Universität Bremen

Abstract on

Optimization and Extension of Numerical Model for Quenching Process with Experimental Investigation

Prof. Dr.-Ing. habil. Udo Fritsching, M.Sc. Nithin Mohan Narayan, Prof. Dr.-Ing. habil. Lutz Mädler

University of Bremen, Fachgebiet Mechanische Verfahrenstechnik

Badgasteiner Straße.3, 28359 Bremen

Metals with advanced properties are of great significance for several engineering applications. In this context to achieve the expected pre-determined material properties, heat treatment is often preferred. During heat treatment/quenching, a material is heated to a higher temperature and cooled down by means of water jets or sprays with respect to the demanded cooling rate which finally determines the material property such as hardness. Quenching of metals is considered as a rapid process and is vulnerable to material distortion and cracks if uncontrolled. Therefore, the local cooling rates are to be monitored well during the process. Moreover, due to the higher temperature of the metals which are being cooled, to maintain the water jet/wetting front contact with the hot surface will be a great challenge because of the resultant so called Leidenfrost phenomena. The vapor film generated due to Leidenfrost effect will affect the cooling process adversely and will create non-uniformity in cooling over the plate surface. During jet quenching the interaction of hydrodynamic and thermal effects makes the process rather complex and hard to evaluate it alone experimentally. Therefore, it is obvious that a numerical model is desirable to further investigate the quenching mechanism and finally to judge the influencing parameters.

The existing 2D multiphase numerical model in ANSYS Fluent 14.0 has been extended to 3D in ANSYS Fluent 19.2 and further developed for simulating the two-phase flow in which water act as continuous phase and water vapor as dispersed phase. Eulerian multiphase model is selected to serve this purpose, the source and sink terms of conservation equations are modified in order to account for the phase changes and interactions during the boiling process. The developed global model is able to simulate jet quenching successfully and identifies different boiling zones. Additionally, the Leidenfrost effect is directly visible from the results as seen in Figure 1 as well as the important parameters such as heat transfer coefficient, cooling curves, heat flux, wetting front positions etc. could also be analyzed. Different materials of engineering interest are also examined together with a single full jet, flat sprays and full cone sprays as depicted in Figure 2 and further with multiple jets configuration, such simulations are always computationally demanding. Experiments are conducted in conjunction with simulations to evaluate this numerical model and its reliability. Models will also be modified accordingly to incorporate spray simulation and movement of nozzles.

This project is planned as a Ph.D thesis under the guidance of University of Bremen and planned for a period of 36 months where the basic research idea taken from the AIF project ''Intensivkühlung II'' 20107 BG/1.

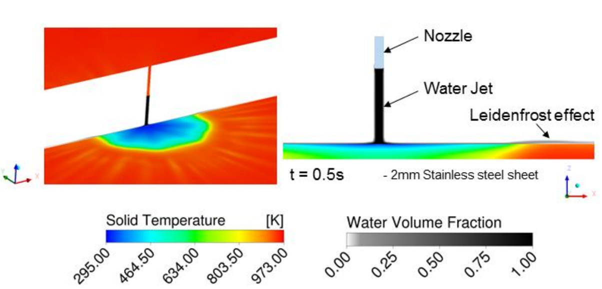

Figure 1: 3D-Simulation result of 2mm sheet quenched with full jet nozzle

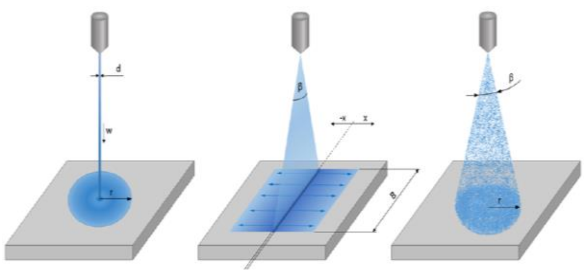

Figure 2: left-full jet, middle-Flat spray, right- full cone spray