

Using PROPID for Inverse Design

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Steady-State Aerodynamics Codes for HAWTs
Selig, Tangler, and Giguère

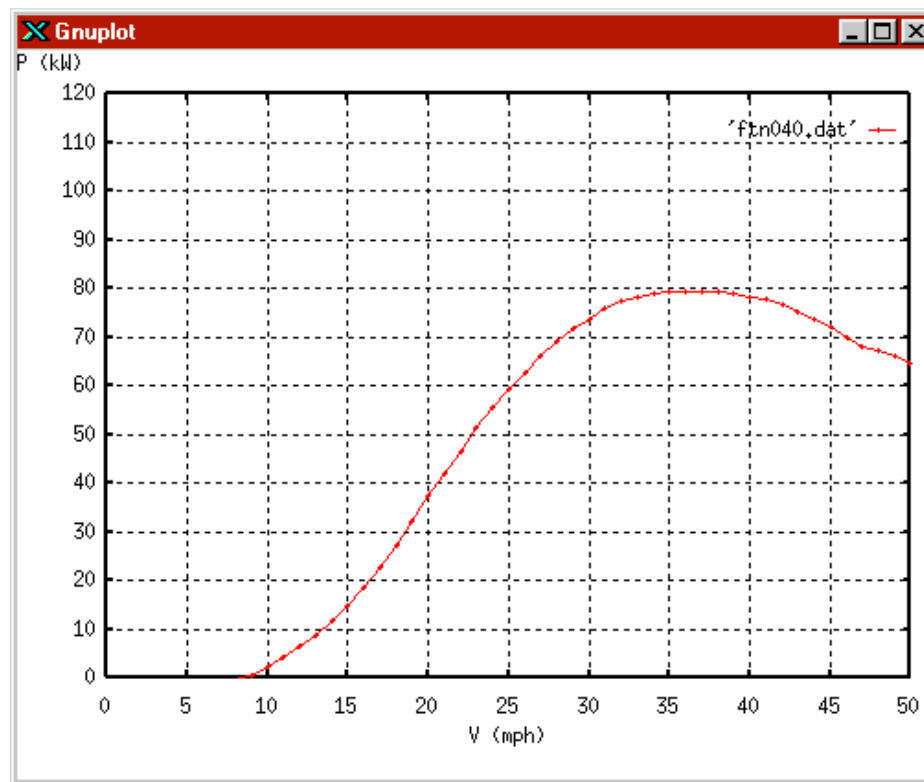


University of Illinois at Urbana-Champaign
National Renewable Energy Laboratory



Peak Power Specification for a Stall Regulated Turbine (1-D Iteration)

- PROPID Run: wt04a.in
 - Baseline Power Curve, No Iteration



- Iterate on Scale factor (% Growth)
- NEWT1ISWP Line

```

X emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Use Newton iteration to prescribe the peak power
# One parameter prescribed via Newton iteration
#      => "NEWT1"
# Peak Power => An Integrated quantity over a wind speed SWEEP
#      => "ISWP"
#
#>>line> NEWT1ISWP <IFTP1(.)> <FNEWT1(.)> -
#      <XJSNT1(.)> <XJFNT1(.)> <DXJNT1(.)> -
#      <KDP RPM1(.)> <KDP FL1(.)> <KDP XJ1(.)> -
#      <ITP1(.)> <ITP2(.)> <ITP3(.)> -
#      | <CLAMP1(.)> | <TOL1(.)>
#
NEWT1ISWP 300 95 25 50 1 1 1 999 1 1 999
IDES
#
# type of variable = 300 for peak power prescription
# peak power = 95 kW
# start, end, inc in windspeed = 25, 50, 1 mph
# rpm, pitch design points = 1, 1, (999 dummy parameter)
# variable for iteration = 1, 1, (999 dummy parameter)
#      = scale the rotor
# no clamp (step limit), no tolerance for automatic convergence
----Emacs: wt04a.in 10:30pm 0.02 Mail (Makefile Font)--L72--C0--

```



– Variables for Iteration (ITP* Parameters)

```

X emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
---Variables for iteration with NEWT1* mode:
Class          Particular          Iteration schedule
variable       variable

ITP1(.)        ITP2(.)              ITP3(.)  CLAMP1(.)

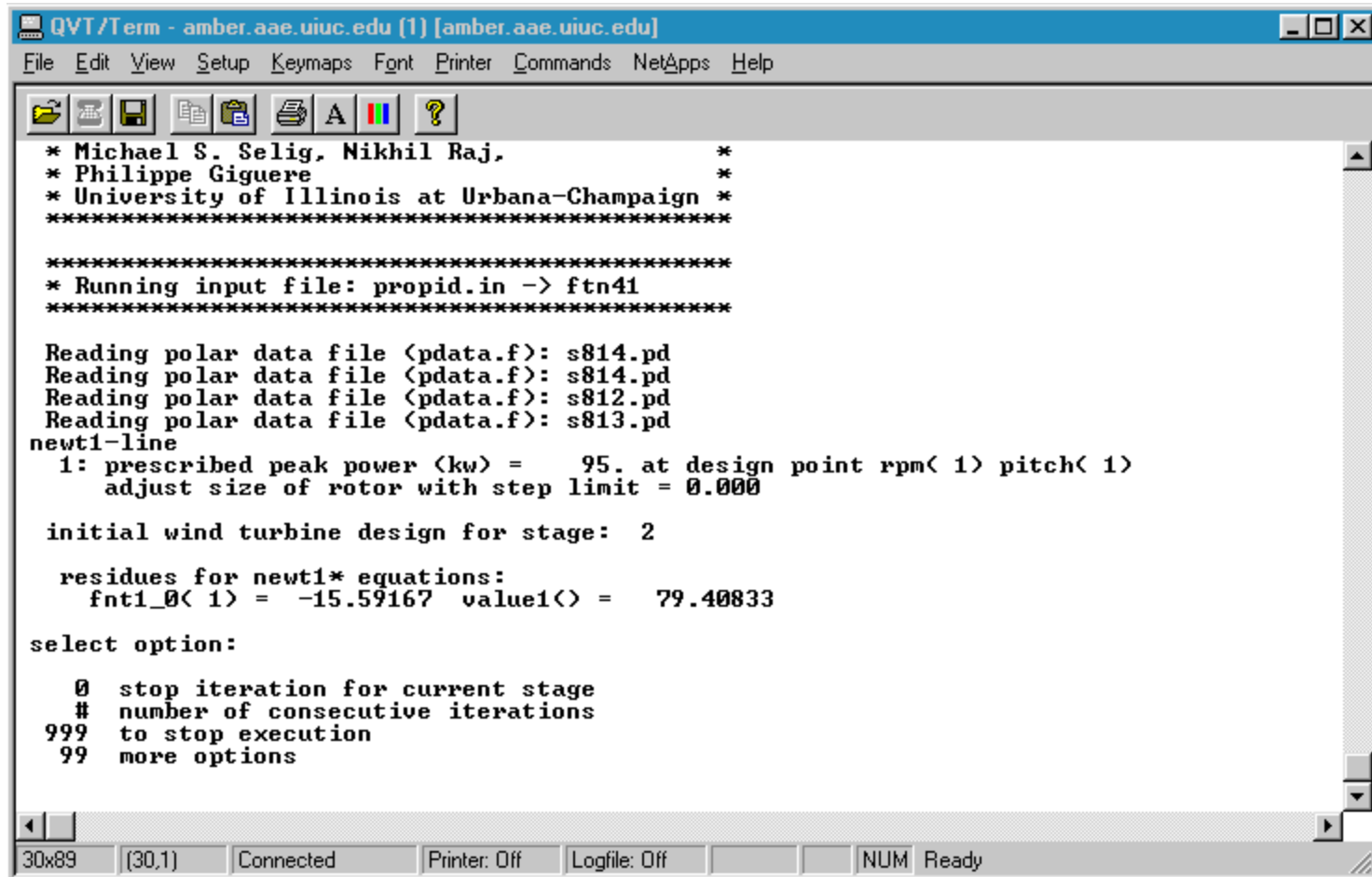
1 single       1 scale rotor                    (999)      1.
  parameters  2 RPM - revs/minute             1,2,3,.. DP value  3.
               3 FL - beta,pitch, degs 1,2,3,.. DP value  .5
               4 XJ - wind speed (IXDIM units) 1,2,3,.. DP value  3
               5 CONE - cone angle, deg      (999)        .5
               6 RHO - density, slugs/ft^3      (999)        .00005
               7 radius                    (999)
               8 TIPEFF (see prop.f)           (999)
               9 CHBASE (modify base chord)     (999)
              11 amount of dirt on blades (DIRT) (999)

-----Emacs: propid-doc.txt  10:48pm 0.07 Mail  (Makefile Font)--L995--C

```



– Running Interactively with Newton Iteration



```
QVT/Term - amber.aae.uiuc.edu [1] [amber.aae.uiuc.edu]
File Edit View Setup Keymaps Font Printer Commands NetApps Help

* Michael S. Selig, Nikhil Raj, *
* Philippe Giguere *
* University of Illinois at Urbana-Champaign *
*****

*****
* Running input file: propid.in -> ftn41
*****

Reading polar data file <pdata.f>: s814.pd
Reading polar data file <pdata.f>: s814.pd
Reading polar data file <pdata.f>: s812.pd
Reading polar data file <pdata.f>: s813.pd
newt1-line
  1: prescribed peak power <kw> = 95. at design point rpm< 1> pitch< 1>
    adjust size of rotor with step limit = 0.000

initial wind turbine design for stage: 2

residues for newt1* equations:
  fnt1_0< 1> = -15.59167 value1< > = 79.40833

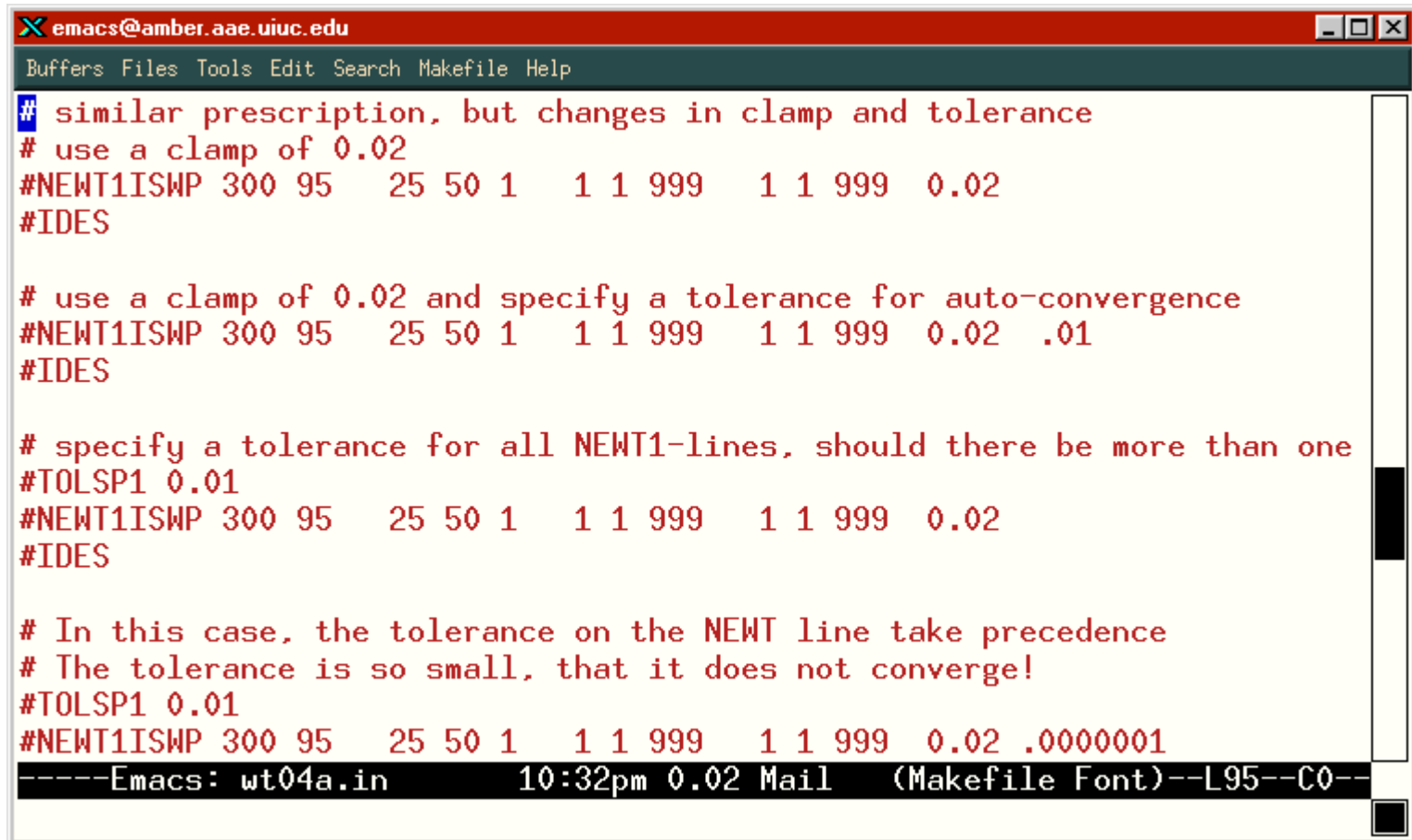
select option:

  0 stop iteration for current stage
  # number of consecutive iterations
999 to stop execution
99 more options

30x89 (30,1) Connected Printer: Off Logfile: Off NUM Ready
```



