

ABSTRACT

Cut-protective textiles are critical components of personal protective equipment used in industrial environments where workers are exposed to sharp tools, abrasive surfaces, thermal hazards, and repeated mechanical loading. Knitted fabrics are widely adopted for cut-protective gloves because of their flexibility, stretchability, and wearer comfort. However, the open-loop architecture of knitted structures can reduce resistance to blade penetration and may lead to performance degradation under realistic service conditions. This thesis presents a systematic investigation into the cut-resistance behavior of knitted textile fabrics by examining the combined influence of yarn reinforcement, knitted structure, cutting direction, thermal exposure, and long-term service-related conditions.

Knitted fabrics were developed using ultra-high-molecular-weight polyethylene (UHMWPE) yarn systems, including 100% UHMWPE yarn and UHMWPE core-spun composite yarns reinforced with stainless steel and glass fibers. Fabric samples were produced on industrial glove knitting machines using controlled knitting parameters and different structural configurations. Cut resistance was evaluated using the ISO 13997 standard, while mechanical properties such as tear, puncture, and abrasion resistance were assessed according to EN 388:2016. Structural and morphological changes were examined using optical microscopy, scanning electron microscopy, X-ray diffraction, and Fourier-transform infrared spectroscopy to establish relationships between material structure and performance.

The study demonstrates that yarn reinforcement has a dominant effect on cut resistance. Stainless-steel reinforced fabrics exhibited the highest cut, puncture, and abrasion resistance at

room temperature due to improved load sharing and enhanced alignment of UHMWPE molecular chains, resulting in higher crystallinity. Cutting direction significantly influenced cut performance, with the highest resistance observed in the widthwise direction, followed by diagonal and lengthwise directions, due to differences in fabric extensibility and loop deformation behavior. Knitted fabric topology was shown to affect both protection and comfort, where selected plain knitted structures provided a balanced combination of moderate cut resistance and high air permeability, improving suitability for prolonged wear.

To evaluate thermal effects, a conventional cut-testing instrument was modified to enable cut testing under controlled contact and radiant heat exposure, for which an Indian patent has been filed. Cut resistance decreased with increasing temperature due to thermal softening and crystallinity loss in UHMWPE. Glass-fiber reinforced fabrics demonstrated better retention of cut performance at elevated temperatures, as the lower thermal conductivity of glass restricted heat transfer and delayed polymer degradation. In contrast, stainless-steel reinforced fabrics showed faster performance reduction under thermal exposure due to more efficient heat conduction.

Service-related performance was examined through repeated rubbing, laundering, fabric stretching, and outdoor environmental exposure. Repeated abrasion and washing caused progressive degradation of cut resistance in all fabrics, with stainless-steel reinforced samples showing superior abrasion durability and glass-fiber reinforced samples exhibiting brittle fracture under mechanical wear. Fabric stretching reduced cut resistance by limiting loop deformation and energy dissipation. Outdoor exposure resulted in chemical and mechanical degradation, particularly in stainless-steel reinforced fabrics due to corrosion-assisted

oxidation of UHMWPE, while glass-fiber reinforced fabrics showed improved environmental stability.

The findings of this thesis establish clear structure–property–performance relationships for knitted cut-protective textiles and provide practical guidance for selecting yarn reinforcement, fabric structure, and protective strategies based on specific industrial service conditions. This work contributes to the advancement of durable, comfortable, and application-oriented cut-protective textile systems and supports the development of testing methodologies that better represent real-world usage.

