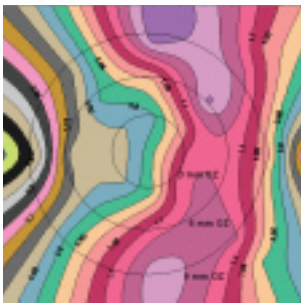
Simulation for **Surgical Precision**

Modeling of LASIK plume evacuation devices increases accuracy of laser surgery.



Contour map of the velocity field above the eye as measured experimentally for the proximal plume removal system

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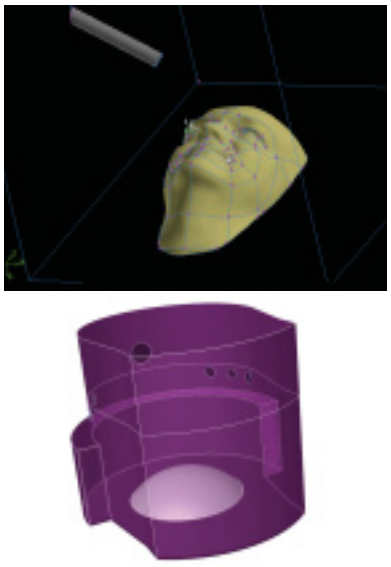
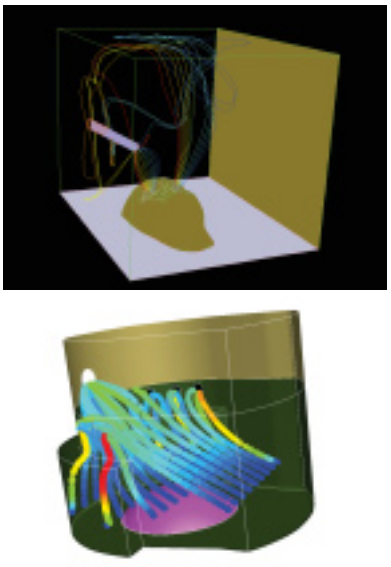
Laser-Assisted *In Situ* Keratomileusis (LASIK) eye surgery involves the use of an excimer laser to correct refractive vision errors. The laser burns off, or ablates, corneal tissue, essentially re-shaping the cornea in a way that increases the focusing power of the eye. During the procedure, the ablated tissue forms a plume just above the eye. Removing this plume during treatment eliminates obstructions from the laser beam path, thereby increasing the precision and accuracy of the laser ablation process.

The majority of the LASIK surgery systems on the market today use a distal plume evacuation system that removes the plume with a vacuum nozzle located above and some distance from the eye. The efficiency of these systems, however, is susceptible to ambient air flow patterns. As a result, the air flow in the surgical suite must be tightly controlled to get optimal performance. To address this issue, a team in the Chemical Engineering Department at the University of Louisiana at Lafayette developed the LA*Haye*SIK™ system. Instead of using a distal plume evacuation system, the LA*Haye*SIK™ employs a proximal plume evacuation technique that completely surrounds the eye, providing for a more controllable flow environment during the surgical procedure.

To compare and contrast the proximal and distal techniques, the research team used a combination of experiments and fluid dynamics simulations. The experiments utilized solid models of human faces to mimic the presence of a patient, in conjunction with a sensor that measured the air flow patterns induced by each device. For the proximal system, speed contours measured during the experiments demonstrated that there is a relatively even air flow distribution above the eye, a clear benefit of this approach.



The vacuum nozzle in the distal plume evacuation system is placed far away from the eye (top). The LA*Haye*SIK™ device is a proximal system that surrounds the eye (bottom).



Particle pathlines are shown for the distal (top) and proximal (bottom) plume evacuation devices, colored by particle ID and time respectively.

An understanding of the velocity field was only the beginning, however. The next step predicted the efficiency of the device in removing ablated material. An experimental approach for evaluating plume removal would be difficult to implement in a reproducible manner. Instead, the discrete-phase model in FLUENT software was utilized to calculate the trajectories of particles seeded in the plume region for both the proximal and the distal techniques.

Simulation results showed that in the distal system the particles follow air flow patterns that sometimes do not result in removal and can lead to beam-masking during the surgical procedure. For the proximal system, however, the simulations indicated that the particles flow away from the path of the laser beam and are captured by the evacuation holes located to the side of the eye. The proximal system not only increased the efficiency of particle removal, but also reduced interference caused by the ablated particles. Furthermore, CFD analysis using the FLUENT software product helped to evaluate and improve instrument features during the development of the new evacuation device, leading to a better optimized design and, ultimately, more effective LASIK surgery for patients. ■