Research On Decision Optimization of Multi-Stage Production Process Based on Decision Tree Model and Simulated Annealing Algorithm

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Abstract. The control of the defective rate of spare parts and finished products in the production process of enterprises is very important for product quality and economic benefit. This paper probes into whether the optimal decision scheme is made for the products generated at each stage in the production process after an enterprise gets the defective rate from sampling inspection, and comprehensively uses the multi-stage decision model and simulated annealing algorithm to discuss and answer. Firstly, a decision tree model is established for a simple process, an objective function is set up to maximize profit, and the possible decisions and results of each link are calculated. Then the optimal decision scheme and results are obtained by simulated annealing algorithm. Secondly, for more complex processes, a comprehensive multi-stage decision model is established, the possible decisions and results of each part and each process are calculated, the objective function of total profit is set up, and the optimal scheme is solved by simulated annealing algorithm. The results show that the decision tree model and simulated annealing algorithm can effectively solve the optimization problem of multi-stage detection decision in the production process of enterprises, so as to help enterprises achieve profit maximization.

Keywords: Sampling detection, Optimal decision detection at each stage, Decision tree model, Profit maximization, Simulated annealing algorithm.

1. Introduction

With the development of science and technology and the improvement of people's living standards, electronic products have gradually come into people's vision, and enterprises producing electronic products are also faced with many practical problems in various stages of production. Making different decisions for different problems will make enterprises get different benefits. In the actual production process, spare parts will be caused by various reasons to fail and even if the spare parts are qualified, the finished product may not be qualified. Therefore, in order to obtain more benefits and enhance their influence, enterprises need to adopt a series of methods to ensure the quality of spare parts and finished products to minimize the impact of nonconforming products.

In recent years, there have been some researches on using decision tree model and simulated annealing algorithm to solve process optimization problems. For example, Cao Li, Yang Ke, Jiang Ziyao based on simulated annealing algorithm solves the relative optimal objective solution in ship maintenance process by taking total maintenance cost and cycle as objective functions [1]; Shen Chunya, Fang Liaoliao, Peng Laihu based on simulated annealing algorithm solves the optimal production scheduling scheme of enterprise warping preparation workshop by taking the number of open axes and processing time as objective functions [2]; Based on the decision tree model, Song Kang, Liu Xinliang, Luo Xiaoxia in Literature three conducted optimization research on the hospitalization cost and case mix of patients with obstructive hydronephrosis [3]; Chen Xu in literature four introduced decision tree model to analyze and calculate the impact of project risk on the realization of construction period objectives, thus providing decision-making basis for construction period compression [4].

It is known that an enterprise needs to buy two kinds of spare parts and equipment to be sold into finished products. In the assembly process, as long as there is one unqualified part and the finished product is unqualified, if the two kinds of spare parts are qualified, the finished product may not be qualified, although the unqualified finished product can be scrapped or dismantled, but it also seriously increases the total cost of the enterprise. Maximizing economic benefits is its primary goal, so designing a reliable decision plan according to the actual situation is particularly important to ensure the quality of spare parts and finished products and achieve sustainable development. This paper focuses on solving the following two problems:

(1) For simple processes, the decision is made in four stages: whether to detect two kinds of parts, whether to detect finished products, and whether to disassemble unqualified finished products, and the optimal decision scheme is established based on the given situation to achieve quality optimization and profit maximization.

(2) For complex processes, make decisions on whether to test eight kinds of parts, whether to test three kinds of semi-finished products, whether to test finished products, whether to disassemble unqualified semi-finished products, and whether to disassemble unqualified finished products in 16 stages, and establish the optimal decision plan based on the given situation to maximize profits.

2. Research method

2.1. Analysis of profit-maximizing production decision problems based on known parts and finished product defect rates

On the premise that the defective rate is known through sampling detection [5], the optimal decision is made for the four stages of production. It is necessary to consider whether parts 1 and 2 are tested in the first and second stages, because testing will generate testing costs; Whether the finished product is tested in the third stage will also have corresponding testing costs; In the fourth stage, whether the unqualified finished products are disassembled, and whether the disassembled parts need to be tested after the disassembly, the disassembly and re-testing have corresponding costs. Corporate profit is the guarantee for the normal operation of an enterprise. Therefore, with the goal of maximizing corporate profit [6], a decision tree model is established to calculate every possible decision and corresponding result, and a certain number of parts are used to simulate the production and sales process of spare parts through the simulated annealing algorithm [7-8], so as to retain the optimal choice with the maximum profit. Thus, the optimal decision scheme of profit maximization can be obtained.

