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Effect of Gravity on the Controlled Cooling of a Steel Block by Impinging Water Jets

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Abstract : The uniform and controlled cooling of hot metals by the circulation of water in canals remains a challenge due to the phase change of the water and the high heat fluxes associated with the phase change. This is because, during the cooling process, the phases are not uniformly distributed along the canals with the liquid phase dominating at the entrances of the canals and the gaseous phase dominating towards the exits. The difference in thermal properties between both phases leads to a heterogeneous temperature distribution in the part being cooled. Slowing down the cooling process is also a challenge due to the high heat fluxes associated with the phase change of water. This study investigates the use of multiple water jets for the controlled and homogenous cooling of hot metal parts and the effect of gravity on the effectiveness of the cooling process with a potential application in the cooling of composite forming moulds. A hole is bored at the centre of a steel block along its length. The jets are generated from the holes of a perforated steel pipe which is placed along the centre of the hole bored in the steel block. The evolution of the temperature with respect to time on the external surface of the steel block is measured simultaneously by thermocouples and an infrared camera. Different jet positions are tested in order to identify the jet placement configuration that ensures the most homogenous cooling of the block while the cooling speed is controlled by an intermittent impingement of the jets. In order to study the effect of gravity on the cooling process, a scenario where the jets are oriented in the opposite direction to that of gravity is compared to one where the jets are aligned in the same direction as gravity. It's observed that orienting the jets in the direction of gravity reduces the effectiveness of the cooling process on the face of the block facing the impinging jets. This is due to the formation of a deeper pool of water due to the effect gravity and of the curved surface of the canal. This deeper pool of water influences the boiling regime characterized by a slower bubble evacuation when compared to the scenario where the jets are opposed to gravity.

Keywords : cooling speed, gravity, homogenous cooling, jet impingement
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