ABSTRACT

The cooling intensity enhancement results in desirable mechanical properties generation into steel, which is desirable in all practical and advanced engineering applications. This dissertation explores the cooling enhancement of heated steel (>900^{o}C) with and without additives-based coolant. The thermophysical properties of coolant favorable for heat transfer enhancement can be attained by fractional additives inclusion and coolant-temperature enhancement, resulting in cooling improvement. In first considered nanofluid, with mono and mixed SiO_2 and CuO nanofluid supported with the surfactant, cooling performance is observed than plain water; moreover, mixed nanofluid performs better than mono nanofluid owing to the synergistic effects of nanoparticles properties. However, at the highest concentration of nanofluids, a reduction in cooling enhancement is observed, possibly due to excessive-deposited nanoparticle-induced blocking of the active nucleation site. In the second considered polymer-based nanofluid, sodium dodecyl sulfate-doped polyaniline Nanofibers temperature stability (up to 150 ^{o}C) depicted in the temperature range of operation in spray cooling, with the nanofluid application at the highest concentration, ~34% enhancement in cooling rate is observed. A comparative study of prepared nanofluid with conventional nanofluid reveals comparable performance at the incurred cost of nanofluid.

In varied-temperature coolant studies, spray characterization reveals residence time reduction, droplet detachment frequency enhancement, and vapor film wavelength reduction, which impacts heat extraction due to reduced liquid film thickness and liquid film transient conduction. About ~20% cooling rate enhancement is attained for the highest enhanced coolant temperature; moreover, enhancement in cooling efficiency and reduction in coolant consumption is observed with enhanced temperature coolant. For inclined nozzle-plate condition, droplet train investigation depicts enhancement in crown disintegration tendency for heated surface condition, which further can reduce the inherent low droplet residence time of enhanced-temperature coolant; therefore, cooling performance reduces at inclination conditions than horizontal conditions for the same enhanced temperature coolant.

Keywords: Spray cooling; Nanofluid; Surfactant; Enhanced-temperature coolant; Cooling Rate, Heat Flux.