

Using PROPID for Inverse Design

Michael S. Selig
Associate Professor

Department of Aerospace Engineering
University of Illinois at Urbana-Champaign

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

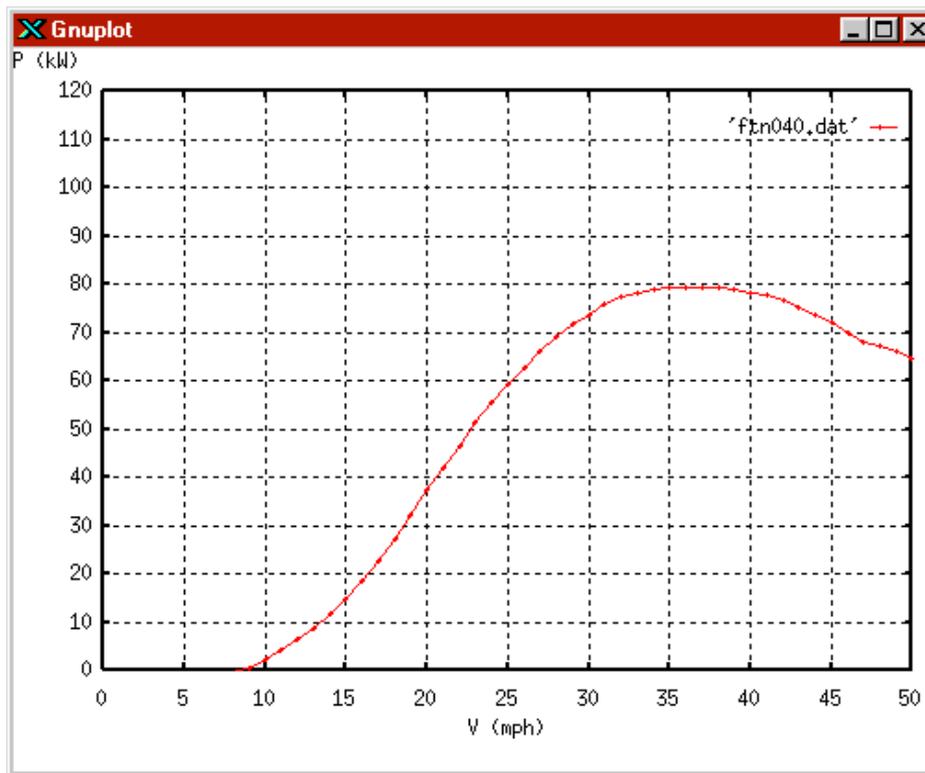


University of Illinois at Urbana-Champaign
National Renewable Energy Laboratory



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

```

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(.)> -
#           <KDPRPM1(.)> <KDPFL1(.)> <KDPXJ1(.)> -
#           <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)

```

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(.)