– NEWT1ISWP Line - Variations



```
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Buffers Files Tools Edit Search Makefile Help

# similar prescription, but changes in clamp and tolerance
# use a clamp of 0.02
#NEWT1ISWP 300 95 25 50 1 1 1 999 1 1 999 0.02
#IDES

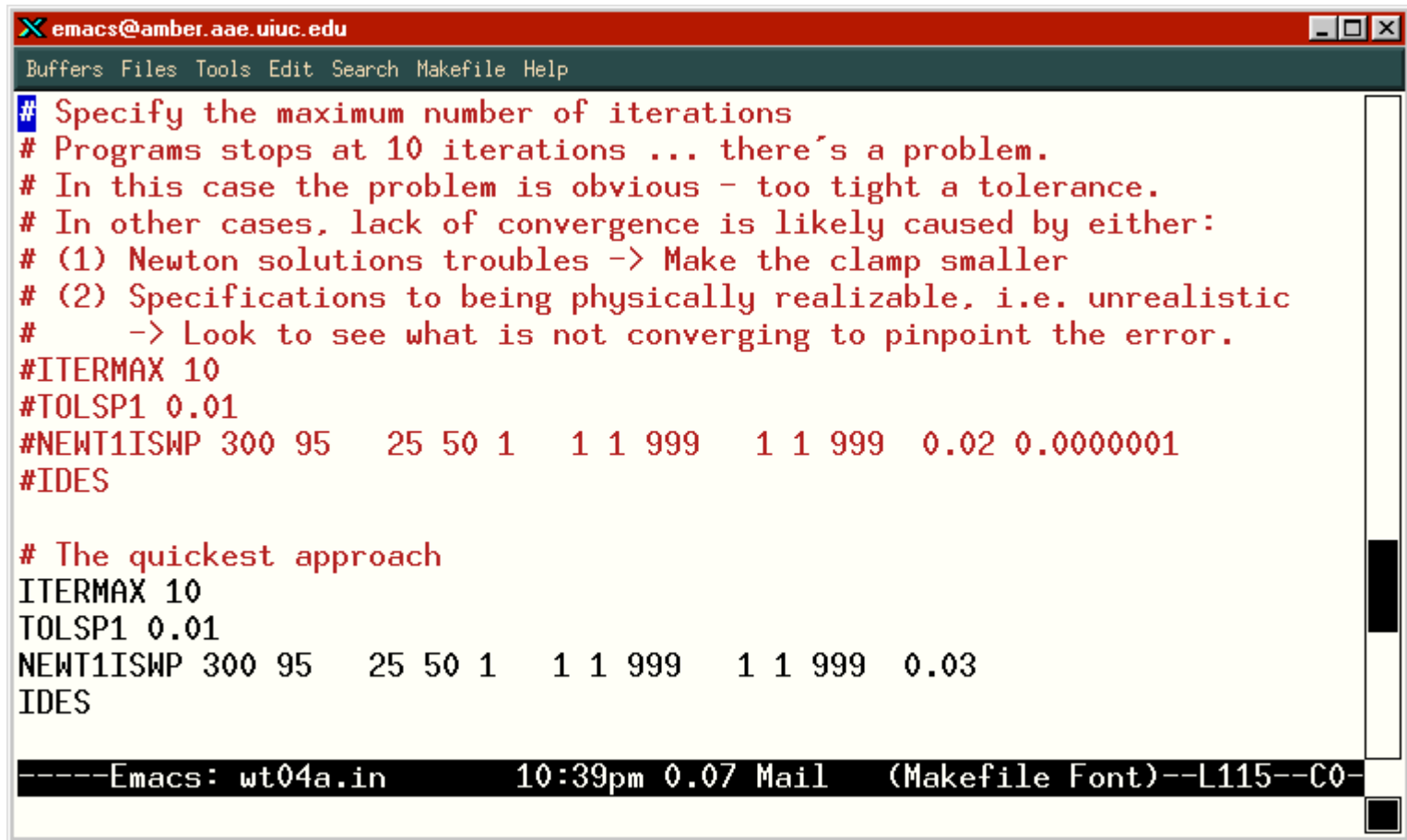
# use a clamp of 0.02 and specify a tolerance for auto-convergence
#NEWT1ISWP 300 95 25 50 1 1 1 999 1 1 999 0.02 .01
#IDES

# specify a tolerance for all NEWT1-lines, should there be more than one
#TOLSP1 0.01
#NEWT1ISWP 300 95 25 50 1 1 1 999 1 1 999 0.02
#IDES

# In this case, the tolerance on the NEWT line take precedence
# The tolerance is so small, that it does not converge!
#TOLSP1 0.01
#NEWT1ISWP 300 95 25 50 1 1 1 999 1 1 999 0.02 .0000001
----Emacs: wt04a.in 10:32pm 0.02 Mail (Makefile Font)--L95--C0--
```



– The Quickest Approach



```
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Buffers Files Tools Edit Search Makefile Help

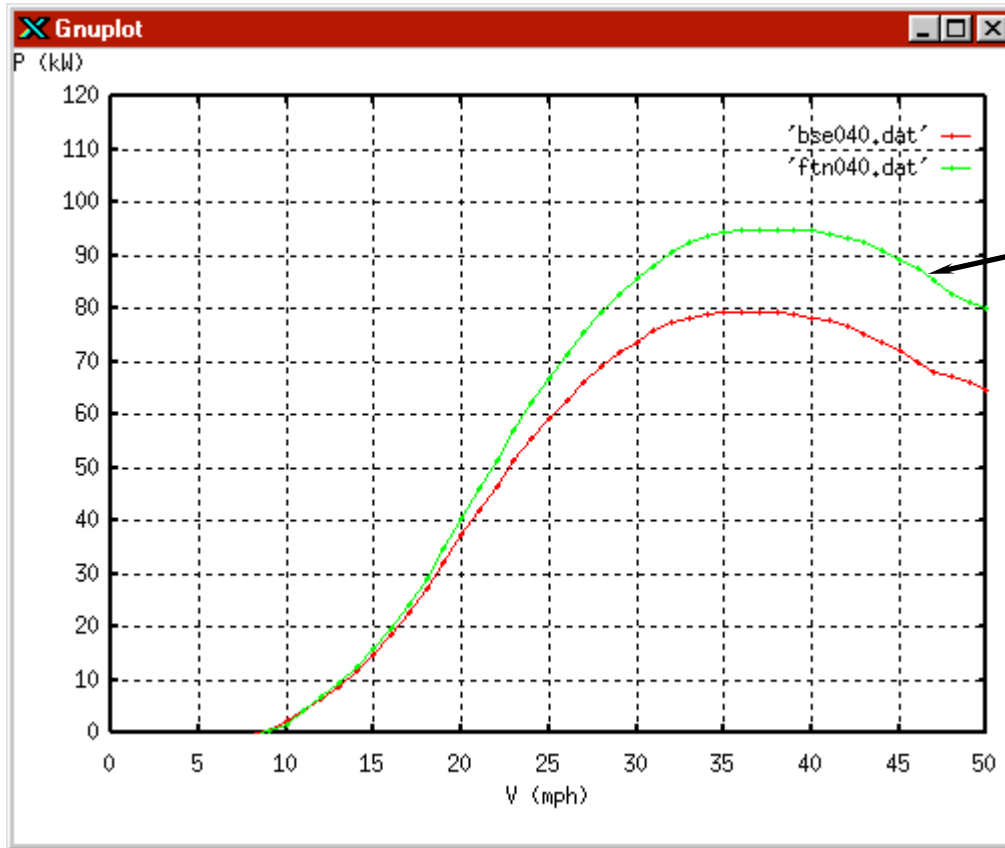
# Specify the maximum number of iterations
# Programs stops at 10 iterations ... there's a problem.
# In this case the problem is obvious - too tight a tolerance.
# In other cases, lack of convergence is likely caused by either:
# (1) Newton solutions troubles -> Make the clamp smaller
# (2) Specifications to being physically realizable, i.e. unrealistic
#     -> Look to see what is not converging to pinpoint the error.
#ITERMAX 10
#TOLSP1 0.01
#NEWT1ISWP 300 95 25 50 1 1 1 999 1 1 999 0.02 0.0000001
#IDES

# The quickest approach
ITERMAX 10
TOLSP1 0.01
NEWT1ISWP 300 95 25 50 1 1 1 999 1 1 999 0.03
IDES

----Emacs: wt04a.in 10:39pm 0.07 Mail (Makefile Font)--L115--C0-
```



- Final Converged Power and Baseline



New rotor

- Radius Grew from 24.6 ft => 25.5 ft (see ftn021.dat)



- PROPID Run: wt05a.in
 - Iteration on Blade Pitch Instead
 - NEWT1ISWP Line

```

X emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
#>>line> NEWT1ISWP <IFTP1(.)> <FNEWT1(.)> -
#               <XJSNT1(.)> <XJFNT1(.)> <DXJNT1(.)> -
#               <KDP RPM1(.)> <KDPFL1(.)> <KDPXJ1(.)> -
#               <ITP1(.)> <ITP2(.)> <ITP3(.)> -
#               | <CLAMP1(.)> | <TOL1(.)>
#
NEWT1ISWP 300 95    25 50 1    1 1 999    1 3 1
IDES
#
# type of variable = 300 for peak power prescription
# peak power = 95 kW
# start, end, inc in windspeed = 25, 50, 1 mph
# rpm, pitch design points = 1, 1, (999 dummy parameter)
# variable for iteration = 1, 3, 1
#                               = change blade pitch for DP 1
# no clamp (step limit), no tolerance for automatic convergence

-----Emacs: wt05a.in          11:00pm 0.10 Mail    (Makefile Font)--L78--C0--

