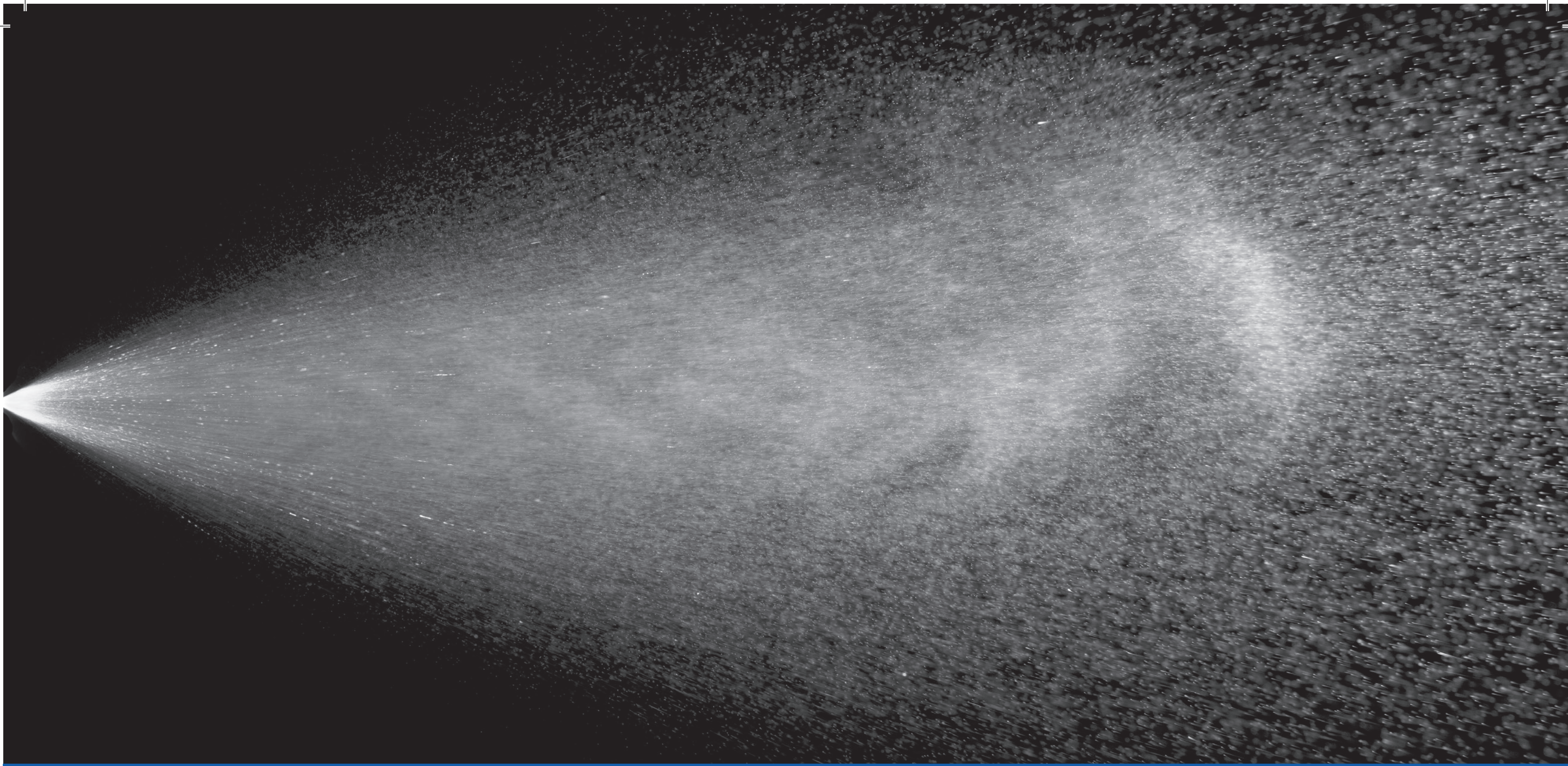


Targeting Energy-Intensive Water Evaporation Processes

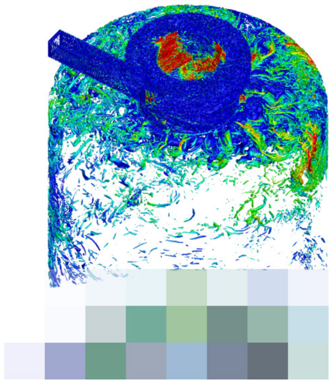
Using advanced models to simulate the physics of spray drying enabled Livermore researchers to increase ZoomEssence's energy efficiency.

Modeling Helps Update Established Processes

Spray drying processes have a major impact on global energy consumption. An estimated 30,000 to 40,000 spray dryer installations exist worldwide. Spray dryers have been used for decades, primarily in the food and pharmaceutical industries, to produce dry powder from small droplets of water using hot air. The process involves rapidly evaporating water from the droplets (that originated from liquid feedstock), which transforms them into powder. New computation fluid dynamics (CFD) codes are helping improve the design of spray dryers to increase energy efficiency.

