**Investigation of Gamma Radiation Absorption Parameters and Comfort Properties of Woven Fabrics with Hybrid Yarns Containing Haynes 25/L625 Alloy**

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The increasing use of X-rays and gamma rays in medical applications has heightened the demand for effective radiation shielding materials to mitigate the harmful effects of ionizing radiation. While traditional lead aprons are effective in providing radiation protection, their significant weight and inflexibility, coupled with the toxicity of lead, pose considerable health risks. This study investigates the potential of woven fabrics containing hybrid yarns made from Haynes 25/L625 alloy as a lightweight, flexible, and non-toxic alternative for gamma radiation shielding. The research focuses on the production of technical fabrics using hybrid yarns composed of Haynes 25/L625 alloy wires and recycled cotton/polyester blend yarns, woven in different patterns (3/1 twill, plain, and 5-harness satin), and evaluates their radiation absorption parameters and comfort properties.

The gamma radiation shielding properties of the fabrics were tested using a NaI(Tl) scintillation detector. The study measured key parameters, including transmission, absorption, linear attenuation coefficients, mass attenuation coefficients, half-value layer, tenth-value layer, mean free path, and radiation protection efficiency, across 15 gamma photon energies ranging from 32 to 1408 keV. The results revealed that the 5-harness satin weave fabric, which has the highest wire weight, exhibited the highest radiation absorption rates, particularly at lower energies, with a mass attenuation coefficient of 6.649 cm²/g at 32 keV. The 3/1 twill weave fabric, with moderate wire weight, demonstrated significant shielding effectiveness, especially at higher energies, achieving a linear attenuation coefficient of 0.291 cm-1 at 356 keV. In contrast, the plain-woven fabric with the lowest wire weight demonstrated the weakest radiation absorption performance among the three fabrics, with a half-value thickness of 1.106 cm at an energy level of 121 keV.

In addition to radiation shielding performance, the comfort properties of the fabrics, including air permeability, thermal behavior, and porosity, were also examined. Air permeability tests conducted in accordance with ISO 9237 standards showed that satin and twill weaves, characterized by floating yarns due to the low number of connections on the fabric surface, exhibit higher air permeability. In contrast, the plain weave, with its tightly woven structure, displayed the lowest air permeability. Thermal measurements, revealed that the plain weave fabric had the highest heat dissipation, while the twill weave exhibited the lowest. Microscopic porosity analysis further confirmed that the satin weave had the highest porosity (22%), followed by the twill (19%) and plain weaves (12%).

The findings show that the weaving type and the varying amount of Haynes 25/L625 alloy per unit area significantly affect both the fabric's radiation shielding performance and comfort properties. The 5-harness satin weave, with its high alloy amount and dense structure, provided superior radiation shielding, making it ideal for high-protection applications. The 3/1 twill weave offered a balanced combination of radiation protection and comfort, while the plain weave with the lowest amount of alloy demonstrated low breathability and high thermal diffusivity.

This study concludes that woven fabrics with Haynes 25/L625 alloy hybrid yarns offer a promising alternative to traditional lead aprons, offering radiation protection, reduced weight, and improved comfort.

***Keywords:*** Hybrid yarns, woven fabrics, gamma radiation, radiation shielding, alloy, Haynes 25/L625

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