NUMERICAL APPROACH IN THE DESIGN OF A QUENCH UNIT FOR NANOPARTICLES SYNTHESIS

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Particles nucleation is studied here in an industrial context of nanopowder production. The current project will concentrate on the design of a quenching unit, which is a part of a larger project focused on the design of a complete nanoparticles plasma reactor.

Nucleation of titanium dioxide TiO_2, obtained from the reaction of Titanium chloride $TiCl_4$ with Oxygen O_2 in supersaturated state, is investigated numerically for two different axisymmetric quenching configurations. In the first configuration a mixture of $TiCl_4$ and air is injected directly in the main stream and will react with a cold mixture of O_2 and air which is injected from the side. In the second configuration a mixture of $TiCl_4$, O_2 and air is injected in a supersonic flow (Mach Number = 2), which will develop expansion fan and shock patterns after a sudden section increase. The first type of quenching is called quenching "by side injection", the second one is called quenching "in supersonic flow". Both cases observe a drop of temperature in the domain either by a very low temperature side injection, or through the expansion fan.

The numerical tool used to simulate the nucleation and other physical processes is a User Defined Function (UDF) for Fluent called "Fine Particle Model" commercialized by the firm "Particle Dynamics". It is based on the "Method of Moments" which gives the particle size distribution from a population by computing and transporting the Moments of this distribution.

The results given by this UDF show that the quenching "by side injection" (which is the most common type used in industry) presents the main disadvantage of having wide spread particle size distribution. Whereas the quenching "in supersonic flow" allows an easier control for both the flow and the size distribution.

Despite the single design of the quenching unit, parametric work is initiated to find the optimal variation of the expanded section leading to the control of the distribution and the nucleation zone far from the walls, where the particles may deposit.

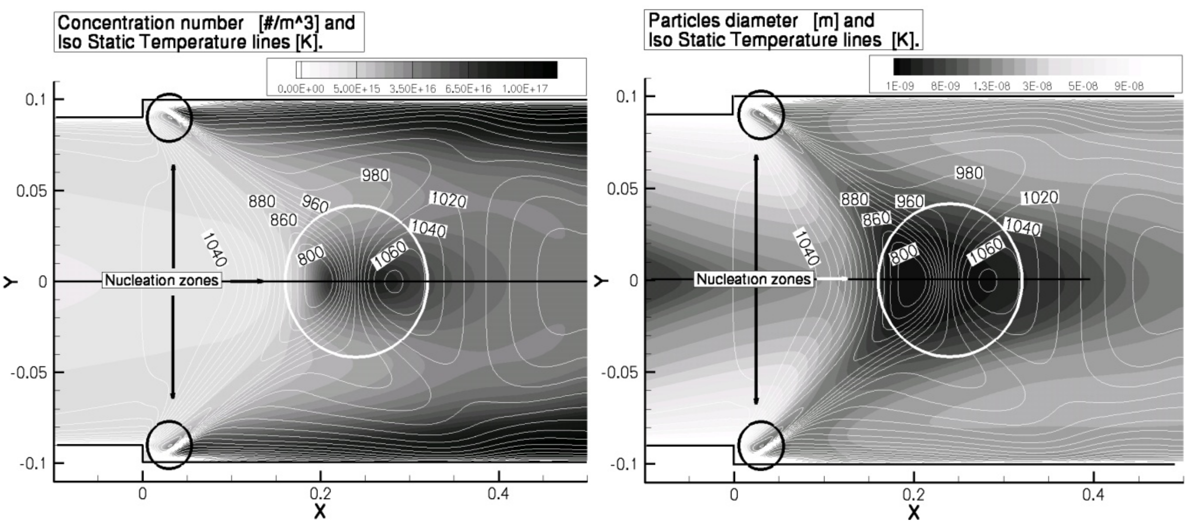

Figure 1: Concentration number and particles diameter fields for the quenching configuration in supersonic flow