Performances of SPG for solving MINPACK-2 applications

Dr. Neculai Andrei
Research Institute for Informatics.
Center for Advanced Modeling and Optimization
8-10, Averescu Avenue, Bucharest 1
Email: nandrei@ici.ro Voice: 0744-777748

September 14, 2010

In this work I present the performances of SPG package [1] for solving some applications from MINPACK-2 collection of Averick, Carter, Moré and Xue [2].

1. Elastic-Plastic Problem

Experiment Nr. 1: $10^{-6} \le x \le 1$

```
    Project: Simple Bounded Optimization
    ====================================

    SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
    ====================================================

    Date: ---  Month: 9  Day: 3  Year: 2010

    Termination criteria:
    cginfn .le. eps
    cgtwon .le. eps2**2
    where :
    cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
    cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

    Line search interpolation:
    Line search with safeguarded quadratic interpolation
    ====================================================================


    Elastic-Plastic Torsion problem    n=  40000

 F=         -4.3926782010D-01
 CGINFNORM=  1.1156588486D-08
 CGTWONORM=  9.9701713719D-07
 FLAG=       1

 ITER=        3311
 FCNT=        5433
 GCNT=        3312
 TIME(csec.)=  11325
```

```
Project: Simple Bounded Optimization
====================================

SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
=====================================================

Date: ---  Month: 9  Day: 3  Year: 2010

Termination criteria:
cginfn .le. eps
cgtwon .le. eps2**2
where :
cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

Line search interpolation:
Line search with safeguarded cubic interpolation
================================================================


Elastic-Plastic Torsion problem    n=  40000

F=         -4.3926782073D-01
CGINFNORM=  2.5174419382D-08
CGTWONORM=  8.0189862450D-07
FLAG=       1

ITER=        2663
FCNT=        3600
GCNT=        2664
TIME(csec.)=   8321
```

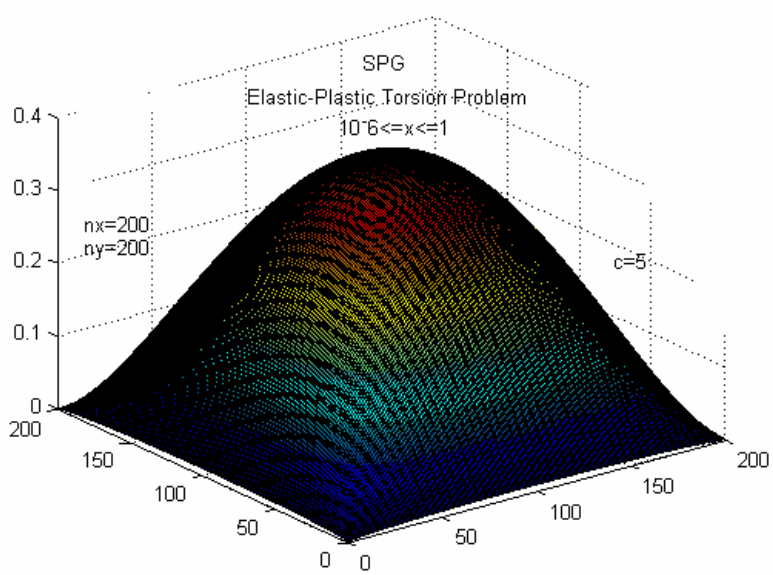

Fig. 1. Elastic-Plastic-Torsion Problem (quadratic).

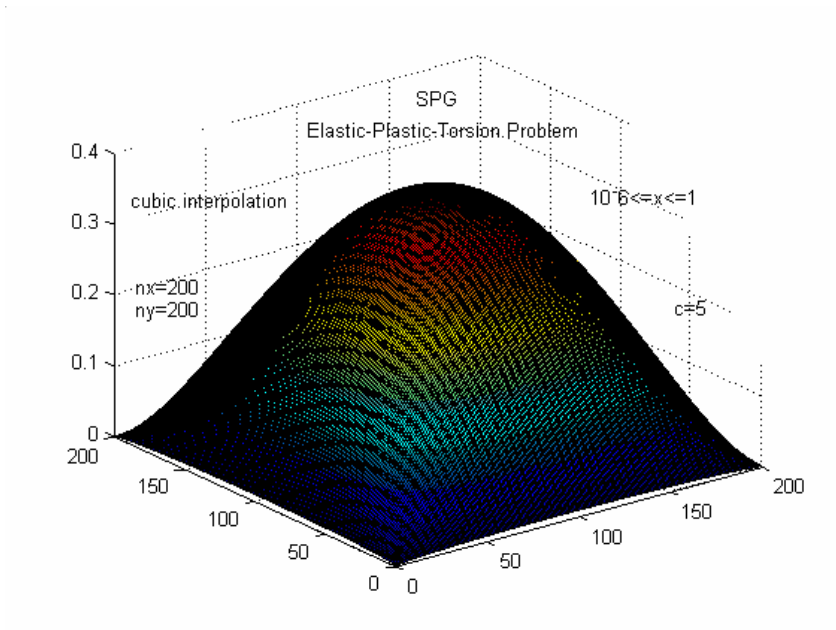

Fig. 2. Elastic-Plastic-Torsion Problem (cubic).

Experiment Nr. 2: $10^{-6} \le x \le 0.01$

```
Project: Simple Bounded Optimization
====================================

SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
=====================================================

Date: ---  Month: 9  Day: 3  Year: 2010

Termination criteria:
cginfn .le. eps
cgtwon .le. eps2**2
where :
cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

Line search interpolation:
Line search with safeguarded quadratic interpolation
====================================================================


Elastic-Plastic Torsion problem    n=  40000

F=         -4.1913749027D-02
CGINFNORM=  4.9814688135D-08
CGTWONORM=  9.5751878157D-07
FLAG=       1

ITER=         152
FCNT=         190
GCNT=         153
TIME(csec.)=    293
```

```
Project: Simple Bounded Optimization
====================================

SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
=====================================================

Date: ---  Month: 9  Day: 3  Year: 2010

Termination criteria:
cginfn .le. eps
cgtwon .le. eps2**2
where :
cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

Line search interpolation:
Line search with safeguarded cubic interpolation
=================================================================


Elastic-Plastic Torsion problem    n=  40000

F=         -4.1913749029D-02
CGINFNORM=  4.3749634771D-08
CGTWONORM=  8.5000284860D-07
FLAG=       1

ITER=         118
FCNT=         132
GCNT=         119
TIME(csec.)=    233
```

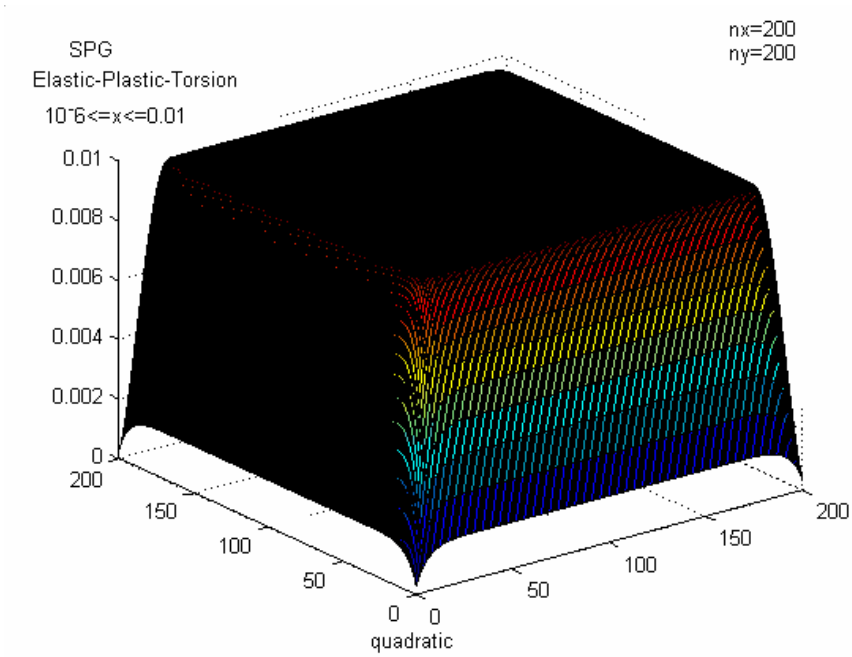

Fig. 3. Elastic-Plastic-Torsion Problem (quadratic).

