Abstract No. 62 ***Mathematics***

MATHEMATICAL OPTIMIZATION AND COMPUTATIONAL GEOMETRIC PACKING ALGORITHMS FOR MAXIMIZING MATERIAL UTILIZATION IN WOOD PROCESSING

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Optimizing the use of timber resources is essential for ensuring sustainable forestry practices and maximizing wood utilization. The primary challenge in wood processing is to achieve the highest possible usable yield while minimizing waste, particularly when it comes to heartwood, which is stronger and more valuable than sapwood. The conventional wood-cutting technique, known as the plain (flat) sawn method, follows a straightforward approach but often results in significant wastage. This study specifically focuses on Jack wood, highlighting the importance of optimization tailored to the wood type. The primary objective is to reduce cutting waste and maximize usable wood by strategically positioning prioritized rectangular cuts within the heartwood. Data were collected from the State Timber Corporation (STC) in Sri Lanka, with each log of wood measured by its length and girth**.** Each timber log is assumed to be in a perfectly cylindrical shape, with no internal damage. The heartwood is assumed to occupy 70% of the timber log's radius, and its cross-sectional area was calculated accordingly. The study framework combines geometry-based optimization with spatial algorithms. The arrangement of rectangular shapes on the cross-sectional area is prioritized (3" x 4") first, then followed by prioritizing larger areas defined by lengths with widths of 28 mm, 31 mm, and 38 mm for the remaining area. An optimization model was formulated to maximize the utilization of the heartwood area under some constraints regarding total heartwood area, rectangular area, non-overlapping and rotation. Compared to plain sawn method, the optimized approach improved material utilization by up to 18% in area and 13% in volume, with a noticeable reduction in remaining usable material. The results of this study show the effectiveness of the optimized cutting method in maximizing material utilization and minimizing wastage compared to the commonly used plain-sawn method. These findings emphasize the benefit of wood-type-specific optimization in enhancing yield and reducing waste in industrial applications.

Keywords: Optimization, Spatial-algorithms, Sustainable forestry, Timber log, Wood utilization