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Subproject A10

Title

Development of simulative approaches for the specific design of the properties of plasma sprayed coatings

Project management/-processing

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Task definiion

- Increase of the understanding of the processes in atmospheric plasma spraying by numerical simulation.
- Development of modelling approaches for the heat transfer inside ceramic particles in the plasma jet.
- Development of an external model to consider the influence of real particle morphologies and geometries on particle heating.
- Coupling of the external particle model with the existing free jet model.

Procedure

Until now, the Lagrangian approach has been used to track particles in the free jet. The particles were considered as discrete points. The coefficients for the gas-particle interaction were calculated using empirical equations. In the newly developed approach the gas-particle interaction is calculated externally using physical models. In the external particle model the three-dimensional particle geometry is resolved. Thus, the influence of the gas flow, both flowing around the particle and penetrating the particle, on the particle heating is taken into account. The particle acceleration is also calculated in the external model, based on physical models. The gas parameters along the particle trajectory serve as boundary conditions for the external particle model. The schematic representation of the external particle model, its boundary conditions and the coupling with the free jet model is shown in Figure 1.

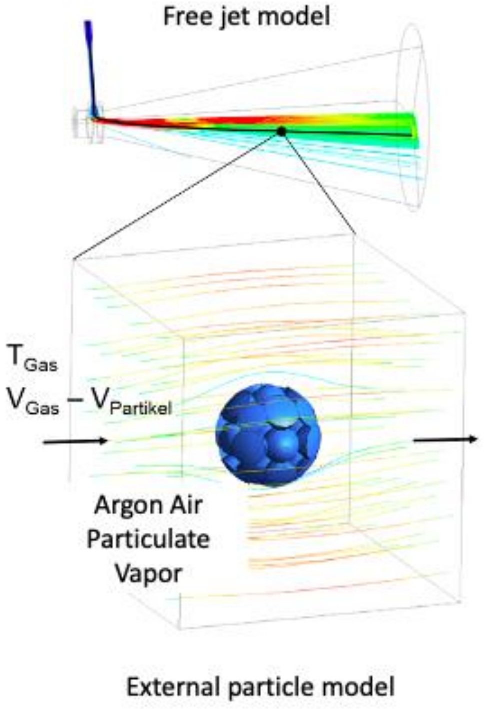

Figure 1: Schematic representation of the external particle model for particle heating and its coupling with the free jet model.

Results

Three agglomerated particles were analysed in the model presented. All three particles have the same diameter of D = 46 µm and consist of 27 spherical primary particles with a diameter of D* = 17 µm. The agglomerates have different packing densities based on the packing distance of the primary particles. The packing distance d was defined as the ratio of the distance between the primary particles and their diameter. The packing distances investigated are d = 0.9, 0.85 and 0.8. Figure 2 shows the isometric view of the agglomerate with the packing distance of d = 0.9 and the cross sections of all three agglomerates. As can be seen in the figure, a higher packing distance corresponds to a looser particle structure.

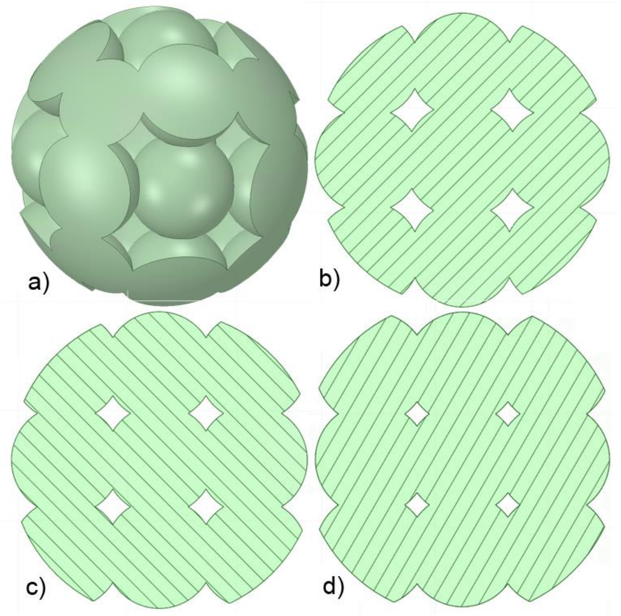

Figure 2: a) Geometry of an agglomerated particle, cross-section of a particle with packing distance of

b) 0,90, c) 0,85, d) 0,80.

