilrate=frate/8.0;
```

```
printf("Enter dilution steam flow rate in kg/hr per zone\n");
scanf("%f",&ws);
fs=(ws/144)*1000;

length=477.8;

printf("Enter composition of feedstock in wt%\n");
printf("Component\t\t Weight%\n");
printf("Methane\t\t\t");scanf("%f",&temp);w[4]=temp;
printf("Ethane\t\t\t");scanf("%f",&temp);w[1]=temp;
printf("Ethylene\t\t");scanf("%f",&temp);w[2]=temp;
printf("Propylene\t\t");scanf("%f",&temp);w[5]=temp;
printf("Propane\t\t\t");scanf("%f",&temp);w[6]=temp;

f[1]=(w[1]*coilrate*10)/30.0;
f[2]=(w[2]*coilrate*10)/28.0;
f[4]=(w[4]*coilrate*10)/16.0;
f[5]=(w[5]*coilrate*10)/42.0;
f[6]=(w[6]*coilrate*10)/44.0;


h=length/NS;
z=NS/4;

for(m=0;m<4;m++)
{
 for(j=0;j<z;j++)
 {


  for(i=1;i<=nc;i++)
   { dumf[i]=f[i];}

  eval();

  for(i=1;i<=nc;i++)
   { l0[i]=h*fun[i]; }

  x=x+h/2.0;
```

```
for(i=1;i<=nc;i++)
 {f[i]=dumf[i]+l0[i]/2.0;}

eval();

for(i=1;i<=nc;i++)
 { l1[i]=h*fun[i]; }

for(i=1;i<=nc;i++)
 {f[i]=dumf[i]+l1[i]/2.0;}

eval();

for(i=1;i<=nc;i++)
```

```
    { l2[i]=h*fun[i]; }

   x=x+h/2.0;

   for(i=1;i<=nc;i++)
    {f[i]=dumf[i]+l2[i];}

   eval();

   for(i=1;i<=nc;i++)
    { l3[i]=h*fun[i];
      f[i]=dumf[i]+(l0[i]+2*l1[i]+2*l2[i]+l3[i])/6.0;
    }
  }
 }

sum=0.0;

pw[1]=30*f[1]; pw[2]=28*f[2];
pw[3]=2*f[3]; pw[4]=16*f[4];
pw[5]=42*f[5]; pw[6]=44*f[6];
pw[7]=26*f[7]; pw[8]=54*f[8];

for(i=1;i<=nc;i++)
{ sum=sum+pw[i];}

for(i=1;i<=nc;i++)
{ pf[i]=(pw[i]*100.0)/sum;}

printf("The Product Composition in wt%% is:\n");
printf("Component\t\t Weight%");
printf("\nHydrogen\t\t %.3f",pf[3]);
printf("\nMethane\t\t\t %.3f",pf[4]);
printf("\nAcetylene\t\t %.3f",pf[7]);
printf("\nEthylene\t\t %.3f",pf[2]);
printf("\nEthane\t\t\t %.3f",pf[1]);
printf("\nPropylene\t\t %.3f",pf[5]);
printf("\nPropane\t\t\t %.3f",pf[6]);
printf("\nButadiene\t\t %.3f",pf[8]);

conv=((w[1]-pf[1])*100)/w[1];
```

```
printf("\nThe percentage conversion is: %.3f",conv);

getche();
return;

}

void eval(void)
{
 int i;
 double r,rr,rt,prt,ft,kc1,kc5,kc4;
 double k1,k2,k5,k6,k8,k3,k4,k7,r1,r2,r3,r4,r5,r6,r8,r7,p,t,c;
```

```
      ft=0.0;
      t=969.81+1.05495*x-59.6595e-4*x*x+17.8821e-6*pow(x,3)-17.9787e-
9*pow(x,4)
                                                              ;
      p=(3.29441-43.2254e-4*x+4.656734e-6*x*x-3.63109e-9*pow(x,3))/1.01325;

      r=0.0821;
      rr=1.987;
      rt=rr*t/1000.0;
      prt=p/(r*t);
      for(i=1;i<=nc;i++)
      { ft=ft+f[i]; }
      ft=ft+fs;
      c=M_PI*dt[m]*dt[m]*900;

      kc1=5.48e4*exp(-32.58/rt);
      kc5=1.91e4*exp(-30.16/rt);
      kc4=0.138;
      k1=4.652e13*exp(-65.20/(rt));
      k2=3.85e11*exp(-65.25/(rt));
      k3=4.692e10*exp(-50.6/(rt));
      k4=5.888e10*exp(-51.29/(rt));
      k5=9.814e8*exp(-36.92/(rt));
      k6=1.026e12*exp(-41.26/(rt));
      k7=1.514e11*exp(-55.8/rt);
      k8=7.083e13*exp(-60.43/(rt));

      r1=k1*((f[1]*prt/ft)-(f[2]*f[3]*prt*prt)/(ft*ft*kc1));
      r2=k2*(f[1]*prt/ft);
      r3=k3*(f[6]*prt/ft);
      r4=k4*(f[6]*prt/ft)-((f[5]*f[3]*prt*prt)/(ft*ft*kc4));
      r5=k5*((f[5]*prt)/ft-(f[7]*f[4]*prt*prt)/(ft*ft*kc5));
      r6=k6*((f[7]*f[2]*prt*prt)/(ft*ft));
      r7=k7*(f[5]*prt/ft);
      r8=k8*((f[1]*f[2]*prt*prt)/(ft*ft));

      fun[1]=-1*c*(r1+2*r2+r8);
      fun[2]=c*(r1-r6-r8+r3+3*r7);
      fun[3]=c*(r1+r4);
      fun[4]=c*(r2+r8+r5+r3);
      fun[5]=c*(r8-r5+r4-2*r7);
```