Through a project funded by the Department of Energy's High Performance Computing for Manufacturing (HPC4Mfg) Program, which provides supercomputing resources to industry partners, Livermore is working with ZoomEssence, a company that makes flavored powdered food products using a novel low-heat method. By applying advanced CFD methods, the project aims to help improve airflow through the dryer.

ZoomEssence developed DriZoom spray drying technology, which uses considerably less energy and results in a higher quality product than traditional spray drying. To optimize the technology, ZoomEssence partnered with Livermore to run advanced CFD codes on the Laboratory's high-performance computers. The simulations accurately model major flow structures simultaneously and



Large eddy simulations made possible through high-performance computing illustrate the turbulent mixing vortex that drives the drying process. (Pixelated block represents proprietary design.)

fine turbulence structures, enabling researchers to understand the dryer's flow conditions.

Modeling Large Flows and Small-scale Turbulence Simultaneously

Using both commercial and ultramodern computer codes, Livermore researchers identified the major sources of turbulence production in ZoomEssence dryers. They also

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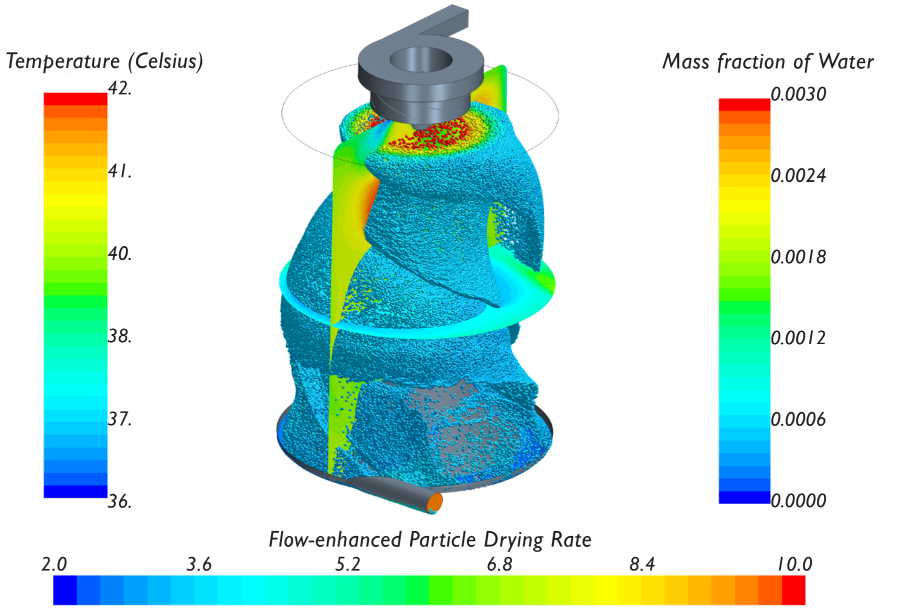
characterized the turbulence intensity throughout the dryer.

Livermore researchers chose two separate methodologies to simulate the drying physics in the ZoomEssence system. In the first model, researchers used Reynolds-Averaged Navier-Stokes (RANS) simulations and solved the complete mass-heat-momentum transfer problem in the presence of discrete drops of liquid. This system-level model provided a coarse representation of the system dynamics but could not yield detailed information about the local effects of turbulence dynamics. Although RANS modeling is the industry standard for performing turbulence calculations, it may not accurately capture the flow physics.

To augment the RANS models, large eddy simulations (LES) were conducted to explore the temporally and spatially varying turbulence in the dryer. Such simulations are more accurate than RANS models, but they require high-performance computers. For this problem, the team selected a code based on low-Mach variable-density formulations, which are both computationally efficient and capture the critical evaporation dynamics that are within the ZoomEssence dryers.

Benefits of Advanced Modeling

Researchers found that turbulence aids in mixing the fluid, and increased turbulence could greatly enhance particle drying.



This numerical simulation shows the distribution of water concentration, temperature, flow-enhanced particle drying rate, and evaporation rate throughout the ZoomEssence particle dryer system. In this model, red indicates higher flow-enhanced particle drying rates and blue indicates lower flow-enhanced particle drying rates.

The work provided a direct characterization of how turbulence affects the current drying effectiveness of ZoomEssence technologies. It also provided guidelines for increasing the turbulence on drying rates. Future work will focus on directly establishing the connection between the high- and low-fidelity simulations. This effect will provide a concrete assessment of the current low-fidelity methods used by industry to design and characterize low-temperature, turbulence-enhanced spray drying systems.

Further, in low-turbulence environments, the lower fidelity simulations provided an effective tool for studying the dynamics of particle drying.

By implementing turbulent mixing with no-heat spray drying, the energy required to evaporate a ton of water could be reduced from 4.8 gigajoule/ton down to approximately 240 megajoule/ton per spray dryer. This gives an estimated domestic energy savings of approximately 114,000 gigajoules in spray dried food products alone.

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