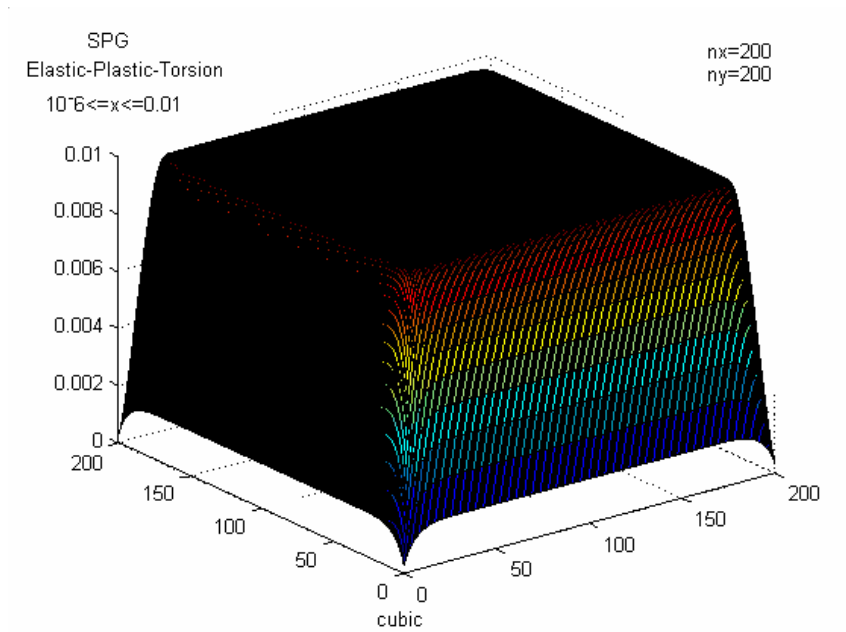

Fig. 4. Elastic-Plastic-Torsioin Problem (cubic).

2. Pressure Distribution in a Journal Bearing

Experiment Nr. 1: $-1 \le x \le 1$

```
Project: Simple Bounded Optimization
====================================

SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
=====================================================

Date: ---  Month: 9  Day: 7  Year: 2010

Termination criteria:
cginfn .le. eps
cgtwon .le. eps2**2
where :
cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

Line search interpolation:
Line search with safeguarded quadratic interpolation
====================================================================
```

```
   Pressure Distribution in a Journal Bearing Problem    n=  40000

F=         -2.8289294907D-01
CGINFNORM=  1.1427951653D-08
CGTWONORM=  9.9341353557D-07
FLAG=       1

ITER=        4179
FCNT=        7071
GCNT=        4180
TIME(csec.)=  14973



   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ================================================================


   Pressure Distribution in a Journal Bearing Problem    n=  40000

F=         -2.8289294954D-01
CGINFNORM=  1.7258658877D-08
CGTWONORM=  5.4390730011D-07
FLAG=       1

ITER=        2663
FCNT=        3553
GCNT=        2664
TIME(csec.)=   8396
```

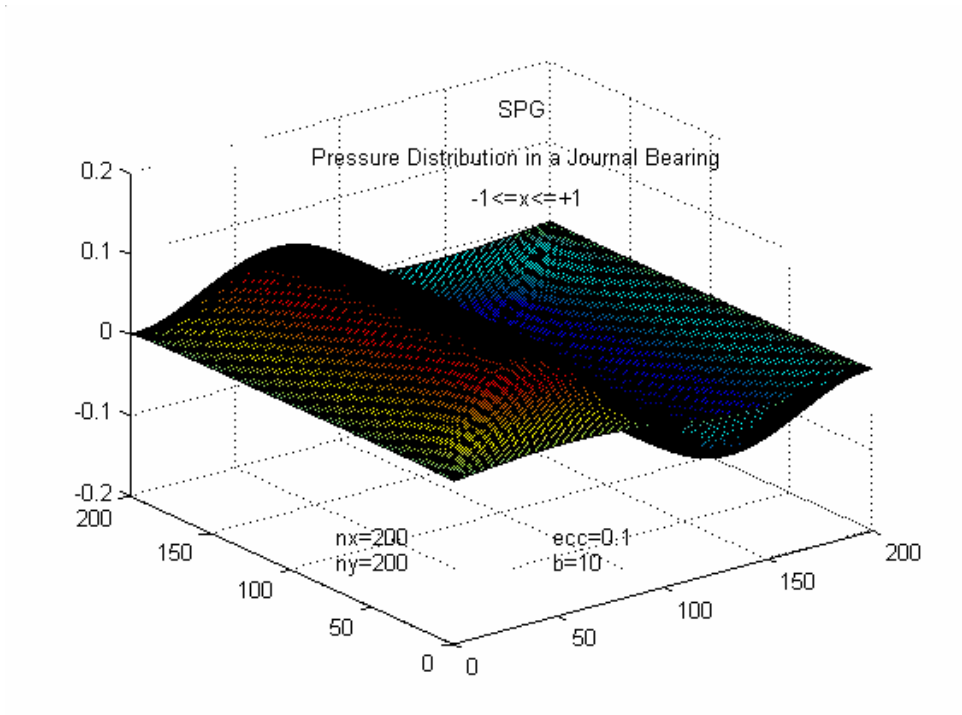

Fig. 5. Pressure Distribution in a Journal Bearing (quadratic)

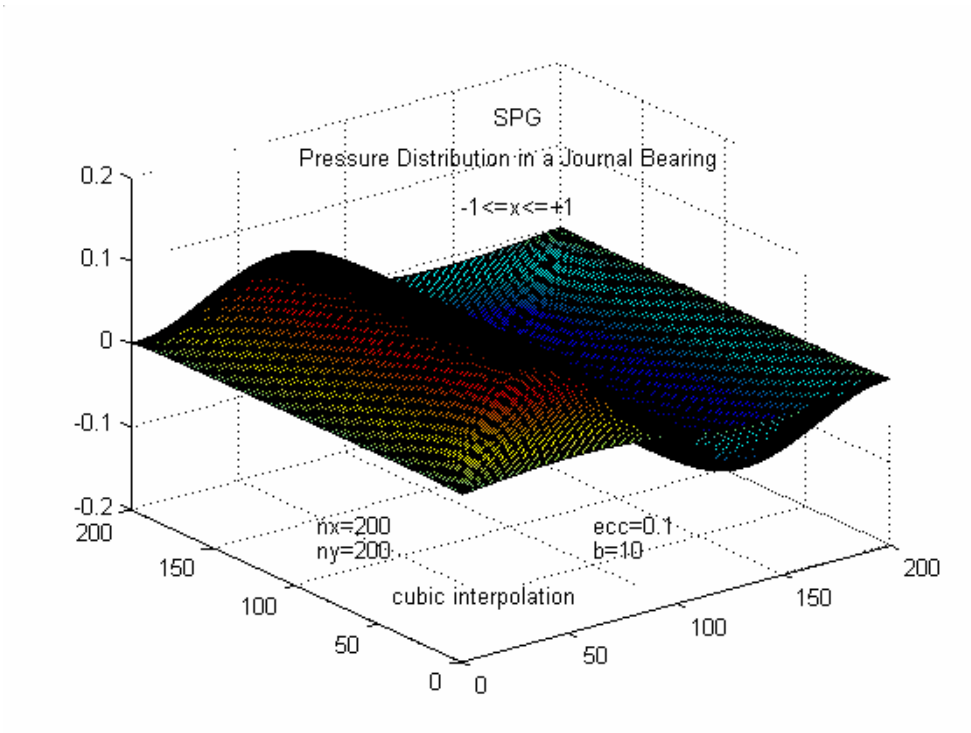

Fig. 6. Pressure Distribution in a Journal Bearing (cubic)

Experiment Nr. 2: $0 \le x \le +1$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================

