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Enhancing the spatter-removal rate in laser powder-bed fusion using a gas-intake system with dual inlets

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Back ground

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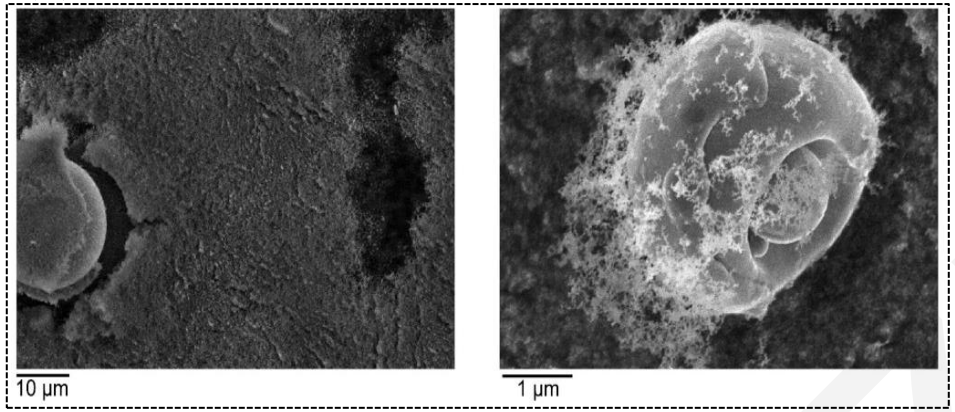
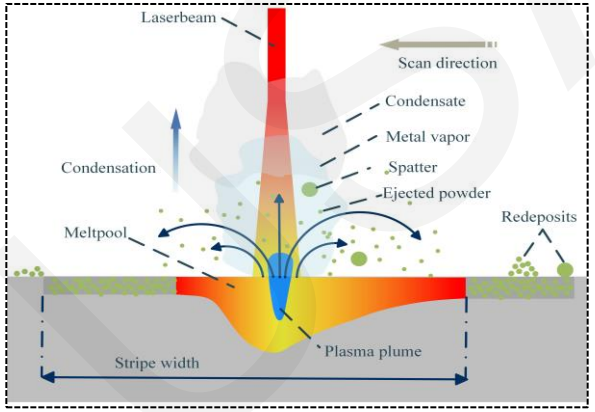
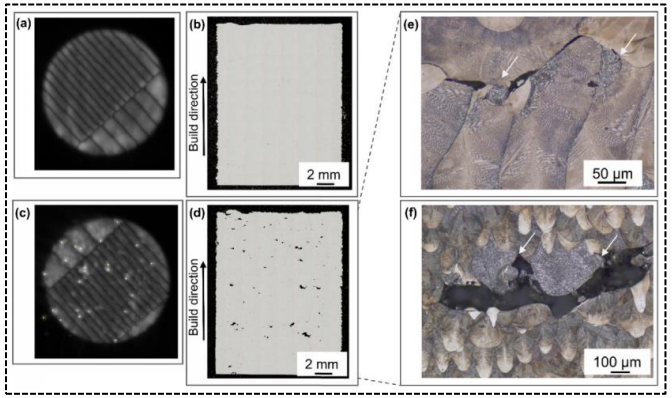
Laser powder bed fusion (L-PBF) is widely used in additive manufacturing but is adversely affected by splash effects

Effect of spatter on powder recycling

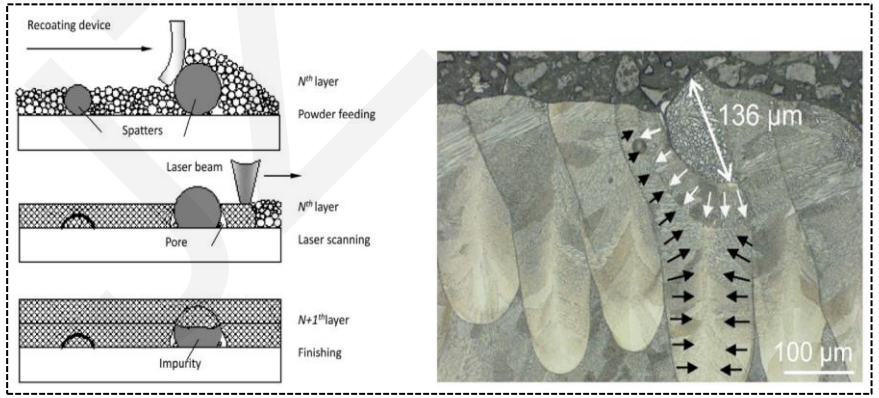


Effect of Spatter on Energy Absorption





Effect of Spatter on Structure and Performance



Effect of Spatter on Powder Re-Coating

Applications of L-PBF

- ✓ **Automotive**
- ✓ **Aerospace**
- ✓ **Medical devices**
- ✓ **Consumer products**

