HEAT TRANSFER UNDER NON-STEADY JETS: EFFECTS OF UNSTEADY JET IMPINGEMENT

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A standard situation in convective heat transfer is an impinging jet on a plane surface in an otherwise quiescent ambient. This arrangement is often used for body cooling . Due to the analogy of convective heat and mass transfer it is also important in drying processes.

Though the geometry of the jet/plate combination is quite simple there are nevertheless a large number of parameters in this convective heat transfer arrangement, like: nozzle to plate distance, Re number, turbulence level, nozzle inclination angle (if not vertical), wall roughness just to mention a few. All these parameters affect the heat transfer performance of the arrangement and can be changed systematically in order to influence the rate of heat transfer.

Within the special means by which impinging jet heat transfer can be manipulated unsteadiness of the flow field is rarely used. However, unsteady flows are distinctly different compared to their steady counterparts, so that there should be a high potential to affect the heat transfer performance of such flows. Studies about the influence of unsteady flow fields on convective heat transfer almost always generate the unsteady flow by external means like forced pulsation or periodic interruption of the jet impingement.

Our approach, however, is a selfsustained unsteadiness without external input of energy and without moving parts in the system providing the flow field for convective heat transfer. Three different nozzle designs will be presented that fulfil these requirements. They are sketched in Fig. 1 a - c.

The *vortex jet* is generated by von Karman vortex streets behind certain inserts in the otherwise homogeneous jet.

The *flipflop jet* occurs in a nozzle with square cross section when inserts like in Fig. 1b lead to a small (plane) inner jet that alternatively sticks to the left and the right wall. The length L of the feedback loop between the two nozzle chambers determines the frequency f_F with which this happens.

A *precessing jet* occurs in a perfectly axisymmetric arrangement like in Fig. 1c when an envelope tube acts like the adjacent wall in the plane counterpart with the Coanda effect.

For all three nozzles heat transfer measurements on the impingement wall will be presented as well as characteristic features of the flow field.

These measurements are performed on a heat transfer plate for measuring wall heat flux densities and wall temperatures simultaneously. The main part the heat transfer surface which has the double function of heating and measuring is an electrical circuit board with a special circuit design on both surfaces. The central part of the plate is subdivided into 64 single fields of size $(46{,}8\ \text{mm})^2$ so that the whole heat transfer surface covers an area of $(374{,}4\ \text{mm})^2$.

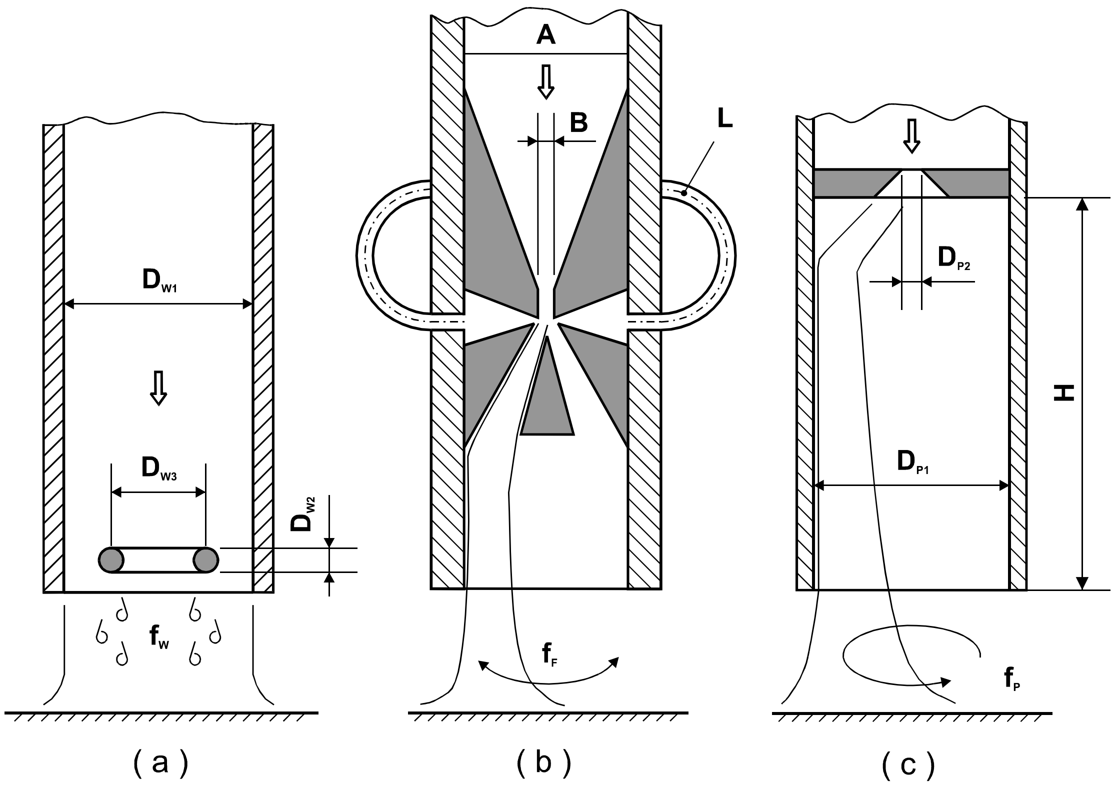

Fig. 1: Unsteady jet arrangements

a) Vortex jet
b) Flipflop jet
c) Precessing jet

If now the board is heated with a constant electrical current (typical value: 4A) we measure the electrical current which is the same for each of the 64 single fields and the single field voltage. When the whole arrangement is calibrated with respect to its temperature/electrical resistance behaviour we find the electrical power density of a single field, as well as the single field temperature. From these quantities Nusselt numbers can be determined which are in good agreement with infrared measurements we conducted for certain selected cases.

On the basis of the three unsteady jet flows the potential for affecting convective heat transfer by unsteadiness of the flow field is discussed and recommendations for research in the future are made.