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TABLE OF CONTENTS

DYNAMIC SCHEDULING STRATEGY OF INTELLIGENT RGV

Author: Kong Weikang
Zhejiang University Ningbo Institute of Technology (China)

Abstract. *With the development of the intelligent industry, intelligent processing systems have received extensive attention, and the planning of the production process is the key to the entire processing system. This paper mainly studies the dynamic scheduling problem of RGV in different situations without faults, and gives the corresponding algorithm, discusses the scheduling strategy and operation efficiency, and tests the practicability of the model and the effectiveness of the algorithm.*

In the case of a trouble-free process, firstly, the maximum production material in a unit shift is the goal, and the above blanking time, waiting time, remaining working time, moving time and other constraints are used, and the recursive relationship between loading time and waiting time is used at the same time A 0-1 RGV dynamic scheduling 0-1 planning model for a trouble-free process is established. Based on this model, using the idea of directed acyclic shortest, the corresponding global optimization algorithm is designed, and the three sets of data are used to calculate the optimal scheduling strategy of RGV within the unit shift. At this time, the system's operating efficiency is 365, 347, 374 per shift. Finally, a process error detection model is established, and sensitivity analysis is performed to determine that the model has strong stability. Comparing the global optimization algorithm with the traditional greedy local optimization algorithm, the improvement percentages are 2.52%, 3.27%, and 2.18%, indicating that the algorithm is effective.

For the case of two programs without failure, the improvement is based on the case-one model. Increase the tool selection 0-1 variable, tool selection position, cleaning sequence and work flow constraints, with the goal of completing the second process with the largest amount of materials, and establish a trouble-free two process RGV dynamic scheduling 0-1 model. Combined with this model, the corresponding global optimization algorithm is designed. Then based on the 3 sets of data, 3 sets of tool arrangements are calculated. At the same time, the optimal scheduling strategy of RGV in one shift was obtained. At this time, the system's operating efficiency was 248, 203, and 243 per shift, respectively. Finally, based on a process error detection model, a two-process error detection model was established, and a sensitivity analysis was performed to determine that the model is more stable. Comparing the global optimization algorithm with the traditional greedy local optimization algorithm, the improvement percentages are 5.46%, 0.49%, and 0.41%, indicating that the algorithm is effective.

Finally, the paper evaluates the advantages and disadvantages of the model, proposes improvements, promotes the model, and obtains the intelligent RGV dynamic scheduling strategy in the event of a fault.

Keywords: *intelligent processing system,dynamic scheduling, global optimization, 0-1 planning, directed acyclic*

1 Problem background and restatement

Background of the problem

With the advent of the era of Industry 4.0, in the face of global competition, manufacturers at home and abroad are facing the globalization of competition, the company's automation awareness and the automation industry are constantly developing, and intelligent processing systems have emerged. Intelligent processing systems mainly include rgv systems and agv systems. The agv system is mainly guided by the driverless system, and the rgv system relies on the track for movement.The rgv system has a simple structure and strong anti-interference ability. It is widely used in logistics systems and factory processing systems, and is more suitable for the needs of modern production. Different, rgv system is divided into assembly type rgv intelligent system and transportation type rgv intelligent system [1], which provides convenience for material transportation and workshop assembly. According to the movement mode, it can be divided into ring orbit type and linear reciprocating type [1] The ring-track rgv system has high working efficiency and adopts the mode of multiple vehicles working at the same time.The linear reciprocating rgv system generally only has one rgv for linear reciprocating motion, so its line planning and dynamic scheduling are particularly important.

Restatement of the problem

An existing intelligent processing system is composed of 8 CNC machine tools cnc, 1 guide car rgv, one rgv linear track, one loading conveyor and one unloading conveyor. Cnc can complete the tasks of sending and receiving instructions and loading and unloading processing, And there is a possibility of failure.The rgv can orientate the track, send and receive instructions, load and unload, and clean the material.

