

CONCEPT FEASIBILITY STUDY OF USING DUAL-STREAM JETS IN COLD SPRAY

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Introduction

Cold sprayed coatings can be the most effective means of protecting substrate surfaces from wear and corrosion. These are processes in which spray particles are deposited via supersonic velocity impact at a temperature lower than the melting point of the spray material. The particle acceleration and the heat transfer directly determine whether particles have sufficient energy to deposit and form the coating. Whereas many cold spray facilities use high-speed single jets for accelerating the particles, it is of interest to consider the advantages and drawbacks of an alternative dual-stream jet configuration.

Modelling

Detached Eddy Simulations (DES) are used to obtain time-resolved predictions of the particle carrying compressible flow from single and coaxial nozzles. Dry air at constant specific heats is used under ideal gas assumptions. The nozzles are operated under-expanded. The in-house flow solver Cosmic is used, which is an explicit density-based solver with MUSCL interpolation. The flow is time-marched by a second-order Runge-Kutta integration scheme using up to third-order accurate discretization in space. Turbulence closure in the DES is by the $k - \omega$ SST model of Wilcox and the Yoshizawa LES model. Preliminary results are obtained in which only the carrier phase is modelled.

Single vs dual-stream jets

In a single jet, particles are carried by an unsteady flow and undergo accelerations and decelerations through a train of shock cells (Fig. 1). This is not functional to the deposition process. There is a relative large variation in the flow velocity and in temperature radially across the jet (Fig. 2). This is not conducive to uniform film coating as particles will impact the surface with a large range of kinetic energy as well as temperature, which affects the plastic deformation process on impact. It is therefore desirable to enhance the radial uniformity of the velocity and temperature in the carrier phase.

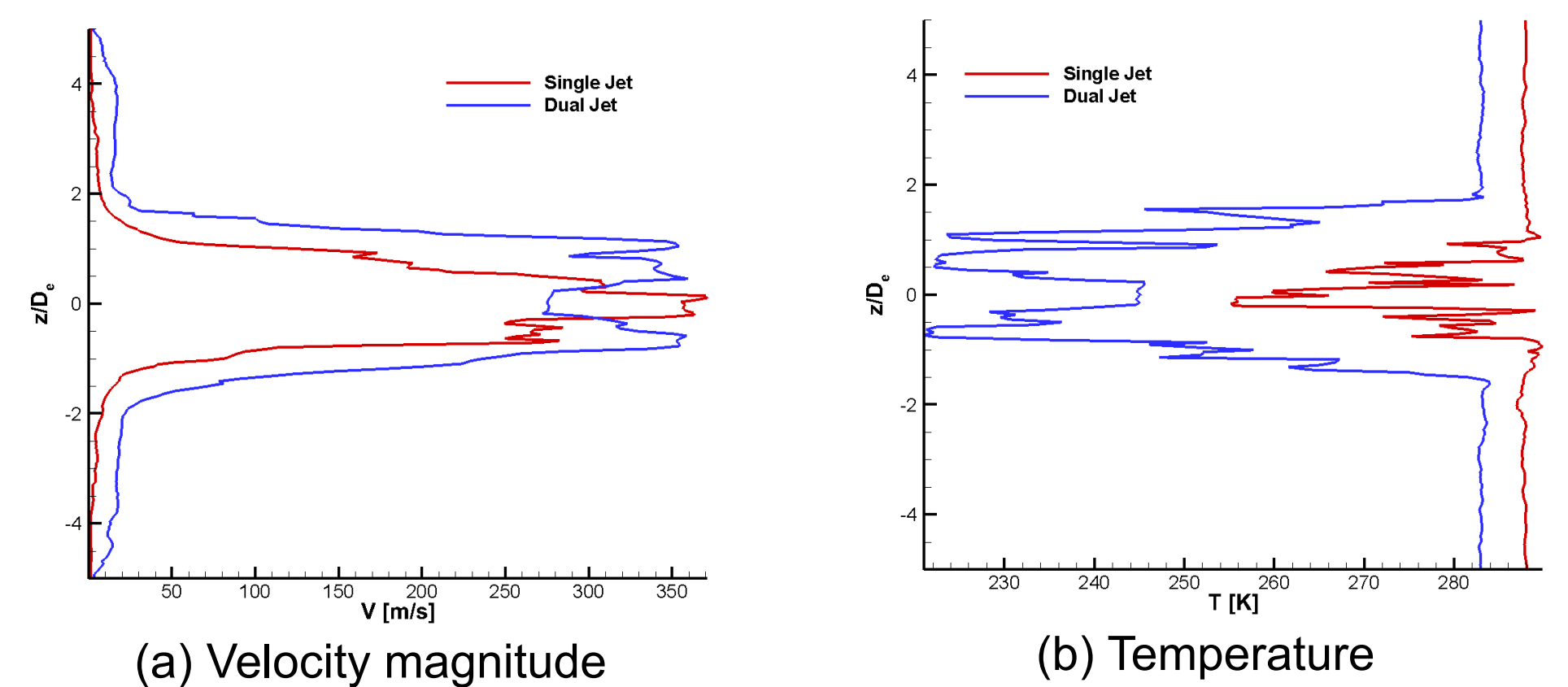


Fig. 2. Instantaneous radial profiles at $5x/D_e$.

