ASIA-PACIFIC
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# Reconfiguring and rethinking tubular receivers: findings from the Bladed Receivers with Active Airflow project

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Increasingly, central tower systems are becoming dominant among new-build commercial solar-thermal power plants. These systems typically make use of a molten salt ($NaNO_3$ and $KNO_3$) receiver with a large two-tank storage system. The ‘conventional’ molten salt receivers are limited in the upper temperature they can achieve. One of the limiting factors is thermal degradation of the salt when heated much beyond 600°C. The other is thermal creep/fatigue in the pipes. These factors together combine to impose an effective peak flux limit on molten salt receiver tubes. The result of these factors has been that typical molten salt receivers, with a convex cylindrical shape, achieve an efficiency of the order of 90%.

Bladed receivers have been proposed as a concept which could allow a significant increase in receiver efficiency, by rearranging tube banks from the usual convex tube-bank panels into a bladed or louvred arrangement which places the same total tube surface area into a much reduced aperture. The reduced aperture area would result in lower total radiative losses. Some of the tube-banks would be double sided, which, if having the same exposed surface area, would facilitate a reduction in mass of tubes compared to the original convex receiver. The flow path through the tube-banks would be configured to pass the cooler fluid through the outermost surfaces, reducing the overall thermal losses. Finally, convective losses would be expected to be lower, since the same-area tube banks would be configured into quasi-cavity structures that somewhat trap hot air and increase the average thickness of the convective boundary layer. In addition to the bladed geometry, it was also proposed the use of air curtains, mounted across the aperture of such a receiver, could further reduce convective losses. It was considered feasible that the combination of these effects could reduce total receiver losses by half, allowing central receivers to operate at an efficiency of up to potentially 95%.

An extensive study of bladed receivers is now nearing completion, and all aspects of the design of bladed receivers have been examined in detail. Models of the internal flow path through the receiver, including friction and heat transfer have been coupled with models of the incident solar flux, thermal radiative emissions, external natural and forced convection, and conduction through the tube-walls. These models have been furthermore optimised together with adapted aiming strategies for the heliostat field, and compared with an optimised convex receiver for the same assumed heliostat field.

In addition to these models, there have been experimental evaluations of convective heat loss, conducted in still air, water tanks and a wind tunnel. Both bladed and flat receiver configurations have been tested, as have air curtains. Finally, a detailed design for an on-sun bladed receiver has been developed, which is currently being built and will be tested around October 2018.

In this paper, the key finding from this project are presented in detail. It has been found that bladed receivers can indeed reduce receiver losses by at least 2% (and probably more with the addition of air curtains) but that it will be a significant challenge to build these receivers cheaply enough to make them cost effective in a commercial project: optical constraints imposed by the large spot size of far-off heliostats effectively limit the opportunity to reduce the receiver size as much as had been anticipated. A range of options to further refine these concepts do exist, however, and are presented here as topics for future work.