The schematic diagram of the intelligent processing system is shown in Figure 1:

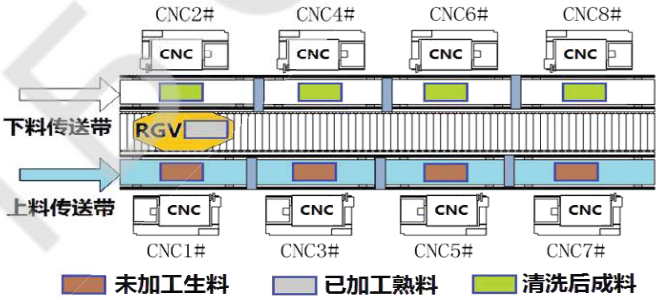


Figure 1 Schematic diagram of intelligent processing system

The processing process is divided into two cases: one ideal process and two ideal processes. For the two cases, complete the following tasks:

Task: Use the parameters of the system operation found on the Internet to test the practicability of the model and the effectiveness of the solution algorithm, and give the rgv scheduling strategy in the processing system and the operation efficiency of the processing system. The parameters are shown in Table 1:

Table 1: 3 sets of data table of intelligent processing system operating parameters Time unit: second

System operation parameters	Group 1	Group 2	Group 3
rgv time required to move 1 unit	20	23	18
rgv time required to move 2 units	33	41	32
rgv time required to move 3 units	46	59	46
cnc processing time to complete a one-step material	560	580	545
cnc processing time to complete the first operation of a two-process material	400	280	455
cnc processing time required to complete the second operation of a two-process material	378	500	182
rgv is cnc1 #, 3 #, 5 #, 7 #	28	30	27
rgv is cnc2 #, 4 #, 6 #, 8 #	31	35	32
rgv time required to complete a material cleaning operation	25	30	25

Model assumptions

Assumption 1: The capacity of each CNC machine tool cnc is 1 unit, which means that only one material can be processed at a time; Assumption 2: Do not consider the time for the robot to switch the grip of the robot;

Assumption 3: For the material that has failed, the time of unloading is the time of failure;

Hypothesis 4: On the loading conveyor, when there is raw material removed, there will be a raw material replacement immediately; on the unloading conveyor, when clinker is placed, it will be transported away immediately.

Explanation of symbols

symbol	Description
x_{ij}	Whether the i-th item is placed in the 0-1th CNC's 0-1 variable
Q_{ij}	0-1 variable of whether the j-th CNC works when the i-th material is loaded
R_{ij}	0-1 variable whether the i-th material is being cleaned at the j-th CNC
t_j	Time required for j-th CNC machine to load and unload at one time

c	Time to finish cleaning a material
m	Number of materials processed
ZF_j	0-1 variable of whether j is installed with the first process tool
ZS_j	0-1 variable of whether the jth stage is equipped with the second process tool

4 Problem analysis

4.1 Overall analysis of the problem

This question is to study the dynamic scheduling problem of intelligent rgv processing system, so it is necessary to understand the working principle of intelligent rgv processing system [2]. According to the different processing methods, the processing system is divided into four working states: one process without failure, two without failure. One process, one process with faults, two processes with faults.

4.2 Analysis of a trouble-free process

Task 1: Investigate the problem of dynamic programming of the materials processed by the unit shift. The factors to be considered before each planning include the working status of each cnc job, the time consumed by displacement, the remaining cnc working time, and cleaning time. The most demand, get the shortest time course, determine the most processed materials.

Task 2: Bring 3 sets of data into the task 1 model to find the scheduling strategy and the system's operating efficiency. Test the practicability of the model from the aspects of possible errors and stability, and compare the effectiveness of the algorithms by comparing different algorithms.

4.3 Analysis of two failure-free processes

Task 1: On the basis of question 1, add a second process, the goal is to process the most materials per unit shift. Before planning, you must consider both the assignment of the cnc process and the connection between the two processes. Simulate all The distribution of cnc operations, the shortest time route is determined according to the connection relationship between the two operations, and the most processed materials are determined.

Task 2: Based on the first case, increase the error analysis of loading and unloading, test the practicability of the model from the aspects of possible errors and stability, and compare the effectiveness of the algorithms by comparing different algorithms.

5 Model establishment and solution

Due to format requirements, if all the formulas are typed in the article, the article will be too long, which will cause the number of pages to exceed the standard. Therefore, the introduction of various constraints and formulas is given in the form of pictures after using latex typesetting.

5.1 rgv scheduling for a fault-free process

5.1.1 Establishment of a Failure-Free Process Scheduling Model——Task 1

5.1.1.1 Selection of variables

To facilitate the same labeling, the 8 cncs are numbered accordingly, and the numbering diagram is shown in Figure 2:

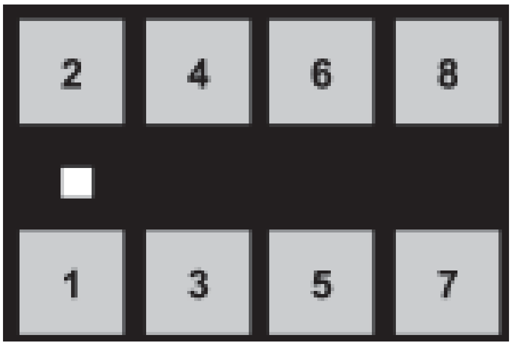


Figure 2 CNC numbering diagram of CNC machine tools

As shown in Figure 2, the numbers 1 to 8 are CNC machine tools cnc, and the white squares are the guide cars rgv.

