Design and Application of Cigarette Automated Logistics System Based on Computer Simulation Technology

LinWang, ShengnanXu*, ZhantaoZhang, QiluHuang
Zhengzhou Tobacco Research Institute of Cnctc, Zhengzhou, 450001, China
Corresponding Author: ShengnanXu, 421509777 @qq.com

Abstract. The automatic logistics system of cigarette factory is a typical application of industrial informationization. Its purpose is to realize the automatic transportation of raw materials and finished products in the process of cigarette production through the automation system. In this paper, aiming at the automatic logistics system of recycling production waste, the computer simulation technology is applied to design and apply the system. In order to solve the problem of optimum solution of AVG, dumper and scheme selection in the process of production waste recycling, this paper uses computer simulation technology to model the business in actual operation, sets a series of evaluation indicators, simulates multiple collocations, processes and analyses the simulation results, and finally determines the automated deployment scheme of flow system.

1. Introduction
Computer simulation technology is a typical application of information technology in industry. With the help of computer simulation technology, every business process of industrial engineering can be simulated in the computer system. Through the environment variables of the control system operation, the business operation environment can be simulated to the maximum extent, thus helping industrial engineering designers and implementers to debug and optimize the system configuration with lower trial and error costs and modification costs, thereby improving the system operation efficiency, reducing the installation, commissioning and operation costs, and directly bringing economic benefits to enterprises.

The automatic logistics system of cigarette factory is a typical application of industrial informationization. Its purpose is to realize the automatic transportation of raw materials and finished products in the process of cigarette production through the automation system. With this system, tobacco enterprises can reduce the number of front-line employees as much as possible, improve the utilization rate of raw materials, enhance the stability and reliability of business operation, and ultimately realize the true sense of unmanned workshop. In the design and application of automatic logistics system in cigarette factory, computer simulation technology also plays a key role.

2. Simulation Target
The essence of computer simulation technology is to create greater value with the existing resources unchanged, that is, to obtain the best effect with the smallest resources. In this process, operational research, intelligent optimization technology, simulation and other subdivision simulation technology are needed. For automation systems, the goal of simulation is to make overall planning of manpower, material resources, financial resources, and time costs, so as to maximize the efficiency of the system. The simulation objectives in the field of logistics may include transportation path planning, material transportation and delivery optimization, waste transshipment optimization, vehicle scheduling.
optimization, etc. [2]. In this paper, aiming at the automatic logistics system of recycling production waste, the computer simulation technology is applied to design and apply the system.

Automated Guided Vehicle (AGV) and dumper are used to carry and dump waste in cigarette production workshop. The staff call AGV to carry the waste after it is full. The task of recycling waste is accomplished through AGV, dumper and AGV. The specific process can be seen in Figure 1. The system obtains the preliminary simulation model through queuing theory analysis, path planning and so on. Because AGV also undertakes the business of excipient distribution, empty tray recycling, product sampling and self-charging in the cigarette production workshop, the waste recycling business occupies more AGV resources, which affects the operation efficiency of other business [3-5]. The aim of the system simulation is to shorten the cycle of waste recycling and handling, and to minimize the number of AGV and dumper.

![Figure 1 Waste Automated Logistics System Operation Process](image)

3. Design of Simulation Process

3.1 Setting Factors, Levels and Indicators

Through analytic hierarchy process, the influencing factors of the system can be obtained, and the factors and levels that can not be implemented can be eliminated, that is, the set simulation factors and levels. Operating indicators are put forward according to the needs, which are summarized and sorted out as simulation indicators [6]. It can be seen from the analysis that the main factors affecting the waste recycling logistics system are the number of AGV, the number of dumpers and the scheduling method. Three factors were designed:

Factor A: The quantity of AGV is set at 5 levels of 4 to 8 units, so that waste recovery business occupies as little as possible the resources of AGV system, and the fewer AGV quantity is, the better under the condition of index optimization.

