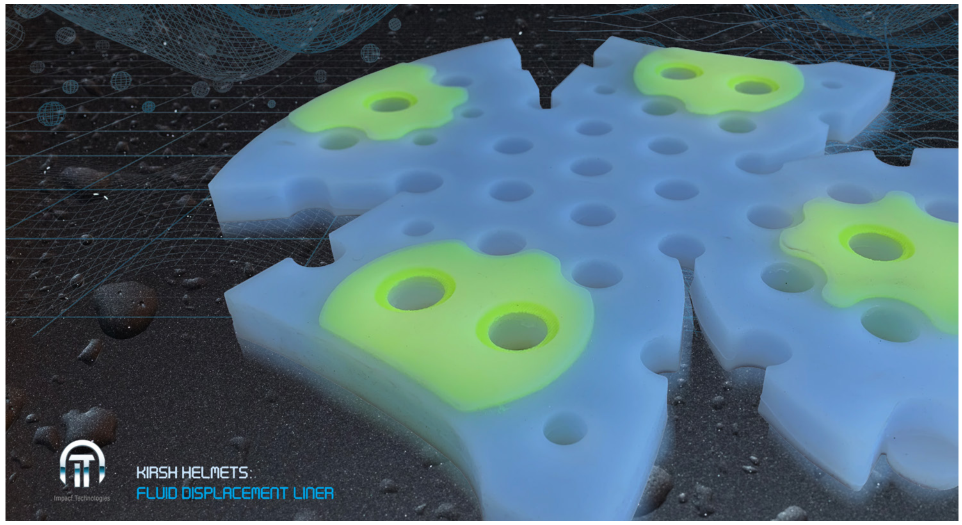
MEDICAL DESIGN BRIEFS

FEBRUARY 1, 2020

Safer Helmets
Reduce Potential for Traumatic Injury

NEW MATERIALS AND DESIGN ENABLE HELMETS TO MORE EFFECTIVELY ABSORB ENERGY DURING IMPACT.



"Seventy-five percent of all fatal motorcycle accidents globally involve brain injury, with rotational forces acting on the brain being the primary cause of death," According to NHTSA. By implementing a novel helmet design and materials set, KIRSH Helmets is to working to develop a more effective helmet for motorcycle riders, as well as in other applications. A patented design, in which fluid displacement technology replaces the typically used foam compression, utilizes a silicone liner injected with fluid. The resulting structure reduces rotational and angular forces during acceleration impacts.

KIRSH, which stands for Kinetic Impact Reactive Safety Helmet, has implemented a radical new design to more effectively mitigate linear and rotational forces that can result in traumatic brain injury, concussion, or other head injuries that can occur in a crash.

For years, since the U.S. Department of Transportation (DOT) began regulating motorcycle helmets, the industry trend has been to develop lighter weight helmets that meet the requirements of a simple one-dimensional acceleration test. Although some efforts have been made to reduce rotational forces that occur during angular impact — for example, multidirectional impact protection system (MIPS) designs — it has become clear that more radical improvements are needed. KIRSH has implemented a patented liquid-gel impact reaction liner technology inside a hard-shell helmet design that more effectively reduces the effects of such impacts. Three key components — the helmet liner, the fluid fill inside the liner, and the foam pegs that hold the liner in place — use novel materials and design to accomplish this goal.

The helmet liner — called a fluid displacement liner (FDL) — is made of a specialty silicone implemented in a design that provides strength, durability, and increased elasticity, which reduces the angular rotation applied to the head in the event of a crash. Upon impact, fluid displacement allows for energy to travel laterally within the liner, efficiently dissipating kinetic energy before it is transmitted to the skull. The liner material and structure adapt to absorb a wide range of applied energy via multiple mechanisms — each one is designed to operate in a specific energy range, with the different mechanisms covering overlapping energy ranges.

Fig. 2 - KIRSH motorcycle helmet showing the FDL inside a tough hard shell helmet.

Using this fluid displacement approach enables a smaller overall helmet design. The smaller design results in decreased torque during angular impact, which reduces risk of rotational injury. Reducing torque and energy transmission leads to a significant decrease in the energy transmitted to the wearer's head. The smaller helmet also increases comfort for the wearer.

"The brain sits in fluid in the skull," says Jason Kirshon, the FDL inventor. "With the FDL, the skull sits in fluid within the helmet. This design enables lower total helmet mass, reducing impact torque, while providing a fluid buffer that effectively protects the skull and brain." In initial testing, KIRSH's motorcycle helmet prototype surpasses government requirements, and KIRSH's design has been shown to outperform current EPS or EPP liner technology, demonstrating increased energy absorption capabilities throughout a wider impact energy range and impact duration times.

HOW IT WORKS

As shown in Figure 1, the FDL design is a complex shape that contains both "closed" areas (that are fluid filled) and "holes." The liner is composed of a highly elastic and durable silicone casing currently filled with a nontoxic silicone fluid. The casing is designed to allow unrestricted laminar flow throughout the entire helmet, which diffuses energy upon impact. The specific silicone elastomer was chosen to provide the right feel inside the helmet while achieving the desired mechanical properties needed to withstand impact.

The second critical component liner system is the fluid that is injected inside the liner. The displacement of the fluid within the liner during impact is critical to the helmet's effectiveness. The designers chose a nontoxic silicone fluid with the specific rheological properties needed to mitigate the high forces experienced during impact. Additionally, the fluid is an important component of temperature management within the helmet — a feature critical to the helmet user. Finally, foam pegs were designed to hold the liner in place within the shell. The material chosen and the design of the pegs are critical in "tying together" the whole design. A unique foam peg was developed that attaches to the hard shell and holds the liner in place. The resulting design, shown in Figure 2, minimizes weight while providing effective energy absorption during both low- and high-energy impacts from any direction.

Jason Kirshon and Donnie DeVito working in the KIRSH lab.

The new helmet technology is designed to more effectively protect users from head injuries, such as chronic traumatic encephalopathy, concussion, skull fracture, and other types of brain damage. The FDL technology efficiently dissipates kinetic energy, enabling a more effective helmet design that significantly reduces energy transmitted to the head, decreases risk of rotational injury, and increases comfort.

This article was written by Thomas Feist for KIRSH.

The KIRSH helmet. (Photo Courtesy of World Wide Business with kathy ireland®/James Patrick Cooper Photography)