(1) Selection of 0-1 variables

$$x_{ij}=\begin{cases}0,第i个物料不放置在第j台CNC\\1,第i个物料放置在第j台CNC\end{cases}(1)$$

$$Q_{ij}=\begin{cases}0,CNC不工作\\1,CNC工作\end{cases}(2)$$

$$R_{ij}=\begin{cases}0,第i个物料不在第j台CNC清洗\\1,第i个物料在第j台CNC清洗\end{cases}(3)$$

(2) Selection of time variables

$$TM_i=\sum_{j=1}^{n}(x_{ij}\cdot T_{L_i j})(4)$$

$$TL_i=\sum_{j=1}^{n}(x_{ij}t_j)(5)$$

$$TC_i=\sum_{j=1}^{n}R_{ij}x_{ij}c \qquad (6)$$

$$T_i=TW_i+TM_i+TJ_i+TL_i+TC_i \qquad (7)$$

Among them, tw_i is the possible waiting time; tm_i is the moving time; tj_i is the processing time, which is determined by the processing method and the nature of the workpiece itself; tl_i is the loading and unloading time; tc_i Is the cleaning time.

(3) Selection of ordinal variables

Set the number of materials processed in a shift working time as m.

In order to obtain the distance between the 1st-i material and the i-th material processing machine CNC, the serial number of the 1st-i material processing station is required. Because RGV is initially in the middle of the 1st CNC and the 2nd CNC Position, when i-1 = 0, $L_1 = 1$ (8)

In order to obtain the serial number L $_i$ of the 1-i material processing station, the definition of the j label of the station is used as the intermediate variable for conversion. Here, the logarithmic algorithm is used, that is, the basic relationship between the index and the logarithm can be converted to a as a base to get

$$n = \log_a(a^n) \quad (9)$$

Using equation (3), when i-1> 0 $L_i = \log_2\left(\sum_{j=1}^{n}(x_{i-1,j} \cdot 2^j)\right)$ (10)

$$L_i = \begin{cases} 1, & i = 1 \\ \log_2\left(\sum_{j=1}^{n}(x_{i-1,j} \cdot 2^j)\right), & i > 1 \end{cases} \quad (11)$$

The CNC serial number w $_I$ in the working state when the i-th material is loaded. In order to extract the CNC serial number that is in the working state when the i-th material is loaded, the basic relationship between the index and the logarithm can be converted to each other. Extract the CNC serial number, i.e.

$$w_{ik} = \log_2\left(\sum_{k=1}^{m} x_{kj} R_{kj} \cdot 2^j\right) + m - i \quad (12)$$

Among them, R $_{kj}$ is a 0-1 variable whether the k-th material is cleaned at the j-th CNC; m is the number of processed materials.

5.1.1.2 Determination of constraints

(1) Constraints on 0-1 variables

$$\sum_{j=1}^{n} x_{ij} = 1 \quad (13)$$

$$\sum_{j=1}^{n} x_{ij} = 0 \quad (14)$$

$$0 \le \sum_{j=1}^{n} x_{ij} \le 1 \quad (15)$$

$$R_{ij} \le \left\lfloor \sum_{k=1}^{i} x_{ij} / 2 \right\rfloor \le R_{ij} \cdot M \quad (16)$$

Among them, R $_{ij}$ is a 0-1 variable whether the i-th material is cleaned at the j-th CNC; M is a very large constant.

(2) Time constraint

$$T_i, TM_i, TJ_i, TL_i, TC_i > 0 \qquad (17)$$

$$TW_i \geq 0$$

$$\sum_{i=1}^{m} T_i \leq T \qquad (18)$$

$$\sum_{i=1}^{m} T_i > T \qquad (19)$$

$$t_{2\alpha} > t_{2\beta+1} \qquad (20)$$

$$TD_i = TU_{i+N} \qquad (21)$$

$$Q_{ij} \leq \sum D_{ij} \leq Q_{ij} \cdot M \qquad (22)$$

$$TW_i = \left\lfloor \sum_{j=1}^{n} Q_{ij} / n \right\rfloor \cdot \min\{D_{ij}\} \qquad (23)$$

Among them, Q_{ij} is a 0-1 variable whether the j-th CNC is working when the i-th material is loaded; n is the total number of CNC machine tools CNC, this question is 8; D_{ij} is the remaining working time.