```
      fun[6]=c*(r2-r3-r4);
      fun[7]=c*(r5-r6);
      fun[8]=c*r6;
     /* printf("k1=%.3f  k2=%.3f  k5=%.3f  k6=%.3f  k8=%.3f",k1,k2,k5,k6,k8);*/
      return;
     }
 208   model cracking /all/;
 209   solve cracking using lp maximizing f;
 210   display f.l,x1.l,x2.l,x3.l;

**** LIST OF STRAY NAMES - CHECK DECLARATIONS FOR SPURIOUS
COMMAS
**** STRAY NAME k OF TYPE VAR


COMPILATION TIME     =        0.000 SECONDS    0.7 Mb      WIN200-121
```

---- profit =E=

profit.. f - pro + feed =E= 0 ; (LHS = 0)

---- ethylene =E=

ethylene.. - 8.875*x1 - 6.2125*x2 - 3.55*x3 - 4.4375*x4 - 8.875*x5

     - 6.2125*x6 + et =E= 0 ; (LHS = 0)

---- propylene =E=

propylene.. - 0.1379*x1 - 2.0685*x2 - 2.0685*x3 - 2.4822*x4 - 0.1379*x5

     - 2.0685*x6 + p =E= 0 ; (LHS = 0)

---- butene =E=

butene.. - 0.2664*x1 - 0.5328*x2 - 1.0656*x3 - 1.332*x4 - 0.2664*x5

     - 0.5328*x6 + b =E= 0 ; (LHS = 0)

---- gasoil =E=

gasoil.. - 0.0993*x1 - 0.6951*x2 - 2.4825*x3 - 2.979*x4 - 0.0993*x5

     - 0.6951*x6 + g =E= 0 ; (LHS = 0)

---- procost =E=

procost.. - et - p - b - g + pro =E= 0 ; (LHS = 0)

---- feedcost =E=

feedcost.. - 6.55*x1 - 9.73*x2 - 12.5*x3 - 10.14*x4 + feed =E= 0 ; (LHS = 0)

---- ccap =L=

ccap.. 1.1*x1 + 0.9*x2 + 0.9*x3 + x4 + 1.1*x5 + 0.9*x6 =L= 200000 ; (LHS = 0)

---- pcap =L=

pcap.. 0.01*x1 + 0.15*x2 + 0.15*x3 + 0.18*x4 + 0.01*x5 + 0.15*x6 =L= 20000 ;

     (LHS = 0)

---- ecap =L=

ecap.. 0.5*x1 + 0.35*x2 + 0.25*x3 + 0.25*x4 + 0.5*x5 + 0.35*x6 =L= 100000 ;

     (LHS = 0)

---- prec =E=

prec.. - 0.1*x2 - 0.01*x3 - 0.01*x4 + 0.9*x6 =E= 0 ; (LHS = 0)

---- erec =E=

erec.. - 0.4*x1 - 0.06*x2 - 0.04*x3 - 0.05*x4 + 0.6*x5 - 0.06*x6 =E= 0 ;

     (LHS = 0)

---- thv =E=

thv.. 6857*x1 - 364*x2 - 2032*x3 + 1145*x4 + 6857.6*x5 - 364*x6 - 21520*x7

=E= -2.000000E+7 ; (LHS = 0, INFES = 2.0000000E+7 ***)

---- x1

x1
(.LO, .L, .UP = 0, 0, +INF)
-8.875 ethylene
-0.1379 propylene
-0.2664 butene
-0.0993 gasoil
-6.55 feedcost
1.1 ccap
0.01 pcap
0.5 ecap
-0.4 erec
6857 thv

---- x2

x2
(.LO, .L, .UP = 0, 0, +INF)
-6.2125 ethylene
-2.0685 propylene
-0.5328 butene
-0.6951 gasoil
-9.73 feedcost
0.9 ccap
0.15 pcap
0.35 ecap
-0.1 prec
-0.06 erec
-364 thv

---- x3

x3
(.LO, .L, .UP = 0, 0, +INF)
-3.55 ethylene

-2.0685 propylene
-1.0656 butene
-2.4825 gasoil
-12.5 feedcost
0.9 ccap
0.15 pcap
0.25 ecap
-0.01 prec
-0.04 erec
-2032 thv

---- x4

x4
(.LO, .L, .UP = 0, 0, +INF)
-4.4375 ethylene
-2.4822 propylene
-1.332 butene
-2.979 gasoil
-10.14 feedcost
1 ccap
0.18 pcap
0.25 ecap
-0.01 prec
-0.05 erec
1145 thv

---- x5

x5
(.LO, .L, .UP = 0, 0, +INF)
-8.875 ethylene
-0.1379 propylene
-0.2664 butene
-0.0993 gasoil
1.1 ccap
0.01 pcap
0.5 ecap
0.6 erec
6857.6 thv

---- x6

x6
(.LO, .L, .UP = 0, 0, +INF)
-6.2125 ethylene
-2.0685 propylene

-0.5328 butene
-0.6951 gasoil