   Pressure Distribution in a Journal Bearing Problem    n=  40000

F=         -1.8059754456D-01
CGINFNORM=  1.7536325350D-08
CGTWONORM=  9.9307582671D-07
FLAG=       1

ITER=        4964
FCNT=        7796
GCNT=        4965
TIME(csec.)=  15202

   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================

   Pressure Distribution in a Journal Bearing Problem    n=  40000

F=         -1.8059754456D-01
CGINFNORM=  3.2455560570D-08
```

```
CGTWONORM=  9.9598246430D-07
FLAG=       1

ITER=        4808
FCNT=        6301
GCNT=        4809
TIME(csec.)=  13378
```

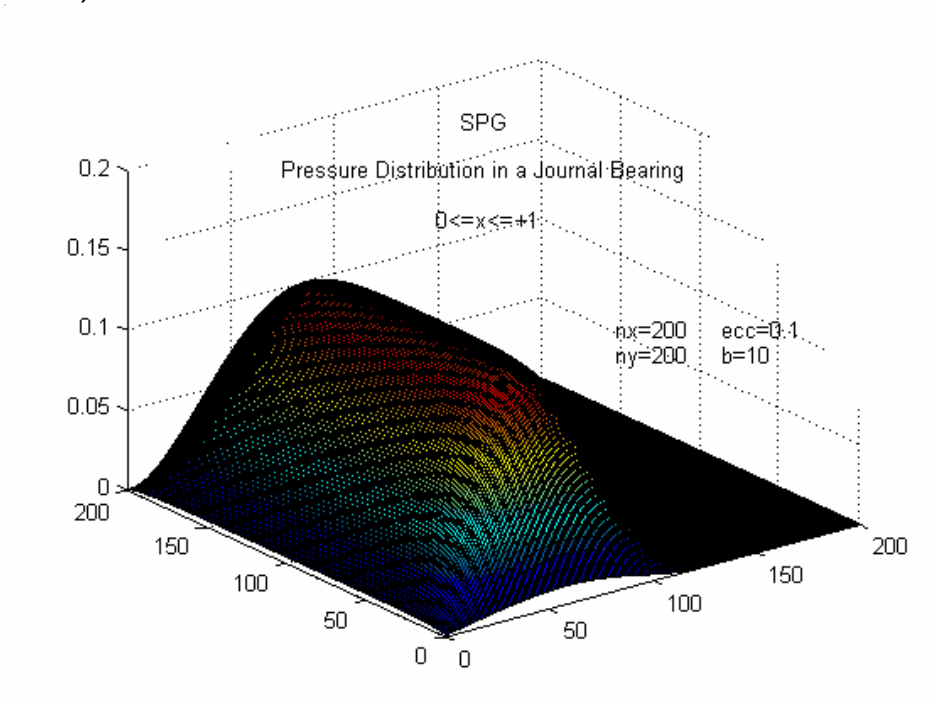

Fig. 7. Pressure Distribution in a Journal Bearing (quadratic)

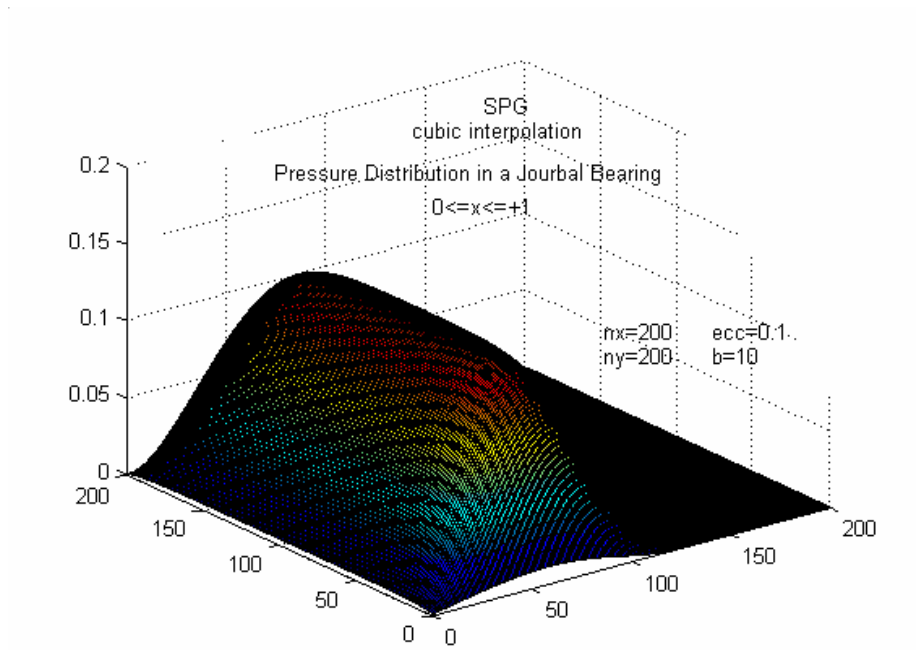

Fig. 8. Pressure Distribution in a Journal Bearing (cubic)

Experiment Nr. 3 $-1 \le x \le 0$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================

   Pressure Distribution in a Journal Bearing Problem    n=  40000

F=         -1.8059754455D-01
CGINFNORM=  1.3853286775D-08
CGTWONORM=  9.9760220449D-07
FLAG=       1

ITER=        3881
FCNT=        6179
GCNT=        3882
TIME(csec.)=  11635

   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================

   Pressure Distribution in a Journal Bearing Problem    n=  40000

F=         -1.8059754456D-01
CGINFNORM=  3.7006498776D-08
```

```
CGTWONORM=  9.9670674200D-07
FLAG=       1

ITER=        3154
FCNT=        4170
GCNT=        3155
TIME(csec.)=   8699
```

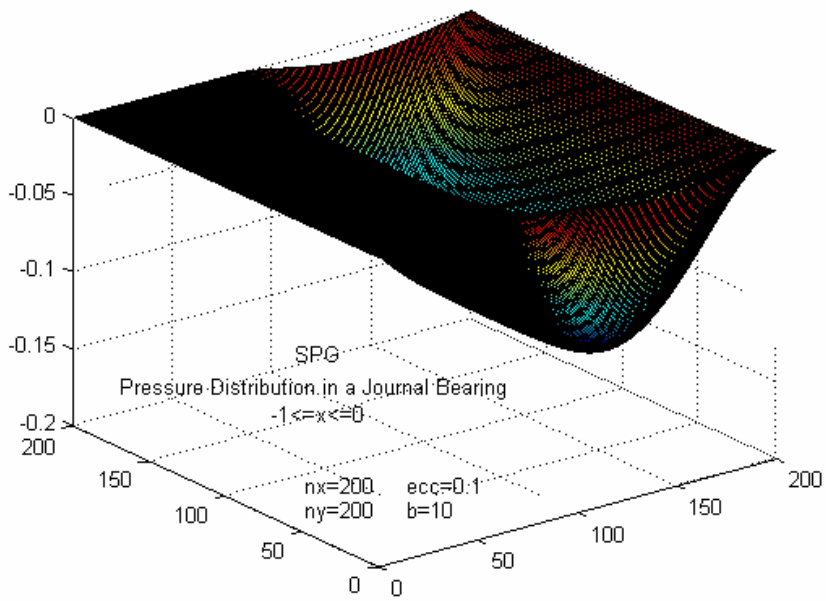

Fig. 8. Pressure Distribution in a Journal Bearing (quadratic)

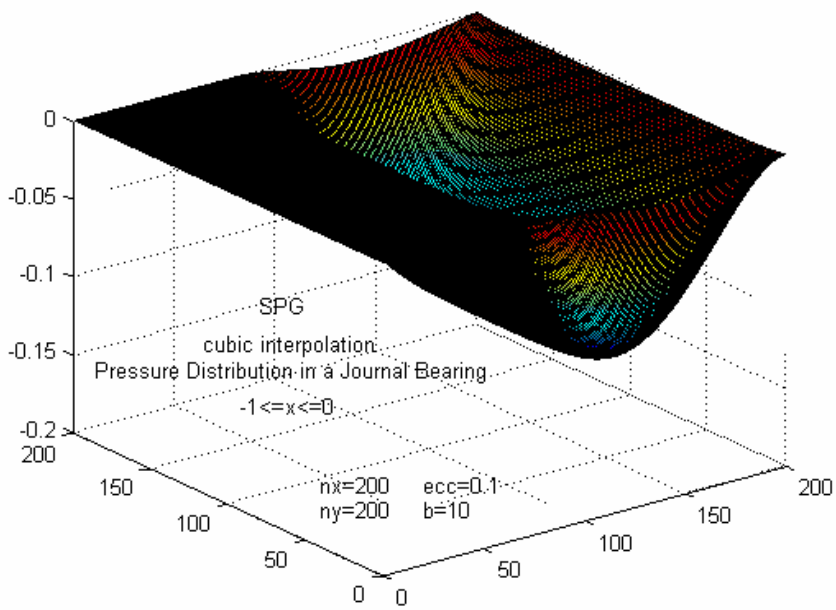

Fig. 10. Pressure Distribution in a Journal Bearing (cubic)