Factor B: The number of tippers should be set at 1-2 levels. In order to reduce capital investment, the design scheme determines that the fewer tippers the better under the optimal conditions of indicators.
Factor C: There are three levels in the scheduling method. Among them, C1 is AGV, which puts empty boxes back to the original platform to trigger the handling of cached waste boxes. C2 is AGV, which takes empty boxes off the dumper and triggers the handling of cached waste boxes. C3 is AGV, which moves full boxes to the dumper and triggers the handling of cached waste boxes.

The system index is the average handling cycle, and the less the average time used, the higher the efficiency of waste disposal. Each level of the above three factors constitutes a total of $5 \times 2 \times 3 = 30$ recycling logistics schemes. The simulation software is used to test these schemes and determine the optimal scheme.

3.2 Simulation Model Construction

The process of building the model is the re-mapping process of the business model, that is, to transform the real physical object into the simulation object, which is simulated by the computer system [7]. Here we use Plant Simulation to simulate. Using this software, the business simulation model is built first, as shown in Figure 2. According to the definition of the process and the adjustment of the system parameters, the business simulation model is constructed, and the data needed for the model is collected in the subsequent stage, and the simulation data is prepared based on the normal system operation mode.

![Figure 2 Task Simulation Model](Image)

3.3 Data Acquisition of Simulation Model

Data input and execution are based on the established simulation model to determine the processing of each stage. In the process of data input and execution, it is sometimes assumed that the constant or distribution function is good. When the input and execution process can not be assumed, an initial system can be constructed to collect data during the use of the system. By fitting and checking each group of data, we can determine which distribution law is in line with [8]. If the distribution law is not easy to express with the function, we can make an empirical distribution table. By observing the operation process of routine business, collecting the data of active link in waste recycling process, and using Minitab statistical tool to test the goodness of fit of the data, the operation rules of each link can be obtained [9-11]. The active links of waste recycling include task arrival, carrying full boxes, turning over boxes, and returning empty boxes. The data collection process is as follows:

Random collection of 150 tasks arrived at data. In Minitab, the goodness-of-fit test is carried out by using the individual distribution marking tool. In the probability map obtained, the rule of arrival of tasks does not obey the normal function distribution. It is expressed by the empirical distribution table as shown in Table 1.

150 pieces of data were collected randomly. In Minitab, the goodness-of-fit test is carried out by using the tool of individual distribution identification. In the probability map obtained, the confidence interval P value of 95% of normal distribution after Johnson transformation is 0.412 > 0.05. Therefore, this group of data obeys the normal distribution $N(5.06, 1.24)$ min, which is the operation rule of the full container handling of AGV.

The feeding link of turning over the box is a fixed constant of 1 minute.

Data of 150 empty container links were collected randomly. In Minitab, the probability maps obtained by goodness-of-fit test using individual distribution marking tool show that the confidence interval P value of 95% of normal distribution after Johnson transformation is 0.211 > 0.05. So this group of data obeys normal distribution $N(5.18, 1.21)$ min, which is the operation rule of AGV returning to
empty container.

### 3.4 Simulation Process

The simulation process includes the following steps:

In Fig. 2, the distribution functions or tables of attributes (attributes from data collected in Section 2.3) are loaded in each entity object of the simulation model to represent the operation rule of the entity [12].

| Serial number | time interval /min | Probability /% |
|---------------|-------------------|----------------|
| 1             | 0.070–3.770       | 76             |
| 2             | 3.770–7.465       | 7              |
| 3             | 7.465–11.160      | 2              |
| 4             | 11.160–14.855     | 5              |
| 5             | 14.855–18.550     | 1              |
| 6             | 18.550–22.245     | 4              |
| 7             | 22.245–25.94      | 1              |
| 8             | 25.940–29.635     | 3              |
| 9             | 29.635–33.330     | 0              |
| 10            | 33.330–37.025     | 1              |

Table 1 Task Arrival Interval Experience Distribution Table

All factors and their levels are used as input values of experimental tools to generate full factor or orthogonal experimental schemes.

The index is used as the output of the experiment.

Set up 95% confidence interval of simulation statistics, run simulation 30, 50, 100, 200, 500 times respectively, and output simulation results. The column Right interval bound-Left interval bound is the judgment confidence interval. By comparing the average confidence intervals of 30, 50, 100, 200, 500 simulations, the best result is to choose the smallest average confidence interval. The best result of this experiment is the result of simulation 50 times.

