Spring 2012

The Airflow Update
AIRFLOW SCIENCES CORPORATION

Aerodynamic Optimization of Solar Panel Racks

The falling price of silicon photovoltaic (PV) solar panels is making large scale installations an economically viable option for renewable energy production. Arrays of PV panels are being installed on the roofs of large buildings such as factories and warehouses to provide supplemental power for the facility. A typical installation is shown in Figure 1.

Figure 1: Roof-top PV array (Montgomery County, MD)

On flat roofs, the PV panels are mounted on freestanding racks with south-facing inclinations. Ballast is applied to each rack to provide stability in winds up to 120 mph.

To minimize the ballast requirements, and therefore the total load on the roof, the racks must be designed to minimize the aerodynamic lift force. In a worst case scenario, with high winds from the north, the inclined panels may experience lift forces on the order of hundreds of pounds.

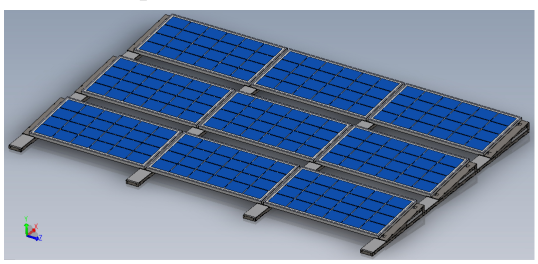

Figure 2: PV panel array CAD Model

To reduce the lift force under these conditions, the racks are designed with wind deflectors and baffle plates. Figure 2 shows a CAD model of the panels.

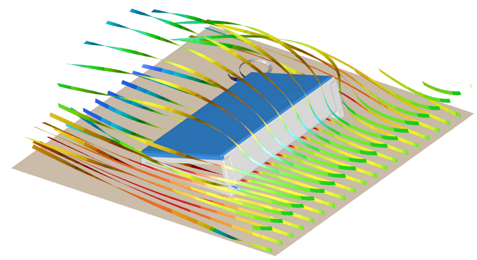

Figure 3: Pathlines colored by velocity.

ASC has been working with Solar Mounting Solutions of Newburgh, NY to provide CFD modeling in support of their design optimization efforts. Rack systems are simulated under various wind conditions to determine the optimal size and placement of deflector plates.

Simulations of larger panel arrays are conducted to determine the variation of aerodynamic forces at different positions within the array. Pathlines colored by velocity are detailed in Figure 3, while a side view of velocity contours are in Figure 4.

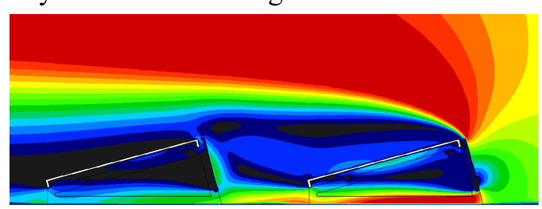

Figure 4: Contours of velocity magnitude.

Worst case lift forces may occur on panels at the edges of the arrays, or on interior panels, depending on the row spacing and panel geometry. In most cases, **the lift forces can be reduced by a factor to 2-3 times** with an optimal deflector design.

From the Editor

Well, 2012 has been a busy year so far. ASC has been awarded a multi-year project from the U.S. Air Force to improve the quality of jet engine and helicopter parts. We are excited about this cutting edge work (see page 2 for details). And our work in the power industry has expanded to include not just flow modeling, field testing, and supply of portable testing equipment, but also fabrication, installation, and calibration of permanent flow instrumentation to monitor plant performance. We've already installed two systems this year, one in the U.S. and one in Morocco.

To ensure we provide our customers the expertise and support they require for all of their flow modeling and testing needs, ASC has expanded our staff and space. We've added another 7500 ft^2 to our lab (we now feature over 28,000 ft^2 of space!) and added six (6) more people. Please join me in welcoming Sally Haselschwardt, Trevor Frantz, Ed Mello, Dr. Hank Newsome, Josh Schober, and Ryan Shelton to our staff.

We'd also like to congratulate John Nitz, P.E. for his hard work and diligence in obtaining his Michigan Professional Engineering license. Way to go John!

Edited by Kevin Linfield, P.E.