Experiment Nr. 4 $-0.5 \le x \le 0.5$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================

   Pressure Distribution in a Journal Bearing Problem    n=  40000

F=         -2.8289294910D-01
CGINFNORM=  1.0195428499D-08
CGTWONORM=  9.9766551753D-07
FLAG=       1

ITER=        4054
FCNT=        6820
GCNT=        4055
TIME(csec.)=  14309

   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================

   Pressure Distribution in a Journal Bearing Problem    n=  40000

F=         -2.8289294950D-01
CGINFNORM=  5.6516445827D-09
```

```
CGTWONORM=  4.8165804218D-07
FLAG=       1

ITER=        2969
FCNT=        4105
GCNT=        2970
TIME(csec.)=   9484
```

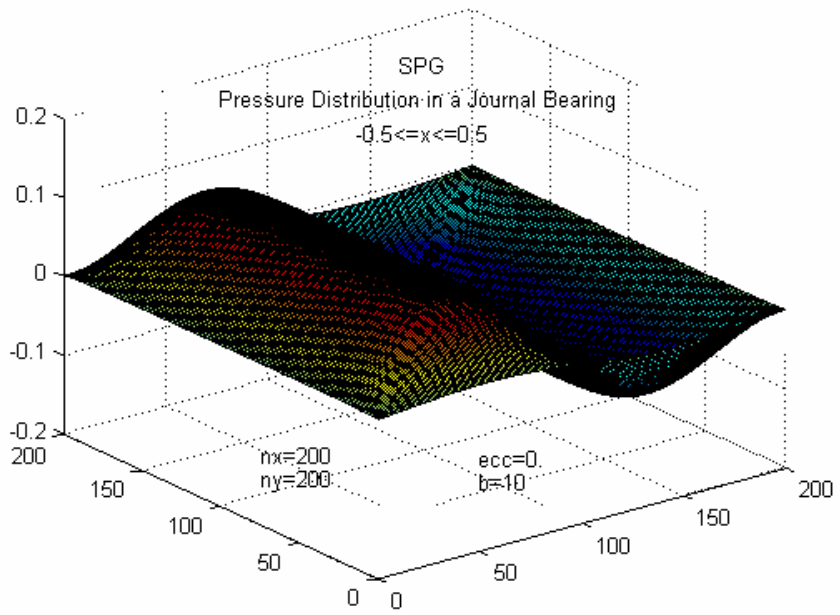

Fig. 11. Pressure Distribution in a Journal Bearing (quadratic)

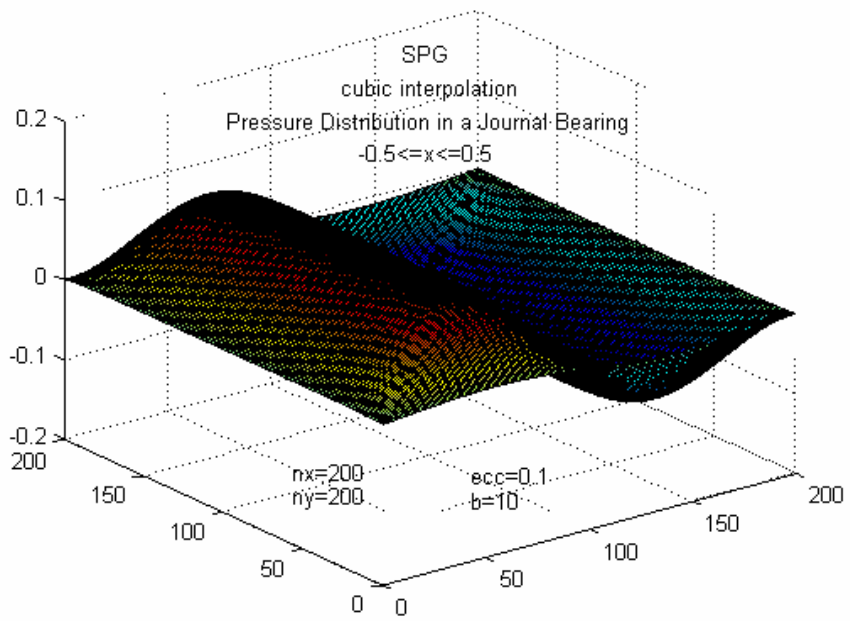

Fig. 12. Pressure Distribution in a Journal Bearing (cubic)

3. Optimal Design with Composite Materials

Experiment Nr. 1: $-1 \le x \le 0$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================

   Optimal Design with Composite Materials Problem    n=  40000

F=         -1.1381297204D-02
CGINFNORM=  6.4141788970D-08
CGTWONORM=  9.9511281084D-07
FLAG=       1

ITER=       22515
FCNT=       34686
GCNT=       22516
TIME(csec.)= 125982

   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================

   Optimal Design with Composite Materials Problem    n=  40000
```

```
F=          -1.1381297098D-02
CGINFNORM=   9.0640360981D-09
CGTWONORM=   9.9757695281D-07
FLAG=        1

ITER=        20969
FCNT=        27964
GCNT=        20970
TIME(csec.)= 108320
```

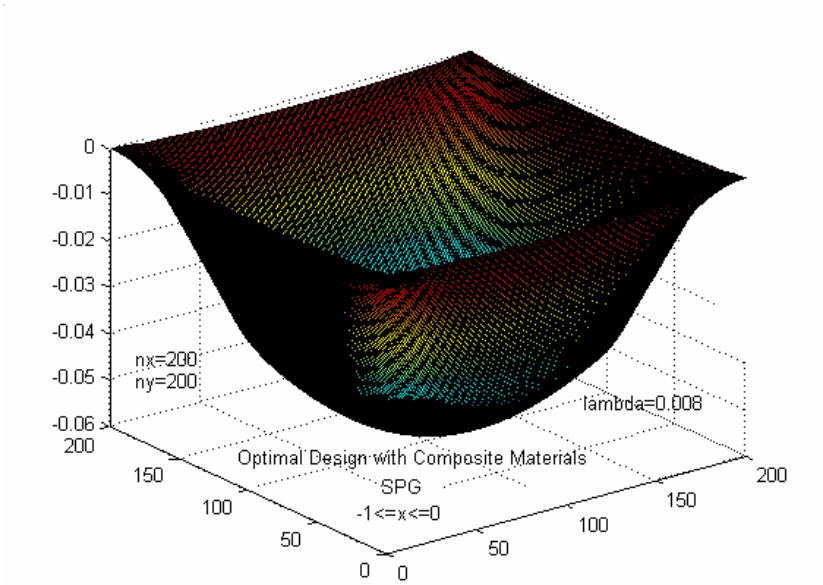

Fig. 13. Optimal Design with Composite Materials (quadratic).

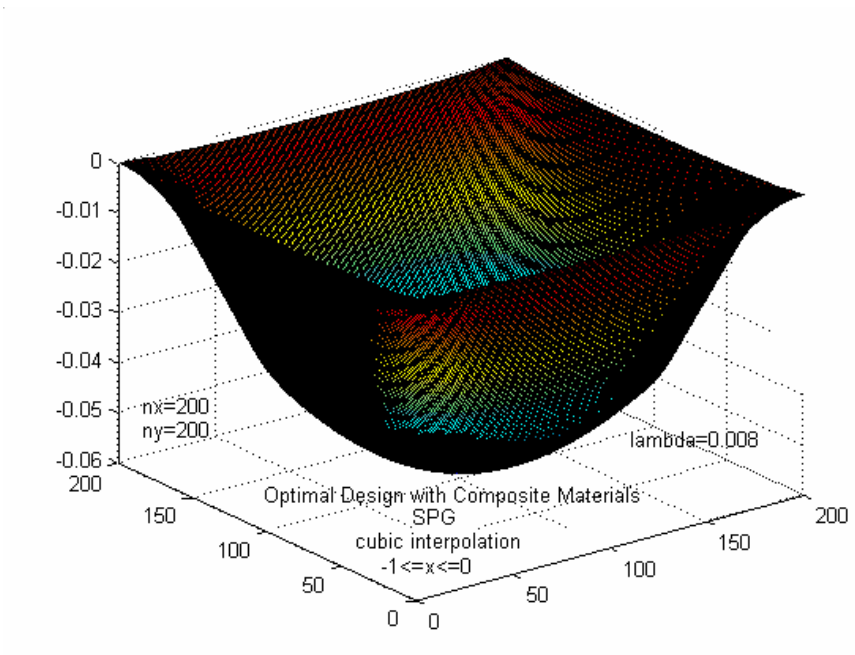

Fig. 14. Optimal Design with Composite Materials (cubic).