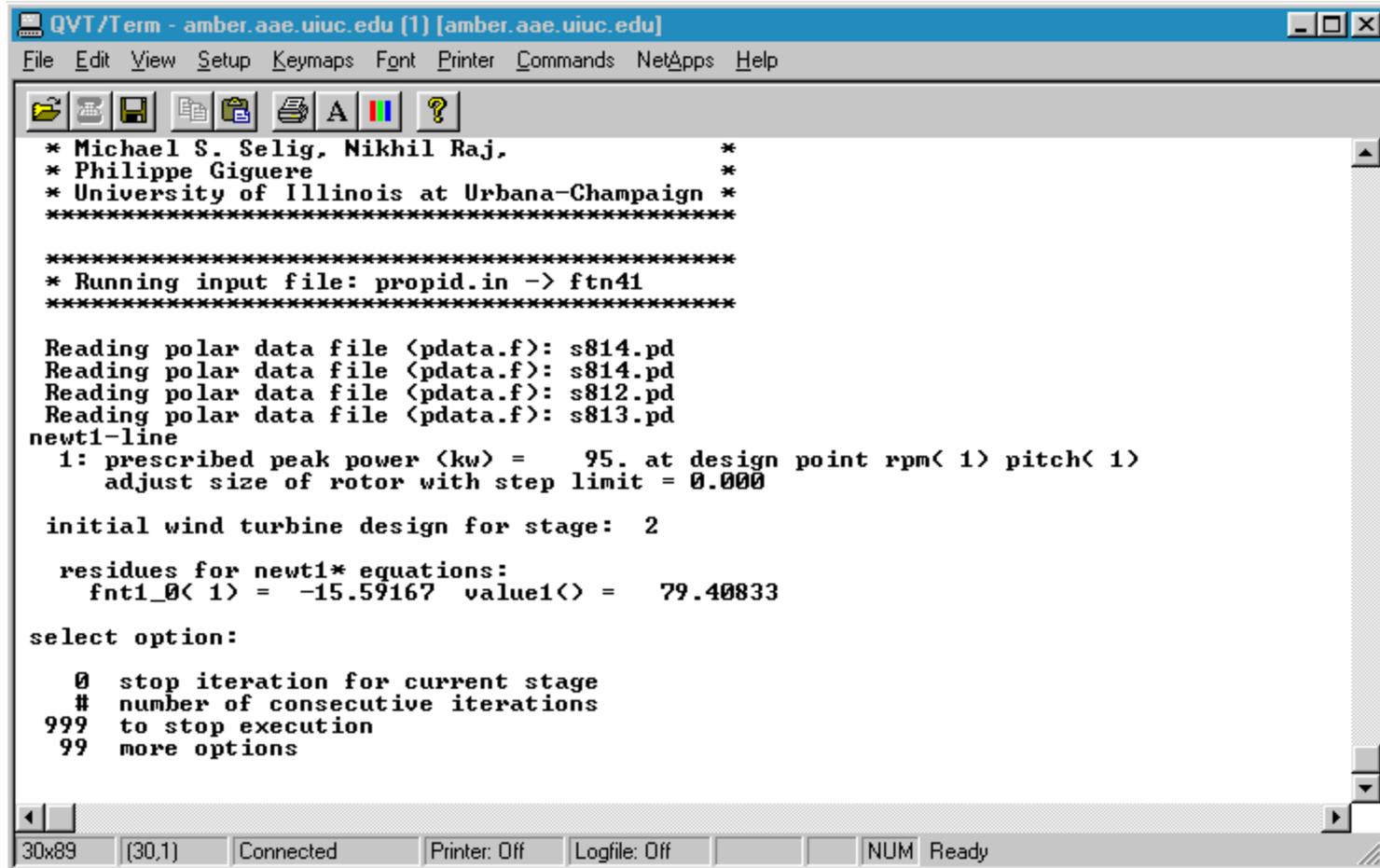
1 single       1 scale rotor          (999)      1.
  parameters   2 RPM - revs/minute   1,2,3,.. DP value  3.
               3 FL - beta,pitch, degs 1,2,3,.. DP value  .5
               4 XJ - wind speed (IXDIM units) 1,2,3,.. DP value  3
               5 CONE - cone angle, deg  (999)      .5
               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

```
emacs@amber.aae.uiuc.edu
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

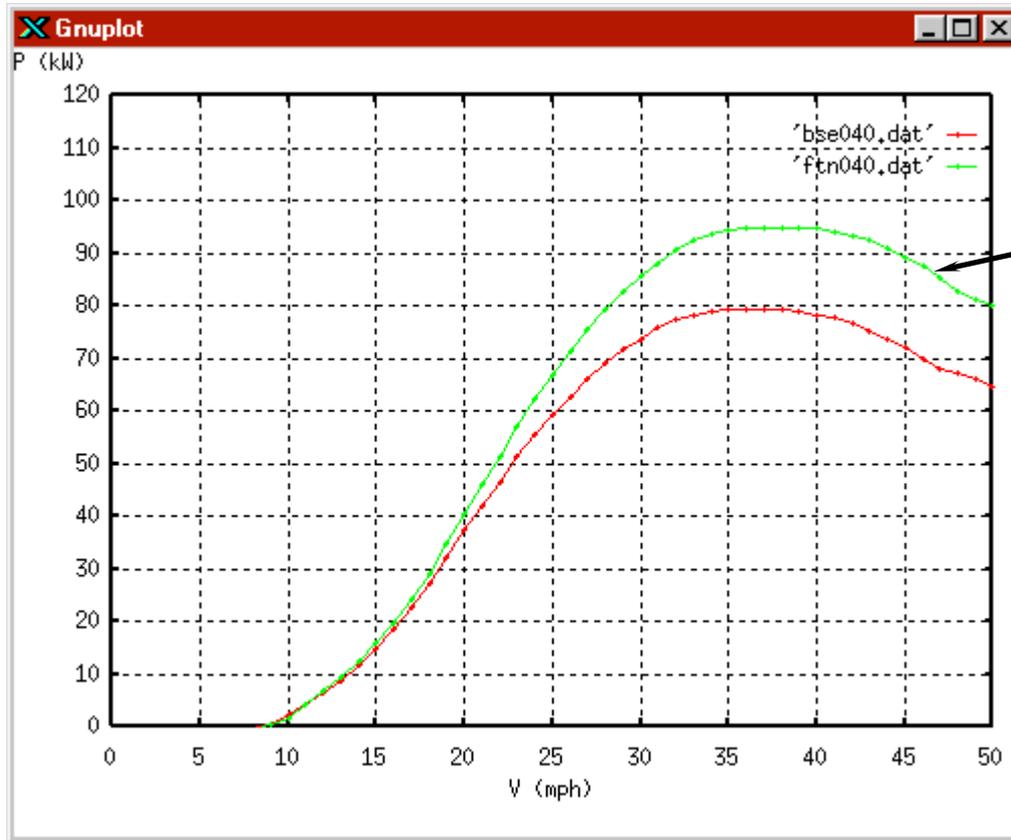
```
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Specify the maximum number of iterations
# Programs stops at 10 iterations ... there's a problem.
# In this case the problem is obvious - too tight a tolerance.
# In other cases, lack of convergence is likely caused by either:
# (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(.)> -
#           <KDPRPM1(.)> <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)

```

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(.)