Reducing NOx at Refineries

In order to reduce smog and acid rain, the elimination of NOx (nitrous oxides) from heavy industry such as refinery Fluid Catalytic Cracking Units (FCCU) is required. Recently, ASC had the pleasure to work with Haldor Topsoe Inc of Houston, TX to provide both CFD and physical flow modeling of a new Selective Catalytic Reduction (SCR) unit at a refinery in the great plains. The existing ESP was removed from service resulting in a "high dust" content flue gas, which required a custom SCR catalyst that would withstand the erosive environment and still perform well over a 5-year continuous run.

The new SCR unit was to be installed upstream of a wet gas scrubber (for removing particulate, SO_2, and ammonia). Haldor Topsoe's design philosophy calls for a vertical down flow unit with a uniform temperature and velocity profile at the inlet face of the catalyst. In order to ensure these flow requirements, flow modeling was used to design turning vanes and static mixers.

A CFD model (Figure 5) was the main tool used to develop the flow control devices throughout the system. Performed at full scale, major internal components such as the mixers and turning vanes are represented precisely in the model. Results detailed the 3-D velocity flow field, pressure and ammonia distribution.

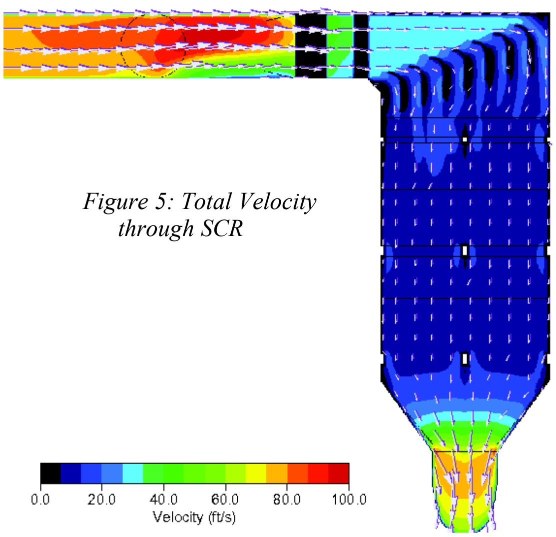

Figure 5: Total Velocity through SCR

The physical flow model (Figure 6) duplicated the geometry at 1:12 scale and was made of clear acrylic to facilitate flow visualization. Measured data included the velocity distribution at the planes of interest, pressure drop, ammonia concentration, and dust drop-out and re-entrainment.

Figure 6: Physical Model

The ultimate objective of the flow modeling was to design the FCCU SCR with a wide operating window that is able to perform at 116% of design throughput and at a turndown of 66%. A series of simulations were performed to develop design modifications to meet the project goals.

The final flow control devices consisted of a static mixer and two sets of flow directing vanes with 60% open flow distribution grids. The SCR went on line as planned, with the **outlet NOx measured at about 75% below the guarantee value.**

ASC Awarded SBIR Phase 2 from U.S. Air Force

In 2011, ASC completed a Phase 1 research grant from the Air Force to improve the quality and reliability of high-stress jet engine parts. Just last month, the Air Force decided to continue the project as a Phase 2 Small Business Innovative Research (SBIR) grant. This means that ASC will be conducting experiments in our lab over the next few years to analyze the heat transfer mechanisms involved in the quenching and heat treating of forged aircraft parts.

The experimental data will be incorporated into CFD software that ASC is writing. The software's objective is to predict the residual stress and microstructure of the final part even before the machining and heat treating processes begin. The ultimate goal is to reduce the per-part manufacturing costs while ensuring high quality and reliability. Look for more updates as this multi-year project continues.

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Airflow Events

We hope to see you at future industry conferences including:

- Worldwide Pollution Control Association (June 5-6, Detroit, MI)
- AeroMat (June 18-20, Charlotte, NC)
- Air Pollution Control Users Group (July 16-17, Baltimore, MD)
- Coal-Gen (Aug 15-17, Louisville, KY)
- Quenching & Control (Sept 10-13, Chicago)
- **Your Office:** Looking to host a seminar on modeling, fluid flows, or heat transfer?

We make house calls!

CFD Modeling of Ring Gears

ASC has been developing CFD methods to predict heat transfer coefficients of rolled ring gears for wind turbines and auto transmissions. The full technical paper can be down-loaded from ASC's website.

Photo from ASC's Kim Charette (on her land near Lake Superior.)