```



– Variables for Iteration (ITP* Parameters)

```

X emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
---Variables for iteration with NEWT1* mode:
Class          Particular          Iteration schedule
variable       variable

ITP1(.)        ITP2(.)              ITP3(.)  CLAMP1(.)

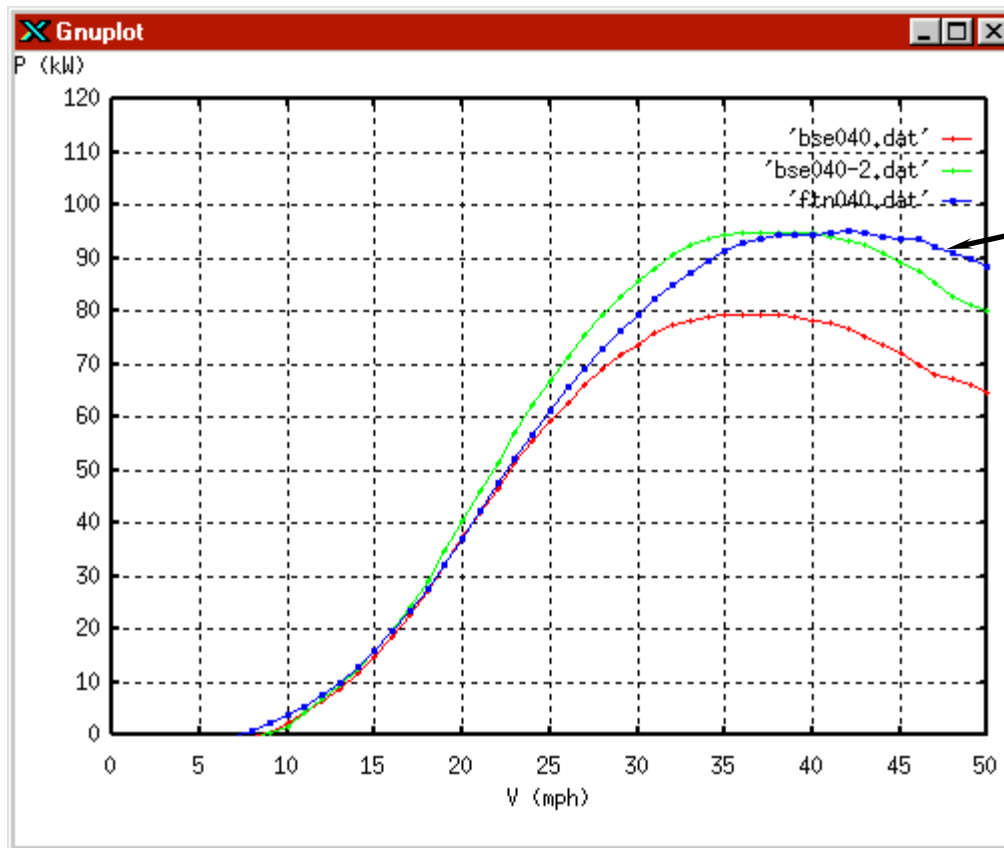
1 single       1 scale rotor                    (999)      1.
  parameters   2 RPM - revs/minute             1,2,3,.. DP value  3.
               3 FL - beta,pitch, degs 1,2,3,.. DP value  .5
               4 XJ - wind speed (IXDIM units) 1,2,3,.. DP value  3
               5 CONE - cone angle, deg (999)      .5
               6 RHO - density, slugs/ft^3 (999)    .00005
               7 radius (999)
               8 TIPEFF (see prop.f) (999)
               9 CHBASE (modify base chord) (999)
              11 amount of dirt on blades (DIRT)(999)

-----Emacs: propid-doc.txt 10:48pm 0.07 Mail (Makefile Font)--L995--C

```



– Final Converged Power Curve and Previous Ones



New rotor

– Pitch Change: 2 deg => 4.3 deg

- wt04a.in & wt05a.in Example of 1-D Newton Iteration



2-D Newton Iteration

- PROPID Run: wt06a.in
 - Rotor Scale \Rightarrow Peak Power (500 kW)
 - Rotor RPM \Rightarrow Tip Speed (150 mph, 220 ft/sec)

```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Design point: 64 rpm, 2 deg pitch, 45 mph
DP 1 64 2.00 15.000 2

# Specify the peak power (500 kW) and iterate on the rotor scale
NEWT1ISWP 300 500 25 50 1 1 1 999 1 1 999 .3
IDES

# Specify the tip speed (150 mph, 220 ft/sec) and
# iterate on the rpm at a given design point DP
#>>line> NEWT1IDP <IFTP1(.)> <FNEWT1(.)> -
# <KDP RPM1(.)> <KDP FL1(.)> <KDP XJ1(.)> -
# <ITP1(.)> <ITP2(.)> <ITP3(.)> -
# | <CLAMP1(.)> | <TOL1(.)>
NEWT1IDP 207 220 1 1 999 1 2 1
IDES

-----Emacs: wt06a.in 11:42pm 0.14 Mail (Makefile Font)--L66--C0--
```



– Screen Grab from Run - Stages

```
newt1-line
1: prescribed peak power (kw) = 500. at design point rpm( 1) pitch( 1)
   adjust size of rotor with step limit = 0.300

initial wind turbine design for stage: 1

residues for newt1* equations:
  fnt1_0( 1) = -420.59170 value1( ) = 79.40833

select option:

  0 stop iteration for current stage
  # number of consecutive iterations
999 to stop execution
  99 more options

0

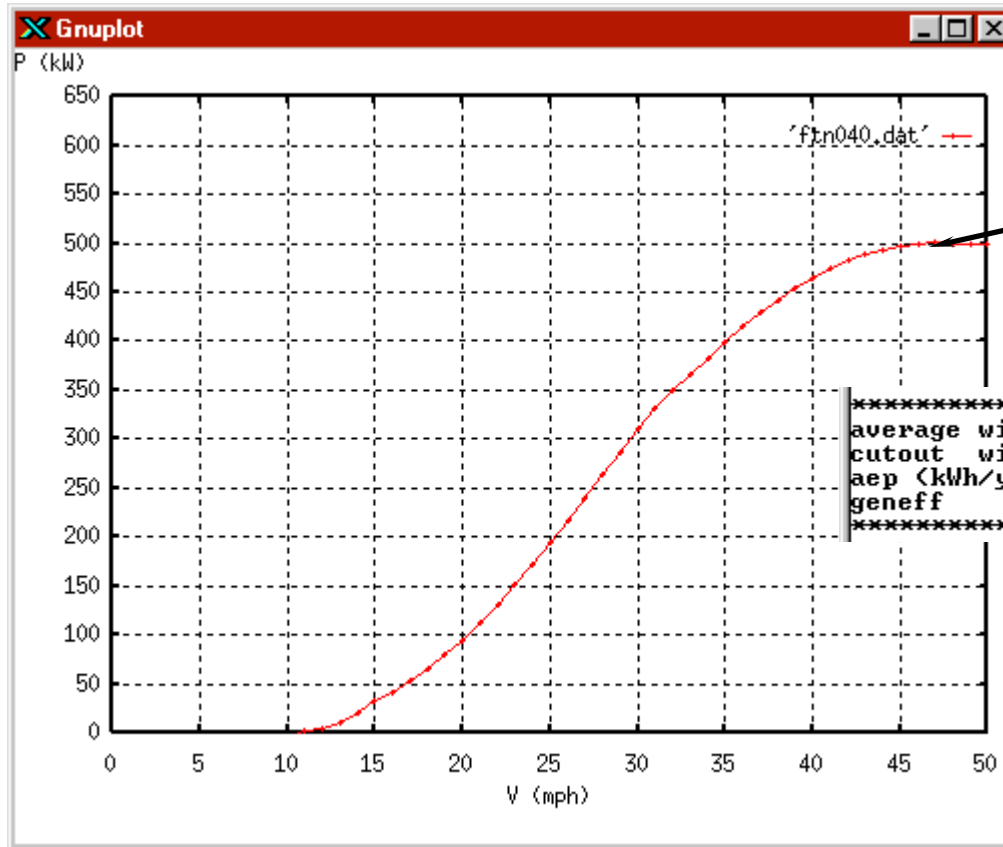
newt1-line
2: prescribed tip speed = 220.0000 at design point rpm( 1) pitch( 1) xj(**)
   adjust rpm( 1) with step limit = 0.000 (rpm)

initial wind turbine design for stage: 2

residues for newt1* equations:
  fnt1_0( 1) = -420.59170 value1( ) = 79.40833
  fnt1_0( 2) = -55.06219 value1( ) = 164.93780
```



– Resulting Power Curve



*500 kW
Peak Power*

AEP = 694 MWh/yr

- Radius Change: 24.61 ft => 39.9 ft
- RPM Change: 64 rpm => 52.6 rpm



Lift and Axial Inflow Specifications (Multidimensional Newton Iteration)

- PROPID Run: wt07a.in (analysis only)
 - Rotor Radius Same as wt06a.in (39.9 ft)
 - Variable Speed Turbine Design, $TSR = 6$



– DP and Special Input Lines



```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# RPM set according to a TSR = 6 @ 16 mph
DP 1 33.66 2.00 16.000 2

IDES

# Used these lines to get the RPM (33.66) for TSR = 6 @ 16 mph
# tip speed = 6*16*88/60
#NEWT1IDP 207 140.8 1 1 999 1 2 1
#IDES
#REPORT_DP 1 1 1

# Special lines required for variable speed turbines
LCOL45
VS_MODE

---Emacs: wt07a.in 8:49pm Mail (Makefile Font)--L71--C0--47%--
Find file: ~/propid5080/runs/990802-shortcourse/
```



– Cp (2D_SWEEP) & Power Curve (2D_SWEEP)

