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The Influence of Temperature Distribution and Wind Speed on the Losses from a Heated Cavity

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An experimental investigation is presented of the effects of wind speed (0 - 9 m/s), yaw angle (0° and 90°), and tilt angle (90°, 15° and -90°) on the convective heat losses from a cylindrical cavity heated with different internal wall temperature distributions. The internal wall comprised 16 individually controlled heating elements to allow the distribution of the surface temperature to be well controlled, while the air flow was controlled with a wind tunnel. The key aim of the present investigation is to provide direct measurements of the influence of temperature distribution, tilt angle and wind speed on the mixed convective heat losses from a solar cavity receiver. This study also aims to compare the effect of wind on the heat losses from a downward tilted and an upward facing receiver. It is found that temperature distribution has a strong influence on the convective heat losses, with a joint dependence on the wind speed and its direction. For the no-wind and side-on wind conditions, the measured range of the heat losses varied by up to 50% with a change in the wall temperature distribution. For the no-wind condition, the 'upper surface hotter' cases have the best overall performance, but for the side-on wind direction, the convective losses are lowest with the hottest surface at the back. However, for high head-on wind speeds, this variation reduced down to ~20%. For the downward tilted cavity, the convective losses from the head-on wind direction cases can be ~3 times larger than the side-on wind cases. In general, the heat losses tend to be minimised with the rear or upper surface to be hottest for a downward tilted solar cavity receiver ($\varphi = 15°$). The convective heat losses from a downward facing cavity ($\varphi = 90°$) are lowest. However, convective heat losses from an upward facing cavity ($\varphi = -90°$) are not the highest, which are ~3 times less than the downward tilted heated cavity (typical of beam-down and tower-mounted configurations, respectively). The main reason for this difference is that the wind direction is always normal to the cavity for the beam-up and beam-down orientations, which is the orientation with the lowest convective losses. These configurations avoid the wind flowing directly into the cavity, which has the greatest connective losses. This experimental investigation provides new measurement data, which is needed for the influence of the controlling parameters of receiver geometry (cavity aspect ratio, aperture ratio), wind speed and direction (yaw angle), cavity orientation (tilt angle), operating temperature, and wall temperature distribution.