The cross-slot is a common [geometric shape](https://www.sciencedirect.com/topics/engineering/geometric-shape) in [microfluidic](https://www.sciencedirect.com/topics/engineering/microfluidics) applications. In this article we investigate the influence of a purely-inertial flow instability on the enhancement of heat transfer in a cross-slot micro-geometry where symmetry is broken but the flow remains steady. The cross-slot comprises two crossed square channels with opposed inlets and outlets, which generate a [stagnation point](https://www.sciencedirect.com/topics/engineering/stagnation-point) at the geometric centre (when the flow remains stable and symmetric). In the experiments, Rhodamine-B is utilised as a temperature-sensitive dye to measure the temperature distribution, these results compare well with three-dimensional numerical simulations, which are used to further elucidate the flow behaviour and heat transfer characteristics. The flow of a [Newtonian fluid](https://www.sciencedirect.com/topics/engineering/newtonian-fluid) is steady, two-dimensional and produces a sharp symmetric boundary between fluid streams entering the cross-slot from opposite directions at [low Reynolds numbers](https://www.sciencedirect.com/topics/engineering/low-reynolds-number) (Re). Therefore, only [conduction heat transfer](https://www.sciencedirect.com/topics/engineering/conduction-heat-transfer) occurs between the fluid streams as there is virtually no mixing between them. Beyond a certain critical value of Re, approximately 40, a steady symmetry-breaking bifurcation occurs and convective heat transfer arises because an axially oriented spiral vortex is created in the outlet arms. The effects of this purely-inertial instability suggest it is an effective method of enhancing mixing and heat transfer in [microfluidic devices](https://www.sciencedirect.com/topics/engineering/microfluidic-device) that can be exploited in applications such as lab-on-chip and micro chemical-reaction devices at relatively low Reynolds numbers (i.e. Re < 100).