ROCKY

BISSELL Validates Effectiveness of New Projects through Testing with Rocky DEM

BISSELL proves Rocky-Fluent effectiveness while developing new cyclone device

> We have been using Rocky DEM for almost one year and have found it essential to our process: It has proved to be the only one with flexible fiber model coupled with CFD — flow solution and real representation of the particles, being able to analyze our equipment with the exact number of particles and format."

Kon Leung, Ph.D.
Staff Simulation Engineer at BISSELL Homecare, Inc.

BISSELL® is a family-owned company, a leader in the home-care business for over five generations. It is committed to understanding how proper cleaning can improve people's lives, especially when it comes to pets.

As pet owners' number-one choice in floorcare in the U.S.A., BISSELL focuses on cleaning products designed specifically for animal messes, such as carpet cleaners, vacuum cleaners, steam and hard floor cleaners, and sweepers.

And if there is an Achilles' heel when it comes to house cleaning, it is pet hair. With that in mind, Dr. Kon Leung, staff simulation engineer at BISSELL Inc., was assigned to work on a numerical model for hair flow inside vacuum cleaners — one that could be used throughout the company's new-design development process.

Since BISSELL is an innovative company, it leverages computer simulation using ANSYS® Fluent® computational fluid dynamics (CFD) software in its development process. For this project, the development team's hair-simulation challenge requires an approach that models particles while also taking fluid physics into account.

The team had previously performed tests using a variety of discrete element modeling (DEM) software, but none matched BISSELL's established criteria for simulation efficiency and accuracy. In most cases, a high computational cost limited the amount of hair strands that could be included in a single simulation, affecting development deadlines. In addition, other DEM tools used simpler particle models, which reduced simulation accuracy.

BISSELL needed something different and unique, so it turned to Rocky DEM.

BEATING A CHALLENGE

The engineering team's challenge was to develop a computational model by coupling CFD and DEM approaches for modeling pet hair flow inside vacuum cleaners. Once validated, the model would allow BISSELL to evaluate geometric design variation for performance, reducing the cost involved with new prototypes and experimental testing.

The model needed to address a large number of hair strands, and depict behaviors such as flexibility and inter-fiber interaction. It also needed to incorporate the effect of fluids on fibers through coupled simulation with ANSYS Fluent.

One main modeling issue that BISSELL faced is the hair strands' high aspect-ratio, at 4 cm long and 50 to 130 µm diameter. A second issue is an accurate drag-force computation on these long, slender fibers within the turbulent flow established inside the cyclonic device.

Leung opted for Rocky DEM because the software uses flexible fiber particle shapes, which allowed hair strands to be modeled at a reduced computational cost by using sphero-cylinders connected by virtual bonds. Rocky also has a special drag law for fibers, which produces an accurate fluid-particle interaction computation by taking into account fiber orientation.

NUMERICAL RESULTS COMPARED TO EXPERIMENTAL DATA

After an initial step of DEM coefficient calibration, the coupled model was applied to a full-feature, multi-cyclonic device; experimental data was obtained by reproducing the same tests in the lab.

The behavior of hair inside the equipment was evaluated by comparing hair clumps predicted by the numerical model against the experimental pictures, which showed close agreement, as shown in Figures 1.

To assess the efficiency of different designs, hair clump density at the end of the simulation was monitored by tracking regions where hair could be found along with hair volume fraction, as shown in Figure 2.

The simulations predicted improved efficiency for a modified geometry, compared to initial geometry. Using Rocky-Fluent coupling as a tool for hair modeling enables conceptual device testing, reducing the number of lab-tested prototypes and, therefore, minimizing development time and cost.

Figure 1. Model validation comparing the simulation with the laboratory tests.

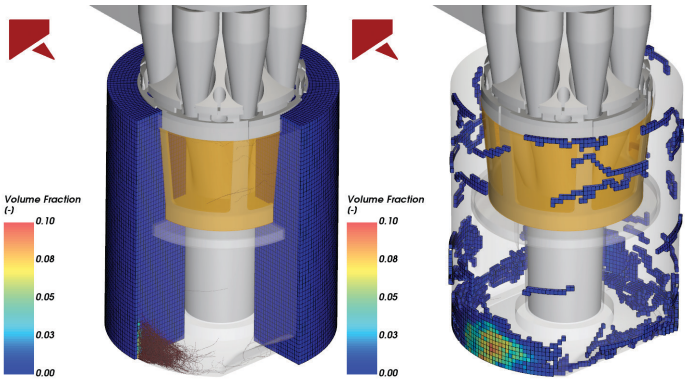

Figure 2. The domain was subdivided and hair volume fraction was monitored, showing the regions where hair could be found as well as how compacted the hair clumps were for different designs.

CONCLUSION

"We discovered that Rocky DEM has the power to test conceptual devices, reduce the number of prototypes, and decrease our time and costs — and this is fantastic!" Leung says. "It provides the proof we need that Rocky-Fluent coupling works as a modeling tool for analyzing hair."

Further, Leung states that the team plans to use Rocky DEM for other BISSELL products, since the development application demonstrated the software's power, versatility, and suitability to a wide range of applications for all types of industry.

CHALLENGE

Optimize product design of a cyclone device, using a model capable of accurately predicting the behavior of pet hair

SOLUTION

Evaluate performance of geometric design variations while reducing cost of prototypes through CFD-DEM coupled simulation

BENEFITS

With proof of accuracy, BISSELL improved a tested application. The company plans to expand the use of the discrete element method as R&D methodology to a wider range of products — all thanks to results that confirm the efficiency of Rocky DEM and ANSYS Fluent coupling.

