Research on Two-dimension pattern based on shear cutting Problems

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Abstract: The cutting problem is a practical engineering problem. It is classified according to the two-dimensional pattern problem. According to the requirement of blanking technology, a blanking method based on homogeneous block is proposed, and the blanking characteristics of this kind of blanking method are pointed out.

1. Introduction

Pattern problem is a problem from engineering practice, which mainly involves operations research, engineering technology, mathematics, computer and other disciplines. It is an old and famous problem. At the beginning, the pattern problem is a simple mathematical problem. With the needs of industrial development, manual pattern began to appear. Since the 1970s, driven by the development of modern manufacturing industry and the competition of market economy, many research institutions and researchers in the world have invested in the research of pattern problem. In the actual production, reasonable pattern plan can not only improve the utilization rate of materials, save the cost of products, but also shorten the production cycle, directly affect the economic benefits of enterprises.

The traditional manual pattern process not only consumes a lot of labor of enterprise technicians, but also takes a long time to pattern, and the utilization rate of materials is low, which greatly reduces the production capacity and market reaction capacity of the enterprise, and increases the production cost. In order to improve the low efficiency of manual pattern, the use of computer pattern has become the development trend to solve the pattern problem [1].

2. Definition of pattern problem

The so-called pattern problem is to give one or more pattern spaces and a number of objects to be arranged, and to reasonably place the objects to be arranged in the pattern space under certain necessary constraints, and to achieve some optimal performance index [2].

Performance indicators are generally as follows:
(1) the largest space utilization;
(2) or lowest cost;
(3) Or the largest number of objects.

The constraints are generally:
(1) the objects to be arranged are placed in the arrangement space;
(2) there is no interference between the objects to be arranged;
(3) Certain process constraints.
3. Two dimensional pattern problem

Many scholars at home and abroad have classified the pattern problem. For example, Dyckhoff [3], Wascher [4], etc. According to the dimension division of pattern space, the pattern problem can be divided into one-dimensional pattern problem, two-dimensional pattern problem and three-dimensional pattern problem. This paper mainly classifies two-dimensional pattern problems. The two-dimensional pattern problem, also known as the plate pattern problem, is to place a series of blanks in the plate without overlapping each other. The pattern goal is to maximize the total value of the blanks contained in the plate. The two-dimensional pattern problem is widely used in production practice, mainly including plane plate cutting (such as metal plate cutting, clothing cloth cutting, leather cutting), plane figure filling (such as puzzle problem), plane pattern (such as circuit board pattern problem), etc. There are many classification methods for two-dimensional pattern problems, as follows:

3.1. According to the shape of the object to be arranged, it can be divided into rectangular pattern and irregular pattern. Figure 1a shows the pattern of rectangular pieces, while figure 1b shows the pattern of irregular pieces.

![Figure 1. The classification according to the objects of pattern shape](image)

3.2. Classification according to blanking process

In the actual production, the pattern must meet the specific cutting process requirements. According to the cutting process, it can be classified into cutting mode and non cutting mode. Cutting mode is also called guillotine cutting: each cutting track on the plate is a connected line from edge to edge, also known as "edge to edge" (Figure 2A [5]). Non guillotine, also known as orthogonal cutting, has no edge to edge limit during cutting (Fig. 2B [6]), which is generally suitable for flame cutting.

![Figure 2. The classification according to the cutting process](image)

In production, the cutting and punching process is often used to divide the sheet metal into blanks in two stages. The first stage is called the cutting stage, in which the plate is cut into strips with a flat shearing machine; the second stage is called the blanking stage, in which the blank is separated from the strips with a punching machine. The pattern algorithm can be used to determine the optimal arrangement of the strip on the plate in the shear stage, so as to improve the utilization rate of cutting as much as possible.

4. The main pattern methods of two-dimensional cutting pattern problem

The classical two-stage pattern method has been paid attention to in pattern theory and practice. A classic two-stage method is to cut the plate into blanks in two stages, in which the shear lines of each stage are parallel to each other and the adjacent two stages are
perpendicular to each other. Figure 3 shows a classic two-stage approach, where the number represents the blank type number. In the first stage, the plate is divided into horizontal strips by the horizontal shear line shown by the arrow, and in the second stage, the strips are cut into blanks by the vertical shear line.

![Figure 3. classic two-stage approach](image)

Homogeneous block, that is, in a plate, only the same size of blanks, and these blanks are arranged in a multi-level standard way. The homogenization block shown in Figure 4 is composed of rectangular blanks, which can be regarded as strips of the same width, including blanks of the same size. When cutting the homogenization block, each knife just cuts a horizontal or vertical strip. The homogenization block can also be regarded as composed of several "stages", and the length and direction of the strip in each stage are the same. Figure 4 contains four levels, which have been numbered in the order in which they were cut off. When cutting, cut two horizontal strips in the first stage from knife 1-2, five vertical strips in the second stage from knife 3-7, three strips in the third stage from knife 8-10, and five strips in the fourth stage from knife 11-15.

After cutting the homogeneous block into strips, the strips need to be cut into blanks. The strip can be cut into blanks by cutting or by punching.

![Figure 4. homogeneous block composed of rectangular blanks.](image)

The following is a typical pattern based on homogeneous blocks (Figure 5). The pattern method based on homogenization block is divided into x mode and Y mode. When the cutting line divides the plate into different homogenization blocks from left to right, it is called X mode; when the cutting line first divides the plate into different homogenization blocks from top to bottom, it is called y mode.
5. Conclusions
In many industries of the national economy, the problem of material segmentation is encountered. The pattern of rectangular parts is often involved in the processing industry. It is the first process of processing and manufacturing. It has a direct relationship with improving the utilization rate of raw materials and reducing the cost of products. In this paper, aiming at two-dimensional pattern problem, a classification method and a pattern method based on homogeneous block are proposed.

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