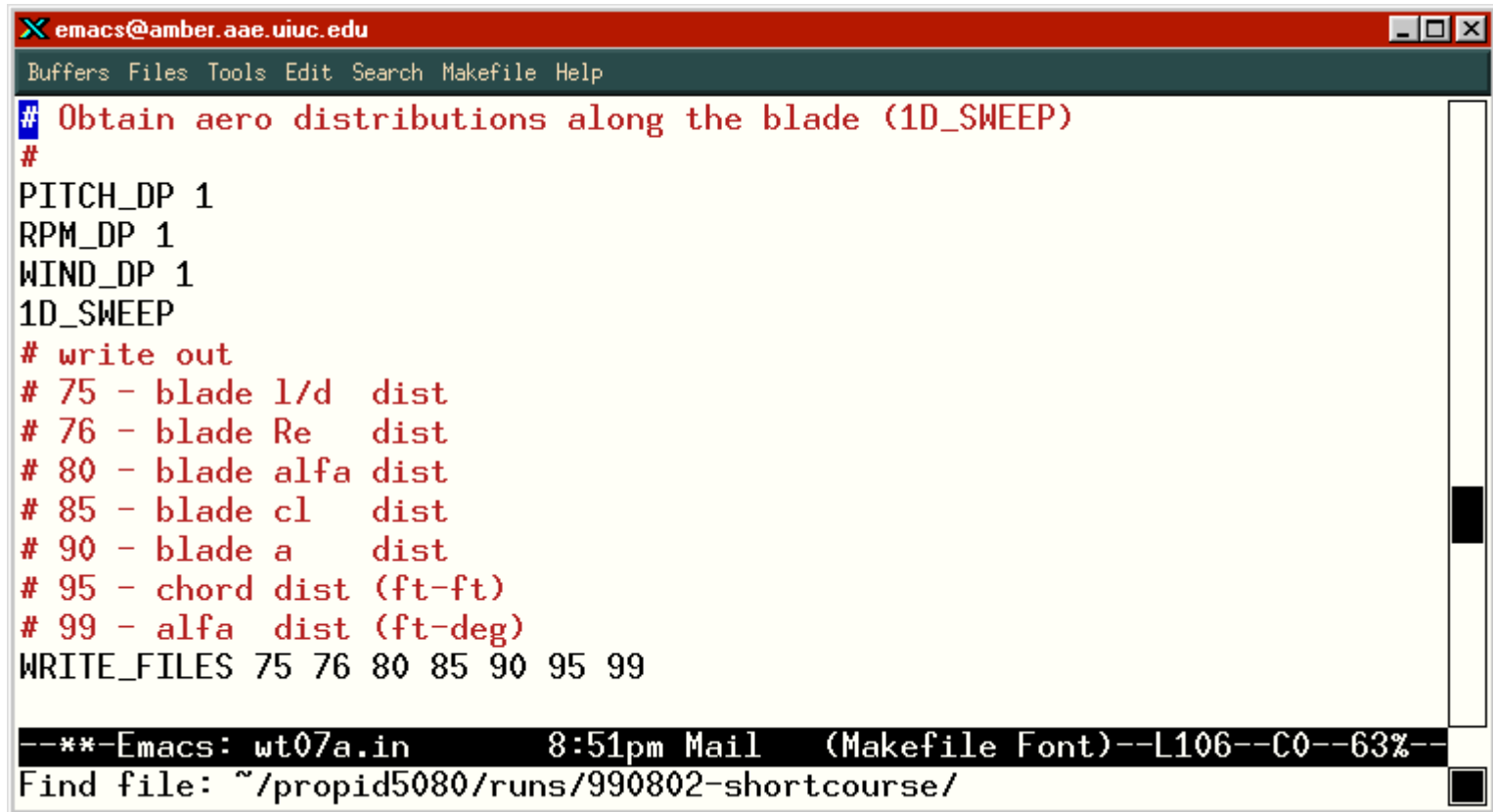
```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help

# Determine cp curve
PITCH_DP 1
TSR_SWEEP .5 14 .25
WIND_SWEEP 16 16 1 2
2D_SWEEP
# 45 - cp vs TSR
WRITE_FILES 45

# Determine the rotor power and thrust curves (2D_SWEEP)
FIXPD 500 1
PITCH_DP 1
TSR_SWEEP 6 6 0
WIND_SWEEP 5 50 1 2
2D_SWEEP
# write out
# 40 - power curve (kW) vs wind speed (mph)
# 51 - rotor thrust curve
WRITE_FILES 40 51
--*-Emacs: wt07a.in      8:50pm Mail  (Makefile Font)--L87--C0--54%--
Find file: ~/propid5080/runs/990802-shortcourse/
```



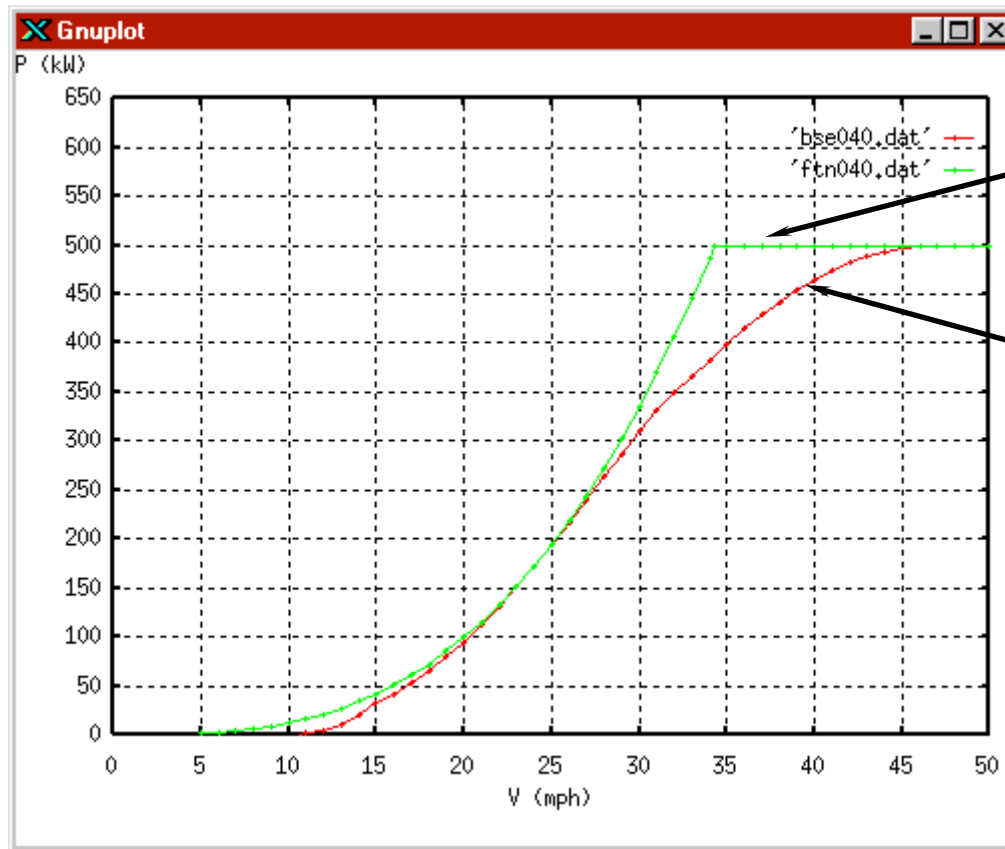
– Blade Aero and Geometry (1D_SWEEP)



```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Obtain aero distributions along the blade (1D_SWEEP)
#
PITCH_DP 1
RPM_DP 1
WIND_DP 1
1D_SWEEP
# write out
# 75 - blade l/d dist
# 76 - blade Re dist
# 80 - blade alfa dist
# 85 - blade cl dist
# 90 - blade a dist
# 95 - chord dist (ft-ft)
# 99 - alfa dist (ft-deg)
WRITE_FILES 75 76 80 85 90 95 99
--*-Emacs: wt07a.in      8:51pm Mail (Makefile Font)--L106--C0--63%--
Find file: ~/propid5080/runs/990802-shortcourse/
```



– Power Curves



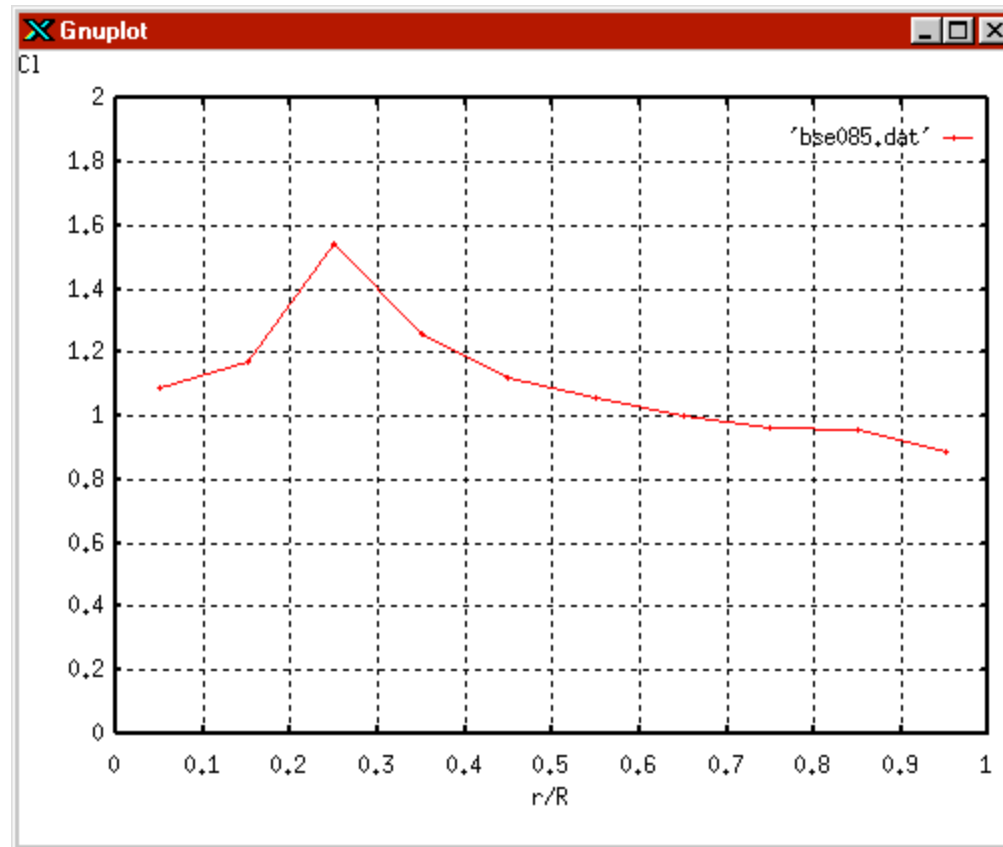
*Variable
Speed Case*

*Stall
Regulated
Baseline*

– AEP 790 MWh/yr (wt07a) vs 694 MWh/yr (wt06a)