The simulation results are sorted out and the corresponding index values of each scheme are listed. The simulation results are shown in Table 2.

| Numbering | AVG / | Number of turning boxes / | Scheduling method | Average period /min |
|-----------|-------|---------------------------|-------------------|---------------------|
| 1         | 4     | 1                         | 1                 | 91.99               |
| 2         | 4     | 1                         | 2                 | 41.95               |
| 3         | 4     | 1                         | 3                 | 34.83               |
| 4         | 4     | 2                         | 1                 | 88.01               |
| 5         | 4     | 2                         | 2                 | 34.31               |
| 6         | 4     | 2                         | 3                 | 32.20               |
| 7         | 5     | 1                         | 1                 | 62.68               |
| 8         | 5     | 1                         | 2                 | 32.46               |
| 9         | 5     | 1                         | 3                 | 29.40               |
| 10        | 5     | 2                         | 1                 | 60.60               |
| 11        | 5     | 2                         | 2                 | 28.60               |
| 12        | 5     | 2                         | 3                 | 26.93               |
| 13        | 6     | 1                         | 1                 | 49.40               |
| 14        | 6     | 1                         | 2                 | 28.67               |
| 15        | 6     | 1                         | 3                 | 26.94               |
| 16        | 6     | 2                         | 1                 | 48.06               |
| 17        | 6     | 2                         | 2                 | 25.44               |
| 18        | 6     | 2                         | 3                 | 24.03               |
4. Result Analysis and Scheme Design

4.1 Anova
Through variance analysis, we can get the sum of squares of deviations to determine the key factors, and preliminarily determine which factors have a significant impact on the output of indicators\(^{[13]}\). In 95% confidence interval, the factors with P value less than 0.05 have a significant impact on the index. Table 3 shows that simulation factors such as the number of AGVs, the number of dumpers and scheduling methods have significant effects, while interaction factors such as the number of AGVs * scheduling methods have significant effects.

| source                                | Degree of freedom | Square sum of dispersion | Mean square | F value | P value |
|----------------------------------------|-------------------|--------------------------|-------------|---------|---------|
| AVG quantity                           | 4                 | 2742.95                  | 681.24      | 769.11  | 0.000   |
| Number of box turning machines         | 1                 | 91.98                    | 91.98       | 103.84  | 0.000   |
| Scheduling method                      | 2                 | 4932.34                  | 2466.17     | 2784.27 | 0.000   |
| AVG quantity * number of box turning machines | 4             | 5.01                     | 1.25        | 1.42    | 0.131   |
| AVG quantity * scheduling method       | 8                 | 1577.02                  | 197.13      | 222.55  | 0.000   |
| Number of turning boxes * scheduling method | 2             | 8.84                     | 4.42        | 4.99    | 0.039   |
| error                                  | 8                 | 7.09                     | 0.89        |         |         |
| total                                  | 29                | 9347.23                  |             |         |         |

4.2 Identify Key Factors
According to the principle of\(^{[14-15]}\), a few key factors lead to major problems. Therefore, the key factor to arrange the sum of squares of deviations, which accounts for more than 80% of the sum of squares of deviations, is the focus of system optimization and improvement. The square deviation of the key factors is checked by chi square. The result is shown in Figure 3. It can be seen that the dispatching method and the number of AGV account for 82.1% of the sum of squares of deviation, so the waste recycling logistics system should be based on Optimization of these two factors; for the number of dumpers, if not as a key factor, the scheme with the least investment should be chosen, only one.
4.3 Isoline Method
The contour can be constructed from the two key factors of scheduling method and AGV quantity. According to the index of average handling cycle, 10 levels were separated from good to bad, and the optimal area was below 27.523 minutes. Combined with Table 2, 12, 15, 17, 18, 20, 21, 23, 24, 26, 27, 29, 30 schemes are in the optimal region, of which 12, 17, 18, 23, 24, 29 and 30 schemes use 2 dumpers, which do not meet the requirements of Section 3.2. The remaining 5, 15, 20, 21, 26, 27, and the 15 (6 AGVs, 1 dumper, dispatching method 3) put in the least amount of AGVs, which can be determined as the optimal scheme.