2.2. Analysis of complex production decision problems based on known profit maximization rates of parts, semi-finished products, and finished products

Under the premise that the defective rate is known through sampling detection, the optimization decision is made for various parts and parts, and the optimal decision plan is made to maximize the profit. Including parts testing, semi-finished product testing, finished product testing and disassembly of unqualified products. A comprehensive decision tree model is also established to calculate every possible decision and corresponding results, and the theoretical maximum optimal choice is obtained by simulated annealing algorithm, from which the decision scheme is obtained.

3. Model establishment and solution

3.1. Profit maximization production decision tree model based on known defective rate of parts and finished products

3.1.1 Establishment of decision tree model

When the defective rates of two kinds of parts and accessories are known, with the goal of profit maximization, we design whether to detect at each stage of the production process, and choose to use the decision tree model to solve the detection problem, and realize it through various possible decision schemes and profit maximization decision objectives [9-10].

The specific flow chart is shown in Figure 1.

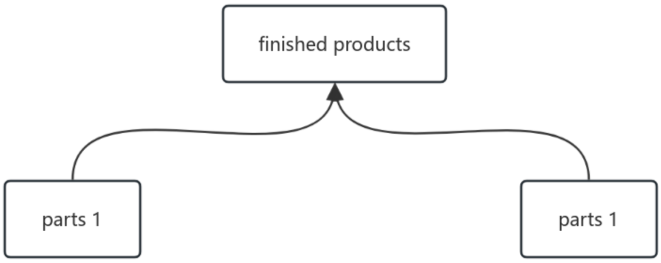

Figure 1. Flow chart of simple model

Step1: Establishment of decision variables:

x_1: Whether to test parts 1

x_2: Whether to test parts 2

x_3: Whether to test the finished product

x_4: Whether to disassemble unqualified products $x_i \in [0,1]$, $x_i=1$ indicates detection, $x_i=0$ indicates no detection

Step2: According to the profit calculation formula profit = cost - selling price, establish the decision basis aiming at maximizing total profit:

(1) The total cost of C from purchasing a batch of spare parts to selling the goods is as follows:

$$C_{Total\ cost} = C_{purchase} + C_{test\ parts} + C_{test\ finished\ products} + C_{disassembly} + C_{exchange} \tag{1}$$

The specific calculation formula of each cost is as follows:

① If the quantity of two kinds of spare parts purchased is N_1 and N_2 respectively, and the corresponding unit price is C_1 and C_2 respectively, the total procurement cost required is:

$$C_{procurement} = N_1 C_1 + N_2 C_2 \tag{2}$$

② Let the cost of each part 1 and part 2 inspected be d_1 and d_2 respectively

Known: $x_1=1$: Test parts 1; $x_2=0$: Do not test parts1;

$x_2=1$: Test parts 2; $x_2=0$: Do not test parts 2.

The total cost of testing parts required is:

$$C_{Testing\ parts} = x_1 N_1 d_1 + x_2 N_2 d_2 \tag{3}$$

③ The defective rates of parts 1 and 2 are P_1 and P_2 respectively

Known: $x_1=1$: N_1 qualified parts 1; $x_1=0$: N_1 (1-P_1) qualified parts 1;

$x_2=1$: N_2 qualified parts 2; $x_2=0$: N_2 (1-P_2) qualified parts 2.

The number of qualified parts 1 is N_3, the number of qualified parts 2 is N_4, and the number of qualified finished products is N_5

Then the number of qualified parts 1.2 and qualified finished products is:

$$N_3 = x_1 N_1 + \left(1 - x_1\right) N_1 \left(1 - P_1\right) \tag{4}$$

$$N_4 = x_2 N_2 + \left(1 - x_2\right) N_2 \left(1 - P_2\right) \tag{5}$$

$$N_5 = min\left\{N_3,\ N_4\right\} \tag{6}$$

Known: $X_3=1$: test the finished product; $X_3=0$: The finished product is not tested.

Suppose the cost of each inspected finished product is d_3, then the total cost of finished product inspection required is:

$$C_{inspected\ finished\ product} = x_3 N_5 d_3 \tag{7}$$

④ Set the defective rate of finished products as P_3, the dismantling cost of each non-cost finished product is d_3, and the replacement loss of each unqualified finished product after entering the market is d_4.