Numerical simulation method

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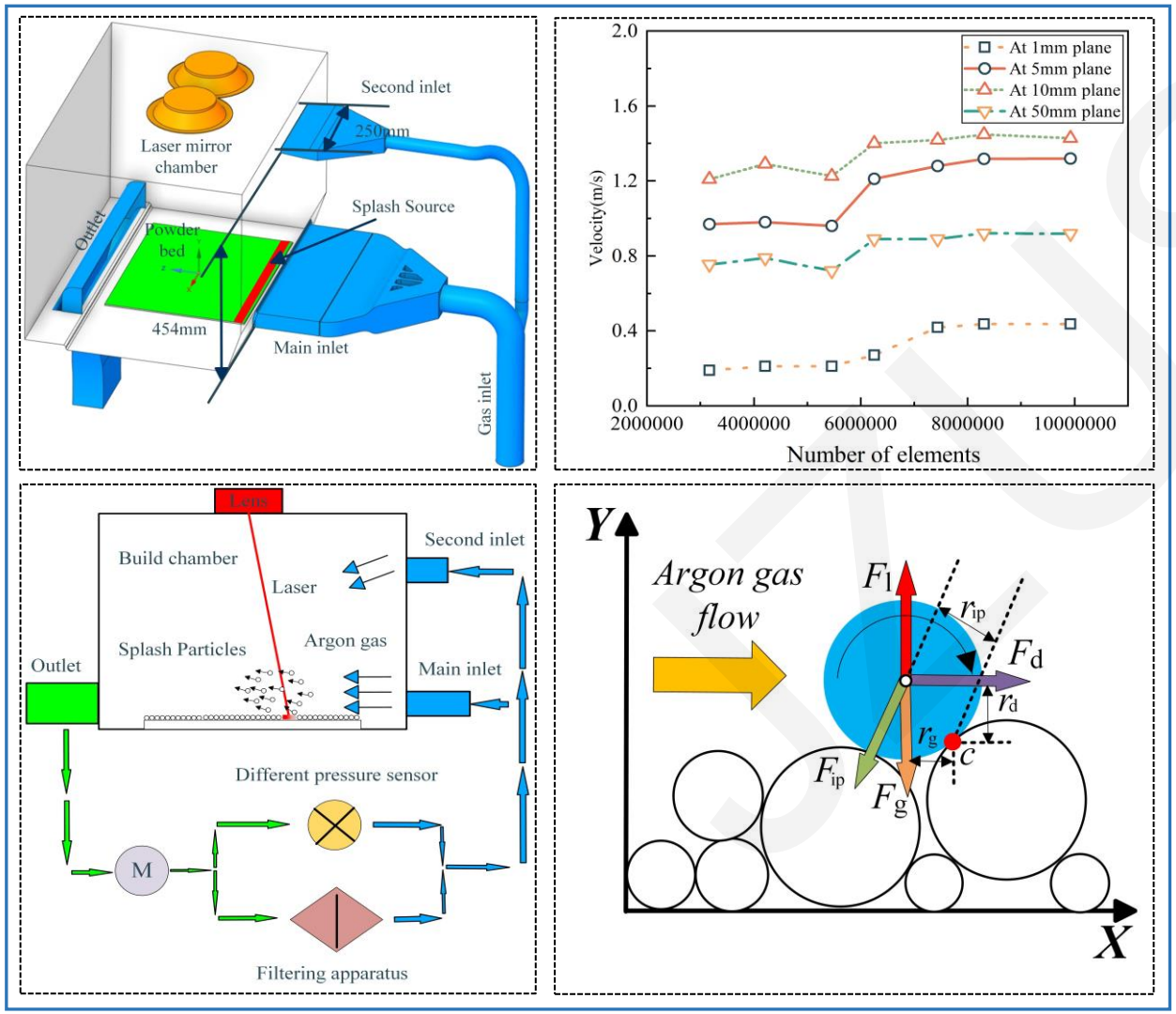
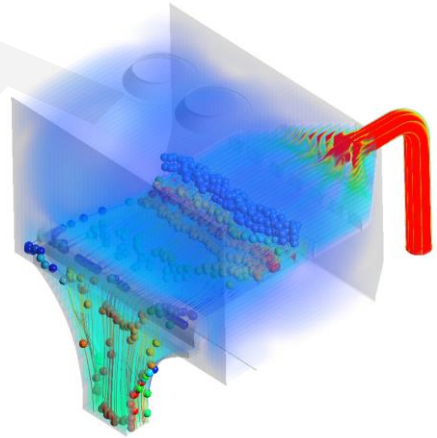
Establish a CFD-DPM model to simulate the complex flow interactions between the protective gas and spatter





