Stanislav Stančík, Justín Murín, Vladimír Kutiš, Juraj Paulech, Róbert Fric

Computer Modelling in the National Center for Research and Application for Renewable Energy Sources

This contribution deals with using of computational engineering methods in research, design and development of devices used in the field of renewable and alternative power sources. Basic information about possibilities of computer modelling are given, mainly modelling and simulation multiphysical processes with the finite element methods as heat or mass transfer, conversion and acquiring energy. The paper shows also some examples of thermal and heat flow multiphysics solutions and flow analyses of liquid or gas and coupled field analyses, generally formulated for devices in power engineering, electrotechnics or lighting. In conclusion the future possibilities of usage of the methods are described.

Keywords: CFD, computational methods, ANSYS, renewable energy

INTRODUCTION

In mathematical modelling of engineering problems there was created complicated systems of ordinary or partial differential equations. So it was necessary to develop numerical computational methods to solve such problems. Finite Element Method (FEM) was in the beginning developed just for the mechanical problems, but this method has shown useful for solution also in other problems such as coupled field problems, mass and heat transfer, flow analyses of fluids, micro and nanostructural analyses. Nowadays, it is the most efficient and useful numerical method for solving engineering problems.

To solve and analyze problems that involve fluid flows Computational Fluid Dynamics (CFD) is used. CFD is based on the principles of the Finite Volume Method (FVM), Finite Differential Method (FDM) and Finite Element Method (FEM). Aerodynamics deals mainly with problems of gas flow, hydrodynamics deals with liquid flow and thermodynamics solves heat transfer in both flows, fluid flows.

In next part of this contribution will be showed examples of optimization devices used in the field of renewable and alternative power sources. These tasks were already solved and i am just bringing you summary and review of possibilities of optimizing methods in area renewable power sources.

http://jeen.fei.tuke.sk/files/journals/1/copytemplates/EEN-style_en.pdf.%0D **OPTIMIZATION OF SOLAR PANEL**

Structural optimization of the pole mount supports of solar panel under wind load increase the structural rigidity of the solar panel and the pole mount attachments to withstand sufficient wind loading which in turn improves the product quality. This could also improve the accuracy of the system that controls the panel tilting.

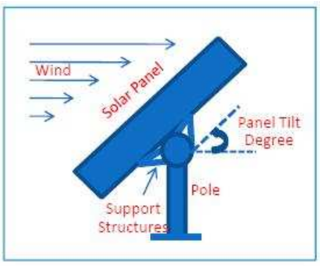

Figure 1. Model of solar panel.

ANSYS was used to find the maximum displacement of the homogenized solar panel subjected to a wind load of 5 m/s. Results available from these analyses are: displacements, pressure, velocity for fluid and solid domains.

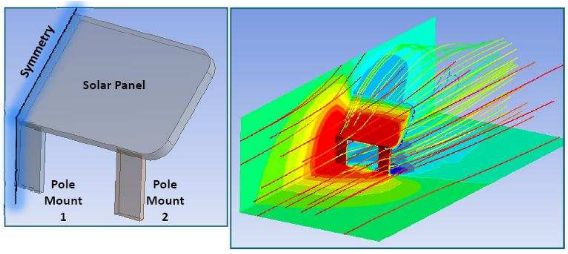

Figure 2. Geometry of the model and ANSYS analysis.

According to the results we can increase the structural rigidity of the solar panel and supports by finding the optimum design configuration for the problem. We can also reduce the material costs by decreasing the support mass or find optimal tilt degree of the solar panel.

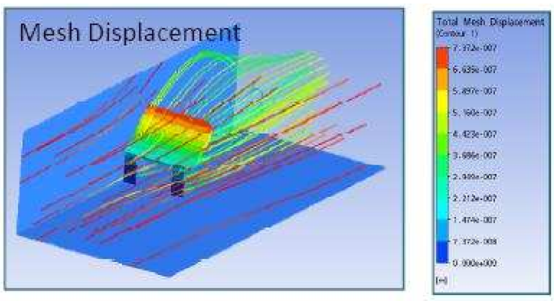

Figure 3. Mesh displacement.

Solid coloured streamlines represent the wind velocity. The Fig. 3. shows the displacement contour plot for the solar panel along with the wind streamlines. The maximum displacement takes place at the solar panel upper edge.

