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/*Optimal Design Of NH3 syntheis Reactor*/
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#define gen_max 100
#define D 1
#define NP 10
#define F 0.5
#define CR 0.9 /* 0.6 */
#define inibound_l 0 /* Please Check f1 & f2 values*/
#define inibound_h 10

/*----Constant for rnd_uni()-----*/
#define IM1 2147483563
#define IM2 2147483399
#define AM (1.0/IM1)
#define IMM1 (IM1-1)
#define IA1 40014
#define IA2 40692
#define IQ1 53668
#define IQ2 52774
#define IR1 12211
#define IR2 3791
#define NTAB 32
#define NDIV (1+IMM1/NTAB)
#define EPS1 1.2e-7
#define RNMX (1.0-EPS1)

/*-----Parameter's Value for solving ODE's-----*/
#define f1 1.78954e4
#define f2 2.5714e16
#define R 1.987
#define hh 0.01
#define N2o 701.2
#define To 694.0
#define Cpf 0.707
#define Cpg 0.719
#define dH 26600.0
#define E1 20800.0
#define E2 47400.0
#define S1 10.0
#define S2 0.78
#define U 500.0
#define W 26400.0

#include<stdlib.h>
#include<stdio.h>
#include<time.h>
#include<math.h>
#include<conio.h>

static double Tg,Tf,N2,x;

void assignd(double a[], double b[]);

void assignd(double a[], double b[])
{
    int j;
    for(j=0;j<D;j++)
    {
        a[j]=b[j];
    }
}

float rnd_uni(long *);

float rnd_uni(long *idum)
{
    long j; long k;
    static long idum2=123456789;
    static long iy=0;static long iv[NTAB]; float temp;
    if(*idum<=0)
    {
        if(-(*idum)<1) *idum=1; else *idum=-(*idum); idum2=(*idum);
        for(j=NTAB+7;j>=0;j--)
        {
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        k=(*idum)/IQ1;
        *idum=IA1*( *idum-k*IQ1)-k*IR1;
        if(*idum<0)      *idum+=IM1;
        if(j<NTAB)      iv[j]=*idum;
    }
    iy=iv[0];
}
k=(*idum)/IQ1;
*idum=IA1*( *idum-k*IQ1)-k*IR1;
if(*idum<0)      *idum+=IM1;
k=idum2/IQ2;
idum2=IA2*( idum2-k*IQ2)-k*IR2;
if(idum2<0)      idum2+=IM2;
j=iy/NDIV;      iy=iv[j]-idum2;      iv[j]=*idum;
if(iy<1)      iy+=IMM1;
if( (temp=AM*iy)>RNMX)      return RNMX;
else      return temp;
}
}
double RKM(double rl);

double RKM(double rl)
{
double h,Tfo,Tgo, cost,N20,pN2,pNH3,pH2; long nstep;
double K1,K2,k1,k2,k3,k4,l1,l2,l3,l4,m1,m2,m3,m4;
int i,j; x=0.0; Tg=To; Tf=To; N2=N20=N2o; Tfo=Tgo=To;

/*printf("Reactor Length=");
scanf("%lf",&rl);*/

nstep= long(rl/hh); /*printf("nstep=%ld",nstep); getch(); */

h=hh;

for(i=0;i<nstep;i++)
{
    k1=h*(-(U*S1*(Tg-Tf)/(W*Cpf)));
    K1=f1*exp(-E1/(R*Tg));
    K2=f2*exp(-E2/(R*Tg));
    pN2=(286.0*N2/(2.598*N2o+2.0*N2)); pH2=3.0*pN2; pNH3=(286.0*(2.23*N2o-2.0*N2)/(2.598*N2o+2.0*N2));
};
    m1=-h*((K1*pN2*pow(pH2,1.5)/pNH3)-(K2*pNH3/(pow(pH2,1.5))));
    l1=h*((-U*S1*(Tg-Tf)/(W*Cpg))+(dH*S2*(-m1/h)/(W*Cpg));

