Computational fluid dynamics

COMPUTATIONAL FLUID DYNAMIC

- Computational fluid dynamics can be a viable tool to analyse and troubleshoot various process equipment used in the pharmaceutical industry. Because typical unit operations process large amounts of fluid, even small improvements in efficiency and performance may increase revenue and decrease costs.
- The integration of CFD methods can lead to shortened product-process development cycles, optimization of existing processes, reduced energy requirements, efficient design of new products and processes, and reduced time to market. Unit operations in the pharmaceutical industry typically handle large amounts of fluid. As a result, small increments in efficiency may generate large increments in product cost savings. Thus, research and development staffs as well as plant and production managers should understand the benefits of CFD so that it can be integrated into the development process.

APPLICATION OF CFD IN PHARMACEUTICS

- The application of CFD to a few key unit operations and processes in the pharmaceutical industry was described as follows.
- **CFD for mixing.**
- **CFD for solids handling.**
- **CFD for separation.**
- **CFD for dryers.**
- **CFD for packaging.**
- **CFD for energy generation and energy-transfer devices.**

CFD FOR MIXING

(a) stirred tank, radially pumping impellers; (b) stirred tank, closely placed impellers; (c) stirred tank, impellers too far apart.

- CFD methods can be applied to examine the performance of static mixers and to predict the degree of mixing achieved, thus indicating whether more mixing elements are required shows surface mesh and blade orientation for a Kinecs mixer depicts the mass fraction concentration of the two species being mixed. The degree of mixing is shown as the color proceeds from distinct inlet streams (red and blue) to the fully mixed outlet stream (green). A CFD solution can be used to derive the pressure drop, hence the power required.

CFD FOR SOLIDS HANDLING

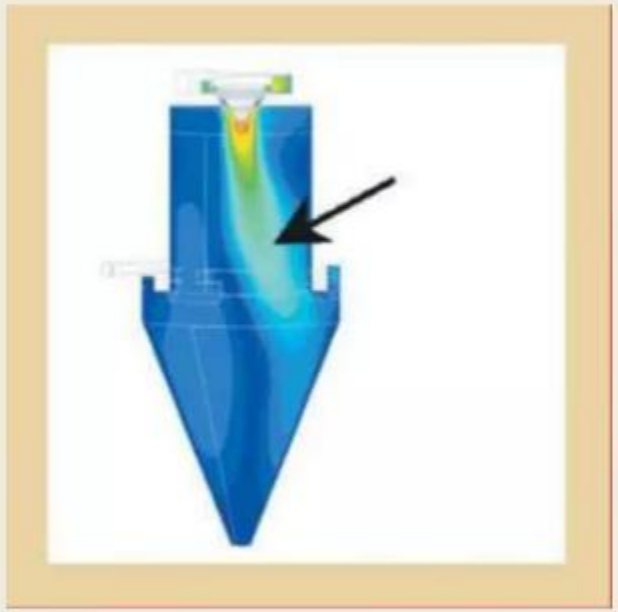
- CFD techniques can be applied to analyze such flows and minimize or eliminate the risk of erosion. CFD also can be applied to analyze the unsteady and chaotic flow behavior in fluidized beds. Simulation of such a flow field requires unsteady flow calculations and small time increments. As a result, performing calculations can take an extensive amount of time. Simulations of gas–solid flows in complex three-dimensional reactors can take months of computational time and are not practically feasible

CFD FOR SEPARATION

(a) cyclone, pathline of 1-m particle; (b) cyclone, pathline of 10-m particle.

- CFD techniques are used for analysing separation devices such as cyclones and scrubbers. The following example incorporates CFD methods to optimize and predict performance of an existing cyclone design. CFD solutions depict particle paths for various particle sizes. In this example, CFD techniques were used to perform what-if analysis for optimization of the design. The performance computed with CFD closely matched that observed in physical testing wherein 90% of 10-m particles were removed, but only 10% of 1-m particles were separated from the air stream.