(3) Recursive constraint

$$TU_i = 0, i = 1 \qquad (24)$$

$$TU_{ij} - TU_{i-1j} = TM_i + TC_{i-1} + TW_i, i > 1 \qquad (25)$$

Among them, tm_i is the moving time; tc_i is the cleaning time; tw_i is the waiting time.

$$D_{ij} = 0, i = 1 \qquad (26)$$

$$D_{ij} - D_{i-1j} = xij[T_{i-1} - TC_{i-1} - TM_{i-1}] \qquad (27)$$

Among them, T_{i-1} is the total working time; x_{ij} is a 0-1 variable whether the i-th material is placed on the j-th platform.

5.1.1.3 Determination of the objective function

Considering that in actual factory production, as many products as possible will be produced for sale within a fixed time, so we set the maximum number of production materials as the goal.

$$\max \sum\sum x_{ij} \qquad (28)$$

Among them, whether the i-th material is placed in the 0-1 variable x_{ij} of the j-th CNC.

5.1.1.4 Model establishment

Based on the analysis of 5.1.1.2 and 5.1.1.3, with formula (28) as the target and formulas (14) to (27) as constraints, a single

The target maximum production material model 0-1 planning expression is as follows:

$$\max \sum \sum x_{ij}$$

s.t.

Recursive constraints:

when $i = 1$ Time

$$\begin{cases} TU_i = 0 \\ D_{ij} = 0 \end{cases} \tag{29}$$

when $i \geq 1$ Time

$$\begin{cases} TU_{ij} - TU_{i-1\,j} = TM_i + TC_{i-1} + TW_i \\ D_{ij} - D_{i-1\,j} = x_{ij}(T_{i-1} - TC_{i-1} - TM_{i-1}) \end{cases} \tag{30}$$

Time constraints:

$$\begin{cases} \sum_{i=1}^{m} T_i \pounds T \\ \sum_{i=1}^{m+1} T_i > T \\ t_{2\alpha} > t_{2\beta+1} \\ Q_{ij} \pounds \sum D_{ij} \pounds Q_{ij} \cdot M \end{cases} \tag{31}$$

0-1 variable constraints:

$$\begin{cases} 0 \pounds \sum_{j=1}^{n} x_{ij} \pounds 1 \\ R_{ij} \pounds \left\lfloor \sum_{k=1}^{i} x_{ij} \ / \ 2 \right\rfloor \pounds R_{ij} \cdot M \end{cases} \tag{32}$$

Ordinal equation constraint:

$$\begin{cases} L_i = \begin{cases} 1, & i = 1 \\ \log_2 \left(\sum_{j=1}^{n} (x_{i-1,\,j} \cdot 2^j) \right), i > 1 \end{cases} \\ w_{ik} = \log_2 \left(\sum_{k=1}^{m} x_{kj} R_{kj} \cdot 2^j \right) + m - i \end{cases} \tag{33}$$

Time equation constraints:

$$\begin{cases} TM_i = \sum_{j=1}^{n} (x_{ij} \cdot T_{L_i j}) \\ TL_i = \sum_{j=1}^{n} (x_{ij} t_j) \\ TC_i = \sum_{j=1}^{n} R_{ij} x_{ij} c \\ TW_i = \left\lfloor \sum_{j=1}^{n} Q_{ij} / n \right\rfloor \cdot \min\left\{ D_{ij} \right\} \\ TD_i = TU_{i+N} \\ T_i = TW_i + TM_i + TJ_i + TL_i + TC_i \end{cases} \tag{34}$$

Variable constraints:

$$\begin{cases} TW_i {}^3 0 \\ T_i, TM_i, TJ_i, TL_i, TC_i > 0 \\ 0 £ \sum_{j=1}^{n} x_{ij} £ 1 \\ x_{ij,} R_{ij,} Q_{ij} \hat{I} \left\{ 0,1 \right\} \end{cases} \tag{35}$$

Model description:

Recursive constraints, time constraints, 0-1 variable constraints, sequence equation constraints, time equation constraints, and variable constraints are listed separately, which reflects the time relationship of each part during the entire period of the material operation.

5.1.2 Solving the rgv scheduling model-task one

The difficulty of this algorithm is the search of the optimal path x $_{ij}$. During the search of the optimal path, two conditions need to be met: (1) RGV cannot move without receiving an instruction; (2) the shortest time.