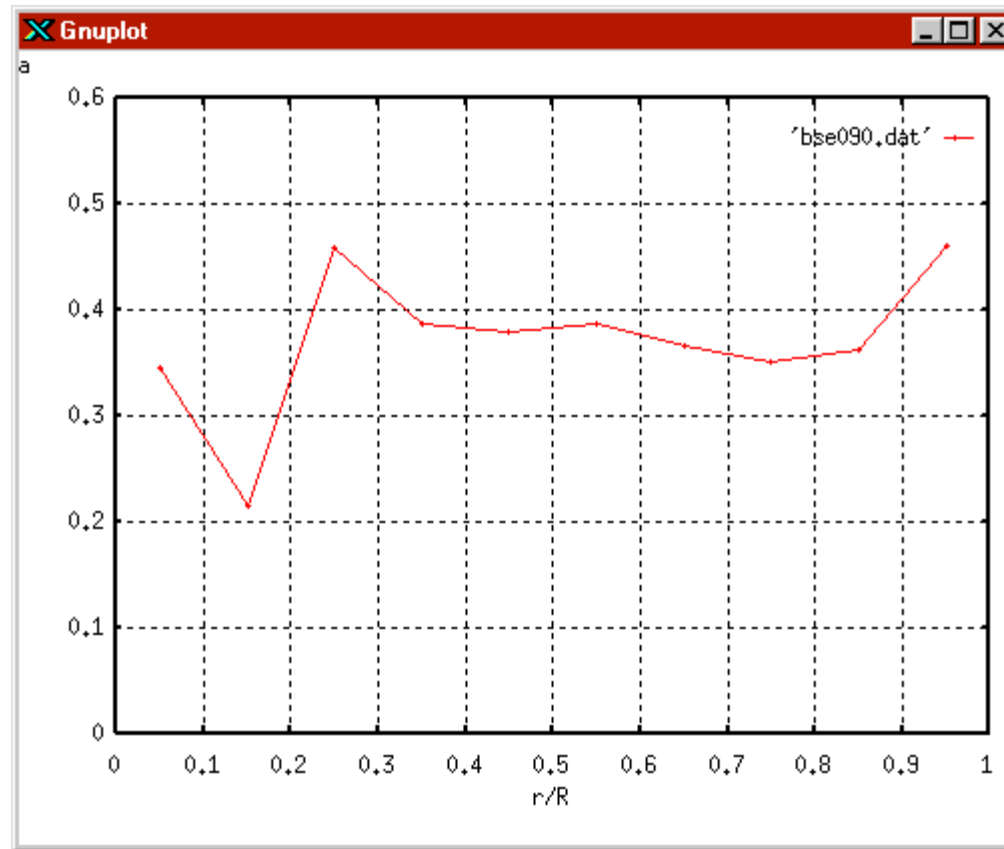
– Lift Distribution



– Desire Cl-dist for Best L/D-dist



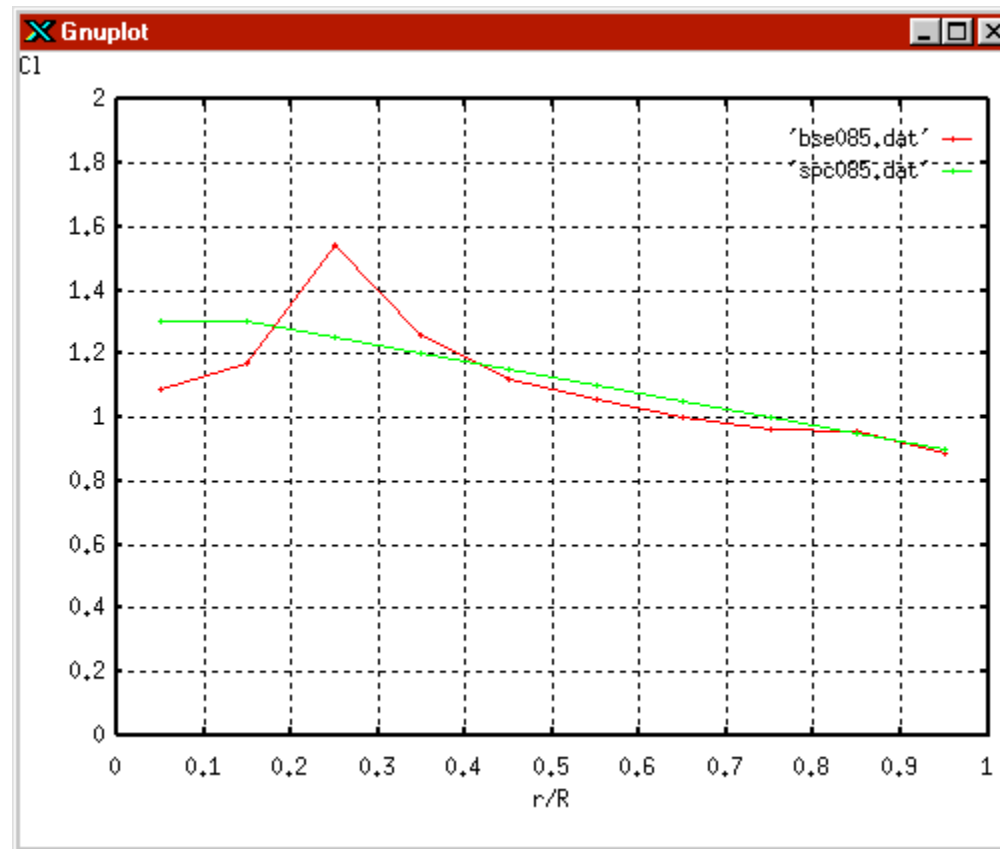
– Axial Induction Factor Distribution



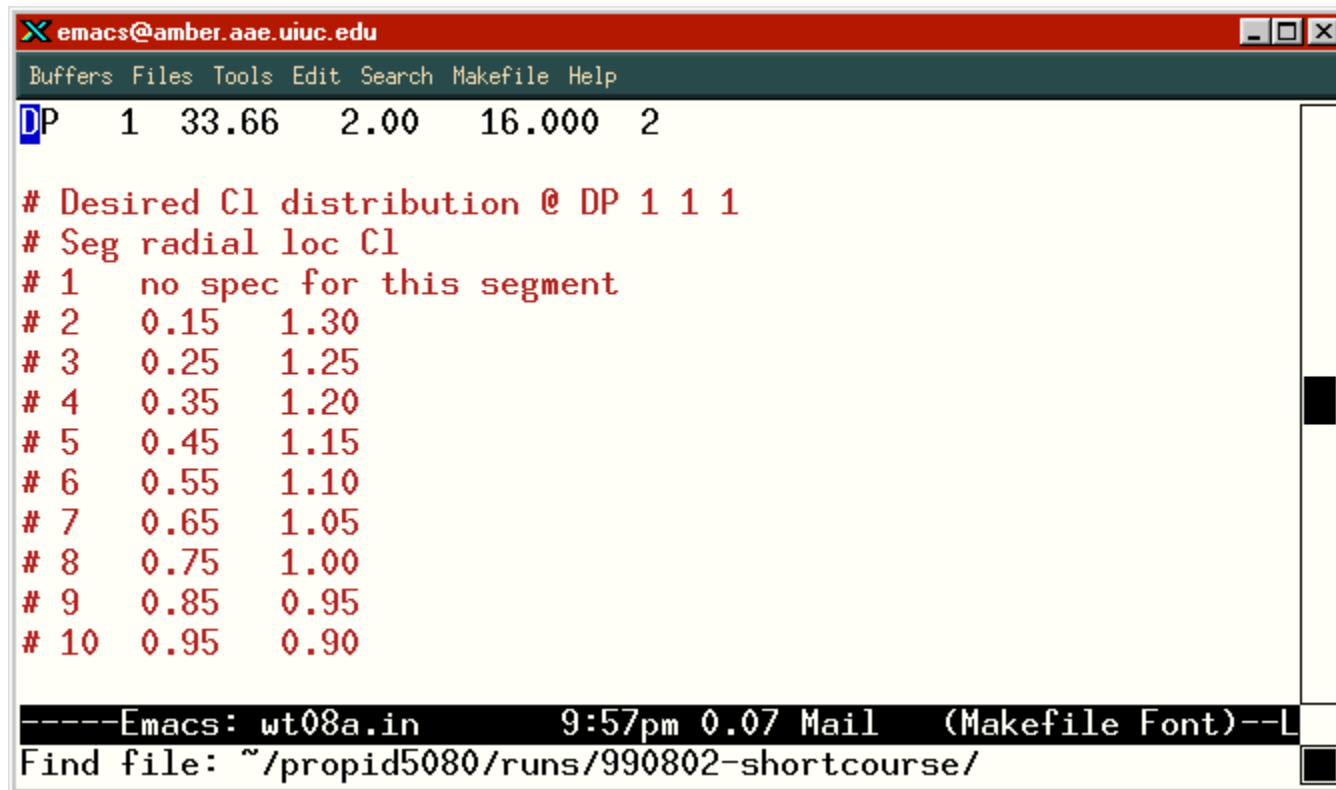
– Desire $a = 1/3$ Betz Optimum



- PROPID Run: wt08a.in
 - Desired Cl-dist vs Baseline



– Tabulated Cl-dist



The screenshot shows an Emacs window titled 'emacs@amber.aae.uiuc.edu'. The menu bar includes 'Buffers', 'Files', 'Tools', 'Edit', 'Search', 'Makefile', and 'Help'. The main text area contains the following content:

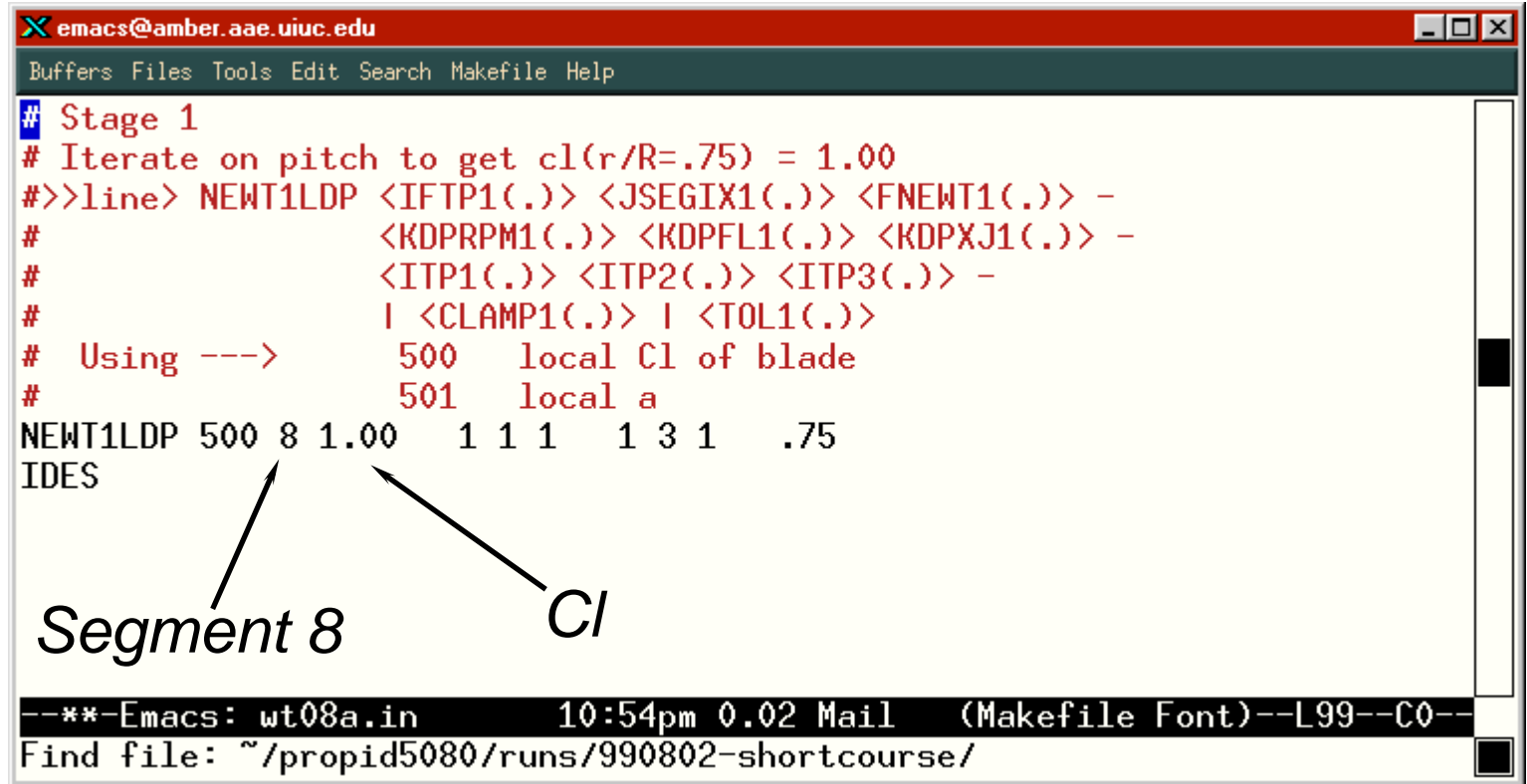
```
DP 1 33.66 2.00 16.000 2

# Desired Cl distribution @ DP 1 1 1
# Seg radial loc Cl
# 1 no spec for this segment
# 2 0.15 1.30
# 3 0.25 1.25
# 4 0.35 1.20
# 5 0.45 1.15
# 6 0.55 1.10
# 7 0.65 1.05
# 8 0.75 1.00
# 9 0.85 0.95
# 10 0.95 0.90
```

The status bar at the bottom displays '-----Emacs: wt08a.in 9:57pm 0.07 Mail (Makefile Font)--L' and a search prompt 'Find file: ~/propid5080/runs/990802-shortcourse/'.