If $x_1=1$ and $x_2=1$, then $P_3=0$

If $x_1=1$ and $x_2=0$, then $P_3=P_2$

If $x_1=0$ and $x_2=1$, then $P_3=P_1$

If $x_1=0$ and $x_2=0$, then $P_3=P_1+P_2-P_1P_2$

The defective rate of the finished product is:

$$P_3 = P_2\left(1-x_2\right) + P_1\left(1-x_1\right) - P_1P_2\left(1-x_1\right)\left(1-x_2\right) \tag{8}$$

The total dismantling and relocation cost of the finished product required is:

$$C_{Disassembly} = x_4P_3N_5d_3 \tag{9}$$

$$C_{swap} = \left(1-x_4\right) P_3N_5d_4 \tag{10}$$

To sum up:

$$C_{Total\ cost} = N_1C_1 + N_2C_2 + x_1N_1d_1 + x_2N_2d_2 + x_3N_5d_3 + x_4p_3N_5d_3 + \left(1-x_4\right) p_3N_5d_4 \tag{11}$$

(2) Calculate the selling price S:

Let's say the price per finished product is d_5

Known: $X_3=1$: test the finished product; $X_3=0$: The finished product is not tested.

When $x_3=1$: $S=N_5\ (1-P_3)\ d_5$

When $x_3=0$: $S=N_5\ (1-P_3)\ d_5-N_5P_3d_4$

The selling price is:

$$S = x_3N_5\left(1-P_3\right) d_5 + \left(1-x_3\right) N_5\left(1-P_3\right) d_5 - N_5P_3d_4 \tag{12}$$

(3) The final total profit obtained by the enterprise is

$$Total\ profit = selling\ price - Total\ cost = S - C_{Total\ cost} \tag{13}$$

In the (13), S is obtained from (12) and $C_{Total\ cost}$ is obtained from (11).

3.1.2 Model solving

Given six scenarios:

Case 1: The defective rate of parts 1 is 10%, the purchase price is 4 yuan, and the testing cost is 2 yuan; The defective rate of parts 2 is 10%, the purchase price is 18 yuan, and the testing cost is 3 yuan; The defective rate of finished products is 10%, the assembly cost is 6 yuan, the inspection cost is 3 yuan, and the market price is 56 yuan; The replacement loss of unqualified finished products is 6 yuan, the dismantling cost is 5 yuan, and the above are each piece.

Case 2: The defective rate of parts 1 is 20%, the purchase price is 4 yuan, and the testing cost is 2 yuan; The defective rate of parts 2 is 20%, the purchase price is 18 yuan, and the testing cost is 3 yuan; The defective rate of finished products is 20%, the assembly cost is 6 yuan, the inspection cost is 3 yuan, and the market price is 56 yuan; The replacement loss of unqualified finished products is 6 yuan, the dismantling cost is 5 yuan, and the above are each piece.

Case 3: The defective rate of parts 1 is 10%, the purchase price is 4 yuan, and the testing cost is 2 yuan; The defective rate of parts 2 is 10%, the purchase price is 18 yuan, and the testing cost is 3 yuan; The defective rate of finished products is 10%, the assembly cost is 6 yuan, the inspection cost is 3 yuan, and the market price is 56 yuan; The replacement loss of unqualified finished products is 30 yuan, the dismantling cost is 5 yuan, and the above are each piece.

Case 4: The defective rate of parts 1 is 20%, the purchase price is 4 yuan, and the testing cost is 1 yuan; The defective rate of parts 2 is 20%, the purchase price is 18 yuan, and the testing cost is 1 yuan; The defective rate of finished products is 20%, the assembly cost is 6 yuan, the inspection cost is 2 yuan, and the market price is 56 yuan; The replacement loss of unqualified finished products is 30 yuan, the dismantling cost is 5 yuan, and the above are each piece.

Case 5: The defective rate of parts 1 is 10%, the purchase price is 4 yuan, and the testing cost is 8 yuan; The defective rate of parts 2 is 20%, the purchase price is 18 yuan, and the testing cost is 1 yuan; The defective rate of finished products is 10%, the assembly cost is 6 yuan, the inspection cost is 2 yuan, and the market price is 56 yuan; The replacement loss of unqualified finished products is 10 yuan, the dismantling cost is 40 yuan, and the above are each piece.