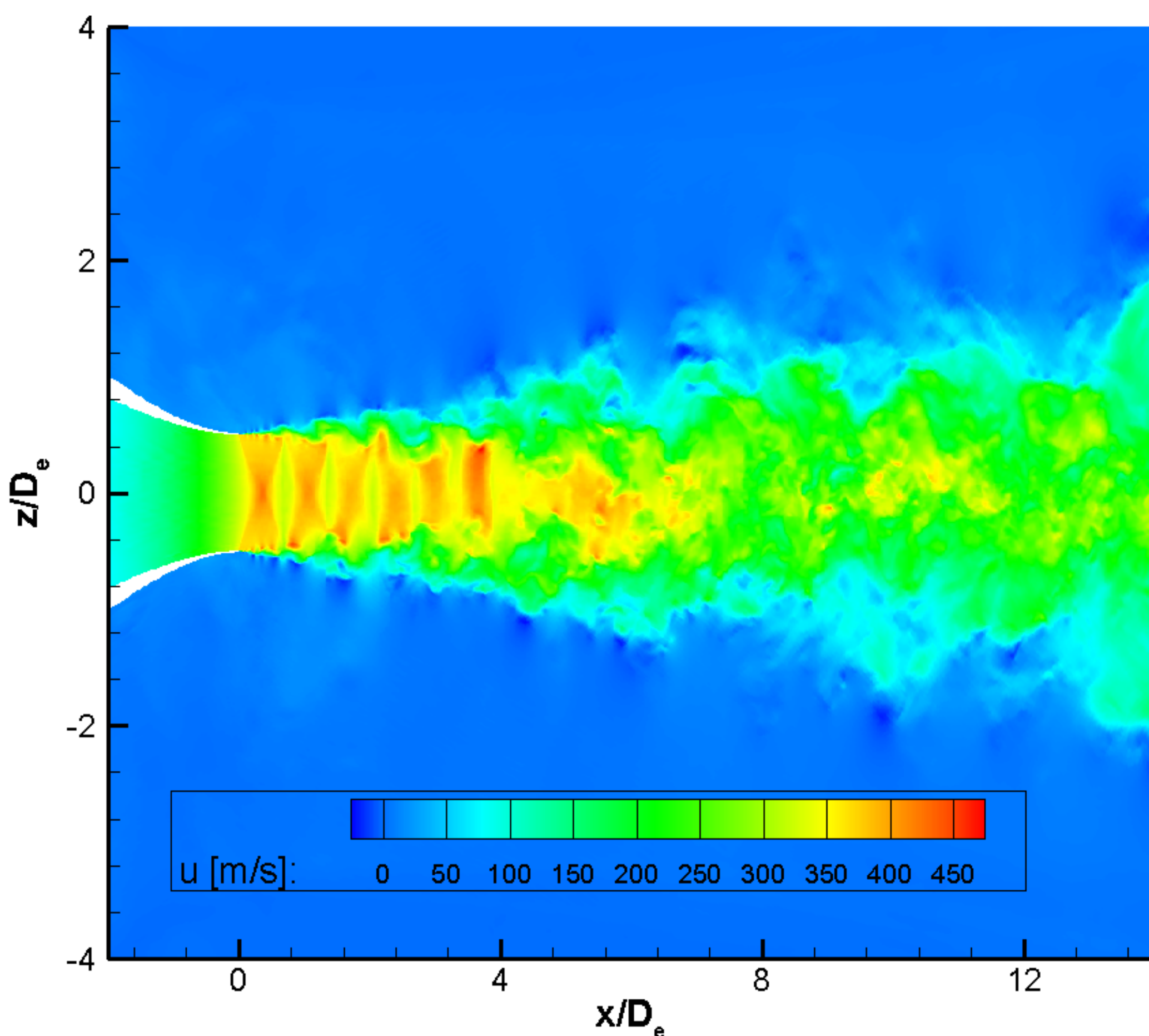


Fig. 1. Instantaneous iso-colour levels of axial velocity. $M_e = 1.0$, $Re_e = 1.2 \times 10^6$, $T_\infty = 288.15$ K, $p_\infty = 98$ kPa, $D_e = 38$ mm

