

## Empirical study on one-dimensional Cutting Stock Problem solutions using only cutting patterns with a limited number of distinct item types

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### ABSTRACT

This study focuses on the approximate solution of the one-dimensional Cutting Stock Problem (CSP) by leveraging insights from studies on the Cutting Stock Problem with a Limited Number of Open Stacks (CS-LOSP). The CS-LOSP, a variant of the classical CSP, imposes a limit on the number of open stacks during production, reflecting constraints observed in many industrial environments. Empirical findings from CS-LOSP studies have shown that high-quality CSP solutions can be achieved with low values of  $C$  (the permitted number of open stacks). Inspired by these observations, we propose a heuristic pattern screening strategy that integrates the  $C$ -limit directly into the pattern generation process. Given  $M$  distinct item types, we enumerate all  $\binom{M}{C}$  (and smaller) combinations of item types, generate all feasible cutting patterns for each combination, and take the union of these sets as the restricted pattern pool for solving the CSP. This procedure ensures that no pattern containing more than  $C$  distinct item types is ever generated, effectively reducing the search space before solving the CSP. Extensive computational experiments were conducted on randomly generated instances and benchmark datasets from CUTGEN1. In terms of material efficiency, the heuristic achieved negligible deviations from the optimal CSP solution: an average relative gap of 0.20% for  $C = 2$  and  $0.17 \times 10^{-2}\%$  for  $C = 3$  in CUTGEN1 instances. For randomly generated instances, the maximum observed discrepancies were 2.92% ( $C = 2$ ) and 0.27% ( $C = 3$ ). Larger gaps were associated with problem classes containing a wide range of item lengths, whereas near-optimal performance was consistently observed when item lengths were uniformly large or uniformly small. When applied in a sequential optimization setting solving the CSP first and then sequencing the cutting patterns to minimize the maximum number of simultaneously open stacks the heuristic produced substantial operational benefits. For random instances, the number of simultaneously open stacks was reduced by an average of 38.64% for  $C = 2$  and 8.26% for  $C = 3$ . For CUTGEN1 instances, reductions averaged 38.91% for  $C = 2$  and 15.09% for  $C = 3$ . The effect was most pronounced for instances with shorter items, where the diversity of possible patterns is greater. These results demonstrate that the proposed method preserves material efficiency while significantly reducing operational complexity. The approach is especially relevant in industrial contexts where cutting patterns must be executed sequentially and both raw material usage and shop floor logistics are critical considerations. By embedding a  $C$ -based restriction into the pattern generation stage, the method offers a computationally efficient and practically viable alternative to unrestricted CSP formulations.

**KEYWORDS.** Cutting stock problem. Open Stacks. Pattern sequencing. Integer linear programming.