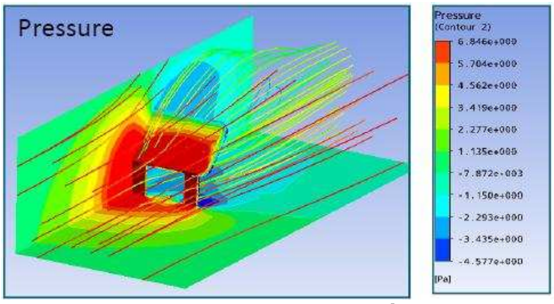

Figure 4. Pressure countour plot.

The pressure figure (Fig. 4.) shows the pressure contour plot of the solar panel, ground and the symmetry planes. The pressure gradient near the solar panel geometry is very obvious due to applied wind load [1].

OPTIMIZATION IN THE WIND ENERGY INDUSTRY

Numerical simulations allow checking the performance of the product before manufacturing. Optimization process coupled with virtual prototyping increase the product performance and minimize costs. Minimizing weight and costs is possible with the deep understanding of the static and dynamic behaviour of the structure. We can prevent from the shadow effect due to wind change by evaluating the interactions between fluid and structural parts. New technologies allow simulating every kind of complex phenomena, included interactions between different fields.

Figure 5. Airflow near wind turbines.

From fluid-thermal analysis of generator of the wind turbine it is possible to evaluate heat exchange between the generator and air. So with optimization of generator design it could be maximized thermal loads distribution and minimized of power losses.

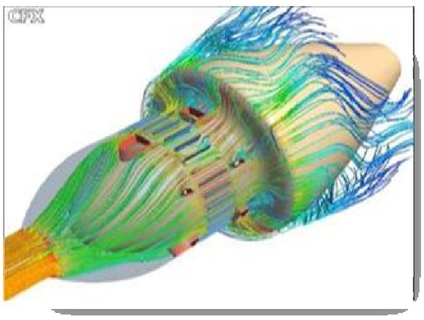

Figure 6. Airflow around generator of wind turbine.

Prototypes are created in CAD systems from which virtual models are built up. The models are subsequently used in the thermo-flow-mechanical analyses using CAE tools [2].

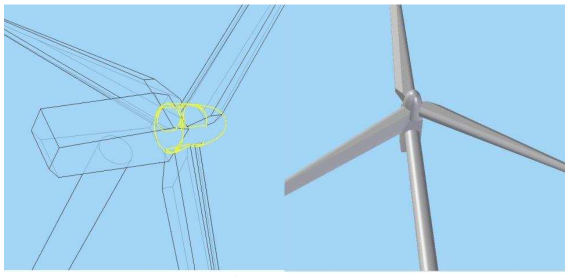

Figure 7. Model of wind turbine in CAD system.

CFD STUDIES OF BIOMASS THERMOCHEMICAL CONVERSION

Computational fluid dynamics (CFD) model applications of biomass thermochemical processes helps to optimize the design and operation of thermochemical reactors and makes thermochemical processes more efficient and economical acceptable. Thermochemical conversion of biomass offers a possible process to provide gaseous, liquid and solid fuels and prepare chemicals derived from biomass. Numerical models of thermochemical reactors can help to design and analyze the thermochemical conversion equipment such as fluidized beds, fixed beds, combustion furnaces, firing boilers and rotary kilns.

In Fig. 8. temperature profile of 2D axisymmetric CFD model of reactor for the oxidation zone in a two-stage down draft gasifier is shown. The oxidation zone is crucial for tar cracking. Heat of reactions is released mainly close to the injector.

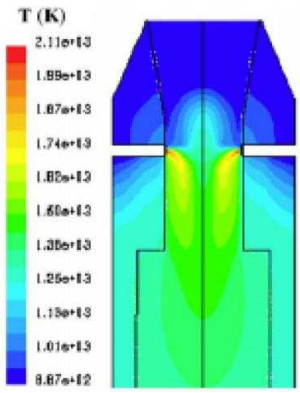

Figure 8. Temperature profile in CFD model of reactor.

The stream function is shown in Fig. 9a., whereas Fig 9b. presents the gas streamlines in the reactor. The gas path strongly depends on the initial departure point. The strong recirculation zone is located above the air injection in the centre of the reactor. It plays a major role in air-gas mixing and thus enhances the quality of the gasification.

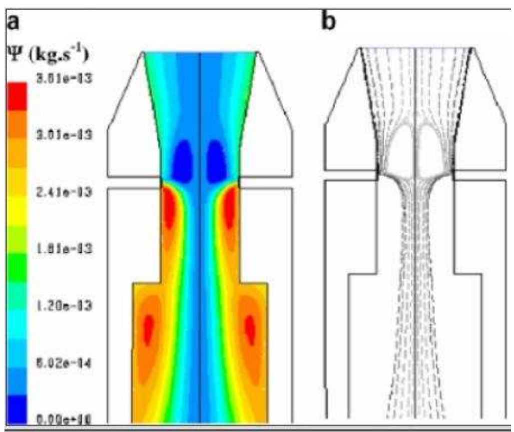

Figure 9. Stream function and gas pathlines in the reactor.

