IDAC
Integrated Design & Analysis Consultants

Case Study

IDAC conducts a 3D Design Optimisation of a Wind Turbine Blade using ANSYS CFX and DesignXplorer

Company Profile

IDAC is an ISO 9001:2008 accredited engineering design and analysis consultancy specialising in Computer-Aided Engineering (CAE), Finite Element Analysis (FEA), and Computational Fluid Dynamics (CFD).

As a value-added reseller of the ANSYS simulation software suite, IDAC provides engineering analysis software sales, consultancy, training and technical services to a variety of UK and global customers. IDAC are well placed to solve the most demanding engineering problems, having provided innovative solutions and faster time to market for thousands of products and engineering teams.

Background

A wind turbine is a device that converts kinetic energy from wind into mechanical energy, which in turn is used to produce electricity. The stronger the wind, the more electricity is produced. Wind generated electricity is a green renewable energy and doesn't release any harmful carbon dioxide or other pollutants. The UK is the windiest country in Europe, so much so that the whole country could be powered several times over using wind energy. Wind is the fastest growing energy source worldwide.

Turbines used in wind farms to produce electric power usually have three blades and are pointed into the wind by computer controlled motors. The blades usually range in length from 20 to 40 metres.

IDAC carried out CFD analyses to optimize a blade design, in order to increase the torque being applied on the blade at a specific rotation speed, hence increasing the power output of the wind turbine.

Optimisation

The design optimisation of the blade was carried out in ANSYS DesignXplorer (DX). DX is an add-on module for the ANSYS environment that provides a wide range of accurate, and rapid parametric solutions so that the engineer can efficiently answer 'what-if' questions and understand the relationship between design variables and the performance of the product.

The blade geometry was parameterised using geometrical design parameters (variables which change in value in every design iteration) within the ANSYS Workbench environment and later input into ANSYS CFD for a full CFD analysis. Traditionally, a designer would have taken months to test a broad set of design parameters on a one-by-one basis. However, DX changes the values of the design parameters automatically, based on the goals set by the user, achieving higher efficiency and reducing the user's time.

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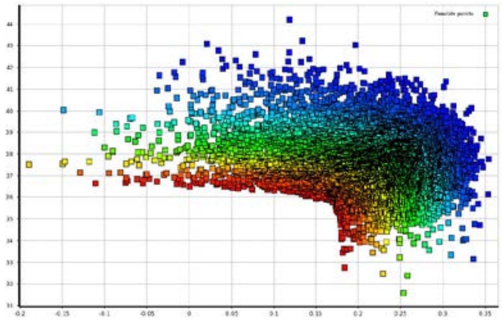
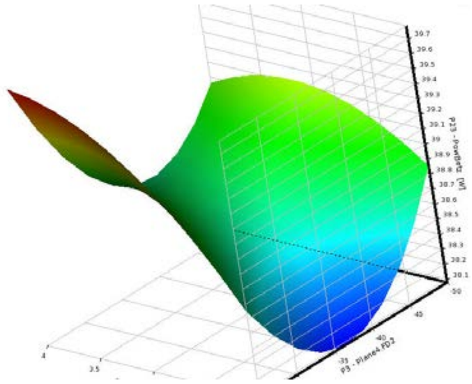


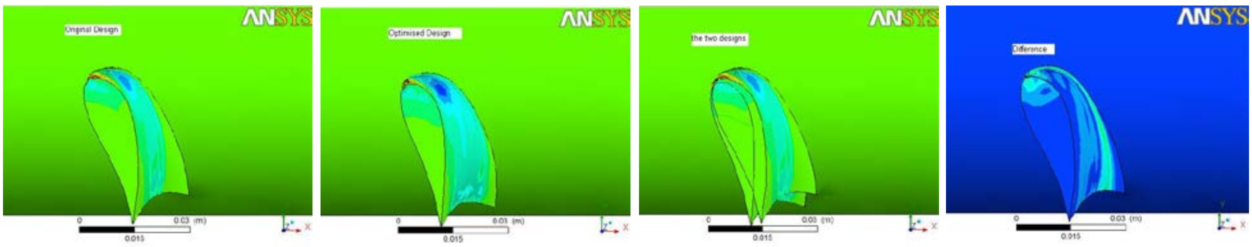
The graphic to the left shows the results of various design iterations in the form of a trade off plot. The red and blue Pareto points indicate extremes and the green Pareto points highlight the optimal and feasible design points.

DX offers several ways to optimise a design - including Response Surface Method (RSM). The RSM allows the engineer to carry out optimisation and probabilistic studies efficiently. The RSM is based on a large amount of data gathered during a first set of runs called Design of Experiments. The solutions from the Design of Experiments allow a response surface to be built up (as seen in the graphic below right). The curve fitting procedure through the results allows designs to be interpolated where no solution exists. The RSM uses a function that best represents the behaviour of the objectives and the constraints within the design space and then implements a direct optimisation algorithm to attempt to find the best estimated objective and test it again. This process is iterated until the accuracy of the RSM is acceptable and/or the best designs found by the process are not improved from one iteration to the next.

The blade geometry was parameterised using 19 design parameters. 551 design points were used to model the continuous behaviour of the changes in blade design covering all 19 of the design parameters. The CFD based optimisation provided a gain of 48% in power output. The optimisation process automated the iterative process of the designer. It would also have been possible to optimise the blade profile individually for each stream section and then to merge the designs afterwards.



The images below show the pressure contours on the original and optimised blade geometries, the two designs superimposed on each other and also the pressure difference on the blade surface obtained upon using the optimised geometry. The increase in torque obtained by optimising the blade geometry is directly proportional to the pressure difference observed between the 2 designs.



Design Benefit

A broad set of design parameters which can take a designer months to test on a "one by one basis", is made possible on a much shorter time scale by using DX. Setting the right design parameters can lead to huge gains. Optimisation has a finite time requirement and has potentially great gains from efficiency to costs with the appropriate cost functions.

For the purpose of this case study, DX was able to provide a better design than the original design, significantly increasing power output by 48%. Many other problems can be optimised using DX within reasonable timeframes. DX offers the possibility to assess, in a more thorough manner, the optimisation solutions by exporting these designs for possible re-meshing and mesh-trends dependency analysis. Thanks to ANSYS Workbench, DX can be used with CFX simulation environment simultaneously. It is also possible to use DX with other workbench solvers and third party CAD models.

All these features help in carrying out "what-if" analyses in a non-interactive manner giving more time for the designer to think rather than perform laborious tasks repeatedly.

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