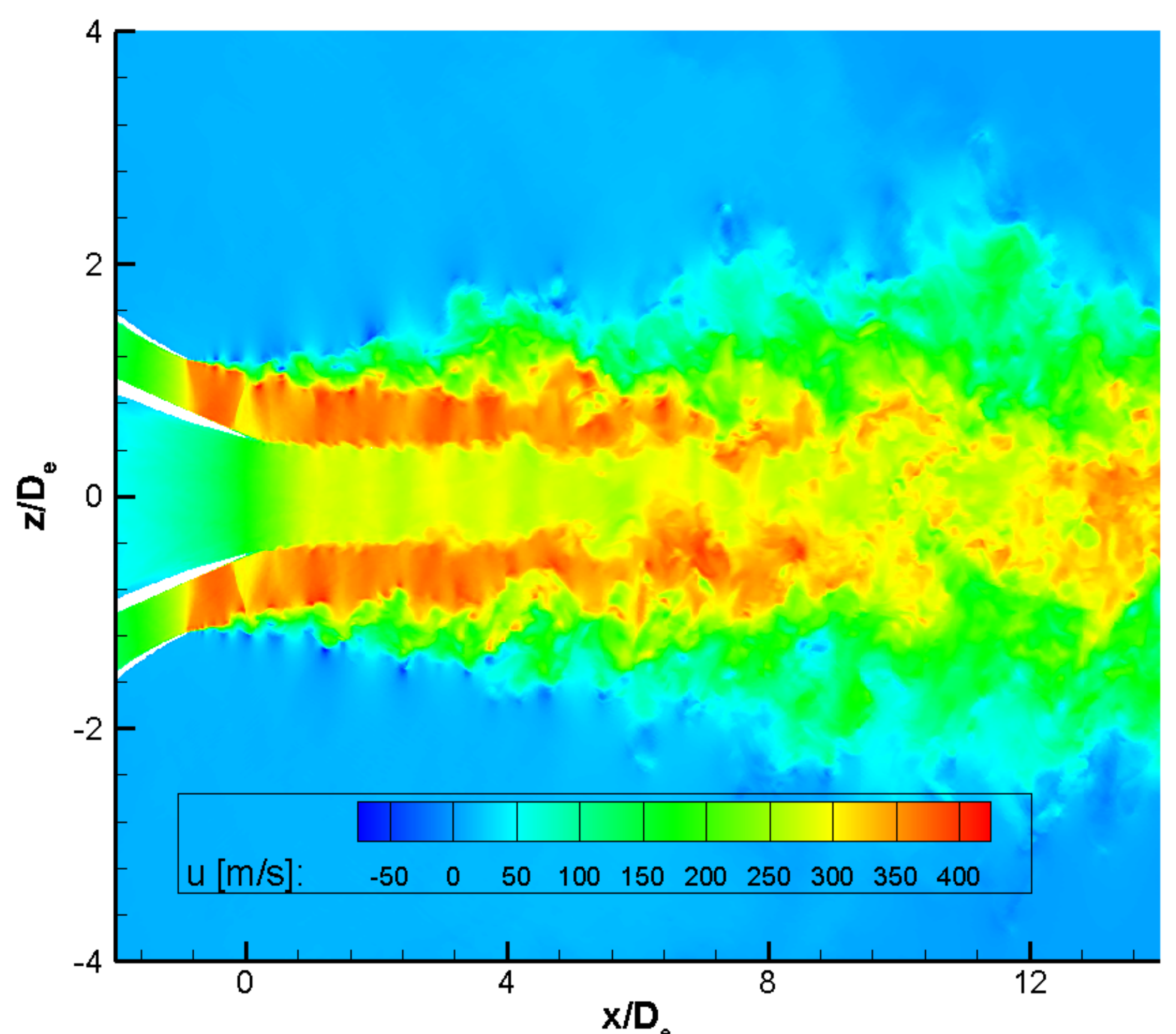


Fig. 3. Instantaneous iso-colour levels of axial velocity. $M_p = 0.89$, $M_s = 1.20$, $Re_p = 0.67 \times 10^6$, $Re_s = 2.64 \times 10^6$, $T_\infty = 283$ K, $p_\infty = 101.325$ kPa, $D_p = 23.4$ mm, $D_s = 55$ mm

Conclusions and future work

By considering an alternative dual-stream jet configuration, the particle velocity, temperature, and distribution upon impact can be significantly improved, which benefits to the final coating formation. Moreover, it is hoped to use the secondary jet as an air shield for the particle laden primary jet to experience reduced flow shear and reduced nozzle wall temperature which is responsible for the nozzle clogging. Further simulations are necessary to assess the behavior of the carrier flow in the region of impact and the dynamics of the particles.

References

- A. Mancini. *Detached eddy simulations of single and coaxial supersonic jets*. PhD thesis, University of Leicester, 2018
- X. Wang, B. Zhang, J. Lv and S. Yin. Investigation on the Clogging Behavior and Additional Wall Cooling for the Axial-Injection Cold Spray Nozzle. *J. Therm. Spray Technol.*, 2015, 24, p 696-701
- S. Yin, M. Meyer, W. Li, H. Liao and R. Lupoi. Gas Flow, Particle Acceleration, and Heat Transfer in Cold Spray: A review. *J. Therm. Spray Technol.*, 2016, 25, p 874-896