The largest application of CFD models are for power station boilers and furnaces. Fig. 10. and 11. show a typical CFD erosion application in a tube bank for the boiler. Gas velocity contours and trajectories for several particle fractions are shown for the as-constructed design (Fig. 10.) and the modified design (Fig. 11.). The improvements in boiler tube erosion performance can be deduced by visual assessment alone of the predicted flow and trajectory patterns [3].

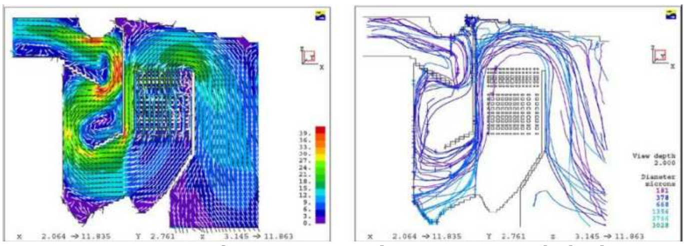
Figure 10. Gas velocity contours and trajectories in a tube bank.

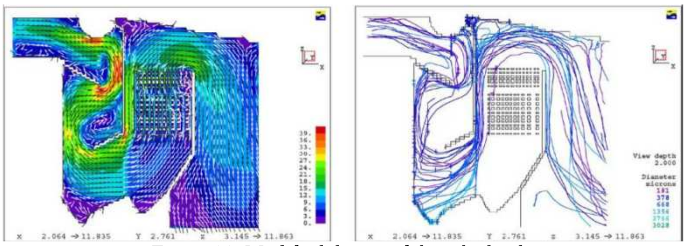
Figure 11. Modified design of the tube bank.

CONCLUSION

CFD has wide possibilities to utilize technology to answer the demand for making wind and solar power more cost-effective, to build cheaper and safer nuclear power plants, and to reduce energy consumption through improved efficiency and retrofits.

ACKNOWLEDGMENT

This contribution is an outcome of a project entitled

“Finalization of Infrastructure
of the National Centre for Research and Application
of Renewable Energy Sources”
ITMS 26240120028

as part of the Operational Programme Research & Development
funded by the ERDF

Operačný program VÝSKUM a VÝVOJ

Agentúra Ministerstva školstva, vedy, výskumu a športu SR pre štrukturálne fondy EÚ

Podporujeme výskumné aktivity na Slovensku/
Projekt je spolufinancovaný zo zdrojov EÚ

Európska únia
Európsky fond regionálneho rozvoja

REFERENCES

[1] Ozen Engineering: Structural Optimization of the Pole Mount Supports of a Solar Panel in a Wind Load Case Study, Presentation, <http://www.ozeninc.com/downloads/solar%20panel%20wind%20load%20fsi%20optimization.pdf>

[2] Ozen Engineering: Simulation and Optimization in Wind Energy Industry, Presentation, <http://www.ozeninc.com/downloads/Simulation_Optimization_in_Wind_Energy_Industry.pdf>

[3] Wang, Y., Yan, L., (2008): CFD Studies on Biomass Thermochemical Conversion, 27 June 2008 Published online, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2658784/>

ADDRESSES OF AUTHORS

Stanislav Stančík, Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology , Department of Mechanics, Ilkovičova 3, Bratislava 1, SK 04210, Slovak Republic, stanislav.stancik@stuba.sk

Justín Murín, Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology , Department of Mechanics, Ilkovičova 3, Bratislava 1, SK 04210, Slovak Republic, justin.murin@stuba.sk

Vladimír Kutiš, Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology , Department of Mechanics, Ilkovičova 3, Bratislava 1, SK 04210, Slovak Republic, vladimir.kutis@stuba.sk

Juraj Paulech, Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology , Department of Mechanics, Ilkovičova 3, Bratislava 1, SK 04210, Slovak Republic, juraj.paulech@stuba.sk

Róbert Fric, Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology , Department of Mechanics, Ilkovičova 3, Bratislava 1, SK 04210, Slovak Republic, robert.fric@stuba.sk

Július Cirák, Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology , Department of Physics, Ilkovičova 3, Bratislava 1, SK 04210, Slovak Republic, julius.cirak@stuba.sk