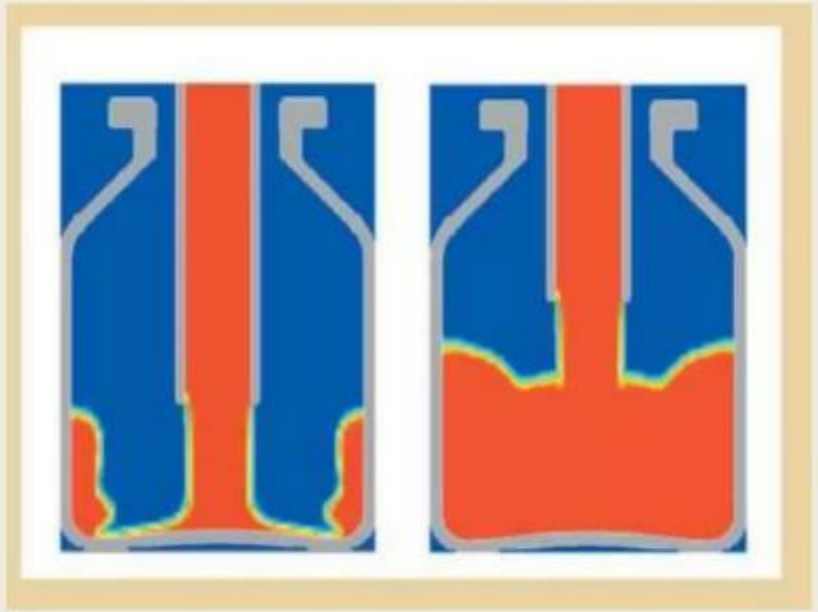
CFD FOR DRYERS



Spray dryer, velocity field

- We used CFD to analyze the performance of an industrial spray dryer before making major structural changes to the dryer. This strategy minimizes the risk of lost profit during changeover, especially if the improvement does not materialize. CFD was applied to examine configuration changes, thus minimizing risk and avoiding unnecessary downtime during testing shows the velocity distribution (skewed flow). This flow is a result of uneven pressure distribution in the airdispersing head.
- CFD models were applied to determine optimum equipment configuration and process settings. CFD results provided the necessary confidence that the proposed modifications would work so capital equipment would be ordered and field-testing could be scheduled.

CFD FOR PACKAGING



(a) filling process, liquid surface location, strong splash; (b) filling process, liquid surface location, no splash.

- CFD can be applied to conduct virtual experiments before changes are made to the filling lines or to the package geometry. This method allows a wide range of conditions to be tested and leads to an optimized filling process. depicts the filling of a container. The figures shown are typical of solution results that are used to optimize filling processes to increase throughput and reduce foaming.

CFD FOR ENERGY GENERATION AND ENERGY- TRANSFER DEVICES

- CFD techniques can be applied to analyze thermal and flow fields within such devices.
- CFD modeling methods also can be applied to gain insight into flame characteristics. Maintaining flame stability and burner efficiency is very critical to the proper functioning of a process heater, power plant, or furnace. Flame length,shape, and size can influence the process. If the flame is too long, then it can impinge on critical regions of the apparatus and cause thermal damage. If the flame is too short, then it may wear out the burner tip. Replacing the burner or associated apparatus results in downtime and loss of product revenue.

ADVANTAGES AND DISADVANTAGE

ADVANTAGES OF CFD

- A great time reduction and cost reduction in new designs
- There is a possibility to analyze different problem whose experiments are very difficult and dangerous
- The CFD techniques offer the capacity of studying system under conditions over its limits.
- The level of detail is practically unlimited.
- The product gets added value. The possibility to generate different graph permits to understand the features of the result. This encourages buying a new product.
- Accuracy in the result is doubted i.e. in certain situations we will not obtain successful result.
- It is necessary to simplify mathematically the phenomenon to facilitate calculus. If the simplification has been good the result will be more accurate.
- There are several incomplete models to describe the turbulence,
- multiphase phenomenon, and other difficult problems.

Untrained user of CFD has the tendency to believe that the output of the pc is always true

DISADVANTAGES OF CFD

- Hi-Tech CFD is a computer aided engineering company which provides total solutions to engineering problems in the field of Computational Fluid Dynamics (CFD),Computational Electromagnetic, Computational Structural Mechanics, Dynamics and Controls.

CURRENT CHALLENGES/ FUTURE ASPECT

- The integration of CFD methods can shorten product-process development cycles, optimize existing processes, reduce energy requirements, and lead to the efficient design of new products and processes. Unit operations in the pharmaceutical industry handle large amounts of fluid. As a result, small increments in efficiency, such as those created by implementing CFD solutions, can lead to significant product cost savings. Key processes in the pharmaceutical industry can be improved with CFD techniques. The aerospace and automobile industries already have integrated CFD methods into their design process. The chemical process and the pharmaceutical industries now are beginning to integrate this technology. The full potential for process improvements using CFD solutions is yet to be realized.