- **Establish the model**

  Develop a 3D model and perform mesh independence verification. Establish a fully coupled **CFD-DPM model**.

- **Validate the model**

  Force analysis of powder bed particles to determine the **maximum gas flow velocity threshold**. Preliminary model validation and analysis reveal the spatter removal efficiency before improvements.

Result analysis and optimization

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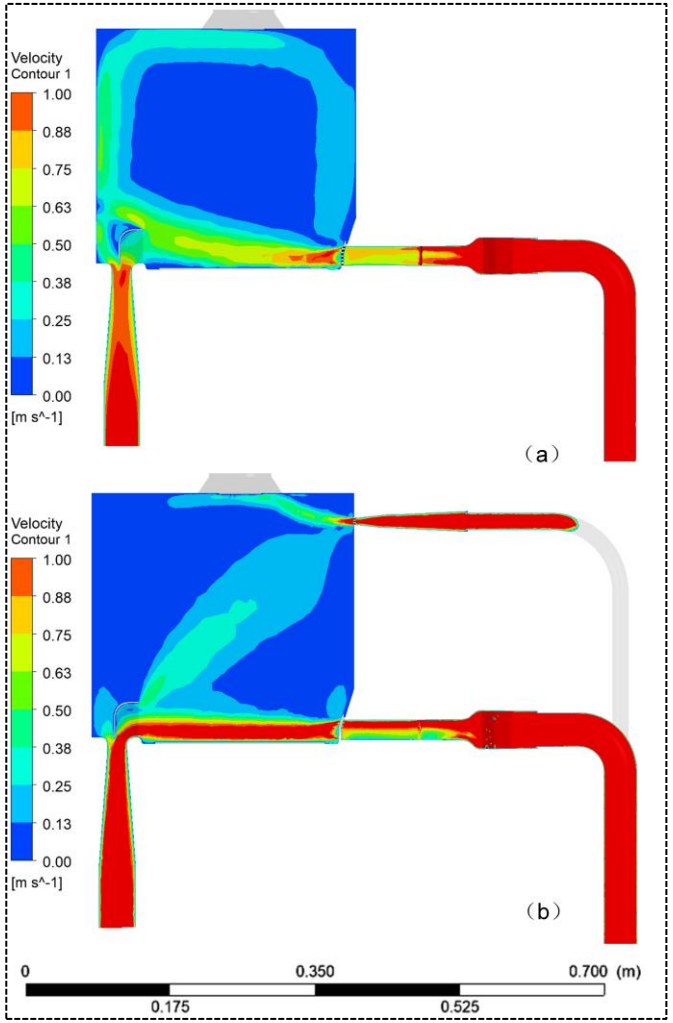
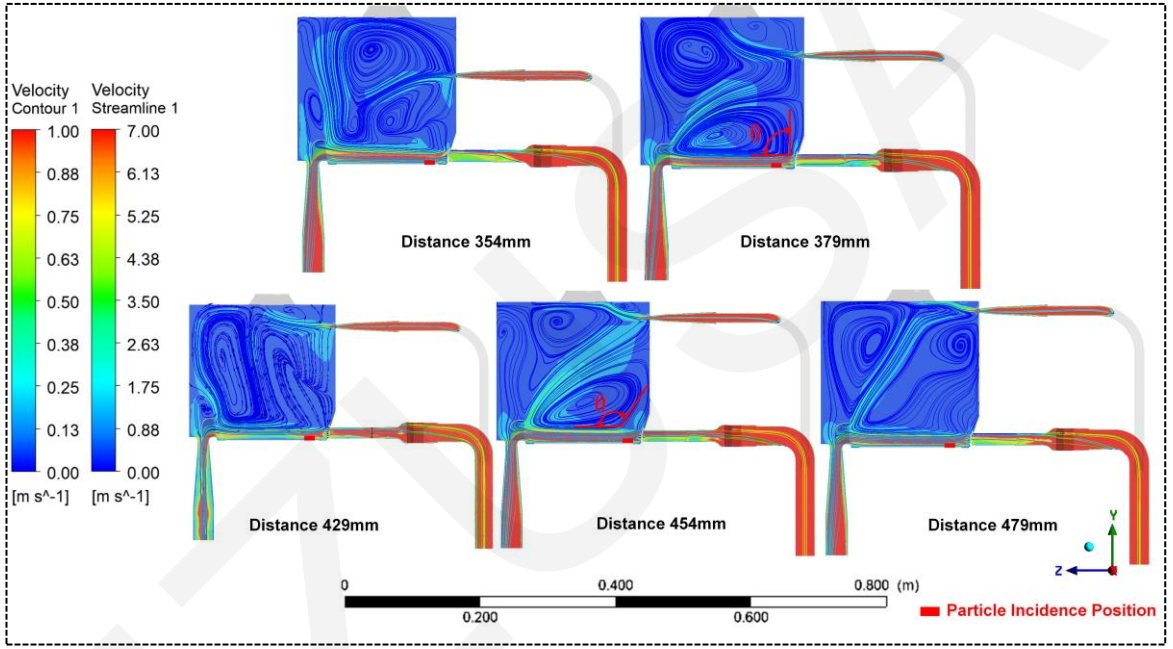
The internal flow field of the build chamber is influenced by the presence and positioning of the second inlet