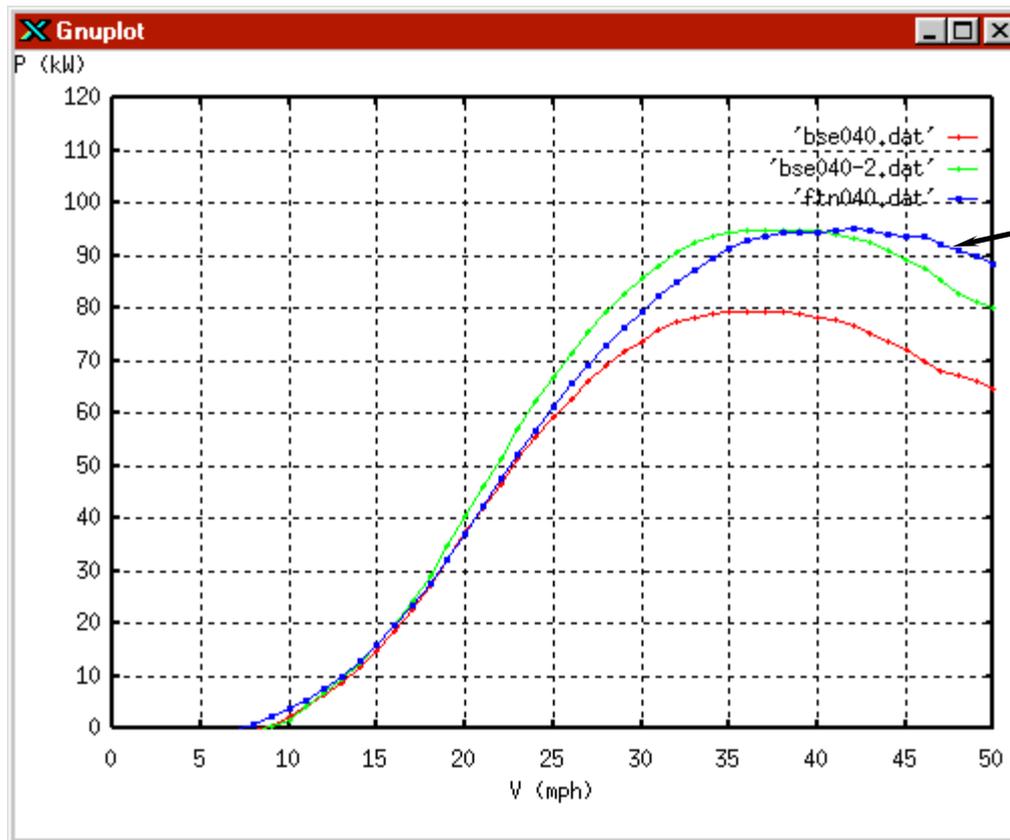
1 single      1 scale rotor        (999)      1.
  parameters  2 RPM - revs/minute  1,2,3,.. DP value  3.
              3 FL - beta,pitch, degs  1,2,3,.. DP value  .5
              4 XJ - wind speed (IXDIM units)  1,2,3,.. DP value  3
              5 CONE - cone angle, deg  (999)        .5
              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 => Peak Power (500 kW)
 - Rotor RPM => 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(.)> <KDPFL1(.)> <KDPXJ1(.)> -
# <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

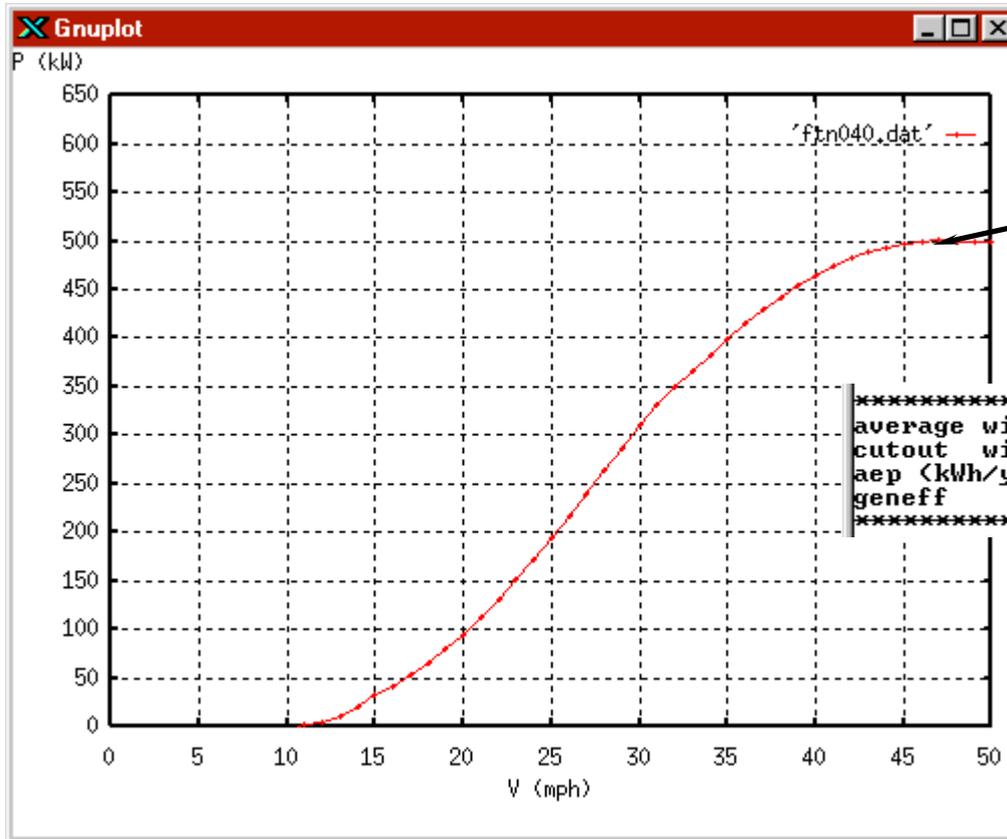
newt1-line
  2: prescribed tip speed = 220.0000 at design point rpm( 1) pitch( 1) xj(**)
    adjust rpm( 1) with step limit = 0.000 (rpm)

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

$AEP = 694 \text{ MWh/yr}$

- Radius Change: 24.61 ft \Rightarrow 39.9 ft
- RPM Change: 64 rpm \Rightarrow 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/
```

