Titre en français : Vélocimétrie Laser des Jets Particulaires Supersoniques

Titre en anglais : Laser Velocimetry of Supersonic Particle-Laden Jets

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Résumé en français

Dans le procédé cold spray, des particules de taille nano à micrométrique sont accélérées par un jet supersonique afin de créer un dépôt sur un substrat. Malgré ses nombreuses applications (métallisation des plastiques, biomatériaux, traitement des surfaces…), la communauté scientifique a très peu étudié le couplage particules/gaz dans l'écoulement supersonique mis en jeux dans ce procédé. Cette thèse porte sur la mesure couplée des vitesses gaz/particules dans un jet supersonique particulaire. Nous utiliserons la vélocimétrie par image des particules (PIV) afin d'obtenir les champs de vitesse du gaz et la vitesse des particules afin de prédire le taux de déposition des poudres dans les applications du cold spray. Ce projet s'encadre dans la continuation du projet PEPS CNRS Mécanique du Fûtur ODISCOS (Optical Diagnostics of Supersonic Cold Spraying) et a bénéficié d'un financement de l'Institut de Mécanique et Ingénierie d'Aix Marseille Université.

Résumé en anglais

Cold spraying has emerged as a promising coating and additive manufacturing process, with a wide range of applications including transport, energy, and environmental technologies (An *et al.* 2020). Its principle relies on the aerodynamic acceleration of micro/nano particles to be deposited onto a solid substrate. The large energy carried by these particles traveling at supersonic speeds induce bonding and deposition process. The plastic bonding only takes place when the impacting particle velocity achieves a critical value, commonly over 500 m/s (Papyrin *et al.* 2006). In addition to the critical particle velocity, the complex structure of the supersonic gas stream plays a key role in cold spraying process. The presence of turbulence together with complex shock waves in the supersonic stream significantly affect the impacting particle velocity, hence the deposition rate (Pattison *et al.* 2007, Buchnam *et al.* 2013). The fluid-particle interaction during the coating process is thus of primary importance.

The experimental acquisition of coupled gas-particle coupled velocity is a challenging problem in supersonic flows. To measure the gas velocity, submicron-sized flow tracers are injected in the stream and imaged by a high-sensitive camera using a laser sheet. The scattered light from the tracer particles allows one to compute the velocity field using particle image velocimetry. However, as the flow is also feeded with larger, coating particles (5-100 microns), the higher scattered light from the dispersed phase not only induces saturation of the camera's sensor but also a misleading intensity of the flow tracers. A decrease of the laser

power output solves the saturation problem but makes difficult the observation of the submicron flow tracers required for supersonic flows. While phase discriminant methods have been employed to determine gas-particle velocity in low-speed flows (Khalitov & Longmire 2002), their application in supersonic multiphase flows needs careful extension. Here, we propose to perform coupled gas-particle velocity measurements in a simplified cold spray model feeded with both the flow tracers (0.5-1 microns) and the coating particles (20-100 microns). Particle Image Velocimetry (PIV) will be applied to measure both the gaz and the particle velocity fields, in multiple flow configurations presenting shock waves and under/overexpanded jets depending on the input pressure upstream of the nozzle. Preliminary results from the PEPS CNRS Mécanique du Fûtur ODISCOS (Optical Diagnostics of Supersonic Cold Spraying) project show a promising avenue for this investigation.

Profil du candidat recherché : Diplôme Master 2 / Ecole d'Ingénieur ; spécialisation aéronautique, mécanique, physique, mécanique des fluides ; compétences en expérimentation, mesures, analyse des données.

Publications sur le sujet

- An, S., Joshi, B., Yarin, A. L., Swihart, M. T., & Yoon, S. S. (2020). Supersonic Cold Spraying for Energy and Environmental Applications: One-Step Scalable Coating Technology for Advanced Micro-and Nanotextured Materials. *Advanced Materials*, *32*(2), 1905028.
- Buchmann, N. A., Atkinson, C., & Soria, J. (2012). Ultra-high-speed tomographic digital holographic velocimetry in supersonic particle-laden jet flows. *Measurement Science and Technology*, *24*(2), 024005.
- Khalitov, D. A., & Longmire, E. K. (2002). Simultaneous two-phase PIV by two-parameter phase discrimination. *Experiments in Fluids*, *32*(2), 252-268.
- Papyrin, A., Kosarev, V., Klinkov, S., Alkhimov, A., & Fomin, V. M. (2006). *Cold spray technology*. Elsevier.
- Pattison, J., Celotto, S., Khan, A., & O'neill, W. (2008). Standoff distance and bow shock phenomena in the Cold Spray process. *Surface and Coatings Technology*, *202*(8), 1443-1454.

Insertion professionnelle après thèse : publique et/ou privée