Design of Wind Energy Systems – Summer Semester 2015
Design-Tutorial 2: Advanced BEM – Theory corrections

Prof. Dr. Martin Kühn

Bernd Kuhnle, Luis Vera-Tudela

Introduction

In tutorial 02 you understood and implemented a BEM algorithm to calculate aerodynamic loads. During the design of a wind turbine, the blade geometry is (chord length, twist angle) defined for its optimum operation. You will compare the results from Betz and Schmitz theory.

Additionally, you also made some assumptions to simplify your calculation. The tools we will use later in class will take care of the complex calculation. In the second part of this design-tutorial we will explore their impact on our results.

Section 1

Estimate the geometry of your blade using results from Design-Tutorial 1.

1. Design your blade according to the Betz theory.

   Hint: Station 1 has a cylindrical shape; for stations 2-5 use the thicker and for 5-10 the thinner profile.

2. Design your blade according to the Schmitz theory.

3. Complete blade geometry defining aerodynamic center and twist angle along the blade.

Section 2

Let's calculate some corrections of BEM theory to understand what the codes do.

1. Calculate the Prandtl factor for the following two wind speeds:
   a. 0.5 * rated wind speed
   b. Rated wind speed

   Hint: r_R is the radius of the first blade sections, which is defined by the blade root length

2. Calculate the corrections of the profile's lift and drag coefficient curves. Choose therefore two blade stations and the same profile. Use the corrections according to Snel and according to Chaviaropoulus and Hansen within the range from -10° to 30° angle of attack

   Hint: You've calculated chord and twist for both profile's along the whole blade, which you can use here

3. Calculate the stationary pitch moment for the following two wind speeds:

a. 0.5 * rated wind speed
b. Rated wind speed

Hint: The moment can be calculated at each blade element similar to lift and drag – with dynamic pressure, area, coefficient – and is then multiplied with a reference length (here: chord) as lever arm and finally summed up along the blade (assuming, the blade is rigid)

4. Transfer the received stationary pitching moment to an illustrative description of the value

—

—