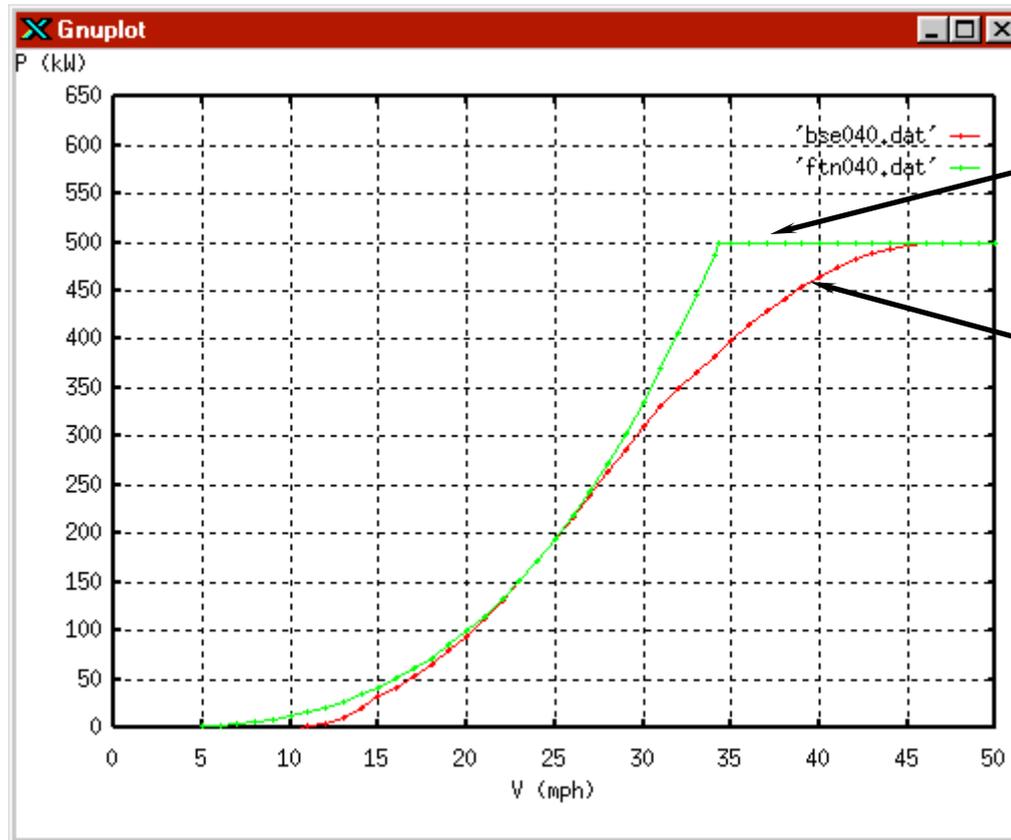


– Blade Aero and Geometry (1D_SWEEP)

```
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



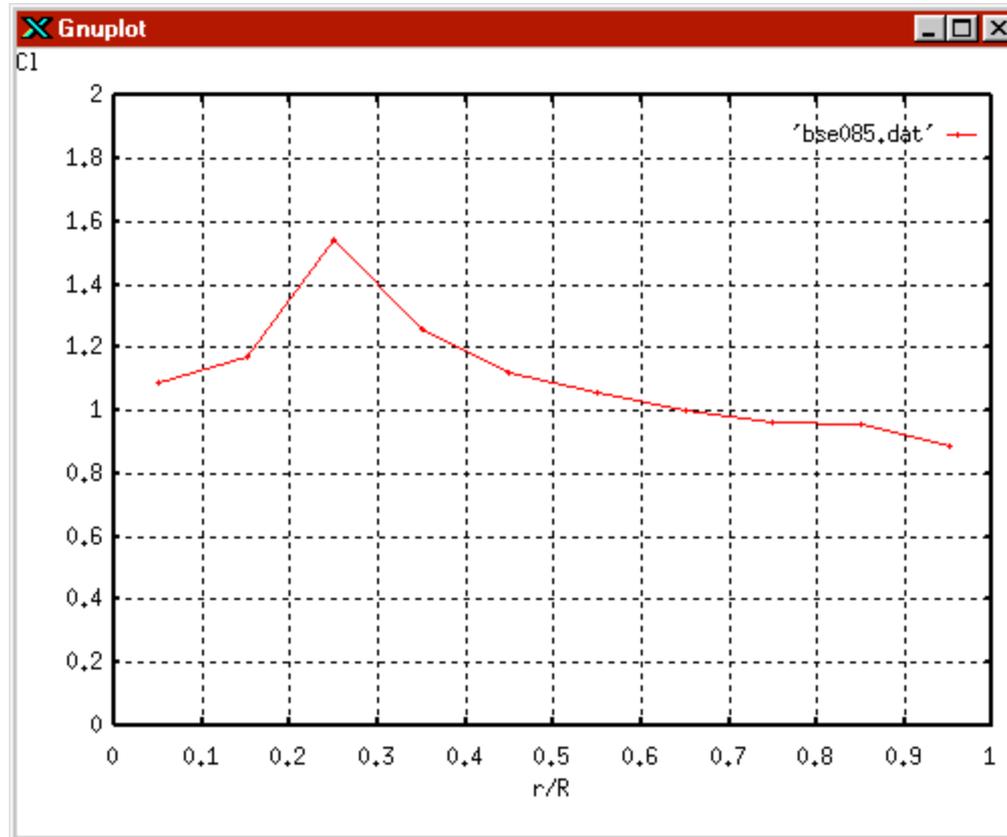
*Variable
Speed Case*

*Stall
Regulated
Baseline*

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



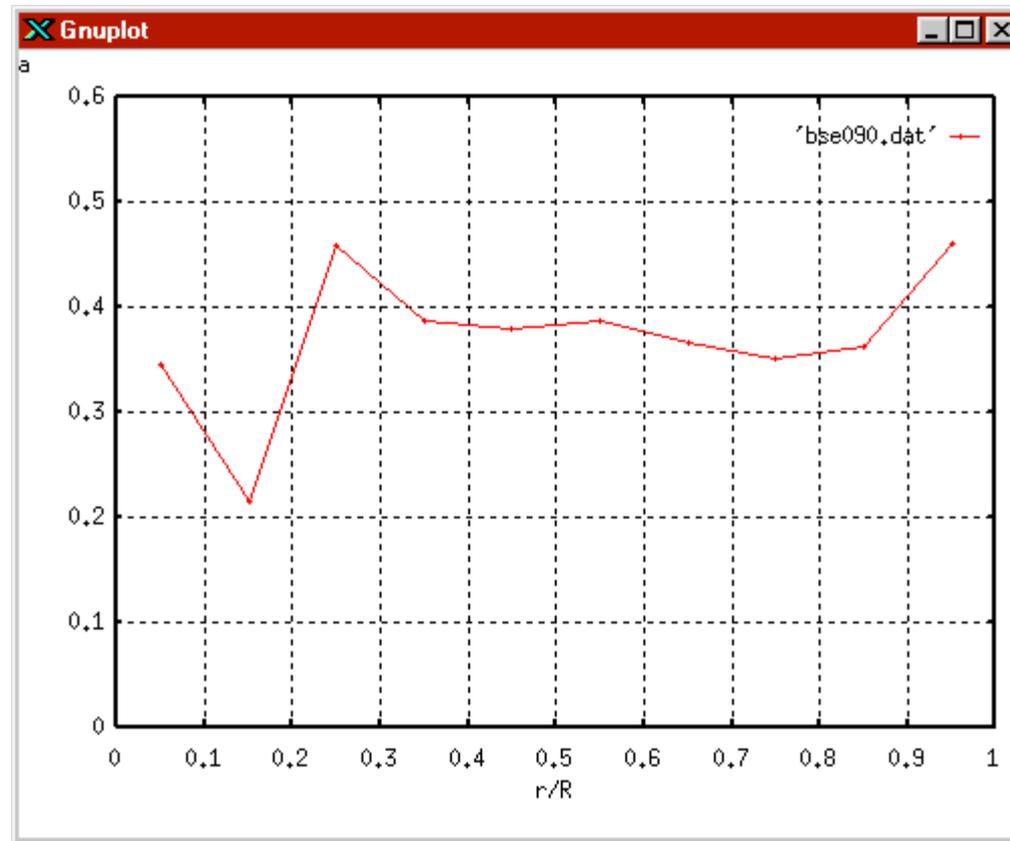
– Lift Distribution



– Desire Cl-dist for Best L/D-dist



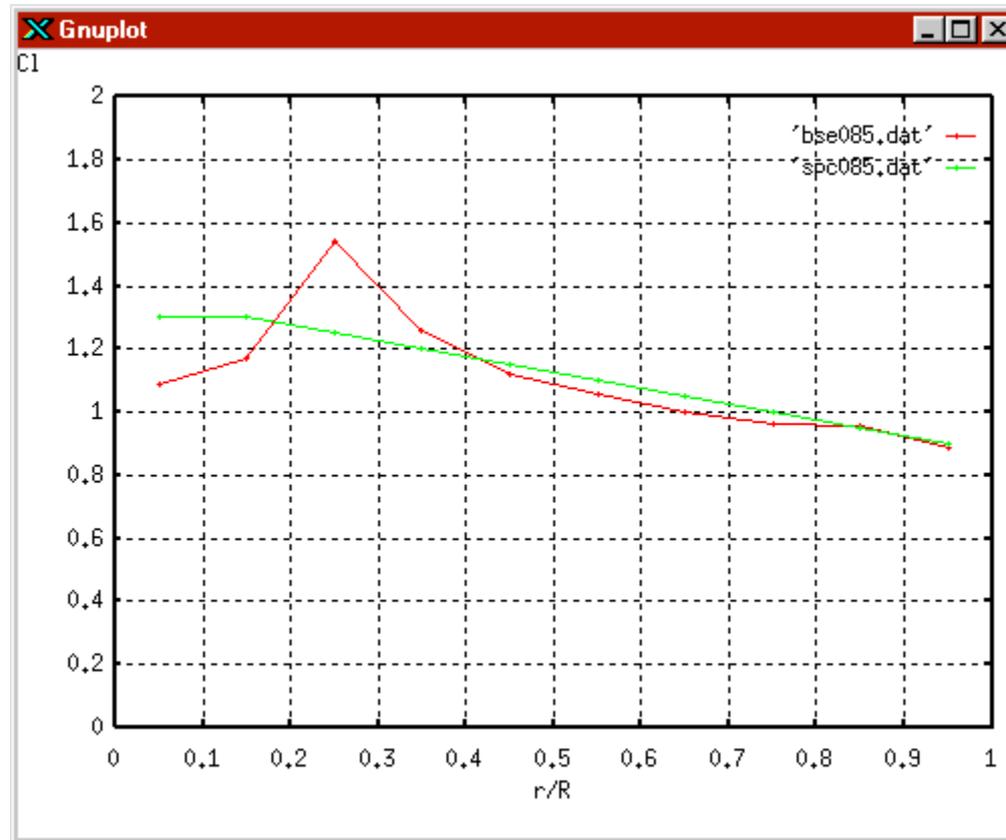
– Axial Induction Factor Distribution



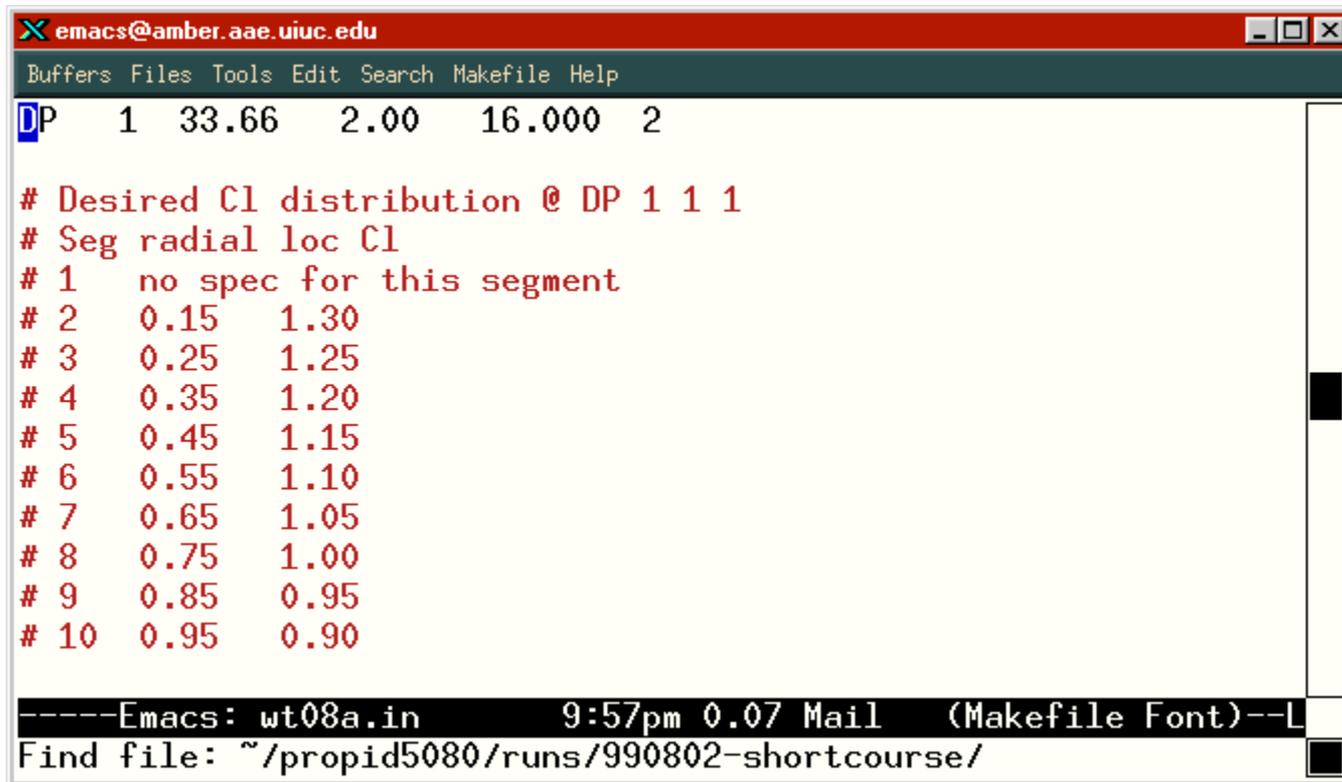
– Desire $a = 1/3$ Betz Optimum



- PROPID Run: wt08a.in
 - Desired CI-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 'Find file: ~/propid5080/runs/990802-shortcourse/'.



- Stage 1: $Cl @ \text{Segment } 8 = 1.00$
- 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(.)> <FNEWT1(.)> -
#               <KDP RPM1(.)> <KDPFL1(.)> <KDPXJ1(.)> -
#               <ITP1(.)> <ITP2(.)> <ITP3(.)> -
#               | <CLAMP1(.)> | <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/