The influence of the packing density on particle heating is shown in Figure 3. The loose agglomerate with the packing distance of d = 0.9 has the highest mean particle temperatures along its particle trajectory. Due to its lower mass, the agglomerate has a lower heat capacity, which should lead to higher temperatures. On the other hand, due to its higher velocity, the agglomerate has a shorter residence time in the hot area of the plasma, which i. This leads to lower temperatures. Since the two phenomena have an opposite influence on particle heating, the higher temperatures of the agglomerate cannot be explained solely by its lower heat capacity. The larger surface area of the agglomerate and wider distances between the primary particles can also have a significant influence. The wider spacing between the primary particles allows increased gas penetration into the particle volume.

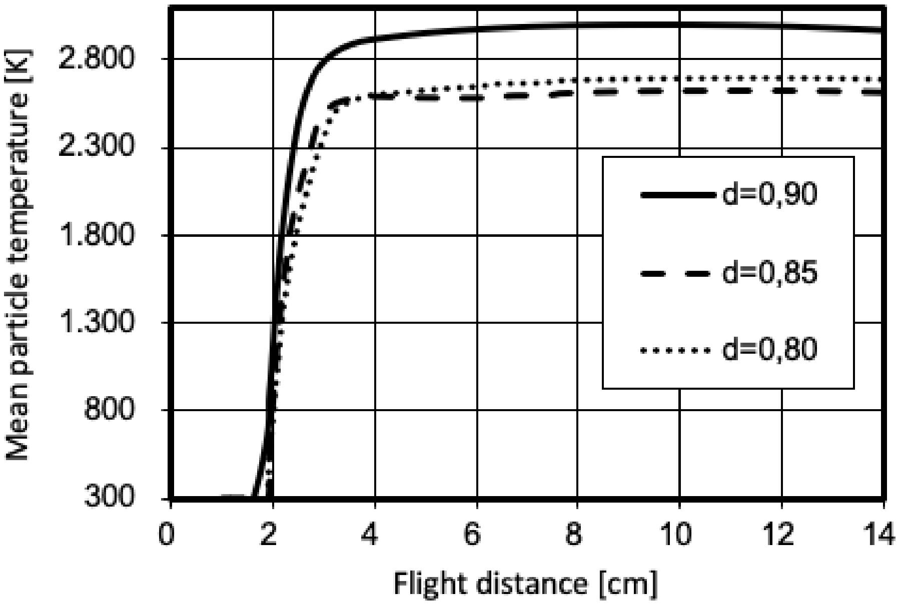

Abbildung 3: Mean particle temperatures of agglomerates of different density along their flight trajectories.

Summary and Conclusion

The above mentioned effects have a significant influence on particle heating and could not be considered without resolving the three-dimensional particle geometry and the surrounding gas flow. Their contribution to particle heating is complex and depends on the particle morphology. In further work the particle trajectory is coupled with the externally calculated particle velocity.

Publication

K. Bobzin, M. Öte, M.A. Knoch, I. Alkhasli: Macroscopic particle modeling in air plasma spraying. In: Surface and Coating Technology, 18.07.2018. DOI: 10.1016/j.surfcoat.2018.07.056

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K. Bobzin, M. Öte, M.A. Knoch, I. Alkhasli: Temperature Distribution on Thermally Sprayed Heating Conductor Coatings. In: IOP Conf. Series Material Science and Engineering, 05.03.2019. DOI: 10.1088/1757-899X/480/1/012002. Reprint von: K. Bobzin, M. Öte, M.A. Knoch, I. Alkhasli: Temperature Distribution on Thermally Sprayed Heating Conductor Coatings. In Tagungsband: Werkstofftechnisches Kolloquium 2019, Chemnitz.