- Stage 1: Cl @ Segment 8 = 1.00
- Iterate Pitch
- NEWT1LDP



```

emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help

# Stage 1
# Iterate on pitch to get  $cl(r/R=.75) = 1.00$ 
#>>line> NEWT1LDP <IFTP1(.)> <JSEGIX1(.)> <FNEW1(.)> -
#               <KDP RPM1(.)> <KDP FL1(.)> <KDP XJ1(.)> -
#               <ITP1(.)> <ITP2(.)> <ITP3(.)> -
#               I <CLAMP1(.)> I <TOL1(.)>
# Using --->      500   local Cl of blade
#               501   local a
NEWT1LDP 500 8 1.00 1 1 1 1 3 1 .75
IDES

--***-Emacs: wt08a.in      10:54pm 0.02 Mail (Makefile Font)--L99--C0--
Find file: ~/propid5080/runs/990802-shortcourse/

```

Segment 8 → 8

Cl → 1.00



- Stage 2: CI @ Segments 9-10 Relative to 8
- Iterate Twist @ Segments 9-10
- NEWT2SDDP

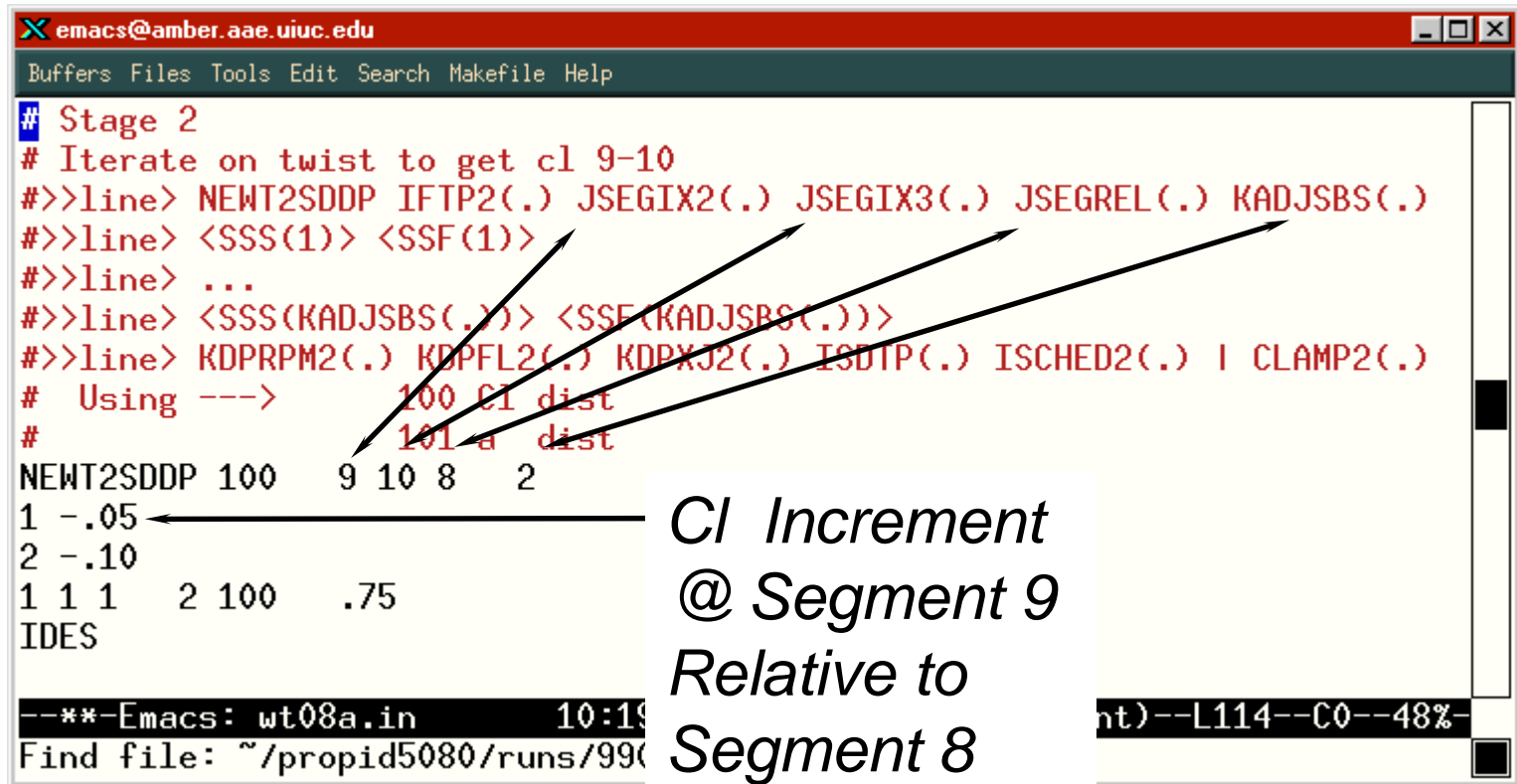
```

emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Stage 2
# Iterate on twist to get c1 9-10
#>>line> NEWT2SDDP IFTP2(.) JSEGIX2(.) JSEGIX3(.) JSEGREL(.) KADJSBS(.)
#>>line> <SSS(1)> <SSF(1)>
#>>line> ...
#>>line> <SSS(KADJSBS(.))> <SSF(KADJSBS(.))>
#>>line> KDP RPM2(.) KDPFL2(.) KDPXJ2(.) ISDTP(.) ISCHED2(.) I CLAMP2(.)
# Using --->      100 CI dist
#              101 a dist
NEWT2SDDP 100    9 10 8    2
1 -.05
2 -.10
1 1 1    2 100    .75
IDES
--*-Emacs: wt08a.in      10:19pm Mail    (Makefile Font)--L114--C0--48%--
Find file: ~/propid5080/runs/990802-shortcourse/

```



– Details

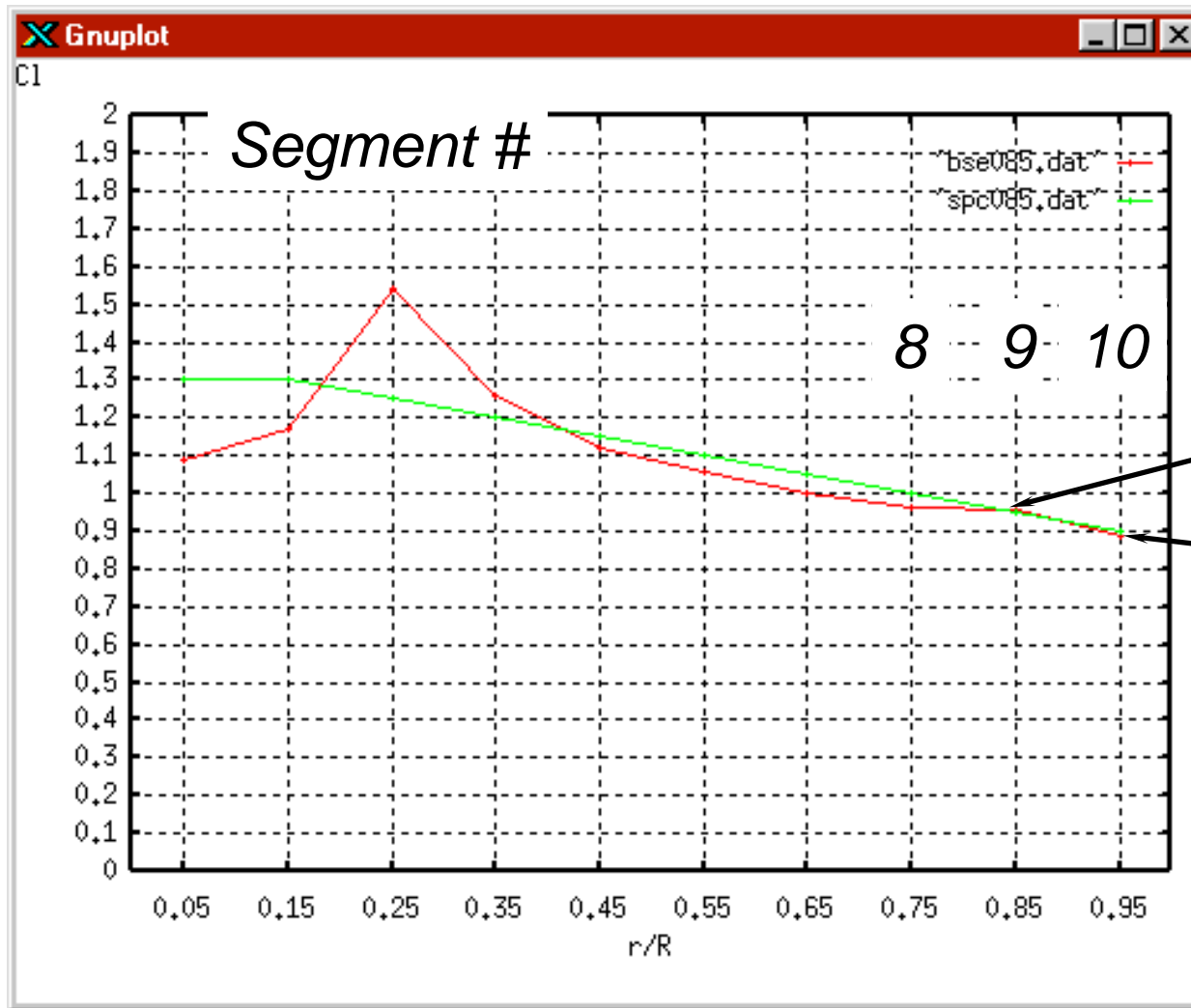


```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Stage 2
# Iterate on twist to get cl 9-10
#>>line> NEWT2SDDP IFTP2(.) JSEGIX2(.) JSEGIX3(.) JSEGREL(.) KADJSBS(.)
#>>line> <SSS(1)> <SSF(1)>
#>>line> ...
#>>line> <SSS(KADJSBS(.))> <SSF(KADJSBS(.))>
#>>line> KDP RPM2(.) KDPFL2(.) KDPXJ2(.) ISDTP(.) ISCHED2(.) | CLAMP2(.)
# Using --->      100 CI dist
#                  101 a dist
NEWT2SDDP 100      9 10 8 2
1 -.05
2 -.10
1 1 1 2 100 .75
IDES
--**--Emacs: wt08a.in 10:19
Find file: ~/propid5080/runs/990
```

*CI Increment
@ Segment 9
Relative to
Segment 8*



- Relative CI Values



– Iteration Schedule for CI

```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
---Variables for iteration NEWT2* mode:
Variable          Particular type of iteration schedule

ISDTP(.)          ISCHED2(.)          CLAMP2(.), suggested value

1  chord          100    move all individually

---*-Emacs: propid-doc.txt  7:47pm 0.10 Mail  (Makefile Font)--L1093--C0--64%
2  twist          100    move all individually
                        201    step to tip          .5
                        202    step from root
                        301    ramp to tip
                        302    ramp from root

---*-Emacs: propid-doc.txt  7:47pm 0.10 Mail  (Makefile Font)--L1112--C0--65%
Find file: ~/propid5080/runs/990802-shortcourse/
```



