Spray Dryer Temperature Simulation used in the Production of Hydroxyapatite Thermal Spray Powder

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INTRODUCTION

Hydroxyapaitite thermal spray powder used to coat hip implants may be produce via a mixed type spray drying technique. The resulting spray dried HA powder (with properties such as; particle size distribution, morphology and density) depends upon the physical and chemical properties of the HA slurry and the spray drying operating parameters [**1**]. For HA powder production, spray drying is an efficient process as the particles become well dispersed in the drying medium, and the high specific surface area contributes to a higher rate of evaporation per unit mass of the HA product [**2**]. Computational fluid dynamics (CFD) can play an effective role in the optimisation of the spray dryer process, such as the initial droplet diameter, the location of sprays, and the mass flow rate of the sprayed material [**3**]. Numerous authors [**3-4**] have used modelling techniques to analyse the production of food products by spray drying, however little research has been applied in the production of ceramics. This research simulated the temperature profile within a Niro Spray Dryer and validated the results experimentally to gain a deeper understanding of the complex operation of the spray drying process.

MODELLING PROCEDURE

The commercial CFD software FLUENT was used to simulate the Niro Production Minor^{TM} spray dryer; to study the various controlling parameters in order to improve the quality of spray dried HA powder. The Reliable R*K*-? model was used to predict temperature and velocity profiles in the drying chamber of the spray dryer. The main spray dryer chamber was meshed axis-symmetrically in the Gambit 2.1 pre-processor with 6300 quadrilateral cells. The inlet boundary was so small (0.75 mm nozzle radius) in comparison with the drying chamber. To overcome this all inlets were meshed with 10 graded elements at either side of the inlets (double aspect ratios) which provided the proper number of elements required to capture the full effect of the inlet conditions. Cells were checked for skewnness and aspect ratio (0.5 and 1.2 respectively), to guarantee fast convergence [**5].**

RESULT AND DISCUSSION

Initially HA slurry and air flow results were simulated and compared to experimental data to assess how the velocity vectors affected the movement of spray dryer particles [**6**]. The temperature profile gives an idea how temperature affect the quality of dried product. The advantage of R*K*-? method over S*K*-? is that it incorporates the swirl movement of particles into its model [**5**]. Figure 1 shows how the model results compare to the experimental data. The inlet of hot air temperature (Figure 1(a)) had little difference between results, which may be due to the fact that the hot air was coming from the top of the dryer and heated the roof which was not accounted in the simulations in terms of heat coefficient. However temperature distribution in the centre part of spray dryer (Figure 1(a)) compared well with the experimental data.

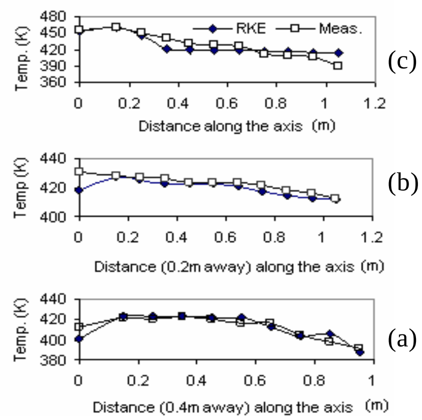

Figure 1: Validation of temperature distribution of the spray dryer

The model also offers the opportunity to analyse the atomisation technique involved in a spray drying. Knowledge of the aforementioned mechanisms, will aid researchers and industrialists to select ideal input parameters to produce particles with the desired size and morphologies as the spray drying HA powder is highly in porous or amorphous state and the sintering of HA powder is compulsory to improve the crystallinity up to 99% for medical application or in the spray drying higher temperature can be used [**7**].

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