➢ Effect of the second gas inlet

- The protective gas supplied by the second inlet **suppresses the nose-up of the laminar flow** from the main inlet. The protective gas from the main inlet becomes nearly parallel to the powder bed and flows directly to the outlet.

➢ Optimized position

- **Angle θ variation** : The location of the vortex core next to the powder bed varied for different distances.
- **Improve spatter removal efficiency** : A relatively high angle θ means the downwash flow on the right of the vortex turns to the horizontal direction at the right of the particle incidence position. Both the spatter height and horizontal travel distance of the particles increase.

Result analysis and optimization

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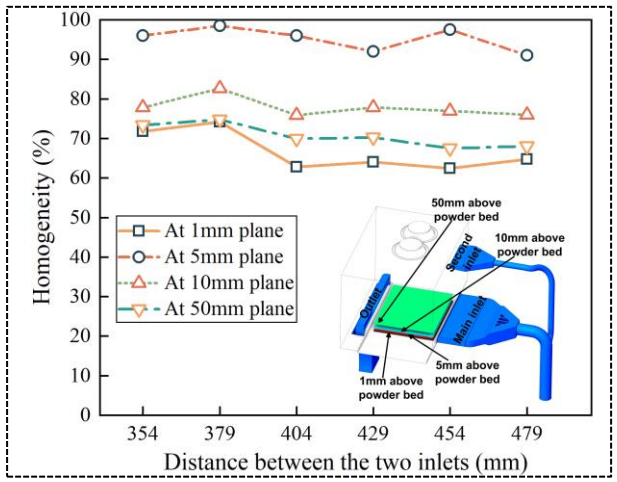
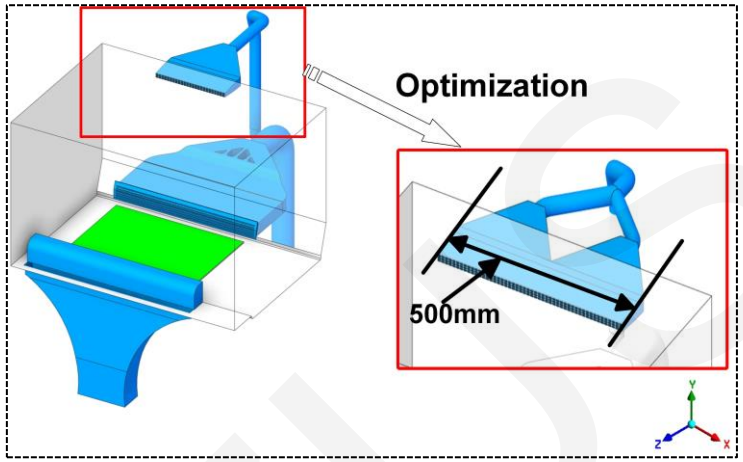
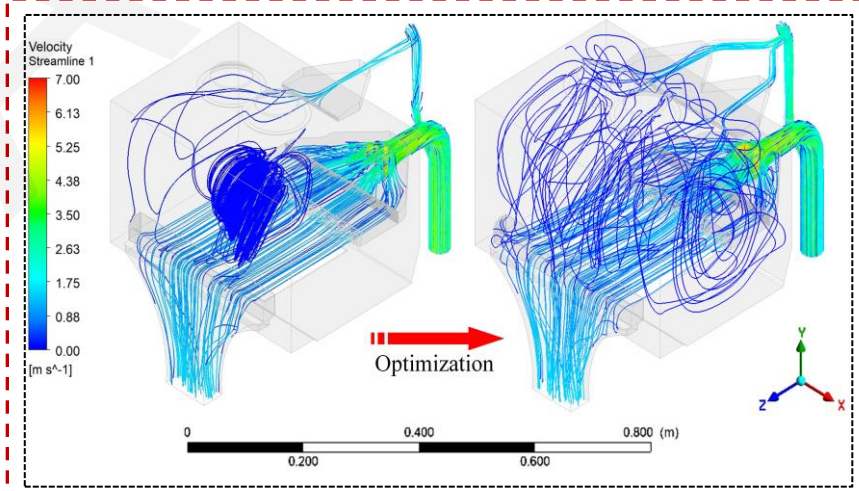
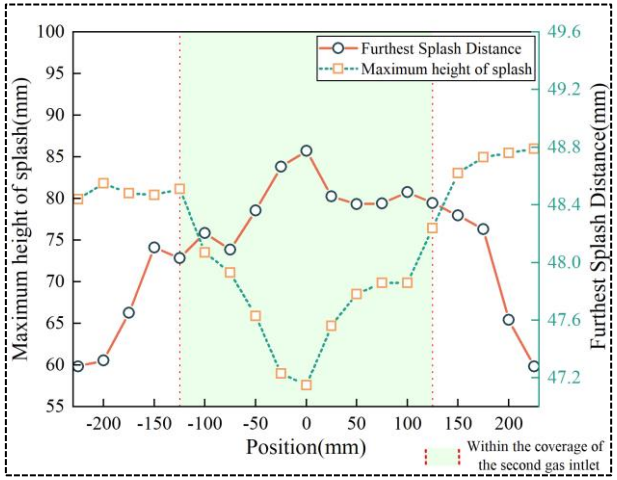
Improving the uniformity and velocity of the laminar flow near the powder bed can enhance the spatter removal efficiency



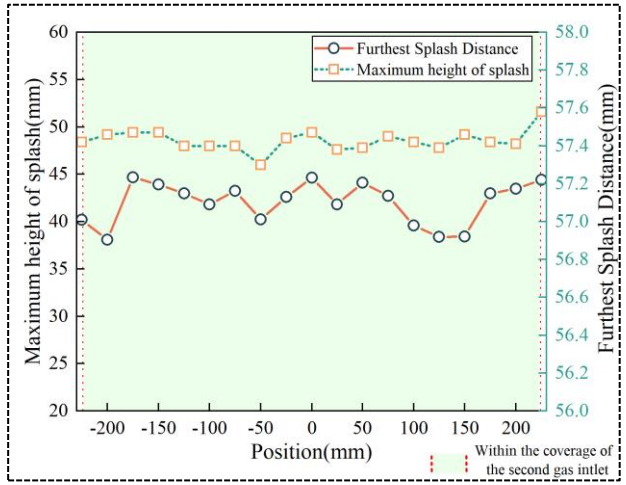






Causes and optimization strategies

- **Causes:** the width of the second inlet was only 250 mm, which was insufficient to cover the entire width of the powder bed.
- **Strategies:** The width of the second inlet was increased to 500 mm. The homogeneity of the spatter trajectory clearly improved at each position in the powder bed.



