Convective and radiative heat losses from a bladed receiver

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Bladed structures have been proposed to improve light trapping and reduce radiative heat losses from central tower receivers. Although bladed receivers improve optical performance, a possible increase of heat losses due to the extended surface area could overshadow this light trapping improvement. Quantifying convective and radiative heat losses from solar receivers is challenging due to the non-linearity of mixed convection, variable wind conditions with turbulence, and non-isothermal boundary effects. The effects of pitch angle (from vertical), yaw angle (relative to the wind direction), and wind speed on an iso-thermal bladed receiver were recently reported [1], showing a reduction of heat transfer coefficients from the flat conventional geometry [2] at characteristic angles. In this study, a computational fluid dynamics (CFD) analysis for convection and a Monte-Carlo ray tracing (MCRT) model for radiation were conducted to estimate heat losses from a bladed receiver with variable geometry and temperature boundary conditions. The aim is to quantify thermal losses from a bladed receiver, compare to the flat configuration, and introduce new guidelines for bladed receiver design.

The effects of wind speed, wall temperature, blade number, aspect ratio (blade length to blade spacing), pitch and yaw angles were studied for both the isothermal and non-isothermal cases. The isothermal case focused on showing a reduction of thermal emissions due to a reduction in view factors and provided a baseline to compare with non-isothermal blades. The non-isothermal configuration showed heat loss reduction, for both convection and radiation, due to an enhanced cavity effect where the surface near the aperture, i.e. blade tips, has a lower temperature than the surface near the backwall. Figure 1 shows the geometry of the CFD model for a given blade geometry and the results of heat transfer coefficient as a function of the wall temperature for both convection and radiation in isothermal configuration. The temperature ranges where each mode of heat transfer is dominant are highlighted.

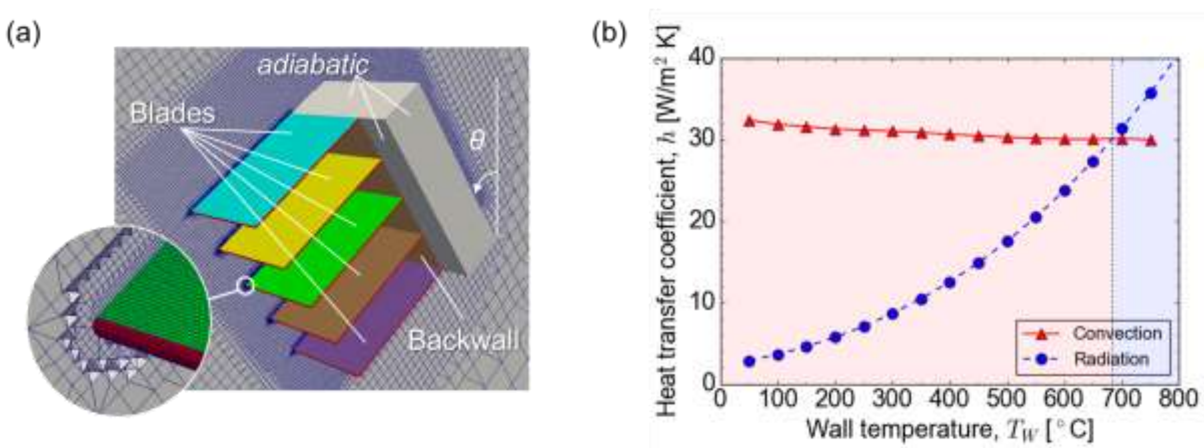

Figure 1. CFD model (a) and heat transfer coefficient as a function of wall temperature for a bladed structure with five blades, aspect ratio R_{BS} = 5, and wind speed U = 5 m/s (b)

[1] Torres, J. F., Ghanadi, F., Arjomandi, M., & Pye, J. In proceedings of the *11th Australasian Heat and Mass Transfer Conference*, Melbourne, Australia, July 2018.

[2] Torres, J. F., Ghanadi, F., Nock, I., Arjomandi, M., & Pye, J. (2018). *International Journal of Heat and Mass Transfer*, 119, 418-432.