Analysis shows that when rgv waits in place, if the next instruction needs to be displaced, because rgv cannot arrive in advance, it will waste the displacement time, so we consider setting the path to the cnc that rgv first arrives and waits in place. The last cnc arrived at the same location, satisfying

$$\left\lceil \frac{a_1}{2} \right\rceil = \left\lceil \frac{a_{end}}{2} \right\rceil$$

That is, the cnc numbered 1 and the cnc numbered 2 are in the same position, so we can abstract the optimal path problem as: starting from the initial cnc position, traversing all cnc positions, and finally reaching the directed acyclic loop of cnc at the same position The shortest problem, and then solve the shortest time.

For a dynamic scheduling planning problem with the largest total number of materials processed in a given time, traditional intelligent algorithms take longer to solve and are easily trapped in local optimal solutions. Based on the dynamic scheduling model, we designed As the goal, the time equation constraint is a recursive condition, and the overall time is a fault-free rgv scheduling algorithm for a process.The algorithm design is as follows:

Step1: Initialize variables. Establish RGV displacement time adjacency matrix T, CNC loading and unloading time direction t, CNC's remaining work completion time matrix D, and ith start feeding time TU i to complete cleaning material time C;

Step 2: Optimal path selection. According to the shortest path, make the i-th material select the j-th platform, record the CNC number a i = j of the i-th material selection, and update the remaining work according to the recursive equation constraint (30) Time D ij = D ij + T, if D ij = 0, go to Step 3, otherwise go to Step 4;

Step3: Update the start time of the i + 1 material and the start time of the i-N material according to the time equation constraint (34) TU i = TU i + minmax (T ij, D ij) + t j + cR ij, turn to Step2;

Step4: Find the station with the minimum remaining working time min (D ij), wait in place for the small remaining working time min (D ij), and update the remaining working time D ij according to the recursive equation constraint (30)) = D ij-min (D ij}, update the start time of the i + 1th material TU i+1 = TU i + min (D ij), go to Step 2;

Step5: According to the overall time constraint formula (34), determine the starting time TU i + c + t j> T i of the i-th material, and the algorithm ends.

5.1.3 Calculation of Scheduling Strategy and Job Efficiency-Task Two

(1) Solve the scheduling scheme

First, the moving time, processing time, loading and unloading time, and cleaning time of the three sets of data are brought into the dynamic scheduling model in 5.1.1, and the algorithm in 5.1.2 is used to solve. The first set of scheduling solutions is shown in Table 2. As shown

Table 2 The first group of dynamic scheduling schemes

Processing material serial number	Processing cnc number	Feeding start time	Cutting start time
1	4	20	611
2	6	71	740
3	5	102	687
4	8	150	869
5	7	181	816
6	2	255	1084
7	1	286	1031
8	3	334	958
9	4	611	1222
□	□	□	□
363	6	27992	28613
364	7	28068	28689
365	8	28121	28742

(2) Solving operation efficiency

The definition of operation efficiency is the number of materials produced in a shift. The operation efficiency of the three sets of data is shown in Table 3:

Table 3 Three sets of operating efficiency

	First group	Second Group	The third group
Work efficiency	365	347	374

5.1.2 Verification of Model Utility-Task Two

For rgv's dynamic scheduling problem, if it is limited to only one scheduling problem, its practicability is not strong. Therefore, we use the three sets of data in Table 1 in the title to study the practicability of the model from the two aspects of error detection and sensitivity test.

A. Use a process processing error detection model for inspection

a) Cnc job inspection at the same time

After the intelligent processing system is started, there may be several CNCs sending signals to RGV at the same time, so it is necessary to check whether the CNC is scheduled at the same time, otherwise confusion will occur. Let the time when the i-th material starts to be unloaded is TD $_i$, the time for the i + N (N ∈ Z) material to start feeding is TU $_{i+N}$ if all the time data matches

$$TD_i = TU_{i+N} \tag{36}$$

It means that in this shift, cnc is not repeatedly scheduled at the same time.

b) Inspection of clinker processing time after cleaning

When processing, it may happen that the material is washed without being processed completely. It is necessary to calculate the processing time of the clinker after cleaning. Let the time when the i material starts to be unloaded is TD $_i$ The time when the i + N (N ∈ 物料Z) material starts feeding is TU $_{i+N}$, the loading and unloading time t $_j$, and the working time is complete T $_i$.

$$TD_i - TU_i - t_j {}^{3} T_i \tag{37}$$

It means that in this shift, there is no case where the material is not cleaned after being processed completely.