/* printf("k1=%f m1=%f l1=%f \n",k1,m1,l1); getch(); */

Tg=Tg+(l1/2.0); Tf=Tf+(k1/2.0); N2=N2+(m1/2.0);

    k2=h*(-(U*S1*(Tg-Tf)/(W*Cpf)));
    K1=f1*exp(-E1/(R*Tg));
    K2=f2*exp(-E2/(R*Tg));
    pN2=(286.0*N2/(2.598*N2o+2.0*N2)); pH2=3*pN2; pNH3=(286.0*(2.23*N2o-2.0*N2)/(2.598*N2o+2.0*N2));
    m2=-h*((K1*pN2*pow(pH2,1.5)/pNH3)-(K2*pNH3/(pow(pH2,1.5))));
    l2=h*((-U*S1*(Tg-Tf)/(W*Cpg))+(dH*S2*(-m2/h)/(W*Cpg));

/* printf("k2=%lf m2=%lf l2=%lf \n",k2,m2,l2); getch(); */

Tg=Tg+(l2/2.0); Tf=Tf+(k2/2.0); N2=N2+(m2/2.0);

    k3=h*(-(U*S1*(Tg-Tf)/(W*Cpf)));
    K1=f1*exp(-E1/(R*Tg));
    K2=f2*exp(-E2/(R*Tg));
    pN2=(286.0*N2/(2.598*N2o+2.0*N2)); pH2=3*pN2; pNH3=(286.0*(2.23*N2o-2.0*N2)/(2.598*N2o+2.0*N2));
    m3=-h*((K1*pN2*pow(pH2,1.5)/pNH3)-(K2*pNH3/(pow(pH2,1.5))));
    l3=h*((-U*S1*(Tg-Tf)/(W*Cpg))+(dH*S2*(-m3/h)/(W*Cpg));

/* printf("k3=%f m3=%f l3=%f \n",k3,m3,l3); */

Tg=Tg+l3; Tf=Tf+k3; N2=N2+m3;

    k4=h*(-(U*S1*(Tg-Tf)/(W*Cpf)));
    K1=f1*exp(-E1/(R*Tg));
    K2=f2*exp(-E2/(R*Tg));
    pN2=(286.0*N2/(2.598*N2o+2.0*N2)); pH2=3*pN2; pNH3=(286.0*(2.23*N2o-2.0*N2)/(2.598*N2o+2.0*N2));
    m4=-h*((K1*pN2*pow(pH2,1.5)/pNH3)-(K2*pNH3/(pow(pH2,1.5))));

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/*      m4=h*((-4.5*K1*286.0*N2*N2)/((2.598*N2o+2.0*N2)*(2.23*N2o-2.0*N2)))+(K2*(2.23*N2o-2*N2)/
(4.5*N2));*/
      l4=h*((-U*S1*(Tg-Tf)/(W*Cpg))+(dH*S2*(-m4/h)/(W*Cpg)));
/*      printf("k4=%f      m4=%f      l4=%f      \n",k4,m4,l4);      */

Tf=Tfo+(k1+(2*k2)+(2*k3)+k4)/6.0;
Tg=Tgo+(l1+(2*l2)+(2*l3)+l4)/6.0;
N2=N20+(m1+(2*m2)+(2*m3)+m4)/6.0;

x=x+h;          if( Tf<=400.0) break;

Tgo=Tg; Tfo=Tf; N20=N2;

}
cost=(13356300.0)-(17084.3*N2)+(704.09*(Tg-To))-(699.27*(Tf-To))-sqrt((34566300.0)+(1983650000.0*
x));
return(cost);
/*printf("cost=%lf\n",cost);      */

}

void main()