```



- 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 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      10:19pm Mail (Makefile Font)--L114--C0--48%--
Find file: ~/propid5080/runs/990802-shortcourse/

```



- Details

```

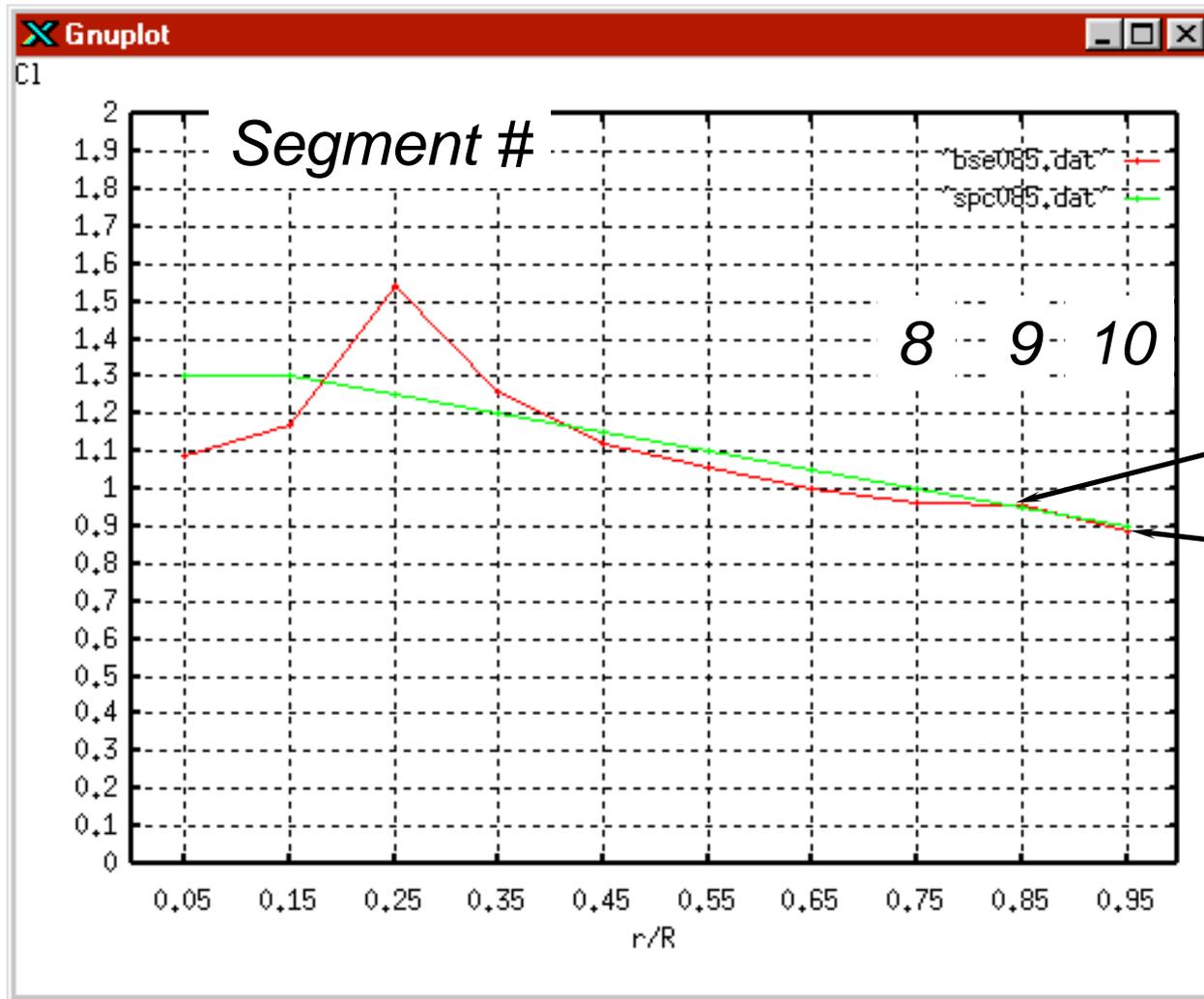
emacs@amber.aae.uiuc.edu
Buffers Files Tools Edit Search Makefile Help
# Stage 2
# Iterate on twist to get cl 9-10
#>>line> NEWT2SDDP IFTP2(.) JSEGIX2(.) JSEGIX3(.) JSEGREL(.) KADJSBS(.)
#>>line> <SSS(1)> <SSF(1)>
#>>line> ...
#>>line> <SSS(KADJSBS(.))> <SSF(KADJSBS(.))>
#>>line> KDP RPM2(.) KDPFL2(.) 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
nt)--L114--C0--48%

```

*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

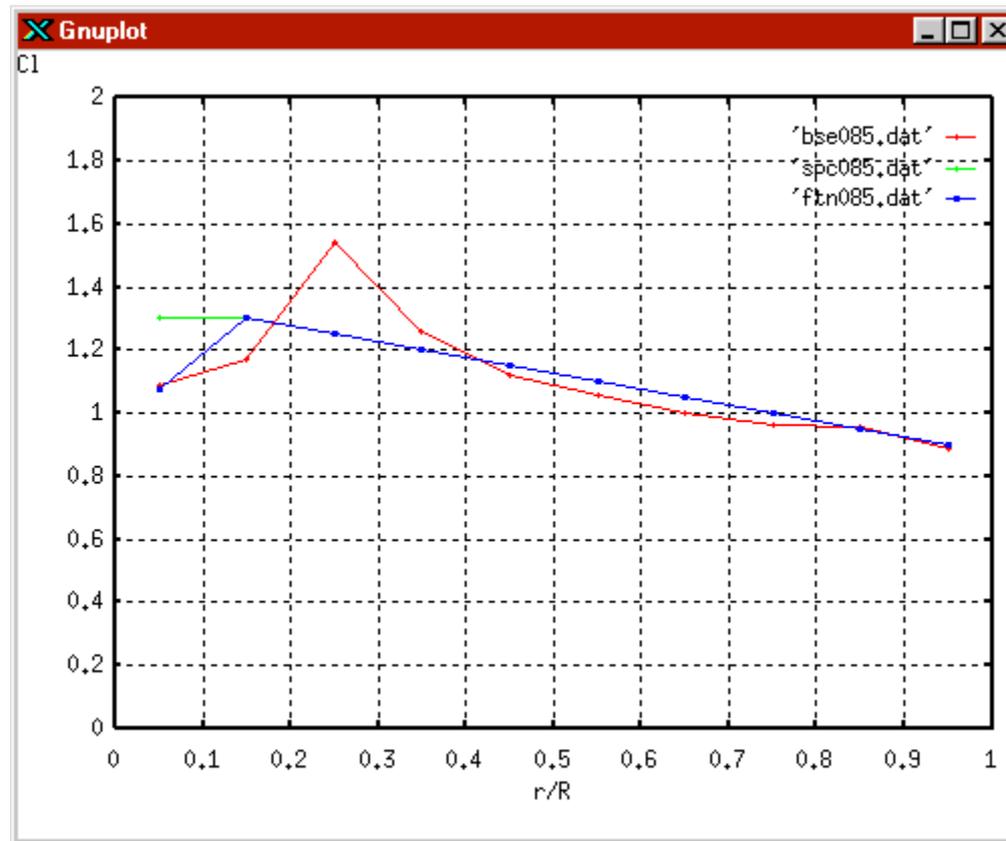
```