Case 6: The defective rate of parts 1 is 5%, the purchase price is 4 yuan, and the testing cost is 2 yuan; The defective rate of parts 2 is 5%, the purchase price is 18 yuan, and the testing cost is 3 yuan; The defective rate of finished products is 5%, the assembly cost is 6 yuan, the inspection cost is 3 yuan, and the market price is 56 yuan; The replacement loss of unqualified finished products is 10 yuan, the dismantling cost is 40 yuan, and the above are each piece.

The simulated annealing algorithm is used to solve the established model, a certain number of parts are used to simulate the production and sales process of parts, and then random decisions are made, the most preferred item with the highest probability of retaining profits is selected, and the probability of selecting the best option is avoided to avoid the extreme situations of qualified products. The probability is higher in the early stage of annealing, and the probability is smaller in the later stage [4,5]. The final decision scheme and index results are shown in Table.1. :

Table.1. Shows the specific decision plans and corresponding index results in six cases

Case	Whether to test parts 1	Whether to test parts 2	Whether to test finished products	Whether to disassemble unqualified finished products	profit
1	No	No	No	Yes	208456
2	No	No	No	Yes	140314
3	No	No	Yes	Yes	194681
4	No	No	Yes	Yes	147614
5	No	No	Yes	Yes	162794
6	No	No	No	No	195652

The results show:

In case 1, the optimal profit is 208,456 yuan, and the corresponding decision scheme is to disassemble only the unqualified finished products without carrying out other decision stages.

In case 2, the optimal profit is 140,314 yuan, and the corresponding decision scheme is to disassemble only the unqualified finished products without carrying out other decision stages.

In case 3, the optimal profit is 194,681 yuan, and the corresponding decision plan is to test the finished product and disassemble the unqualified product, and no other decisions are made.

In case 4, the optimal profit is 147,614 yuan, and the corresponding decision plan is to test the finished product and disassemble the unqualified product. Other decisions are not made.

In case 5, the optimal profit is 162,794 yuan, and the corresponding decision plan is to test the finished product and disassemble the unqualified product. Other decisions are not made.

In case 6, the optimal profit is 195,652 yuan, and the corresponding decision scheme is not to carry out the decision of these four stages.

3.1.3 Analysis of results

(1) Comparing the results of case 1 and case 2, it can be seen that the results of case 1 are relatively stable, while the results of case 2 fluctuate in the detection of finished products. By observing the data of Case 1 and case 2, it can be found that there is only a significant increase in the rate of defective products in case 2, and this difference may be the reason for the fluctuation of the results of case 2 in the detection of finished products.

(2) In case 6, the decision is no. It can be seen from the chart data that the defective rate of parts 1 and 2 and finished products is low, resulting in the inspection of parts 1 and 2 and finished products is no. By comparing the disassembly cost and replacement loss of unqualified finished products, it is found that the disassembly cost is significantly higher than the replacement loss, so the decision is taken not to disassemble unqualified finished products.

3.2. Multi-stage decision model of complex production based on profit maximization with known parts, semi-finished products and finished product defect rates

3.2.1 The establishment of multi-stage decision model

Under the premise of multiple processes of various parts and accessories, with the goal of profit maximization, we design whether to detect each stage of the production process, establish a more complex comprehensive multi-stage decision model for whether to detect the problem, and achieve it through various possible decision schemes and profit maximization decision objectives.

The specific flow chart is shown in Figure 2.