- Stage 3: CI @ Segments 2-7 Relative to 8
- Iterate Twist @ Segments 2-7

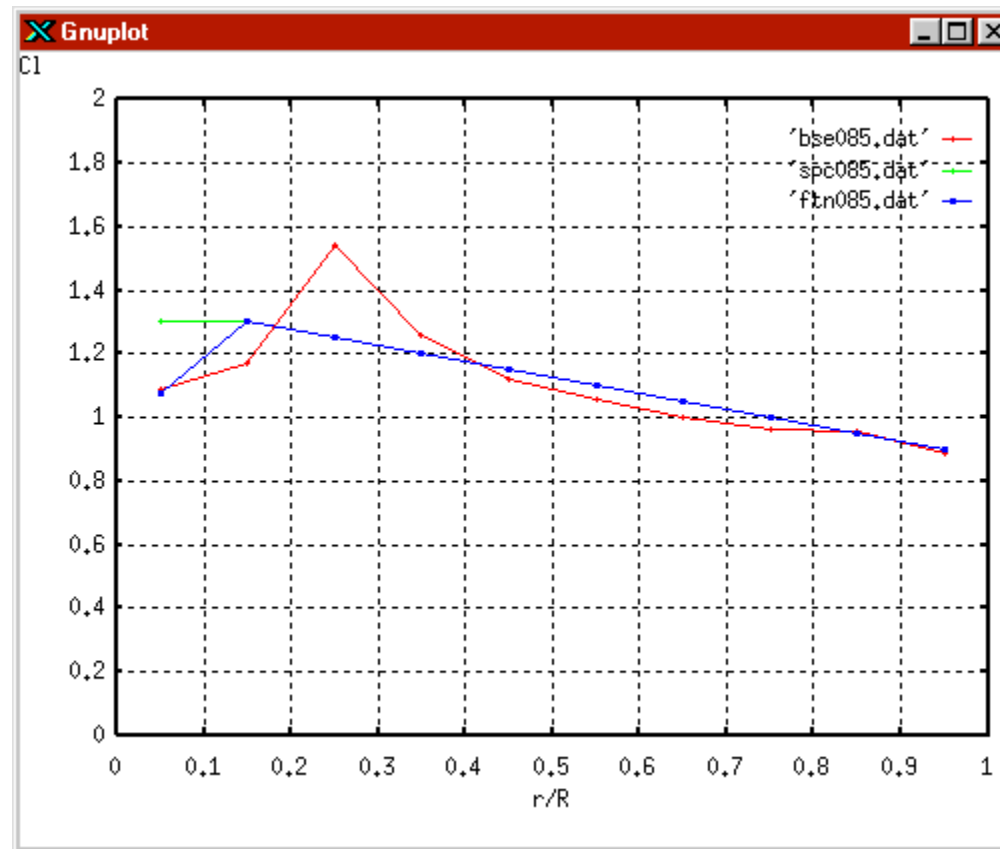
```

X emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Stage 3
# Iterate on twist to get c1 2-7
#>>line> NEWT2SDDP IFTP2(.) JSEGIX2(.) JSEGIX3(.) JSEGREL(.) KADJSBS(.)
#>>line> <SSS(1)> <SSF(1)>
#>>line> ...
#>>line> <SSS(KADJSBS(.))> <SSF(KADJSBS(.))>
#>>line> KDPRPM2(.) KDPFL2(.) KDPXJ2(.) ISDTP(.) ISCHED2(.) I CLAMP2(.)
# Using --->      100 CI dist
#                101 a  dist
NEWT2SDDP 100    2 7 8    6
1 .30
2 .25
3 .20
4 .15
5 .10
6 .05
1 1 1    2 100    .75
IDES
--**-Emacs: wt08a.in      10:20pm Mail (Makefile Font)--L130--C0--55%-
Find file: ~/propid5080/runs/990802-shortcourse/

```



– Converged CI Distribution



- Stage 4: Axial Inflow @ Segment 8 = .333
- Iterate Chord @ Segment 8

```

X emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Stage 4
# Iterate on chord uniformly to get axial inflow(r/R=.75) = .333
#>>line> NEWT1LDP <IFTP1(.)> <JSEGIX1(.)> <FNEWT1(.)> -
#               <KDPRPM1(.)> <KDPFL1(.)> <KDPXJ1(.)> -
#               <ITP1(.)> <ITP2(.)> <ITP3(.)> -
#               | <CLAMP1(.)> | <TOL1(.)>
#               500   local C1 of blade
# Using --->    501   local a
NEWT1LDP 501 8 .333  1 1 1  2 999 100  .02
IDES

--*-Emacs: wt08a.in      10:26pm 0.05 Mail  (Makefile Font)--L149--C0-
Find file: ~/propid5080/runs/990802-shortcourse/

```



- Iteration for Axial Inflow at Segment 8

```

emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help

--Variables for iteration with NEWT1* mode:
Class          Particular          Iteration schedule
variable       variable

ITP1(.)        ITP2(.)              ITP3(.)  CLAMP1(.)

1 single       1 scale rotor              (999)      1.
--**--Emacs: propid-doc.txt  8:12pm Mail  (Makefile Font)--L998--C0--58%-----
      |11amount of dirt on blades (DIRT)(999)
2 chord       1,2,3,... local chord      (999)      .005
(999)                                     100 shift all uniformly \
      1,2,3,... pivot point              201 step to tip \
--**--Emacs: propid-doc.txt  8:12pm Mail  (Makefile Font)--L1016--C0--59%-----
Find file: ~/propid5080/runs/990802-shortcourse/

```



- Stage 5: Axial Inflow @ Segments 9-10 Relative to 8
- Iterate Chord @ Segments 9-10

```

emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Stage 5
# Iterate on chord to get axial inflow 9-10
#>>line> NEWT2SDDP IFTP2(.) JSEGIX2(.) JSEGIX3(.) JSEGREL(.) KADJSBS(.)
#>>line> <SSS(1)> <SSF(1)>
#>>line> ...
#>>line> <SSS(KADJSBS(.))> <SSF(KADJSBS(.))>
#>>line> KDPRPM2(.) KDPFL2(.) KDPXJ2(.) ISDTP(.) ISCHED2(.) | CLAMP2(.) \
| TOL2(.)
#
#           100 C1 dist
# Using ---> 101 a dist
NEWT2SDDP 101  9 10 8  2
1 .0
2 .0
1 1 1  1 100  .02
IDES

--*-Emacs: wt08a.in      10:27pm 0.02 Mail  (Makefile Font)--L168--C0-
Find file: ~/propid5080/runs/990802-shortcourse/

```



– Iteration Schedule for Axial Induction Factor

```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
---Variables for iteration NEWT2* mode:
Variable          Particular type of iteration schedule

ISDTP(.)          ISCHED2(.)          CLAMP2(.), suggested value

1 chord          100    move all individually

---**-Emacs: propid-doc.txt  7:47pm 0.10 Mail  (Makefile Font)--L1093--C0--64%
2 twist          100    move all individually

                201    step to tip          .5
                202    step from root

                301    ramp to tip
                302    ramp from root

---**-Emacs: propid-doc.txt  7:47pm 0.10 Mail  (Makefile Font)--L1112--C0--65%
Find file: ~/propid5080/runs/990802-shortcourse/
```



- Stage 6: Axial Inflow @ Segments 2-7 Relative to 8
- Iterate Chord @ Segments 2-7

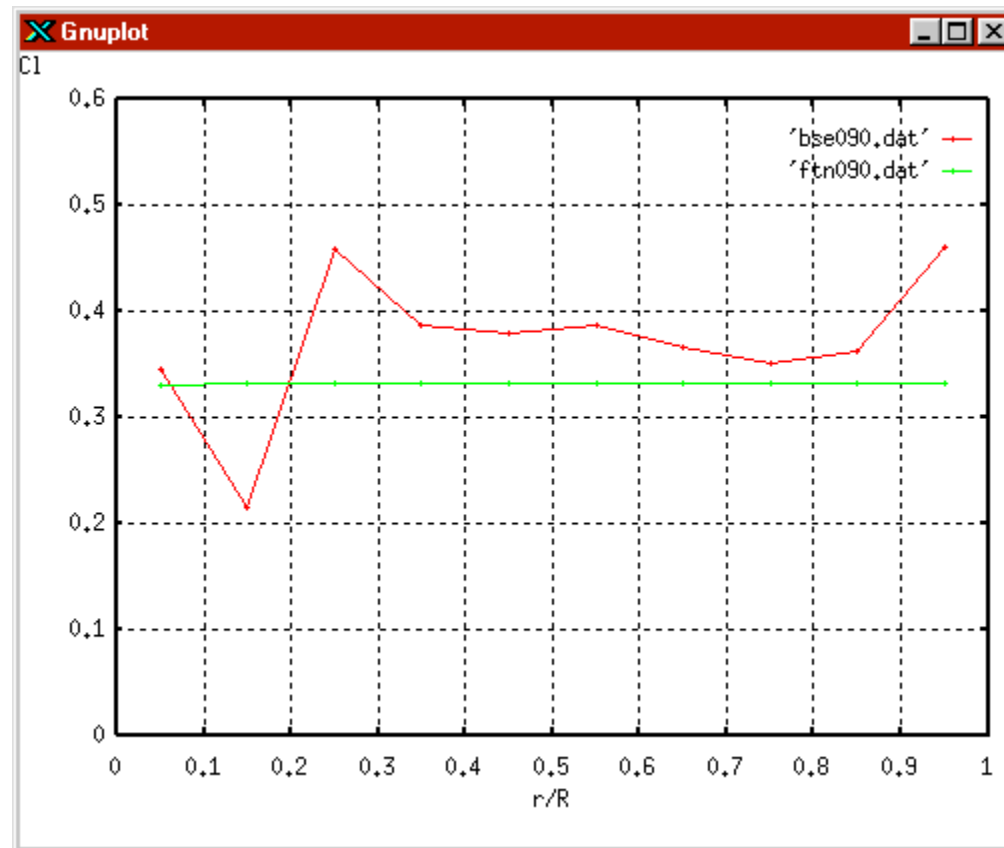
```

emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Stage 6
# Iterate on chord to get axial inflow 2-7
#>>line> NEWT2SDDP IFTP2(.) JSEGIX2(.) JSEGIX3(.) JSEGREL(.) KADJSBS(.)
#>>line> <SSS(1)> <SSF(1)>
#>>line> ...
#>>line> <SSS(KADJSBS(.))> <SSF(KADJSBS(.))>
#>>line> KDPRPM2(.) KDPFL2(.) KDPXJ2(.) ISDTP(.) ISCHED2(.) | CLAMP2(.) \
| TOL2(.)
#
#           100 C1 dist
# Using ---> 101 a dist
NEWT2SDDP 101 2 7 8 6
1 .0
2 .0
3 .0
4 .0
5 .0
6 .0
1 1 1 1 100 .02
--*-Emacs: wt08a.in 10:27pm 0.02 Mail (Makefile Font)--L185--C0-
Find file: ~/propid5080/runs/990802-shortcourse/

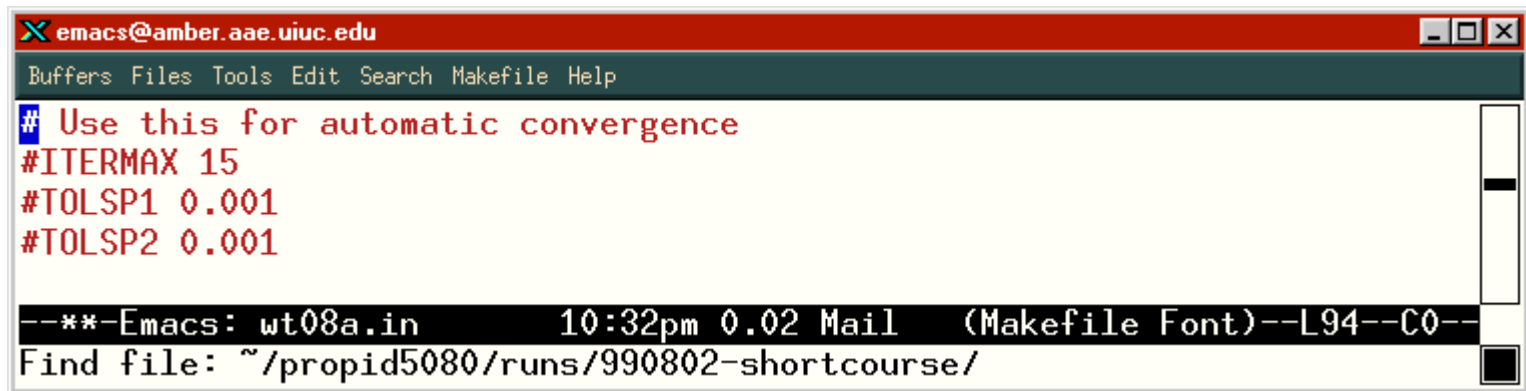
```