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> K DPRPM2(.) KDPFL2(.) KDPXJ2(.) ISDTP(.) ISCHED2(.) | 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

```
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 Cl 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> K DPRPM2(.) KDPFL2(.) KDPXJ2(.) ISDTP(.) ISCHED2(.) | CLAMP2(.) \
| TOL2(.)
#           100 Cl 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

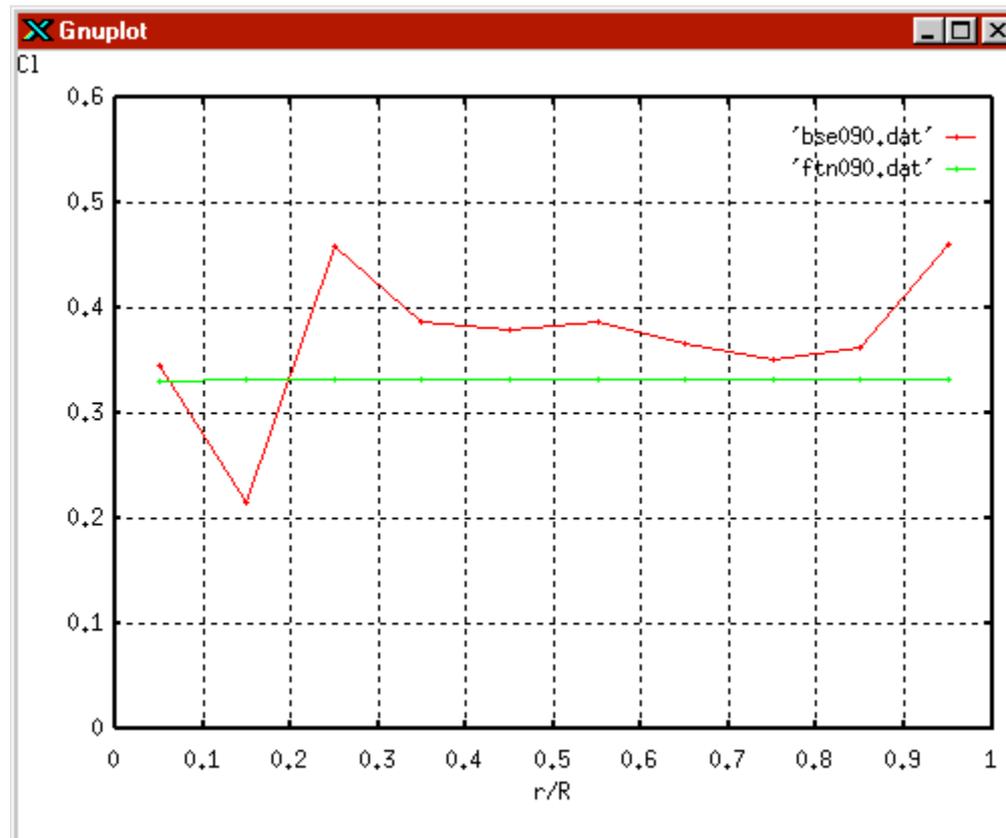
```