Result analysis and optimization

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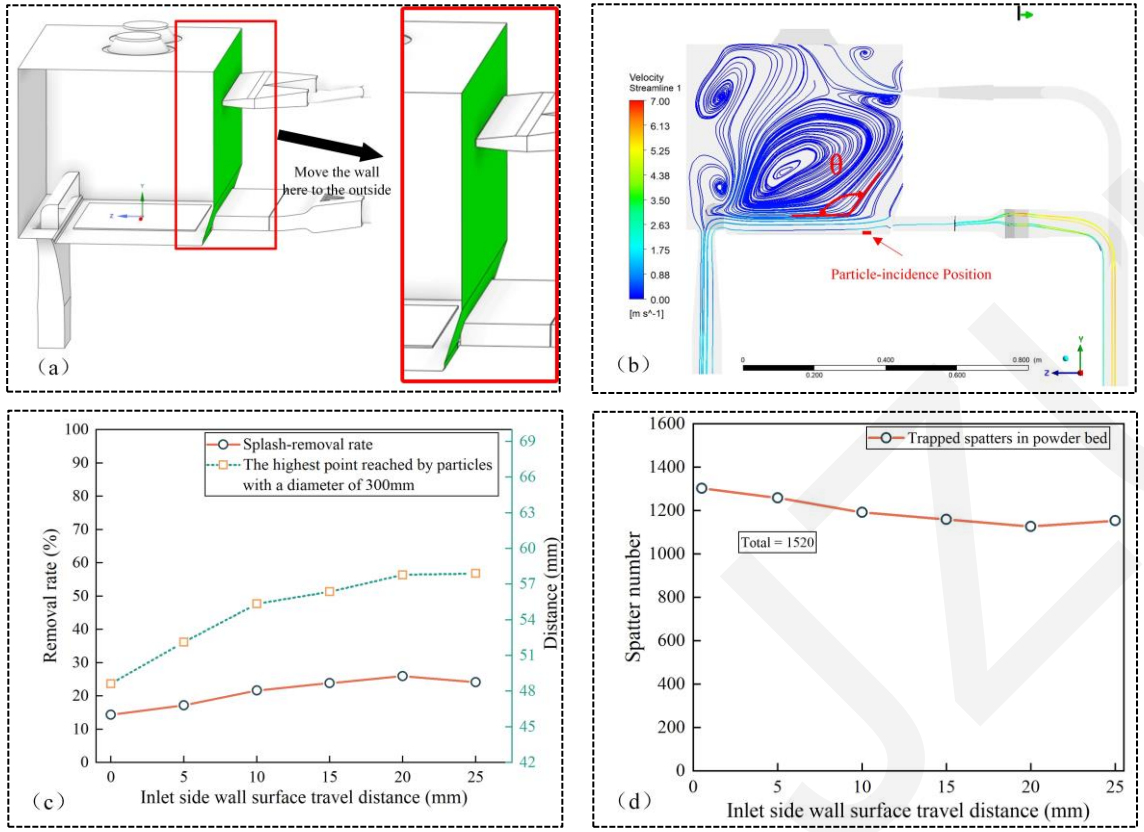
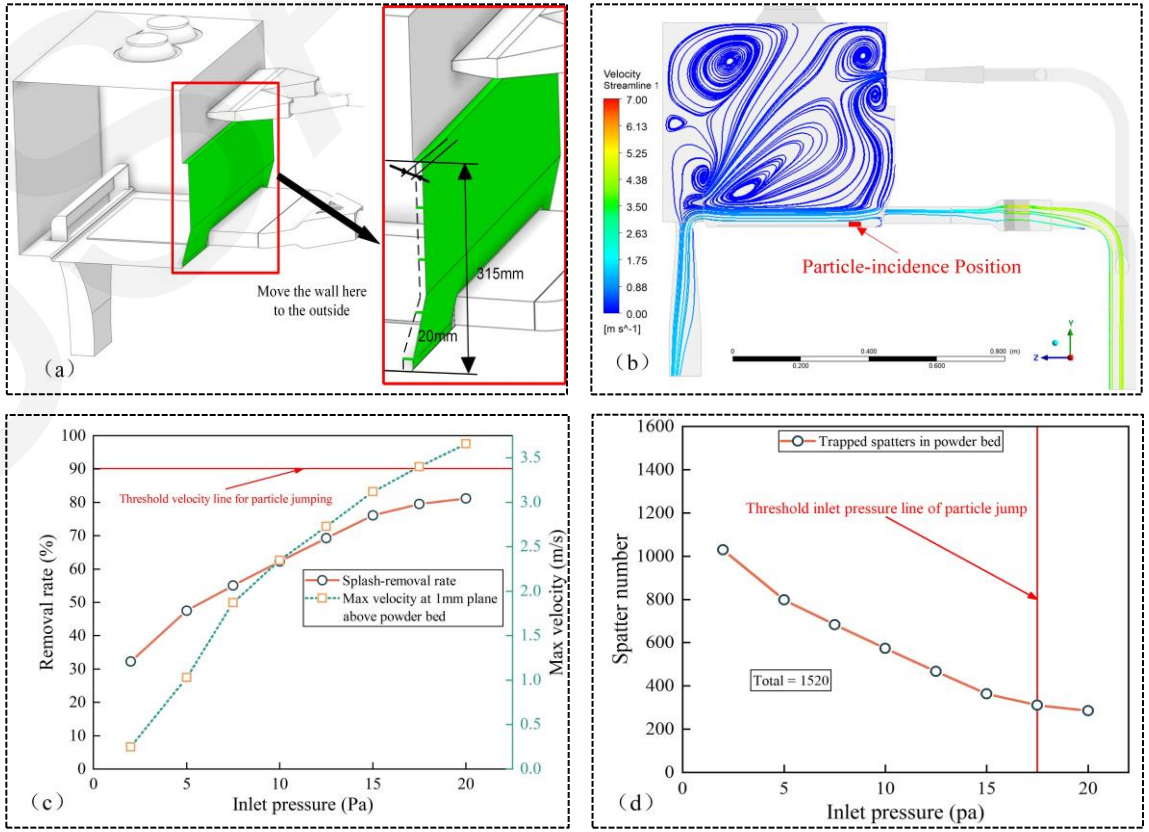
The Coanda effect causes the downwash flow of the vortex to impact the particle injection point from top to bottom, affecting the spatter height and horizontal spatter distance

