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Numericl Analysis of the Fluiddynamic Interaction between Carrier Gas and Powder

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1 Introduction

Selective laser melting (SLM) or electron beam melting (EBM) avoid the constraints of classical subtractive manufacturing and thus, offer a large flexibility for product design. However, thermo-physical processes with complex interactions occur on different length scales and are still not known in detail. In particular, the flow of metallic powder interacting with a carrier shielding gas plays a crucial role during additive manufacturing and therefore, the objective of the current contribution is to analyse numerically the complex fluid-dynamic interaction between powder grains and a carrier gas under relevant geometry and flow conditions. For this purpose an Euler-Lagrange approach is applied that treats the powder by the Discrete-Element-Method (DEM) and describes the carrier gas flow by advanced Computational Fluid Dynamics (CFD) [3]. Hence, the resulting numerical concepts describes the trajectory of powder grains and successively the region of impact into the melt pool, with an acceptable computational burden.

2 Results

As mentioned above, advanced multi-physics simulation technology derived from the Extended Discrete Element Method (XDEM) [2, 1] was applied to predict the injection of metallic powder into a carrier gas atmosphere as shown in fig. 1.

The velocity distribution following a toroidal pattern forces the powder to a converging flow in the centre of the arrangement as depicted in fig. 1. Since powder grains have a negligible inertia, they follow closely the streamlines of the carrier gas. However, the proximity of the work piece forces the carrier gas flow into a diverging flow field that is torus-like as found for selective laser melting. Powder grains also adapt to the carrier gas flow configuration which let the powder grain diverge into four jets. Thus, the four jets impact the melt pool at distinct positions and do not have a single focal point for deposition of the powder.

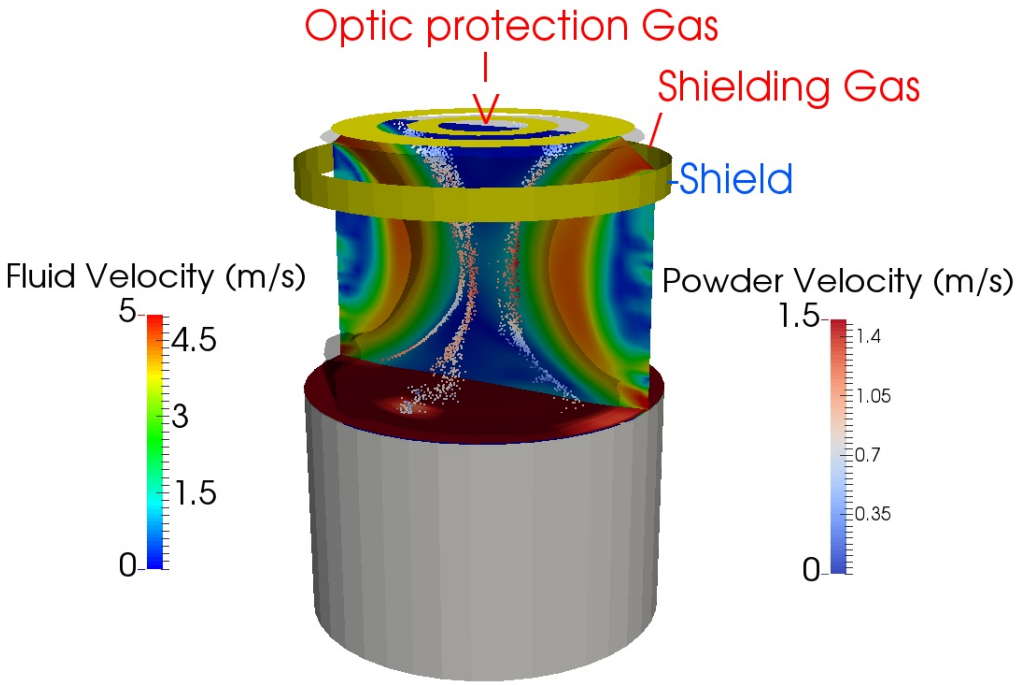

Figure 1: Centre cut through the velocity field with metallic powder impacting the melt pool

3 Summary

An advanced multi-physics simulation technology based on the Extended Discrete Element Method (XDEM) was employed to predict both the fluid dynamics of a carrier gas and the trajectory of metallic powder. Carrier gas flow is described by Computational Fluid Dynamics (CFD) to predict both velocity and pressure fields, while the trajectories of the metallic powder grains were obtained through the Discrete Element Method (DEM). This technology allowed tracking the grains and their impact positions on the work piece. Hence, numerical techniques are complementary to experimental work and lead to a deeper understanding of the underlying physics.

References

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