Experiment Nr. 2: $-0.02 \le x \le 0$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================


   Optimal Design with Composite Materials Problem    n=  40000

F=         -8.2074125873D-03
CGINFNORM=  5.9298561172D-08
CGTWONORM=  8.8942770602D-07
FLAG=       1

ITER=        1855
FCNT=        2769
GCNT=        1856
TIME(csec.)=   8621


   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 7  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================


   Optimal Design with Composite Materials Problem    n=  40000
```

```
F=          -8.2074125860D-03
CGINFNORM=   1.2007121466D-07
CGTWONORM=   9.9581382847D-07
FLAG=        1

ITER=         2228
FCNT=         2890
GCNT=         2229
TIME(csec.)=   9574
```

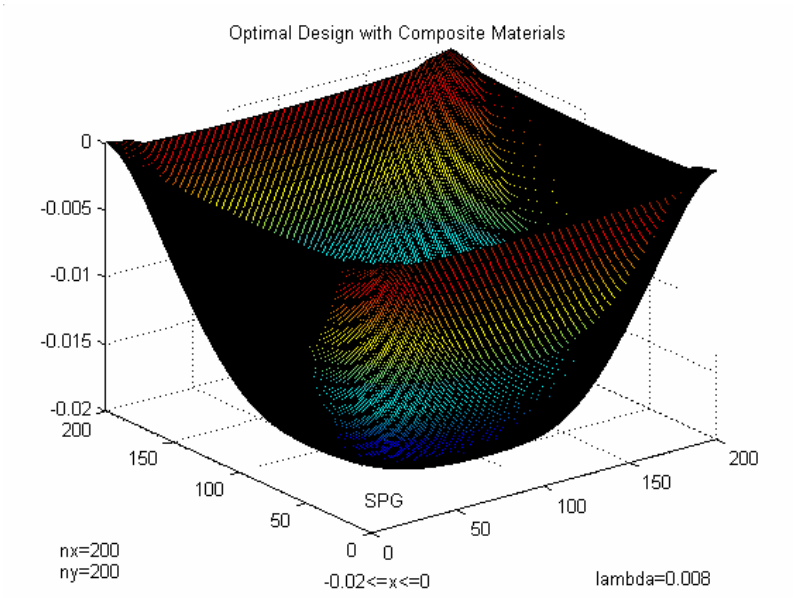

Fig. 15. Optimal Design with Composite Materials (quadratic).

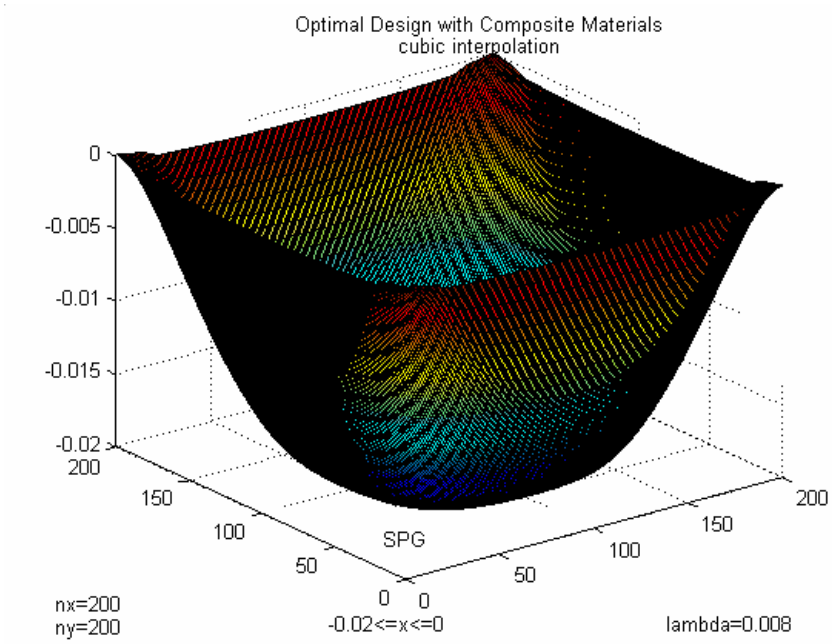

Fig. 16. Optimal Design with Composite Materials (cubic).

4. Inhomogeneous Superconductors
Ginzburg-Landau Problem

Experiment Nr. 1: $0 \le x \le 10^8$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 8  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================

   Ginzburg-Landau (1-dimensional) problem    n=  1000

F=         -1.6748781298D-04
CGINFNORM=  6.4907074271D-05
CGTWONORM=  1.4326190175D-03
FLAG=       3

ITER=        3465
FCNT=        6001
GCNT=        3466
TIME(csec.)=     81

   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 8  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================
```

```
   Ginzburg-Landau (1-dimensional) problem    n=  1000

F=          -1.6745775266D-04
CGINFNORM=   5.3305035033D-03
CGTWONORM=   7.5593823730D-02
FLAG=        3

ITER=         4373
FCNT=         6001
GCNT=         4373
TIME(csec.)=     87
```

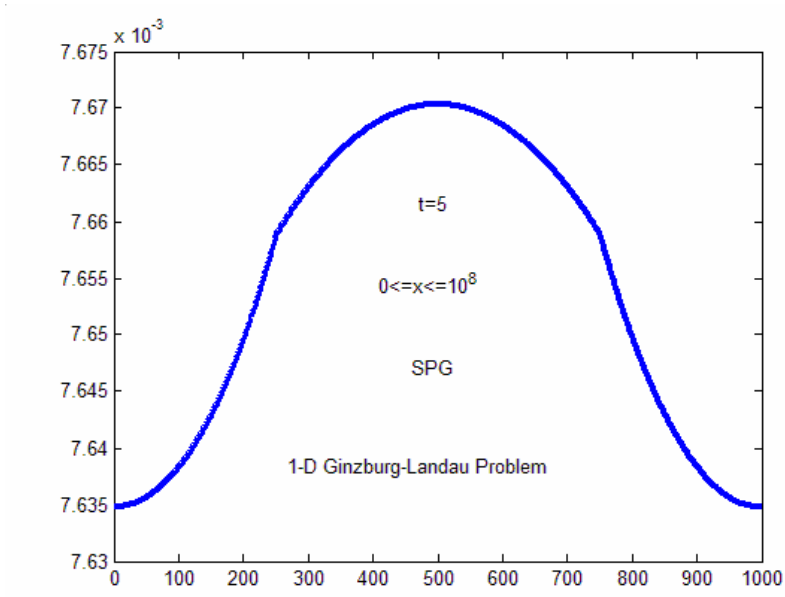

Fig. 17. Inhomogeneous Superconductors. Ginzburg-Landau Problem (quadratic).

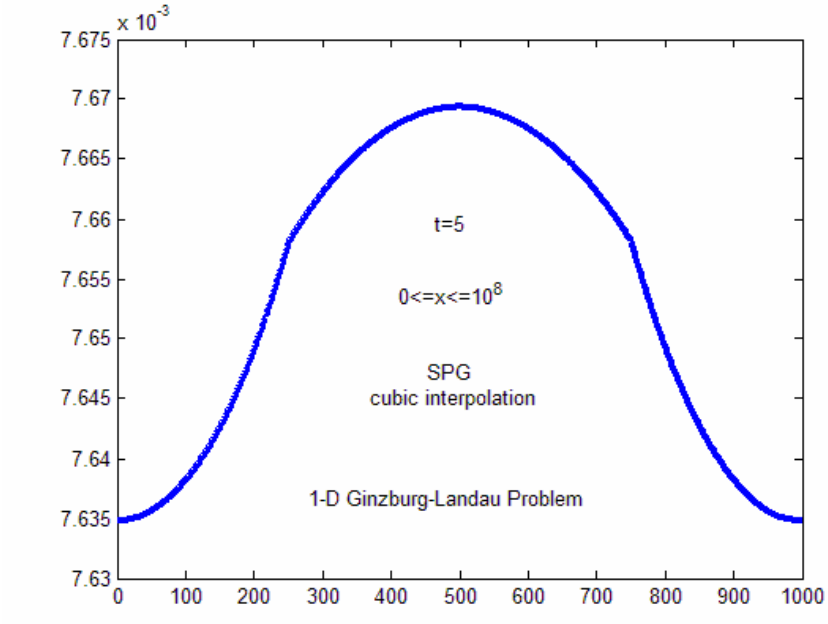

Fig. 18. Inhomogeneous Superconductors. Ginzburg-Landau Problem (cubic).