– Converged Axial Inflow Distribution



- Automatic Convergence: Uncomment these lines

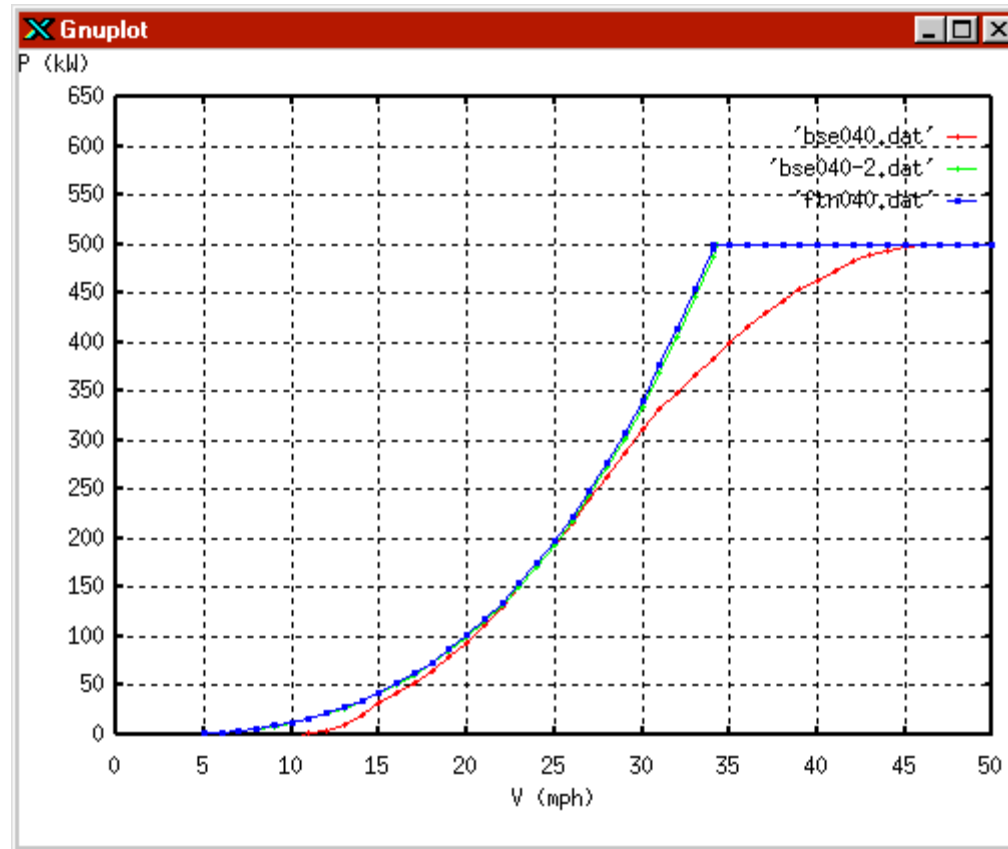


The screenshot shows an Emacs window titled 'emacs@amber.aae.uiuc.edu'. The menu bar includes 'Buffers', 'Files', 'Tools', 'Edit', 'Search', 'Makefile', and 'Help'. The main text area contains the following lines in red font: '# Use this for automatic convergence', '#ITERMAX 15', '#TOLSP1 0.001', and '#TOLSP2 0.001'. The status bar at the bottom displays '--**-Emacs: wt08a.in 10:32pm 0.02 Mail (Makefile Font)--L94--C0--' and a prompt 'Find file: ~/propid5080/runs/990802-shortcourse/'.

```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Use this for automatic convergence
#ITERMAX 15
#TOLSP1 0.001
#TOLSP2 0.001
--**-Emacs: wt08a.in 10:32pm 0.02 Mail (Makefile Font)--L94--C0--
Find file: ~/propid5080/runs/990802-shortcourse/
```



– Power Curve Comparison



– AEP 803 MWh/yr (wt08a) vs 790 MWh/yr (wt07a)



Debugging an Input File

- Screen Dump on Crash

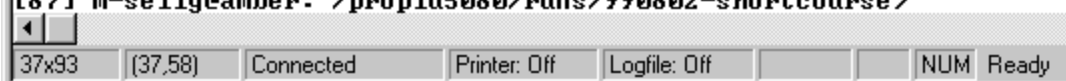
```
[86] m-selig@amber:~/propid5080/runs/990802-shortcourse> runprp

*****
* PROPID                                                         *
* -----                                                         *
* A Multipoint Inverse Design Method for                         *
* Horizontal Axis Wind Turbines                                 *
* Version 3.3 July 1999                                          *
* Michael S. Selig, Nikhil Raj,                                  *
* Philippe Giguere                                              *
* University of Illinois at Urbana-Champaign                    *
*****

*****
* Running input file: propid.in -> ftn41                         *
*****

Reading polar data file <pdata.f>: s814.pd
Reading polar data file <pdata.f>: s814.pd
Reading polar data file <pdata.f>: s812.pd
Reading polar data file <pdata.f>: s813.pd
? FORTRAN Runtime Error:
? Illegal character in numeric input
[87] m-selig@amber:~/propid5080/runs/990802-shortcourse>

```



– Now What?



– Turn on Debugging Feature (ECHO_INPUT Line)

```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help

# Started from wt07a.in
# Variable Speed Turbine
#
# Debugging Feature:
# Echo the input lines ... to the screen.
# The error can be isolated to one line.
ECHO_INPUT

# Basic input
MODE 1.0          # wind turbine
INCV 0.0          # wind turbine mode (use TSR in analysis)
--*-Emacs: wt08a.in    11:01pm Mail    (Makefile Font)--L1--C0--Top--
Find file: ~/propid5080/runs/990802-shortcourse/
```

```
*****
* line 95:#          ! <CLAMP1<.>> ! <TOL1<.>>
*****
* line 96:#          500    local C1 of blade
*****
* line 97:#          501    local a
*****
* line 98:NEWT1LDP 500 1  1 1 1  1 3 1  .5
*****
? FORTRAN Runtime Error:
? Illegal character in numeric input
[86] m-selig@amber:~/propid5080/runs/990802-shortcourse>
```

Bad NEWT1LDP Line

```
37x93  (37,58)  Connected  Printer: Off  Logfile: Off  NUM R.
```



- Errors, Warnings, and Notes at Runtime

```

Performing 1D sweep analysis.
->Done performing 1D sweep analysis.

*****
* Output
* -----
* blade l/d dist      --> ftn075.dat
* blade Re dist       --> ftn076.dat
* blade alfa dist     --> ftn080.dat
* blade cl dist       --> ftn085.dat
* blade a dist        --> ftn090.dat
* blade chord <ft>    --> ftn095.dat
* blade twist <ft>    --> ftn099.dat
*****

Error 1501: Use 40 in WRITE_FILES line for power curve
<menu.f>

*****
Do you wish to stop <1 = yes; 0 = no>?

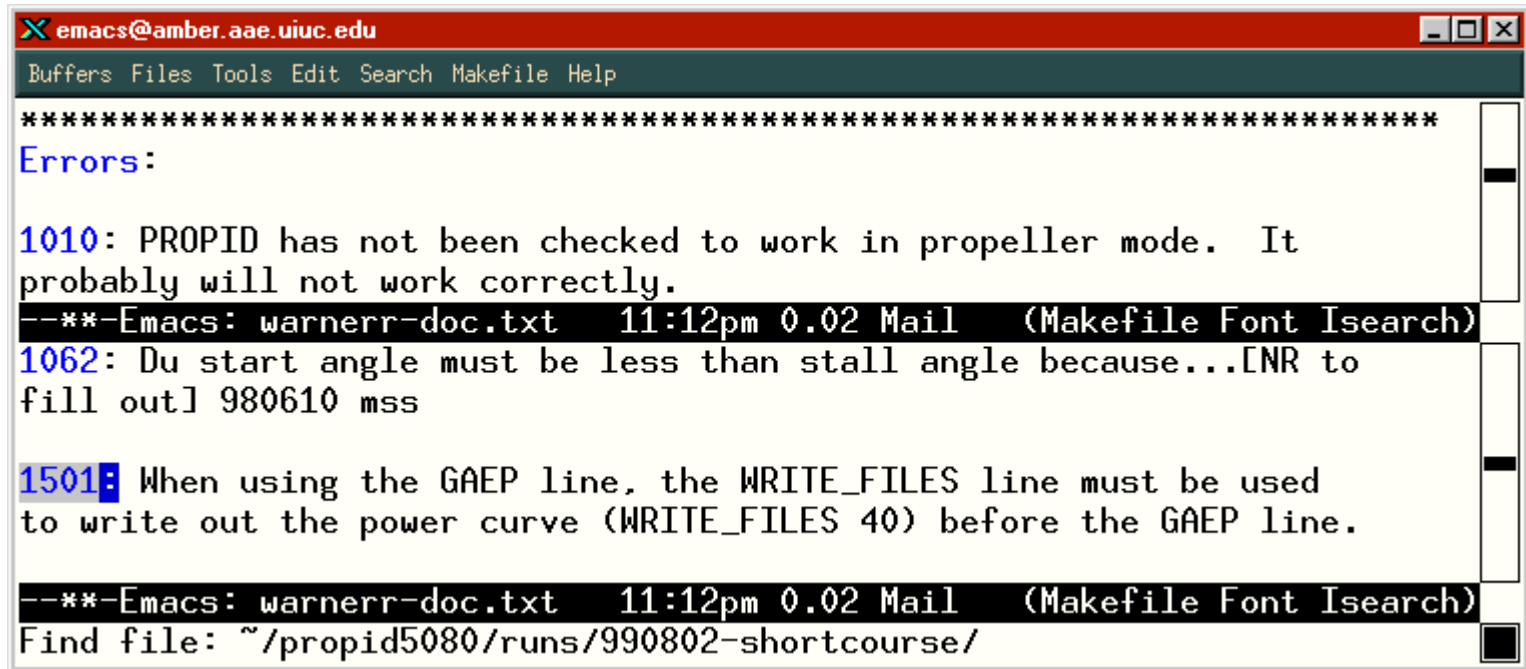
```

37x93 [37,1] Connected Printer: Off Logfile: Off

– Not Again! *&)*^)^(^:)????



– Refer to warnerr-doc.txt



The screenshot shows an Emacs window titled 'emacs@amber.aae.uiuc.edu'. The menu bar includes 'Buffers', 'Files', 'Tools', 'Edit', 'Search', 'Makefile', and 'Help'. The main text area displays error messages from a file named 'warnerr-doc.txt'. The errors are numbered 1010, 1062, and 1501. Error 1010 states that 'PROPID' has not been checked for propeller mode. Error 1062 states that the start angle must be less than the stall angle. Error 1501 states that the 'WRITE_FILES' line must be used before the 'GAEP' line. The window also shows a status bar at the bottom with the text 'Find file: ~/propid5080/runs/990802-shortcourse/'.

```
*****
Errors:

1010: PROPID has not been checked to work in propeller mode. It
probably will not work correctly.
--**-Emacs: warnerr-doc.txt 11:12pm 0.02 Mail (Makefile Font Isearch)
1062: Du start angle must be less than stall angle because...[NR to
fill out] 980610 mss

1501: When using the GAEP line, the WRITE_FILES line must be used
to write out the power curve (WRITE_FILES 40) before the GAEP line.
--**-Emacs: warnerr-doc.txt 11:12pm 0.02 Mail (Makefile Font Isearch)
Find file: ~/propid5080/runs/990802-shortcourse/
```