0.9 ccap
0.15 pcap
0.35 ecap
0.9 prec
-0.06 erec
-364 thv

---- x7

x7
(.LO, .L, .UP = 0, 0, +INF)
-21520 thv

---- f

f
(.LO, .L, .UP = -INF, 0, +INF)
1 profit

---- et

et
(.LO, .L, .UP = -INF, 0, +INF)
1 ethylene
-1 procost

---- p

p
(.LO, .L, .UP = -INF, 0, +INF)
1 propylene
-1 procost

---- b

b
(.LO, .L, .UP = -INF, 0, +INF)
1 butene
-1 procost

---- g

g

(.LO, .L, .UP = -INF, 0, +INF)

1 gasoil

-1 procost

---- pro

pro
(.LO, .L, .UP = -INF, 0, +INF)
-1 profit
1 procost

---- feed

feed
(.LO, .L, .UP = -INF, 0, +INF)
1 profit
1 feedcost

MODEL STATISTICS

BLOCKS OF EQUATIONS 13 SINGLE EQUATIONS 13
BLOCKS OF VARIABLES 14 SINGLE VARIABLES 14
NON ZERO ELEMENTS 76

GENERATION TIME = 0.060 SECONDS 1.4 Mb WIN200-121

EXECUTION TIME = 0.060 SECONDS 1.4 Mb WIN200-121

S O L V E S U M M A R Y

MODEL cracking OBJECTIVE f
TYPE LP DIRECTION MAXIMIZE
SOLVER BDMLP FROM LINE 209

**** SOLVER STATUS 1 NORMAL COMPLETION
**** MODEL STATUS 1 OPTIMAL
**** OBJECTIVE VALUE 990654.5455

RESOURCE USAGE, LIMIT 0.059 1000.000
ITERATION COUNT, LIMIT 5 10000

BDMLP 1.3 Mar 21, 2001 WIN.BD.NA 20.0 056.043.039.WAT

Originally developed by
A. Brooke, A. Drud, and A. Meeraus,
World Bank, Washington, D.C., U.S.A.

Work space allocated -- 0.04 Mb

EXIT -- OPTIMAL SOLUTION FOUND.

	LOWER	LEVEL	UPPER	MARGINAL
---- EQU profit	.	.	.	1.000
---- EQU ethylene	.	.	.	1.000
---- EQU propylene	.	.	.	1.000
---- EQU butene	.	.	.	1.000
---- EQU gasoil	.	.	.	1.000
---- EQU procost	.	.	.	1.000
---- EQU feedcost	.	.	.	-1.000
---- EQU ccap	-INF	2.0000E+5	2.0000E+5	4.953
---- EQU pcap	-INF	1818.182	20000.000	.
---- EQU ecap	-INF	90909.091	1.0000E+5	.
---- EQU prec	.	.	.	6.049
---- EQU erec	.	.	.	6.550
---- EQU thv	-2.000E+7	-2.000E+7	-2.000E+7	EPS

	LOWER	LEVEL	UPPER	MARGINAL

---- VAR x1	.	1.0909E+5	+INF	.
---- VAR x2	.	.	+INF	-3.681
---- VAR x3	.	.	+INF	-7.469
---- VAR x4	.	.	+INF	-3.475
---- VAR x5	.	72727.273	+INF	.
---- VAR x6	.	.	+INF	.
---- VAR x7	.	58864.819	+INF	.
---- VAR f	-INF	9.9065E+5	+INF	.
---- VAR et	-INF	1.6136E+6	+INF	.
---- VAR p	-INF	25072.727	+INF	.
---- VAR b	-INF	48436.364	+INF	.
---- VAR g	-INF	18054.545	+INF	.
---- VAR pro	-INF	1.7052E+6	+INF	.
---- VAR feed	-INF	7.1455E+5	+INF	.

**** REPORT SUMMARY : 0 NONOPT
0 INFEASIBLE
0 UNBOUNDED

```
----  210 VARIABLE  f.L             =   990654.545
          VARIABLE  x1.L            =   109090.909
          VARIABLE  x2.L            =        0.000
          VARIABLE  x3.L            =        0.000


EXECUTION TIME       =        0.000 SECONDS    1.4 Mb      WIN200-121


USER: GAMS Development Corporation, Washington, DC   G871201:0000XX-
XXX
      Free Demo,  202-342-0180,  sales@gams.com,  www.gams.com   DC9999

**** FILE SUMMARY

INPUT      A:\OPTIMISATION\HEMENDRA.GMS
OUTPUT     C:\WINDOWS\GAMSDIR\HEMENDRA.LST
```