{
  int i,j,k,a,b,c,good,count=0,seed,imin; long nfe=0;
  double x1[NP][D],x2[NP][D],cost[NP],trial[D],rl,best[D],bestit[D];
  double cost_trial,costmax,costmin,pen; clock_t start, end;

  printf("\nseed=");
  scanf("%d",&seed);
  long rnd_uni_init= -(long)seed; start = clock();

  for (i=0;i<NP;i++)
  {
    for (j=0;j<D;j++)
    {
      x1[i][j]=inibound_l + rnd_uni(&rnd_uni_init)*(inibound_h-inibound_l);
    }
    /*      printf("x=%f\n",x1[i][0]);      */

    rl=x1[i][0];
    cost[i]=RKM(rl);      x1[i][0]=x;

    /*      printf("cost[%d]=%lf\n",i,cost[i]);      */
  }

  costmax=cost[0];
  imin=0;
  for(i=1;i<NP;i++)
  {
    if(cost[i]>costmax)
    {
      costmax=cost[i];
      imin=i;
    }
  }

  assignd(best,x1[imin]);
  assignd(bestit,x1[imin]);

  while (count<gen_max)
  {
    count++;
    imin=0;

    for (i=0;i<NP;i++)
    {
      do a=int (rnd_uni(&rnd_uni_init)*NP); while (a==i);
      /*printf("a=%d      ",a);*/
    }
  }
}

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do b=int (rnd_uni(&rnd_uni_init)*NP); while (b==i || b==a);
/*printf("\nb=%d ",b);*/

do c=int (rnd_uni(&rnd_uni_init)*NP); while (c==i || c==a || c==b);
/*printf("\n c=%d",c); */

/*-----de/rand/1/bin-----*/

j=int (rnd_uni(&rnd_uni_init)*D);
/*printf(" j=%d",j);
getch(); */

for (k=1;k<=D;k++)
{
if ((rnd_uni(&rnd_uni_init))<CR || k==D)
{
trial[j]=x1[c][j]+F*(x1[a][j]-x1[b][j]);
}
else trial[j]=(x1[i][j]+x1[i+1][j])/2.0;

if(trial[j]<0.0) trial[j]=0.0;
if(trial[j]>10.0) trial[j]=10.0;

/*printf("r1=%f ,trial[%d]=%f , ",r1,j,trial[j]);
getch();*/
j=(j+1)%D;
}

r1=trial[0];
cost_trial=RKM(r1); trial[0]=x;
/* printf("\ntrialcost=%f , cost[%d]=%f ",cost_trial,i,cost[i]);
getch();*/

if (cost_trial>=cost[i])
{
for (j=0;j<D;j++)
x2[i][j]=trial[j];
cost[i]=cost_trial;
if(cost_trial>costmax)
{
costmax=cost_trial;
imin=i;
assignd(best,trial);
}
}
else for (j=0;j<D;j++)

x2[i][j]=x1[i][j];

/* printf("x1=%f x2=%f ",x2[i][0],x2[i][1]);
getch(); */
} /*-----end of FOR loop after while-----*/

assignd(bestit,best);
for (i=0;i<NP;i++)
{
for (j=0;j<D;j++)
x1[i][j]=x2[i][j];
}
costmax=cost[0];
imin=0;
for (i=1;i<NP;i++)
{
if(cost[i]>costmax)
{
costmax=cost[i];
imin=i;
}
}
}

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    costmin=cost[0];
    imin=0;
    for(i=1;i<NP;i++)
    {
        if(cost[i]<costmin)
        {
            costmin=cost[i];
            imin=i;
        }
    }

    if((costmax-costmin)<0.00001)
        break;
} /*-----end of while loop-----*/
end = clock();
printf("The time was: %f\n", (end - start) / CLK_TCK);
for(i=0;i<NP;i++)
{
    printf("x1=%f    ",x1[i][0]);
    printf("cost[%d]=%f    ",i,cost[i]);
}
printf("\ncmax=%f\n",costmax);
printf("\ncount=%d\n",count);
printf("bestx=%f",best[0]);
printf("\n NFE=%ld\n",nfe);
} /*-----end of main()-----*/

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