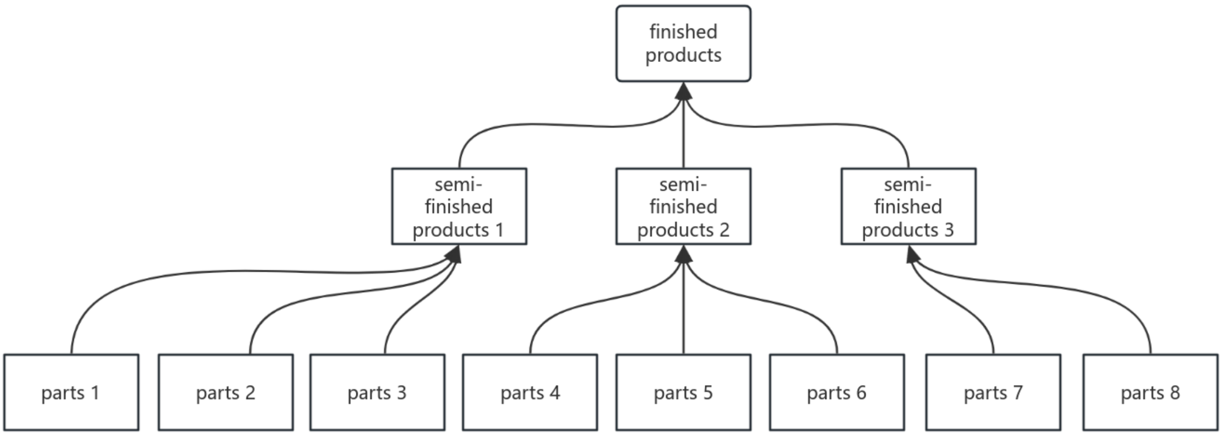

Figure 2. Flow charts of complex models

Step1: Establishment of decision variables

x_1: Whether to test parts 1

x_2: Whether to test parts 2

x_3: Whether to test parts 3

x_4: Whether to test parts 4

x_5: Whether to test parts 5

x_6: Whether to test parts 6

x_7: Whether to test parts 7

x_8: Whether to test parts 8

x_9: Whether to test semi-finished product 1

x_{10}: Whether to test semi-finished product 2

x_{11}: Whether to test semi-finished product 3

x_{12}: Whether to test the finished product

Step2: According to the profit calculation formula profit = cost - selling price, establish the decision basis aiming at maximizing total profit:

① (1)$C_{\text{Total cost}} = C_{\text{purchase}} + C_{\text{parts testing}} + C_{\text{parts assembly}} + C_{\text{semi-finished product testing}} + C_{\text{semi-finished product assembly}} + C_{\text{finished product testing}} + C_{\text{exchange}} + C_{\text{disassembly}}$

② The number of parts 1-8 purchased is N_1... N_8, the corresponding unit price is C_1... C_8, then the total procurement cost required is:

$$C_{procurement} = \sum N_i C_i,\ i = 1,2...8 \tag{14}$$

③ For each part checked 1....8, The cost of parts 1....8 is d1.... d8, then the total testing cost of spare parts required is:

$$C_{testing\ spare\ parts} = \sum x_i N_i d_i,\ i = 1,2 ... 8 \tag{15}$$

④ The defective rate of spare parts 1-8 is P_1, ... P_8 respectively, the assembly cost is m_1... m_8, then the total assembly cost of spare parts required is:

$$C_{spare\ parts\ assembly} = \sum N_i P_i m_i,\ i = 1,2 ... 8 \tag{16}$$

Comprehensive ②③ decision:

$$C_{detection\ parts} + C_{parts\ assembly} = \sum \left[x_i N_i d_i + \ (1 - x_i)\ N_i P_i m_i \right] \tag{17}$$

⑤ Let the cost of 1, 2, and 3 per semi-finished product inspected be d_9, d_{10}, d_{11}

Known: x_i=1: qualified parts 1 is N_i P_i; x_i=0: qualified parts 1 is $N_i(1-p_i)$;

Assuming that the quantity of qualified parts 1.2.3 is N_9.N_{10}.N_{11}, and the quantity of qualified semi-finished products 1 is N_{12}, then the quantity of qualified parts 1.2.3 and qualified semi-finished products 1 is:

$$N_9 = x_1 N_1 + (1 - x_1) N_1 (1 - P_1) \tag{18}$$

$$N_{10} = x_2 N_2 + (1 - x2\ ) N_2 (1 - P_2) \tag{19}$$

$$N_{11} = x_3 N_3 + (1 - x3) N_3 (1 - P_3) \tag{20}$$

$$N_{12} = min\{N_9, N_{10}, N_{11}\} \tag{21}$$

Similarly, if the quantity of qualified parts 4.5.6 is N_{13}.N_{14}.N_{15} and the quantity of qualified semi-finished products 2 is N_{16}, then the quantity of qualified parts 4.5.6 and qualified semi-finished products 2 are:

$$N_{13} = x_4 N_4 + (1 - x_4) N_4 (1 - P_4) \tag{22}$$

$$N_{14} = x_5 N_5 + (1 - x_5) N_5 (1 - P_5) \tag{23}$$

$$N_{15} = x_6 N_6 + (1 - x_6) N_6 (1 - P_6) \tag{24}$$

$$N_{16} = min\{N_{13}, N_{14}, N_{15}\} \tag{25}$$

Continue the same way: if the quantity of qualified parts 7.8 is N_{17}, N_{18}, and the quantity of qualified semi-finished products 3 is N_{19}, then the quantity of qualified parts 7.8 and qualified semi-finished products 3 is:

$$N_{17} = x_7 N_7 + (1 - x_7) N_7 (1 - P_7) \tag{26}$$

$$N_{18} = x_8 N_8 + (1 - x_8) N_8 (1 - P_8) \tag{27}$$

$$N_{19} = min\{N_{17}, N_{18}\} \tag{28}$$

Therefore:

$$C_{tests\ semi-finished\ products} = x_9 N_{12} d_9 + x_{10} N_{16} d_{10} + x_{11} N_{19} d_{11} \tag{29}$$

⑥ If the defective rate of semi-finished product 1.2.3 is P_9.P_{10}.P_{11}, and the assembly cost is m_9.m_{10}.m_{11}, the total cost of assembling semi-finished products is as follows:

$$C_{assembling\ semi-finished\ products} = N_{12}P_9m_9 + N_{16}P_{10}m_{10} + N_{19}P_{11}m_{11} \tag{30}$$

Synthesis ④⑤ decision obtained:

$$\begin{aligned} &C_{Test\ semi-finished\ products} + C_{assemble\ semi-finished\ products} = \left[x_9N_{12}d_9 + (1-x_9)N_{12}P_9m_9\right] + \\ &\left[x_{10}N_{16}d_{10} + (1-x_{10})N_{16}P_{10}m_{10}\right] + \left[x_{11}N_{19}d_{11} + (1-x_{11})N_{19}P_{11}m_{11}\right] \end{aligned} \tag{31}$$

⑦ Let's say the cost of a finished product is d_{12}

Known: $x_9=1$: the number of qualified semi-finished product 1 is N_{12}; $x_9=0$: the quantity of qualified semi-finished product 1 is N_{12} $(1-P_9)$;

$x_{10}=1$: the number of qualified semi-finished products 2 is N_{16}; $x_{10}=0$: The number of qualified semi-finished products 2 is N_{16} $(1-P_{10})$;

$x_{11}=1$: the number of qualified semi-finished products 3 is N_{19}; $x_{11}=0$: The number of qualified semi-finished products 3 is N_{19} $(1-P_{11})$;

The number of qualified semi-finished products 1.2.3 is N_{20}, N_{21}, N_{22}, the number of finished products is N_{23}, then the number of qualified semi-finished products 1.2.3 and finished products are respectively:

$$N_{20} = x_9N_{12} + (1-x_9)N_{12}(1-P_9) \tag{32}$$

$$N_{21} = x_{10}N_{16} + (1-x_{10})N_{16}(1-P_{10}) \tag{33}$$

$$N_{22} = x_{11}N_{19} + (1-x_{11})N_{19}(1-P_{11}) \tag{34}$$

$$N_{23} = min\{N_{20}, N_{21}, N_{22}\} \tag{35}$$

So:

$$C_{tests\ the\ finished\ product} = x_{12}N_{23}d_{12} \tag{36}$$

⑧ Suppose that the defective rate of the finished product is P_{12}, the replacement cost of each finished product is m_{12}, and the dismantling cost of each finished product is m_{13}, then the total cost of the replacement and dismantling of the finished product is:

$$C_{swap} = (1-x_{13})\ N_{23}P_{12}m_{12} \tag{37}$$

$$C_{Disassembly} = x_{13}N_{23}P_{12}m_{13} \tag{38}$$

To sum up:

$$\begin{aligned} &C_{total\ cost} = \sum N_iC_i + \sum\left[x_iN_id_i + (1-x_i)\ N_iP_im_i\right] \\ &+\left[x_9N_{12}d_9 + (1-x_9)N_{12}P_9m_9\right] + \left[x_{10}N_{16}d_{10} + (1-x_{10})N_{16}P_{10}m_{10}\right] + \\ &\left[x_{11}N_{19}d_{11} + (1-x_{11})N_{19}P_{11}m_{11}\right] + x_{12}N_{23}d_{12+}(1-x_{13})\ N_{23}P_{12}m_{12+}x_{13}N_{23}P_{12}m_{13}i = 1,\ldots 8 \end{aligned} \tag{39}$$