From this, a processing error detection model is established, and this model is used to verify the three sets of scheduling schemes in the first case. The test results are shown in Table 4:

Table 4 Three sets of test results

	First group		Second Group		The third group	
	cnc inspection	processing time inspection	cnc inspection	processing time inspection	cnc inspection	processing time inspection
Number of tests	365	365	347	347	374	374
Number of errors	0	0	0	0	0	0
Error rate	0%	0%	0%	0%	0%	0%

Known from Table 4, no abnormalities were found in the three groups of scheduling schemes, indicating that the scheduling scheme can be applied in practice.

B. sensitivity analysis

Combining the recursive constraints in 5.1.1.4, considering the two variables of cleaning time tc and moving time tm, and because the moving time tm is related to the moving distance, a sensitivity analysis is performed on the cleaning time tc to check the stability of the model. 1 second For the step size, the cleaning time is changed, and the sensitivity analysis is performed. The test results of the first group are shown in Table 5. The complete results of the three groups are shown in the appendix.

table 5 Partial sensitivity analysis results

Cleaning time	Total number of items	Cleaning time	Total number of items
1	357	26	364
2	357	27	364
3	357	28	364
□	□	□	□
13	357	45	318
14	357	46	314
15	365	47	311
□	□	48	307
24	365	49	304
25	365	50	301

Visualization of the results of the sensitive analysis test is shown in Figure 3:

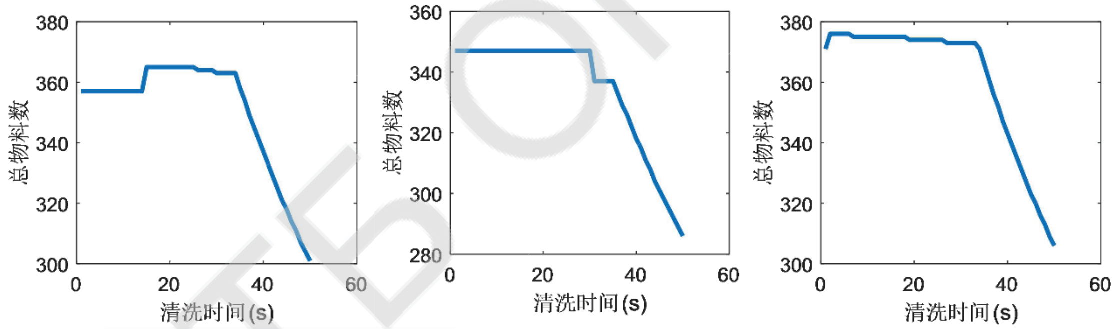


Figure 3 (a) The first set of visualization results Figure 3 (b) The second set of visualization results Figure 3 (c) The third set of visualization results

Through the joint analysis of Table 2 and Figure 3, it is calculated that when the cleaning time is between 1 and 38 seconds, the change rate of the total number of materials is within 6%, and the stability of the model is strong. In actual production and processing, the cleaning time generally does not exceed 35 seconds [3], so the model has strong stability and can be applied in actual production.

In summary, after solving the scheduling scheme, we first checked whether the model would cause actual errors, no errors were found through the test, and then a sensitivity analysis was performed on the model. It was found that the model was stable and could be used in actual production. Make sure the model is practical.

5.1.5 Verification of Algorithm Effectiveness-Task 2

In the process of using greedy-based local optimization algorithm for rgv dynamic scheduling, each scheduling is the current optimal solution, but it does not start from the overall scheduling optimization. Therefore, the greedy-based local optimization algorithm only obtains Locally optimal solution.

For example, when the rgv does not receive other job instructions, it waits in place until a cnc issues a job instruction. If the rgv is at another position at this time, the rgv needs to move to the target cnc before executing the corresponding job. During the process, displacement time overhead is bound to occur.

And if starting from the overall optimal, rgv makes the position of the target cnc exactly where it waits for instructions when performing dynamic scheduling, which can avoid unnecessary time overhead. Based on this, we have designed an overall dynamic scheduling algorithm. The operating efficiency of the rgv dynamic scheduling system was improved, and compared with the results of the local optimization algorithm based on greedy in three groups of environments, the results are shown in Table 6:

Table 6 Comparison of the results of two algorithms in one process

	First group	Second Group	The third group
Local optimization algorithm based on greedy	356	336	366
Global optimization algorithm	365	347	374
Lift percentage	2.52%	3.27%	2.18%

As shown in Table 6, the global optimization algorithm is more accurate than the greedy local optimization algorithm, so the algorithm is effective.

