Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
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Country	France

PhD information	
Title	Experimental Study of Metallic Piece Cooling by Quenching Process.
Main topics regards to CSC list (3 topics at maximum)	Quenching Process, Thermal Measurements, Inverse Problems.
Required skills in science and	Heat Transfer, Two Phase Flow, Experimental

engineering	Methods.

Subject description (two pages maximum)

Related to the metal parts manufacturing, the automotive, aeronautic, nuclear and energy markets require to design lighter parts together with seeking for more and more security and increased life cycles. This antagonist trend is solved by enhancing the overall quality and processes fine tuning. As such, the heat treatment, one of the more sensitive process steps is critical. In the same time, environmental context claims for an almost re-engineered current quenching process by substituting the quenching fluids by more environment friendly ones. This implies the absolute necessity of the knowledge and control of the metal parts thermal history all along their manufacturing process paths.

The experimental determination of the law of the transferred heat flux from the part to the bath which is *local*: $\phi(M,t)$ represents a scientific challenge. It requires an implementation of an experimental approach which considers a fine and robust instrumentation by thermocouple of samples and the choice of a non-linear post-processing model that can take into account any source term. The estimate of local superficial thermal conditions conducted by appropriate inverse techniques must be qualified according to the region of the part to characterize. Indeed, the observation by experiment [1] shows (the theory as well) that, according to the regions, the cooling can be 1D, 2D or 3D. For example, on a parallelepiped part, cooling is almost always 1D in the middle of its main faces, 2D in the regions near the edges (away from summits) and 3D around the summits. In order to characteriz the entire surface of the part many precautions must be observed for the choice of implantations of thermocouple wires which must follow isotherms. In LTeN, significant efforts have been made to improve and refine the techniques of instrumentation by thermocouple [2] to characterize accurately and reproducibly surface or interface thermal conditions, which are often inaccessible to non-contact measurement.

The measurement results must be presented under the form of local transient evaporation curve: $\varphi(M) = f\,[T(M)]$, where T and φ are respectively local surface temperature and heat flux density (at point M). Then, it can be checked by the optical results given by a movie obtained by means of a high speed camera which records the transient cooling of the part in the bath; knowing that chronological order of appearance of transfer modes remains the same: film boiling, transition boiling, nucleate boiling and convection. The relative duration of each transfer mode must obey to the mean Biot rule [3].

recently we carried out experimental study in order to characterize the agitation of the bath which strongly influences the transient cooling of the part [4, 5]. The velocity field genrated either by pump or turbine was measured by 2D-PIV system.

The proposed work will focus on the relationship between the transient cooling and the agitation aspect. The study of the evolution of critical heat flux in this transient process will be of particular interest.

The supervision of this thesis will involve Pr. Brahim BOUROUGA who has a recognized expertise in the characterization and analysis of heat transfer in the forming processes (hot forging, hot stamping, high speed machining) and heat treatments (quenching).

References:

[1] J. Gilles, B. Bourouga, A.Sorin, Quinching Operation of aluminium alloys : measurements and numerical simulations, La Revue de Métallurgie, pp 695-703, 2004.

[2] B. Bourouga, V. Goizet et J.P. Bardon J.-P., Les aspects théoriques régissant l'instrumentation d'un capteur thermique pariétal à faible inertie, Int. J. Therm. Sci., vol. 39, pp 96-109, 2000.

[3] B. Bourouga, J. Gilles, Roles of heat transfer modes on transient cooling by quenching process, Int J Mater Form, DOI 10.1007/s12289-009-0645-z, 2009

[4] Comparison of Flow Fields in an agitated Tank for cooling of metallic piece by quenching process, *A. Ould El Moctar, B. Bourouga, B. Guenerie*, Appl. J. Envir. Eng. Sci. 4 N°2(SV) (2018) 291-298
[5] Ould El Moctar, A., Bourouga, B., and Guenerie, B., "Transient Cooling of Metallic Piece during a Quenching Process: Effect of Bath Agitation," *Materials Performance and Characterization*, https://doi.org/10.1520/MPC20180017. ISSN 2379-1365.