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> KDP RPM2(.) KDPFL2(.) KDPXJ2(.) ISDTP(.) ISCHED2(.) | CLAMP2(.) \
| TOL2(.)
#           100 Cl 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/

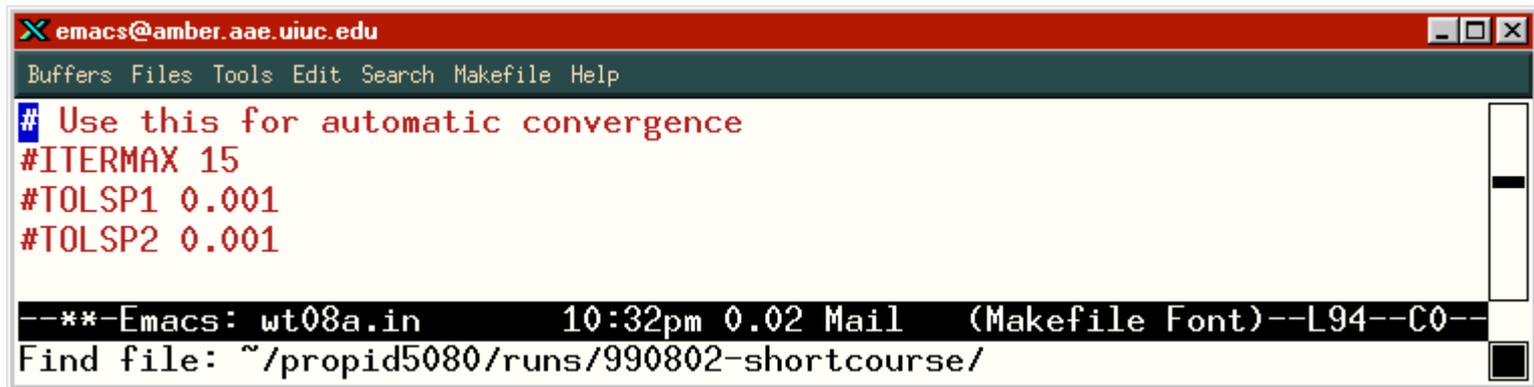
```



– Converged Axial Inflow Distribution



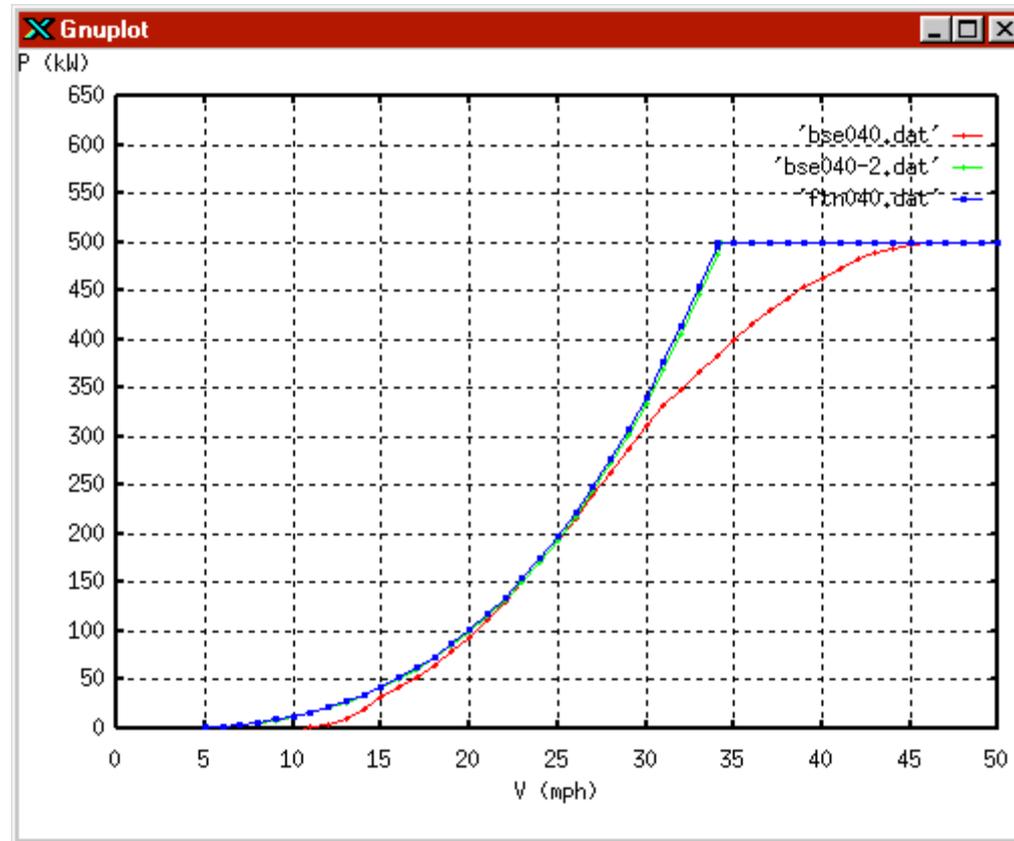
- Automatic Convergence: Uncomment these lines



```
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>

```

37x93 (37,58) Connected Printer: Off Logfile: Off NUM Ready

– 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>?

```



A terminal window status bar with a back arrow icon, a cursor, and several status indicators: '37x93', '(37,1)', 'Connected', 'Printer: Off', and 'Logfile: Off'.

– Not Again! *&)*^)^(^:)????



– Refer to warnerr-doc.txt

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

