EXPERIMENTAL INVESTIGATION OF SPRAY COOLING ON HIGH TEMPERATURE METAL SURFACES

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EXTENDED ABSTRACT

Traditionally water sprays have been used extensively in metallurgical industries for the cooling of high temperature metals at film boiling Experimental studies were conducted to reveal the heat transfer mechanism of impacting water mist on high temperature metal surfaces. Local heat transfer coefficients were measured in the film boiling regime at various air velocities and liquid mass fluxes. The test conditions of water mist cover the variations of air velocity from 0 to 50.29 m/sec, liquid mass flux from 0 to 7.67 kg/m^{2}sec, and surface temperature of stainless steel between 525°C and 500°C. Radial heat transfer distributions were measured at different liquid mass fluxes. The tests revealed that the radial variation of heat transfer coefficients of water mist has a similar trend to the air jet cooling. At the stagnation point, heat transfer coefficient increases with both the air velocity and the liquid mass flux. The convective air heat transfer is consistent with the published correlation in the literature [1,2]. The heat transfer contribution due to the presence of water increases almost linearly with the liquid mass flux. The total heat transfer coefficient can be established as two separable effects, which is the summation of the heat transfer coefficient of air and of liquid mass flux, respectively. This study shows that with a small amount of water added in the impacting air jet, the heat transfer is dramatically increased. The Leidenfrost temperature under water mist cooling was also measured. The Leidenfrost temperature increased with both the air velocity and the liquid mass flux. The experimental apparatus consisted of an air atomizer nozzle, an air flow system, a liquid supply system, an oven, the test plate, and a data acquisition unit are

shown in a schematic diagram in figure 1. At the bottom of air chamber, there is an opening of 7.9 mm diameter. Typically, The air atomizer nozzle produced a mist of 22.7 cm^3/min (0.006 gpm) of water flow at about 20 micron volume median diameter, when applied with 96.5 kPa (14 psig) air pressure and 68.9 kPa (10 psig) water pressure. The test plate was made of stainless steel (SS304) with 101.6 mm in diameter, and 1 mm in thickness. Plates are regularly changed after a few tests. To measure the temperature-time history of test plate during cooling, two bare thermocouple wires (Type K) with 0.1778 mm in diameter were attached to the backside of the plates by spot-welding. The wires are insulated using ceramic beads. The backside of the plate is insulated with a shallow cavity. The temperature variations in time were recorded using a digital data acquisition system.

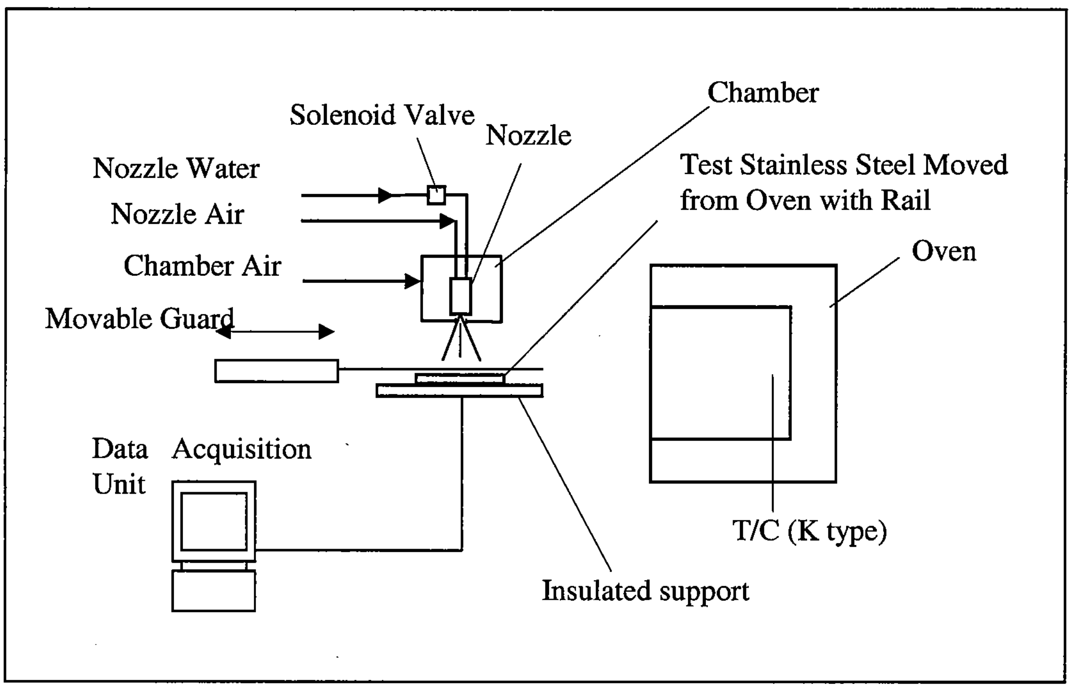

Figure 1 Schematic of experimental apparatus

Local heat transfer coefficients were measured in film boiling regime at various air velocities and liquid mass fluxes. Radial heat transfer distributions were also studied. The Leidenfrost temperature against the air velocity and the liquid mass flux was discussed. The major conclusions from the study are as follows:

1. With a small amount of water in the air jet, the heat transfer is dramatically increased. The water mist heat transfer coefficient increases with both the air velocity and the liquid mass flux. Mist and air heat transfer are independent.
2. The convective air heat transfer is consistent with the predictions based on correlation in the literature.
3. Mist heat transfer increases almost linear with the water mass flux. The velocity effect is small.
4. The overall convective heat transfer coefficient can be viewed as two separable elements, which is the summation of the heat transfer coefficients of air and of liquid mass flux, respectively. For a general prediction, equation (9) can be used where equation (2) and (6) can be applied.
5. The normalized radial distribution of mist flow heat transfer is similar to that of pure air jets. The Leidenfrost temperature increases with both the air velocity and the liquid mass flux.

REFERENCES

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