Wind loads on heliostats in operating position

Jeremy Shiyao Yu, Farzin Ghanadi, Matthew Emes, Mazar Arjomandi, Richard Kelso
Centre of Energy. The University of Adelaide, South Australia, Australia

During operation, heliostats act as bluff bodies submersed in the atmospheric boundary layer (ABL) flow, where velocity gradients and high turbulence intensities are characteristic of the conditions [1]. These parameters have significant effects on the static and dynamic loads on heliostats which affect their structural integrity and performance [2, 3]. Knowledge of how heliostats are affected by the ABL would allow designs to be more optimized for specific sites and therefore reduce overall costs.

Objectives

- Investigate the static loads on heliostats under high turbulence intensities at different operating angles
- Investigate the effects on loads for tandem heliostats at various angles,
- Determine the dynamic response of a single heliostat,
- Investigate methods for load reduction such as flow control techniques.

Methods

- Single square facet dimension of 800mm x 800mm heliostat at various operating angles in a closed loop wind tunnel with 3m x 3m test section.
- The heliostat pylon will also have an adjustable pylon in order to experiment at different heights within the boundary layer.
- The velocity of the tests was set to a constant 5.8m/s which represented a Reynolds number of 510,000, with a 200mm boundary layer thickness at the test location and an approximate turbulence intensity of 2%.
- Quantitative numerical analysis of the three-dimensional flow using Embedded Large Eddy Simulation (ELES) has also been conducted to provide a detailed analysis of the forces acting on the heliostat at different orientations.
- The flow was simulated within a channel such that the inlet boundary condition was defined by a power law velocity profile with a roughness exponent of 0.14 and turbulence intensity of 18%. This results in a fully developed atmospheric turbulent boundary layer in the vicinity of the heliostats.
- Fine hexahedral mesh containing 5 to 8 million cells has been used throughout the domain to fit the geometry and support a high amount of skewness and stretching without affecting the results.

- The heliostat facet has a hollowed out compartment in order to house the electronics required for pressure sensors.
- Pressure taps are placed over the facet in order to measure the pressure distribution along the facet at different orientations.
- Load cell platform has been designed and manufactured which allows azimuthal rotations to the heliostat.
- Four three-axis load cells implemented at the four corners of the platform allow all three components of force and moments to be measured.

- There is a significant increase in peak drag coefficient under high turbulence intensities (≥12%)

Results

- The effect of a sharp increase in load at the 30 degree elevation is reduced with increasing azimuthal angle from 0 degrees.
- The loads experienced by the heliostat when facing away from the flow at 135 and 180 degree azimuthal angles are also lower than their counterparts at 0 and 45 degrees, showing that the support pylon has a very noticeable influence on loads.

Future work

- High turbulence generation in wind tunnel
- Tandem heliostat measurements at various angles
- Numerical analysis of flow characteristics behind heliostat facets under various flow conditions