(2) Total sales price

Let the market price of each finished product is m_{14}

If x_{12} =1, the selling price is N_{23} $(1-P_{12})$ m_{14}

If x_{12} =0, the selling price is N_{23} $(1-P_{12})$ $m_{14}-N_{23}P_{12}m_{12}$

The selling price is:

$$S = x_{12}N_{23}(1-P_{12})m_{14} + (1-x_{12})\left[N_{23}(1-P_{12})m_{14} - N_{23}P_{12}m_{12}\right] \tag{40}$$

$$Total\ profit\ P = total\ selling\ price\ -\ total\ cost\ = S\ \text{-}\ C_{Total\ cost} \tag{41}$$

In the (41), S is obtained from (40) and $C_{total\ cost}$ is obtained from (39).

3.2.2 Model solving

Given the following:

The defective rate of spare parts 1 is 10%, the purchase price is 2 yuan, and the testing cost is 1 yuan; The defective rate of parts 2 is 10%, the purchase price is 8 yuan, and the testing cost is 1 yuan; The defective rate of parts 3 is 10%, the purchase price is 12 yuan, and the testing cost is 2 yuan; The defective rate of parts 4 is 10%, the purchase price is 2 yuan, and the testing cost is 1 yuan; The defective rate of spare parts 5 is 10%, the purchase price is 8 yuan, and the testing cost is 1 yuan; The defective rate of parts 6 is 10%, the purchase price is 12 yuan, and the testing cost is 2 yuan; The defective rate of parts 7 is 10%, the purchase price is 8 yuan, and the testing cost is 1 yuan; The defective rate of parts 8 is 10%, the purchase price is 12 yuan, and the testing cost is 2 yuan; The defective rate of semi-finished products 1-3 is 10%, the assembly cost is 8 yuan, the inspection cost is 4 yuan, and the dismantling cost is 6 yuan. The defective rate of the finished product is 10%, the assembly cost is 8 yuan, the detection cost is 6 yuan, the dismantling cost is 10 yuan, the market price is 200 yuan, the replacement loss is 40 yuan, and the above are each piece.

The simulated annealing algorithm is used to substitute various data in specific situations to solve the established model:

The running results are shown in Table.2.:

Table.2. Specific decision plans and corresponding index results under the problem situation

Decision	Answer	Profit
Whether to test parts 1	No	95036
Whether to test parts 2	No	
Whether to test parts 3	No	
Whether to test parts 4	No	
Whether to test parts 5	No	
Whether to test parts 6	No	
Whether to test parts 7	No	
Whether to test parts 8	No	
Whether to test semi-finished products 1	No	
Whether to test semi-finished products 2	No	
Whether to test semi-finished products 3	No	
Whether to test finished products	Yes	
Whether to disassemble the semi-finished product 1	No	
Whether to disassemble the semi-finished product 2	No	
Whether to disassemble the semi-finished product 3	No	
Whether to disassemble the finished product	No	

3.2.3 Analysis of results

It should be said that there should be 2^{16}=65536 possible decision schemes, but considering that there are 2^{12}=4096 cases in which all semi-finished products are not tested and the finished products are not split, that is, some decision schemes do not meet the actual situation, and only when all semi-finished products are not tested and the finished products are not split and the semi-finished products are not split can the actual situation be met in these 4096 cases. That is, 28+1=29=512 cases are reasonable, so the final possible decision scheme should be 65536-4096+512=61952, and finally the optimal solution is obtained by simulated annealing algorithm.

4. Conclusions

The research results show that the decision tree model and simulated annealing algorithm can effectively solve the decision problem of whether to detect products at various stages in the production process of enterprises so as to maximize their profits. This paper solves the optimal decision scheme by combining the model and algorithm for some specific situations, in which the decision tree model in simple processes can clearly show the decision process through the tree structure. It is easy to understand the prediction results of the model, and in the case of complex processes, the decision tree can handle complex nonlinear relations and accurately judge the best decision based on different combinations of variables in each stage. On this basis, the simulated annealing algorithm is used for preliminary analysis of the decision tree model and classification results to determine the initial solution and search scope, and then the global optimal scheme is searched. The combination of the two can comprehensively consider various factors and constraints in the production process, optimize the decision scheme from multiple perspectives, and obtain the decision result with higher quality and more in line with the actual production demand. For enterprises to reduce production costs, improve production efficiency and greatly enhance the market competitiveness.

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