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A cutting-and-inventory control problem in the manufacturing industry of stainless steel wares☆

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Abstract

Circular pieces are often cut from stainless steel roll to make common commodities such as pots and cups. The related factories are often make-to-order ones. The stock rolls usually have the same width. Each working order requires pieces of the same size. Pieces of different sizes cannot appear in the same cutting pattern because the orders do not arrive simultaneously. The approach proposed in this paper assumes that the original roll can be slit into a strip and a partial roll. The strip is used to fulfill the current order. The partial roll will be used to fulfill future orders and cannot be slit further. The approach determines several standard widths for the partial rolls and uses a greedy procedure to select the roll (either the original roll or a partial roll) to fulfill the current order. The computational results indicate that the approach is efficient in improving material utilization.

Keywords: Cutting stock; Two-dimensional cutting; Circle cutting; Stainless steel rolls

1. Introduction

Stainless steel rolls are often cut into circular pieces to make household commodities such as water jugs, buckets, pails, pots, cups, and basins. Typically, a factory producing such products may consume several thousand tons of stainless steel rolls in a year. Because stainless steel is much more expensive than ordinary steel, it is important to take good cutting-and-inventory policies to improve material utilization.

The problem discussed comes from a factory that produces pots, cups, and kettles. The factory consumes about 10 000 tons of stainless steel rolls in a year. The rolls must be cut into circular pieces to make the products. A customer order may include one or more products. Each product is made from circular pieces of the same type (same diameter and thickness). For production management convenience, each working order includes only pieces of the same type. To shorten the throughput time in the cutting shop, a working order is processed immediately after receiving it. Pieces of different types usually cannot appear in the same cutting pattern because the orders do not arrive at the same time. The factory orders rolls each month, and it takes about two months for the ordered rolls to arrive. The rolls in inventory usually have the same width that is 1090 mm in January 2005. Before 2005, the cutting process consisted of two stages. At the first stage, guillotine

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shears cut the roll into equal-size segments. The segment width was equal to the roll width, and the length was not longer than 1.5 m. At the second stage, stamping presses punched out the pieces from the segments. This process had led to poor material utilization and high labor cost. Several automated cutting lines have been set up in the cutting shop since 2005. Each line consists of a numerical controlled stamping press and the feeding devices. Once a roll is set up on the cutting line, it will be cut into pieces continuously without being segmented. It is necessary to implement good cutting-and-inventory policies so that the new lines operate with high level of material utilization. This new type of cutting lines is gaining wider acceptance in industry because it is more efficient in improving material utilization and productivity.

The contents of the paper are arranged as follows: Section 2 introduces two cutting-and-inventory policies and reviews the literature briefly. The first policy referred to as simple slitting is summarized from the practice of the factory, and the second is the proposed policy referred to as planned slitting. Section 3 describes the procedure for performing the simple slitting. Section 4 presents the approach to perform the planned slitting. Section 5 presents the computational results. Section 6 terminates the paper with conclusions.

2. Cutting-and-inventory policies and the literature review

From here on those piece types that are often required are referred to as main piece types or simply main types.

2.1. Simple slitting

The punching process requires that the pieces be arranged in rows within the roll. There is no constraint on the maximum number of piece rows, except that constrained by the roll width. The current practice is to cut a roll according to the pattern shown in Fig. 1, where as many as possible piece rows are arranged in the roll. This practice is referred to as *simple splitting*. Here slitting is necessary to divide the roll into a strip that contains the piece rows and an unoccupied partial roll (the hatched region in the figure) that is kept for possible later use. This process may lead to high material cost because the partial roll has a narrow width that is difficult to be used further. The demand of a working order can be fulfilled either from the original roll, a partial roll, or both of them. The detailed procedure is described in Section 3, and compared with the proposed approach through computational test in Section 5.

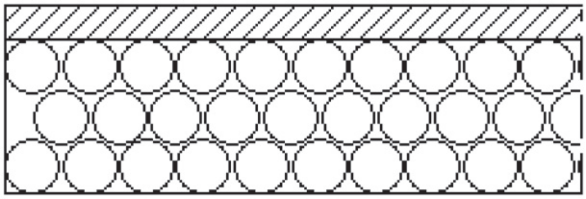

Fig. 1. Simple slitting.

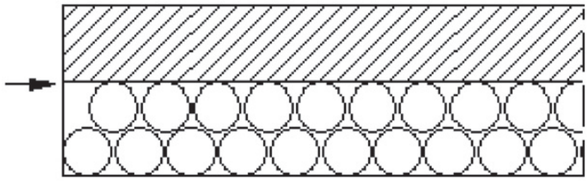

Fig. 2. Planned slitting.

2.2. Planned slitting

One way to improve the material utilization is to specify the roll widths to purchase. This proves to be difficult, since the lead time for supplying ordinary rolls is about two months, and the lead time can be even longer if rolls with specific widths are required. The customer orders are usually fulfilled within one month. The diameters of the piece types and the demands for them cannot be estimated accurately more than two months into the future.

Fig. 2 shows another way to cut the roll. Only two rows are arranged. The roll is also slit into a strip and an unoccupied partial roll. The strip is used to produce the pieces of the current order. The partial roll may be used to fulfill future orders because it has a width larger than most of the piece diameters that may be required. Cutting the roll in this way is referred to as *planned slitting*.

Planned slitting consists of the following steps that will be described in detail in Section 4:

Step 1: Estimate the demand in the coming period. Only the main piece types will be considered.

Step 2: Determine the widths of the standard partial roll types from the estimated demand. The original rolls have the same width. In the cutting process it is assumed that an original roll can be slit according to the pattern in Fig. 2, and the partial roll cannot be slit further. Both standard partial rolls and non-standard ones will be generated. The number of the standard partial roll types is much smaller than the number of piece types. The maximum width of the non-standard partial rolls is smaller than the minimum width of the standard partial rolls.