➢ Moving the right sidewall outwards



- Moving the right sidewall outwards to reduce the effect of the downwash flow induced by the Coanda effect above the particle-injection point.

➢ Modified wall design



- The downwash flow of the vortex above the powder bed is directed to turn along the sidewall on the right side of the particle incidence position.

Conclusions

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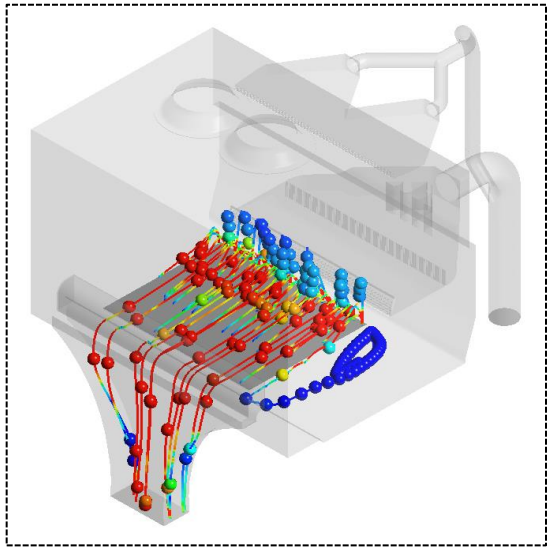
- **We propose a novel gas-intake system with dual gas inlets to improve the flow field of the build chamber for L-PBF and reduce spatter during additive manufacturing. The gas-intake system with dual gas inlets is optimized by adopting CFD technology. We developed a fully integrated CFD-DPM to simulate the interaction between spatter and gas flow. The gas flow around the powder bed and the spatter trajectories were carefully examined. The homogeneity and maximum velocity of the flow around the powder bed, and the spatter-removal, were used as the optimization criteria.**



- **The addition of a second gas inlet greatly alters the flow structure in the L-PBF build chamber.**
- **The distance between the main inlet and second inlet plays an important role in the homogeneity of the laminar flow passing the powder bed.**
- **The width of the second inlet is another key factor that affects the homogeneity of the laminar flow along the width of the powder bed.**
- **The Coanda effect along the right-side wall causes the downwash flow of the vortex to blow the simulated particle-injection point from the top down, which limits particle splash height.**