Kimberly-Clark simulates 'living surfaces' with SIMULIA

By Tim Trainer

Kimberly-Clark Corporation needed to design its protective dust masks so that they are comfortable yet remain airtight during facial movement. The company used realistic simulation solutions from SIMULIA to create a finite element model of the face and mask to simulate the lifelike behavior of the mask as the face changes shape. This enabled engineers to implement the necessary design changes to the mask to eliminate gaps.

As film animators know all too well, the human face is one of the most difficult objects to model realistically. A flexible layer of skin covers a complex array of muscles and bones, producing a seemingly endless number of subtle facial expressions. The design challenge is to make a mask that is comfortable and at the same time maintains an airtight seal against the changing shape of the face.

"Representing the positions and movements of the human face is a big challenge in designing some of our products," says Chris Pieper, Associate Research Fellow at Kimberly-Clark Corporation. In addition to household brands such as Kleenex® and HUGGIES®, Kimberly-Clark also manufactures dust masks, or particle respirators, that are worn by professionals and do-it-yourselfers who are involved in woodworking, machining, and other activities that create by-products that are unhealthy to breathe.

For Pieper and his engineering team, the simulation challenge was to represent a moving deformable surface—a face—in contact with a flexible object—a dust mask. "It's crucial that the mask conform to the face," says Pieper. "The contact pressure between the mask and the face is very important to the proper function of the product and the comfort of the user."

From Motion Capture to Realistic Simulation

Pieper and his group used SIMULIA solutions and motion capture techniques from the entertainment industry to design the mask. "Abaqus FEA is well-suited for studying soft, flexible structures with complex geometry in contact," says Pieper. "The general contact feature makes problem setup easy and solutions stable."

For his analysis, Pieper drew from the computer-generated animation world to realistically recreate human facial movements. His team created a moving facial model for the dust mask by extracting surface-point positions from a lower-resolution set of facial motion capture data, in an open source format called C3D. Pieper and his team created finite element definitions using Geomagic—a surfacing software—and a Python program to write this information to an Abaqus input file so that they could be imported as an orphan mesh part. Using the orphan mesh as the basis for a minimal model definition, they then added a step definition and generated a sparse output database (ODB).

"The Abaqus ODB served as a kind of containment bucket for us," Pieper says. "We added all the displacement data to it to create a global model." The team then used the global model to drive a sub-model representing a human face undergoing a range of expressions and motions. The global ODB was completed by adding nodal displacements using the Abaqus Python scripting interface. To verify that all data was converted correctly, the team viewed the updated ODB as an animation using Abaqus.

The engineering team next used the global model to drive the moving surface portion of the sub-model, which included both the face and the virtual representation of the dust mask. As a final step in creating the finite element model, they added a sub-model boundary condition and additional loads, including a pressure load on the nose piece and an inhaling load on the inner surfaces of the mask. Now the model was ready to run.

Simulation Narrows Down Design Alternatives

Post-processing revealed several regions that exhibited gapping between the mask and the face—such as the areas of greatest curvature around the nose, shown by gaps in contact pressure contours and suggesting the need for design changes. "This demonstrates how realistic simulation gives designers the means to rapidly evaluate the benefits of each alternative. We look to these simulations to help us narrow the field of design possibilities, so that when we do testing with human subjects, we are only looking at the design finalists," says Pieper. "That can really shrink the product design cycle."

Kimberly-Clark

Kimberly-Clark is a leading global health and hygiene company. It provides some of the world's most recognized family and personal care brands including Kleenex, Scott, Andrex, HUGGIES, Pull-Ups, Kotex, Poise and Depend as well as do-it-yourself and home-improvement products. Headquartered in Dallas, Texas, with nearly 56,000 employees worldwide, Kimberly-Clark's global brands are sold in more than 150 countries.

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Pieper sees the value of marrying motion capture with simulation to model what he calls "living surfaces"—complex moving surfaces that are not easily described mathematically. "This technique provides a new way of representing a complex moving surface as a boundary condition or constraint in a simulation," he concludes.

For more information: www.kimberly-clark.com