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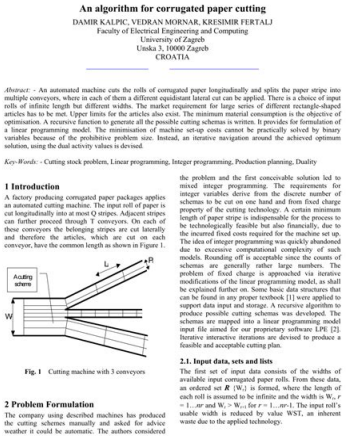

An algorithm for corrugated paper cutting

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Abstract: - An automated machine cuts the rolls of corrugated paper longitudinally and splits the paper stripe into multiple conveyors, where in each of them a different equidistant lateral cut can be applied. There is a choice of input rolls of infinite length but different widths. The market requirement for large series of different rectangle-shaped articles has to be met. Upper limits for the articles also exist. The minimum material consumption is the objective of optimisation. A recursive function to generate all the possible cutting schemas is written. It provides for formulation of a linear programming model. The minimisation of machine set-up costs cannot be practically solved by binary variables because of the prohibitive problem size. Instead, an iterative navigation around the achieved optimum solution, using the dual activity values is devised.

Key-Words: - Cutting stock problem, Linear programming, Integer programming, Production planning, Duality

1 Introduction

A factory producing corrugated paper packages applies an automated cutting machine. The input roll of paper is cut longitudinally into at most Q stripes. Adjacent stripes can further proceed through T conveyors. On each of these conveyors the belonging stripes are cut laterally and therefore the articles, which are cut on each conveyor, have the common length as shown in Figure 1.

Fig. 1 Cutting machine with 3 conveyors

2 Problem Formulation

The company using described machines has produced the cutting schemes manually and asked for advice weather it could be automatic. The authors considered the problem and the first conceivable solution led to mixed integer programming. The requirements for integer variables derive from the discrete number of schemas to be cut on one hand and from fixed charge property of the cutting technology. A certain minimum length of paper stripe is indispensable for the process to be technologically feasible but also financially, due to the incurred fixed costs required for the machine set up. The idea of integer programming was quickly abandoned due to excessive computational complexity of such models. Rounding off is acceptable since the counts of schemas are generally rather large numbers. The problem of fixed charge is approached via iterative modifications of the linear programming model, as shall be explained further on. Some basic data structures that can be found in any proper textbook [1] were applied to support data input and storage. A recursive algorithm to produce possible cutting schemas was developed. The schemas are mapped into a linear programming model input file aimed for our proprietary software LPE [2]. Iterative interactive iterations are devised to produce a feasible and acceptable cutting plan.

2.1. Input data, sets and lists

The first set of input data consists of the widths of available input corrugated paper rolls. From these data, an ordered set $\boldsymbol{R}$ $\{W_r\}$ is formed, where the length of each roll is assumed to be infinite and the width is W_r, $r = 1...nr$ and $W_r > W_{r+1}$ for $r = 1...nr-1$. The input roll's usable width is reduced by value WST, an inherent waste due to the applied technology.