Research on the Status of Two-dimensional Layout Circular Parts

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Abstract: This paper introduces the research background of the two-dimensional circular part layout problem, analyzes the complexity of the layout problem, studies the current research status of the circular part layout problem, and finally, lists the relationship between layout methods and layout schemes of the two-dimensional circular part layout problem.

1. Introduction
The layout problem of two-dimensional circular parts is an important branch of the two-dimensional layout problem. The stator and rotor cores of small and medium-sized motors are made of laminated silicon steel sheets. The silicon steel sheet blank for manufacturing the iron core is round, and the material is usually cut and punched. First, the silicon steel sheet is cut into strips with a shearing machine, and then a punch is used to make the required round sheets, which are usually called "punch sheets". A medium-scale motor manufacturing enterprise can consume thousands of tons of silicon steel plates every year. There are tens of millions of companies in the motor manufacturing industry, and the annual consumption of silicon steel plates is tens of millions of tons. Carrying out research on the layout technology of silicon steel sheet and applying it to guide enterprise layout practice is of great significance for improving the utilization rate of silicon steel sheet cutting and reducing the product cost of the motor [1].

2. Complexity of cutting problems
To study the layout problem, we must first fully realize the complexity of the layout problem. Generally speaking, the complexity of the layout problem is mainly manifested in two aspects: modeling and solving [2]:

2.1. Modeling complexity
The modeling complexity is mainly manifested in the following two aspects:

(1) Modeling of layout space and objects to be deployed
It involves how to describe the geometric and non-geometric features of the layout space and the objects to be deployed. The layout objects are not limited to simple geometric shapes such as rectangles and circles, but may also be irregular shapes.

(2) Modeling of the layout process
Describe the constraints and solution goals of the layout problem. Some of these constraints and goals can be described by mathematical models, and some cannot be described by mathematical methods. In addition, the layout process involves the cognitive activities of a large number of human experts. Some of them can find regularity, but there are also some cognitive activities that cannot be represented...
2. Solving complexity

The layout problem is a typical combinatorial optimization problem. Some of the simplest one-dimensional and two-dimensional layout problems have been proved to be NP-complete problems [3-5], such as 0-1 Knapsack Problem, rectangular packing layout problem. The complexity of NP-complete problems lies in the fact that it is impossible to obtain accurate solutions to large-scale NP-complete problems within a limited and reasonable time. That is, as the scale of the problem continues to expand, the solution space increases exponentially, and only the problem can be obtained, which is a satisfactory solution rather than an optimal solution. The reason is that when the scale of the problem reaches a certain level, a "combination explosion" will occur, and the precise algorithm will exhaust any existing or foreseeable computer resources.

Therefore, the solution of the layout problem is quite difficult, and its thorough solution still needs a long process. At the same time, the research field involved in this problem is extremely wide, so a large number of documents have emerged in recent years to solve the layout problem. The solution methods used are various and the layout effects achieved are also very different.

3. Research status of the two-dimensional circular parts layout problem

The problem of circular slices can be divided into two methods: shear blanking and non-shear blanking. The former means that when cutting, first use a shearing machine to divide the stock plate into horizontal or vertical strips, and each strip contains discs of the same diameter; then the strips are sent to the punch to punch out the discs. The latter can be directly cut out of the wafer by flame or laser cutting.

In Figure 1, the number represents the number of the blank. In Figure 1-a, this layout method is composed of numbers 3, 2, and 1. The diameter, pitch and demand of each circular blank are shown in Table 1.

Table 1 Circular blank data

| No | Blank data (Diameter × pitch× demand) |
|----|--------------------------------------|
| Blanks | 375×5×12, 245×5×8, 190×5×11 |

Area $S$ occupied by all round blanks is as follows:

$$S = (12\times175\times175 + 8\times245\times245 + 11\times190\times190) \times (3.1416 / 4)$$

Aiming at the problem of non-shear blanking, Hihi [6-7] proposed the RBL method. The RBPL method is to adjust the order of the round slices in the BLP method; Stoyan and Yaskov [8] used branch and bound method and successive approximation on the method, round blanks of different sizes are placed on the coil, so that the length of the consumed coil is the shortest. Locatelli and Raber [9] proposed a branching and delimiting method to solve the problem of the same size round pieces on the square plate. Constrain the optimal layout.
Aiming at the problem of cutting and blanking of round blanks, Hifi [10-11] designed a heuristic-based simulated annealing algorithm to place the round blanks in the lower left corner of the rectangular sheet; Cui Yaodong [12-13] proposed to choose on the coil The best cutting length of the board makes the board blanking utilization rate the highest. A series of typical layout methods are proposed to meet the requirements of different processes and utilization rates in actual production, including T-shaped layout methods, multi-section layout methods and multi-level layout methods. The T-shaped layout is to use a straight line to divide the board into two pieces, each piece contains strips with the same direction and length, and the directions of the strips in the two pieces are perpendicular to each other. Use dynamic programming algorithm and enumeration method to find the optimal dividing line, and determine the optimal blank row number, number of strips and direction in the strip, and then use the LP algorithm to consider the overall optimal cutting utilization rate of multiple sheets. The multi-segment layout method is to use some straight lines perpendicular to the long side of the board to cut the board into several segments, and each segment contains strips with the same direction and length. The knapsack algorithm is used to determine the number of sections of the board and the optimal layout of the strips in each section, so that the utilization rate is the highest, and then combined with the LP algorithm to solve the large-scale demand problem.

4. Layout mode and layout plan

The layout method refers to the arrangement of the round blanks on the plate. The layout must be feasible, that is, the total area occupied by the arranged blanks cannot exceed the area of the plates used. When describing a layout, you must specify the length and width of the wire used, and the diameter and quantity of the various blanks arranged in it.

The layout plan is composed of one or more layout methods, and specifies the number of plates to be cut according to each layout method. The layout plan should at least meet the following conditions:

1. The layout method is feasible: every layout method is feasible;
2. Satisfy the demand for blanks: the quantity of various blanks contained is not less than the demand;
3. Satisfy the constraint of the number of sheets available for the plates: the actual number of sheets used for each type of sheet does not exceed the number of sheets available.

5. Conclusions

The two-dimensional circular part layout problem is an important branch of the two-dimensional layout problem, which belongs to the NP difficulty problem. In this paper, the research status analysis and program analysis are carried out for the above problems.

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