5.2 rgv scheduling of two processes without failure

5.2.1 Establishment and Solution of a Two-Process Scheduling Model with No Faults——Task 1

Compared with the first case, the second case has one more process than the first stage in the processing process, and the first and second processes need to be performed in order.The model in 5.1.1 needs to be modified, modified and added. The operation is similar.Once the constraints are obtained, the operation gets the result.

5.2.1.1 Variables and constraints

$$ZF_j \begin{cases} 0, \text{The first process tool is not installed} \\ 1, \text{The first process tool is installed} \end{cases} \quad (38)$$

$$ZS_j \begin{cases} 0, \text{The second process tool is not installed} \\ 1, \text{The second process tool is installed} \end{cases} \quad (39)$$

$$ZF_j + ZS_j = 1 \quad (40)$$

$$ZF_j + R_{ij} = 1 \quad (41)$$

$$R_{ij} \le \left\lfloor \frac{\sum_{k=1}^{i} x_{ij} ZS_j}{2} \right\rfloor \le R_{ij} \cdot M \quad (42)$$

$$x_{ij} \cdot \left[Q_{ij} ZF_j + (1 - Q_{ij}) ZS_j \right] = 1 \qquad (43)$$

$$(x_{ij} \cdot ZS_j) \qquad (44)$$

$$TD_i = TU_{i+N} \qquad (45)$$

$$TD_i - TU_i - t_j \geq T_i \qquad (46)$$

5.2.1.2 Algorithm steps

Step1: Initialize the variables. The number of the first process $n_1 = 1$, find the permutation and combination of C_{8n1} and find the CNC ZF_j of the first process, and the CNC of the first process. ZS_j, others are the same as 5.1.2Step1;

Step 2: Optimal path selection. When the i-th material selects the j-th CNC, $x_{ij} = 1$, determine the two types of CNCs.

Working status Q_{ij}, according to constraint formula (43), that is, $x_{ij} (Q_{ij} ZF_j + (1-Q_{ij}) ZS_j) = 1$, judge the second knife The order is related to the first knife order, the other is the same as 5.1.2Step2;

Step3 ~ Step5: same as 5.1.2Step3 ~ Step5;

5.2.2 Calculation of Scheduling Strategy and Job Efficiency-Task Two

Same as above, the result is easy to get:

Table 7 Tool arrangement

	First group	Second Group	The third group
First process tool	1、3、5、7	4、5、7	1、3、5、6、8
Second process tool	2、4、6、8	1、2、3、6、8	2、4、7

Then the three sets of data movement time, processing time, loading and unloading time, and cleaning time are brought into the dynamic scheduling model in 5.2.1, and solved using the algorithm in 5.2.2. The first group of scheduling schemes obtained is shown in Table 8. As shown, the three complete scheduling schemes are detailed in the supporting materials annex.

Table 8 The first set of dynamic scheduling schemes

Processing material serial number	Step 1 cnc number	Feeding start time	Cutting start time	Step 2 cnc number	Feeding start time	Cutting start time
1	7	46	520	8	548	996
2	3	107	612	4	640	1120
3	5	155	1072	4	1120	1569
4	1	216	691	2	719	1224
5	7	520	968	8	996	1445
6	3	612	1176	2	1224	1673
7	1	691	750	6	811	1341
8	1	750	1280	6	1341	1790
9	7	968	1417	8	1445	1894
□	□	□	□	□	□	□
246	5	27563	28012	4	28060	28509
247	3	27667	28116	2	28164	28613
248	1	27771	28220	6	28281	28730

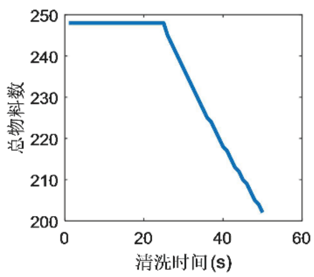
(1) Solving job efficiency

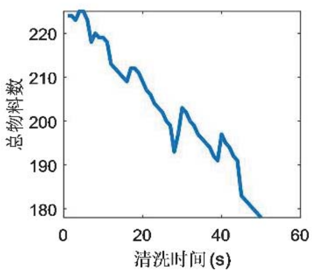
The definition of operating efficiency is the number of materials produced in a shift. The operating efficiency of the three sets of data is shown in Table 9:

Table 9 Three sets of operating efficiency

	First group	Second Group	The third group
Work efficiency	248	203	243

5.2.3 Sensitivity analysis





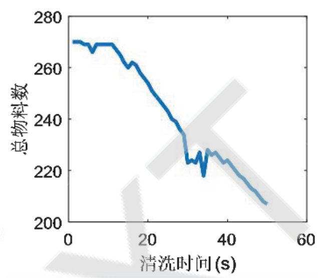


Figure 6 (a) The first set of visualization results Figure 6 (b) The second set of visualization results Figure 6 (c) The third set of visualization results

Through the joint analysis of Table 10 and Figure 6, it is calculated that when the cleaning time is between 1 and 32 seconds, the total material change rate is within 6%, and the model is more stable. In actual production and processing, the cleaning time generally does not exceed 35 seconds [3], so the model has strong stability and can be applied in actual production.