After the above simulation, it can be confirmed that the automatic system is the best design scheme in the whole world, which includes six AGVs, one box-tipping machine and dispatching method 3. The actual deployment and implementation of the scheme can be referred to the scheme from computer simulation.

5. Conclusion
The key factors affecting the system are analyzed by simulation optimization method. The scheme design and optimization of waste recovery system in cigarette workshop are carried out. The optimal scheme with the least input resources is determined by experiment design, which effectively meets the requirements of lean logistics. After improving the traditional simulation optimization method, the simulation model is more practical with the distribution function or empirical distribution table of logistics operation data as the operation law. Using the minimum confidence interval of operation results to determine the optimal time or times of simulation operation, the output index data is more accurate. Through the analysis of variance and the optimization of factors, we can save resource input and improve the effect of system improvement. Combined with isoline method, the optimal scheme can be determined by key factors, which can guide the design and application of the system. Similar simulation
methods can be used to design the system in other automation scenarios of cigarette factory. Computer simulation technology effectively assists the design and construction of automated logistics system. It not only improves the automation level of logistics automation system in cigarette factory, but also greatly improves the work efficiency of cigarette factory in logistics automation system.

References

[1] Zhao Yuguo. Analysis of strategic management of Chinese logistics enterprises [J]. Chinese market, 2008 (11).
[2] Wang Ruijiang. Research on integration and optimization of tobacco logistics system [D]. Beijing: Beijing Jiaotong University, 2010.
[3] Wang Hongping. Some thoughts on the intelligent application of modern logistics [J]. China market, 2014 (44).
[4] Li Changquan, Wu Wei, Liu Feng, et al. Optimization and Improvement of Automatic Guide Vehicle (AGV) System in Cigarette Industry[J]. Tobacco Science & Technology, 2010(11): 18-21.
[5] Gong Maoguo, Jiao Licheng, Yang Wei, et al. Research on Evolutionary Multi-objective Optimization Algorithm[J].Journal of Software,2009,20(2):271-289.
[6] Liang Ruifeng, Cheng Guoquan, Wang Zhuan. Application of FLEXSIM in the Simulation of Automatic Accessories Distribution Logistics System in Cigarette Factory[J].Logistics Technology,2006(2):28-30.
[7] Li Changquan, Wu Wei, Liu Feng, et al. Optimization and Improvement of Automatic Guide Vehicle (AGV) System in Cigarette Industry[J]. Tobacco Science & Technology, 2010(11): 18-21.
[8] Ma Fengshi, Zhou Feng, Liu Chuanbing, et al. Six Sigma Management Statistics Guide [M]. 2 Edition. Beijing: China Renmin University Press, 2013.
[9] Liang Zhiqiang, Wang Yong, Yang Zhongwen. Simulation of Logistics System for Flexible Tobacco Production Line Based on EM-Plant[J]. Tobacco Science & Technology, 2009(3): 26-29.
[10] Liang Ruifeng, Cheng Guoquan, Wang Zhuan. Application of FLEXSIM in the Simulation of Automatic Accessories Distribution Logistics System in Cigarette Factory[J].Logistics Technology,2006(2):28-30.
[11] Knife Ronggui, Zhang Jinwu, Yang Xiang. Modeling and Analysis of Waste Recycling Logistics System in Cigarette Production Line[J]. Tobacco Science & Technology, 2010(12): 16-20
[12] Banks J, Carson J S, Nelson B L, et al. Discrete Event System Simulation [M]. Xiao Tianyuan, Fan Wenhui. Trans. Beijing: Mechanical Industry Press, 2007.
[13] Shi Yuren, Deng Yiyuan, Jiang Wei, et al. eM-Plant simulation technology course [M]. Beijing: Science Press, 2009.
[14] Li Chen. Discussion on the status quo and development strategy of Chinese enterprise logistics operation [J]. Chinese market, 2016 (23).
[15] Yan Youzi, Zhao Yaqing, Song Wubin. Research on function optimization of agricultural product logistics park in the era of smart logistics [J]. Chinese market, 2015 (15).