Experiment Nr. 2: $0 \le x \le 10^{-3}$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 8  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================

   Ginzburg-Landau (1-dimensional) problem    n=  1000

F=         -2.8506126485D-06
CGINFNORM=  1.2754051055D-05
CGTWONORM=  6.0947115351D-05
FLAG=       3

ITER=        3967
FCNT=        6001
GCNT=        3968
TIME(csec.)=     74

   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day: 8  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================

   Ginzburg-Landau (1-dimensional) problem    n=  1000

F=         -2.8507522910D-06
CGINFNORM=  2.5856929101D-06
CGTWONORM=  4.2072170753D-05
```

```
FLAG=        3

ITER=         4713
FCNT=         6001
GCNT=         4714
TIME(csec.)=      92
```

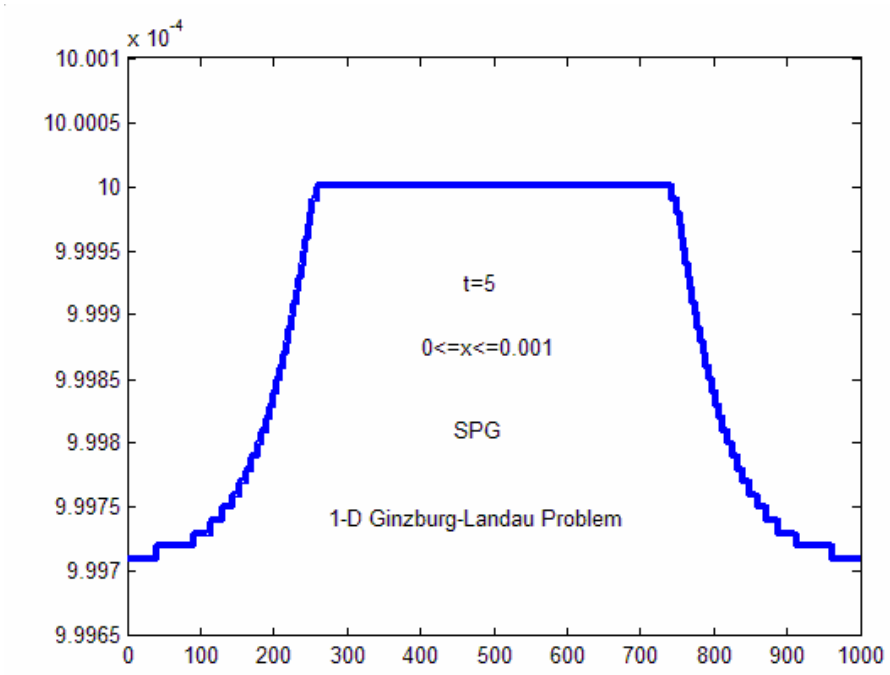

Fig. 19. Inhomogeneous Superconductors. Ginzburg-Landau Problem (quadratic).

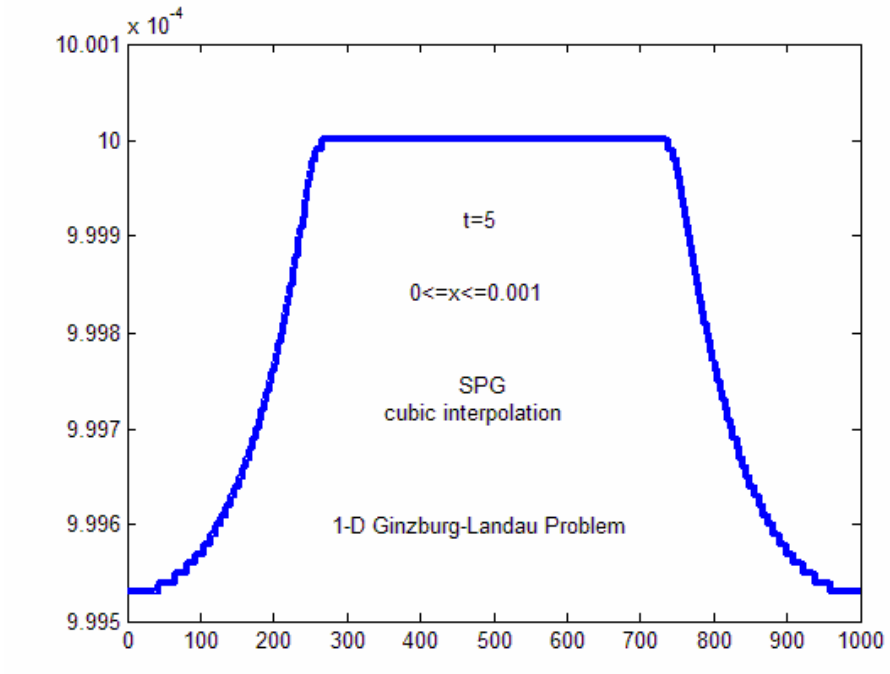

Fig. 20. Inhomogeneous Superconductors. Ginzburg-Landau Problem (cubic).

5. Steady State Combustion Problem

Experiment Nr. 1: $0 \le x \le 1$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day:14  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================


   Steady State Combustion Problem    n=  40000

F=         -5.6114485117D+00
CGINFNORM=  1.0769991071D-07
CGTWONORM=  7.9920712403D-07
FLAG=       1

ITER=        5134
FCNT=        8418
GCNT=        5135
TIME(csec.)=  42192


   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day:14  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================
```

```
   Steady State Combustion Problem    n=  40000

F=          -5.6114485103D+00
CGINFNORM=   1.2148512307D-08
CGTWONORM=   9.8766050698D-07
FLAG=        1

ITER=         5352
FCNT=         7236
GCNT=         5353
TIME(csec.)=   39513
```

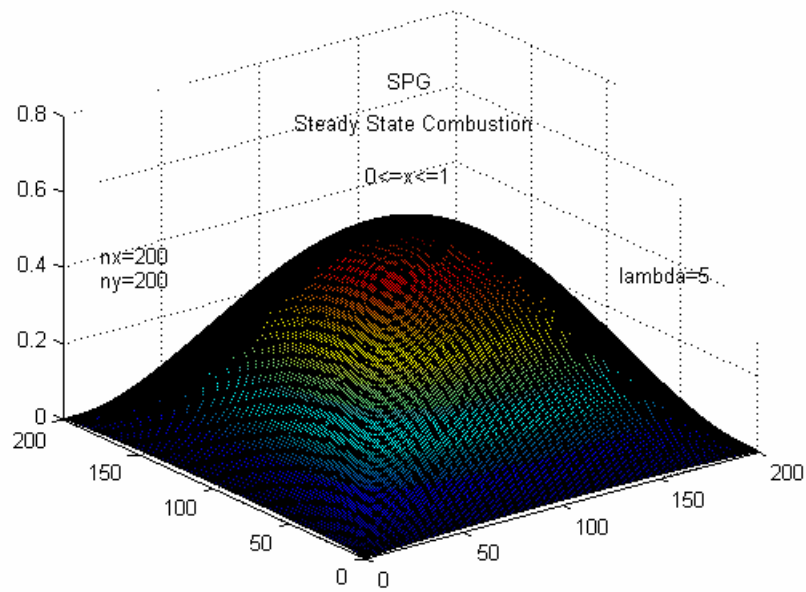

Fig. 21. Steady State Combustion Problem (quadratic).