In summary, after solving the scheduling scheme, we first checked whether the model would cause actual errors, no errors were found through the test, and then a sensitivity analysis was performed on the model. It was found that the model was stable and could be used in actual production. Make sure the model is practical.

5.2.4 Verification of Algorithm Effectiveness-Task 2

As in 5.1.5, the global optimization algorithm and the greedy-based local optimization algorithm are compared in three sets of environments.The results are as follows:

Table 11 Comparison of the results of the two procedures and two algorithms

	First group	Second Group	The third group
Local optimization algorithm based on greedy	235	202	242
Global optimization algorithm	248	203	243
Lift percentage	5.46%	0.49%	0.41%

As shown in Table 11, the global optimization algorithm is more accurate than the greedy local optimization algorithm, so the algorithm is effective.

Evaluation and promotion of 6 models

6.1 Model advantages

This paper establishes a non-linear programming model with time recursive equation as the constraint and the maximum total number of materials as the target according to the system's operation flow. The mathematical formula is used to derive the model with high accuracy. The improved model is used when searching for the optimal allocation scheme The simulation algorithm, because the total number of schemes is less, saves additional memory overhead and time consumption than the intelligent algorithm; this model combines dynamic scheduling and directed acyclic graph in graph theory, that is, it can clearly represent the working status of each cnc .

6.2 Model Disadvantages

Because the pursuit unit produces the most materials in this area, the global search algorithm used is more complicated.

6.3 Generalization of the model

This model is a large 0-1 planning model, which can be directly applied to the actual production with a large number of CNCs; if the amount of sample data increases, the moving time T and the remaining working time D are calculated before each move, and min {T , D) in the shortest time, you can predict the next demand signal in advance; for the RGV dynamic scheduling model of the three processes, you can restrict the connection equation by adding the second to the third and prohibit the first process from reaching The concatenation of the third process results in an RGV scheduling plan for the three processes.

7 Conclusions

Generalizing the problem to a faulty situation, the results are as follows:

For the case of a faulty process, the improvement is based on the situation-one model. Three random factors are added: faulty parts, fault time, and processing time. Constraints such as time recursion and cleaning time are modified to produce materials in one shift. As a goal at most, a faulty process rgv dynamic scheduling 0-1 model is established. Based on this model, the corresponding global optimization algorithm is designed. Then based on 3 sets of data, the optimal scheduling strategy of rgv within a shift is obtained. The operating efficiency of the system is 357, 343, and 366 per shift. Finally, a process is used to process the error detection model to determine the stability of the model. The global optimization algorithm is compared with the traditional greedy local optimization algorithm to improve The percentages are 1.42%, 3.62%, and 1.10%, indicating that the algorithm is effective.

For the two faulty processes, improve on the basis of the second model. Add constraints such as prop selection 0-1 variables, tool selection position, cleaning sequence, and work flow to achieve the maximum amount of materials in the second process Then, a 0-1 model of rgv dynamic scheduling with two faults is established. Based on this model, the corresponding global optimization algorithm is designed. Then, based on 3 sets of data, the optimal scheduling strategy of rgv within a shift is obtained. At this time, the system The operating efficiency is 241, 192, and 236 per shift. Finally, two procedures are used to process the error detection model to determine the stability of the model. The global optimization algorithm is compared with the traditional greedy local optimization algorithm to increase the percentages. It is 6.63%, 0.52%, and 2.16%, indicating that the algorithm is effective.

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USING VR AND AR TECHNOLOGIES IN INCLUSIVE EDUCATION FOR CHILDREN WITH DISABILITIES

Author: Mukhamedali Kusainov
Supervisor: Ekaterina Kim
Turan University (Kazakhstan)

Abstract. *We are currently at a stage similar to the transition between theater and cinema. Initially, films were just another way of showing a theater. Some time passed before the filmmakers developed new technologies, ways of presenting a story unique to this environment. Thus, the same will be true for VR. Currently, a virtual reality computer game is simply a traditional computer game, but displayed on another medium. Over time, a paradigm shift will occur that we cannot know. In other words, VR is a revolution,*