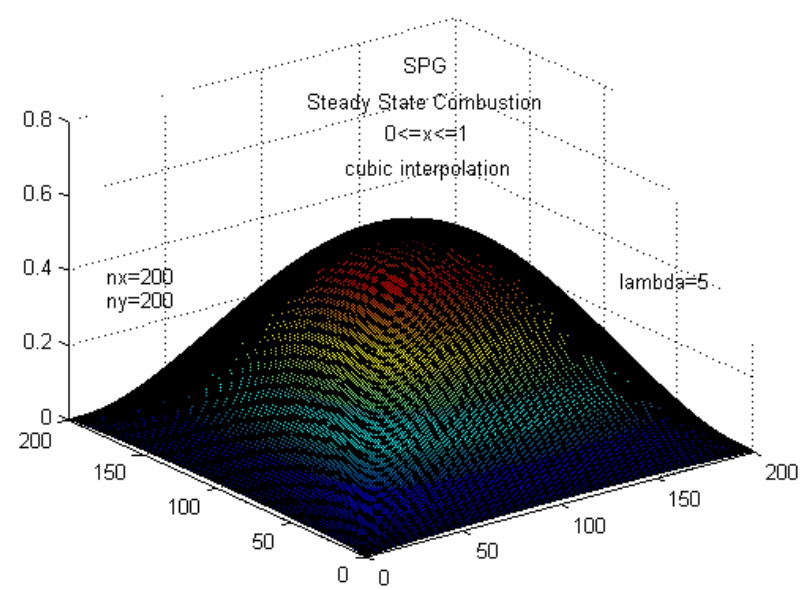

Fig. 22. Steady State Combustion Problem (cubic).

Experiment Nr. 2: $0 \le x \le 0.2$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day:14  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================


   Steady State Combustion Problem    n=  40000

F=         -5.4413175451D+00
CGINFNORM=  2.0415915966D-07
CGTWONORM=  9.0042370018D-07
FLAG=       1

ITER=        1843
FCNT=        2795
GCNT=        1844
TIME(csec.)=  13732

   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day:14  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================


   Steady State Combustion Problem    n=  40000
```

```
F=          -5.4413175450D+00
CGINFNORM=   2.6315125801D-08
CGTWONORM=   9.9506883321D-07
FLAG=        1

ITER=         1764
FCNT=         2286
GCNT=         1765
TIME(csec.)=   12101
```

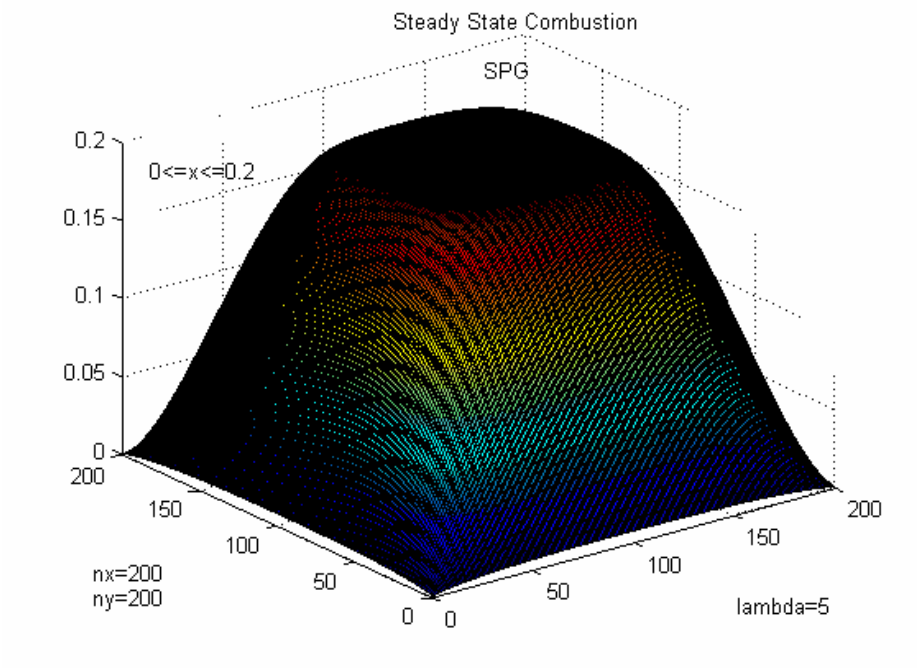

Fig. 23. Steady State Combustion Problem (quadratic).

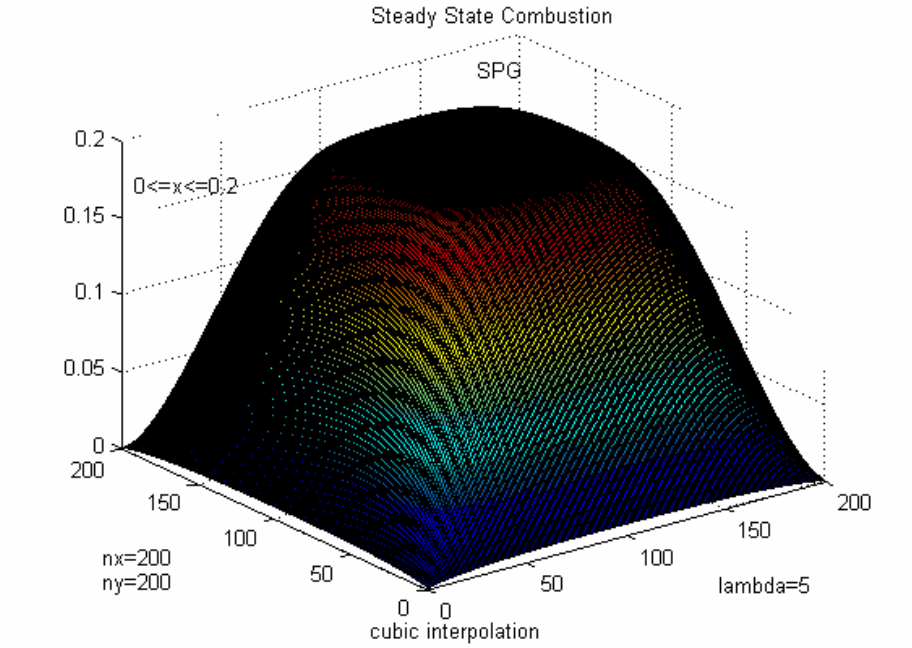

Fig. 24. Steady State Combustion Problem (cubic).

Experiment Nr. 3: $0 \le x \le 0.1$

```
   Project: Simple Bounded Optimization
    ====================================

    SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
    ====================================================

    Date: ---  Month: 9  Day:14  Year: 2010

    Termination criteria:
    cginfn .le. eps
    cgtwon .le. eps2**2
    where :
    cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
    cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

    Line search interpolation:
    Line search with safeguarded quadratic interpolation
    ====================================================================

    Steady State Combustion Problem    n=  40000

 F=         -5.2852405614D+00
 CGINFNORM=  1.6756601870D-08
 CGTWONORM=  9.9178012235D-07
 FLAG=       1

 ITER=        1140
 FCNT=        1724
 GCNT=        1141
 TIME(csec.)=   8152

    Project: Simple Bounded Optimization
    ====================================

    SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
    ====================================================

    Date: ---  Month: 9  Day:14  Year: 2010

    Termination criteria:
    cginfn .le. eps
    cgtwon .le. eps2**2
    where :
    cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
    cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

    Line search interpolation:
    Line search with safeguarded cubic interpolation
    ====================================================================

    Steady State Combustion Problem    n=  40000

 F=         -5.2852405614D+00
 CGINFNORM=  1.4179800306D-08
```

```
CGTWONORM=  9.8735462081D-07
FLAG=       1

ITER=         665
FCNT=         854
GCNT=         666
TIME(csec.)=   4345
```

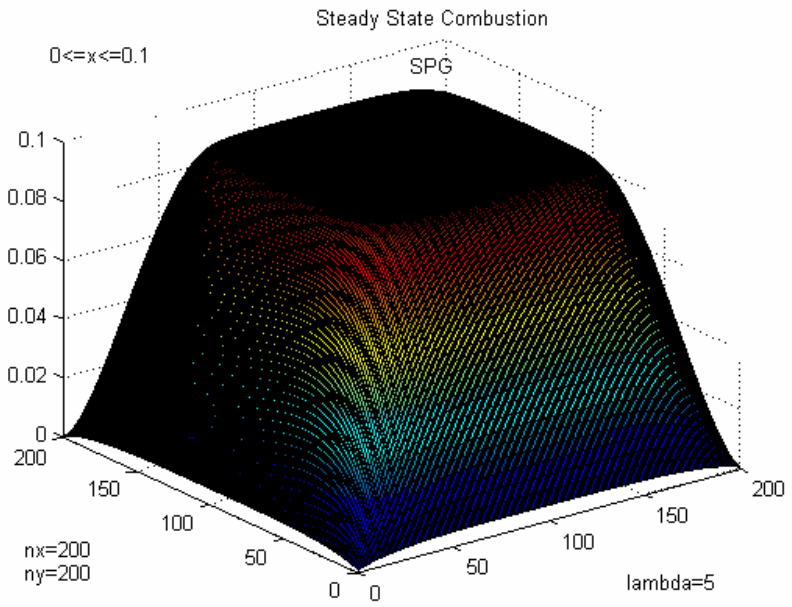

Fig. 25. Steady State Combustion Problem (quadratic).

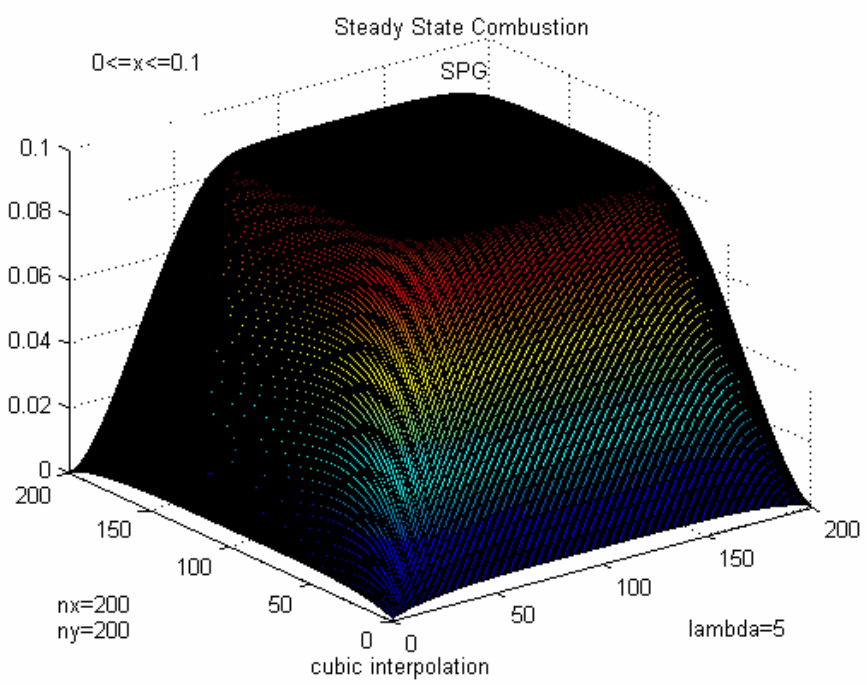

Fig. 26. Steady State Combustion Problem (cubic).

Experiment Nr. 4: $0 \le x \le 0.05$

```
   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day:14  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded quadratic interpolation
   ====================================================================

   Steady State Combustion Problem    n=  40000

F=         -5.1692563011D+00
CGINFNORM=  2.8256471371D-08
CGTWONORM=  9.7633280794D-07
FLAG=       1

ITER=         383
FCNT=         543
GCNT=         384
TIME(csec.)=   2585

   Project: Simple Bounded Optimization
   ====================================

   SPG Program - E.G.Birgin, J.M.Martinez and M.Raydan.
   ====================================================

   Date: ---  Month: 9  Day:14  Year: 2010

   Termination criteria:
   cginfn .le. eps
   cgtwon .le. eps2**2
   where :
   cginfn is the gradient infinite-norm, and eps=  .0000000000000E+00
   cgtwon is the gradient 2-norm, and eps2=  .1000000000000E-05

   Line search interpolation:
   Line search with safeguarded cubic interpolation
   ====================================================================


   Steady State Combustion Problem    n=  40000

F=         -5.1692563011D+00
```

```
CGINFNORM=  2.0536686053D-08
CGTWONORM=  9.8611315784D-07
FLAG=       1

ITER=         468
FCNT=         587
GCNT=         469
TIME(csec.)=   2972
```

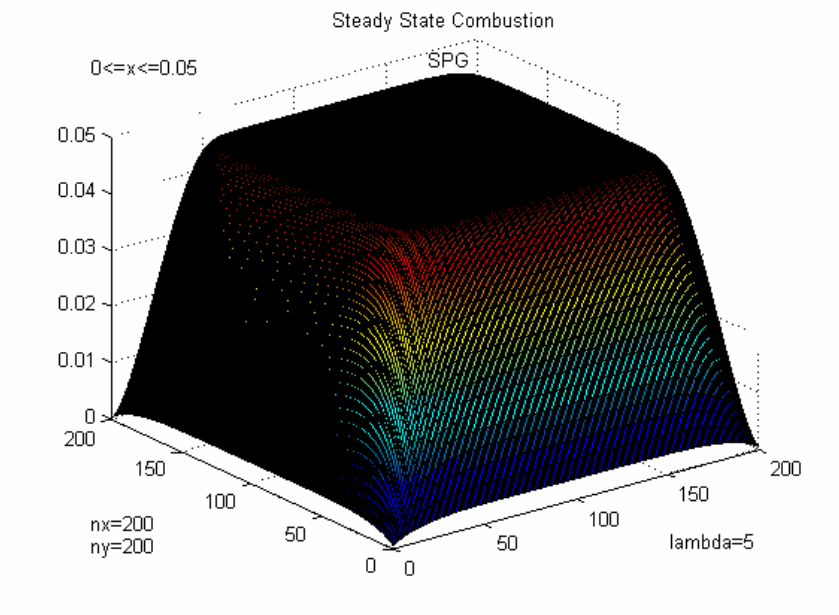

Fig. 27. Steady State Combustion Problem (quadratic).

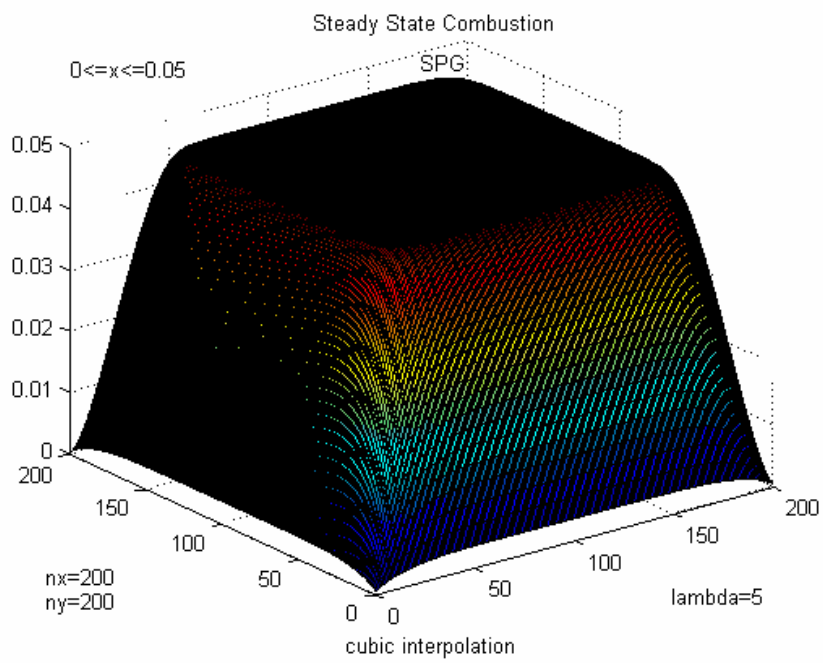

Fig. 28. Steady State Combustion Problem (cubic).

References

[1] **E.G. Birgin, J.M., Martinez and M. Raydan,** "Nonmonotone spectral projected gradient methods for convex sets", SIAM J. on Optimization 10(4), 1196-1211, 2000.

[2] **B.M. Averick, R.G. Carter, J.J. Moré, G-L Xue**, “The MINPACK-2 test problem collection”. Preprint MCS-P153-0692, Mathematics and Computer Science Division, Argonne NationalLaboratory, 9700 South Cass Avenue, Argonne, Illinois, 60439, USA, June 1992.