ISSN: 2664-9640

Logistics Simulation and Optimization Design of Car Coating Production Line Based on Flexsim

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Abstract

This paper analyzes the characteristics of the automobile coating production line, establishes the simulation model with Flexsim simulation software according to the process bottleneck of the model, then proposes two solutions and rebuilt the model to balance the automobile coating production line and improve the efficiency of the bottleneck link. Practice shows that the simulation technology based on Flexsim can be widely used in manufacturing enterprises, greatly improving the accuracy and efficiency of modeling.

Keywords

Automobile coating production line ；Flexsim ；simulation optimization of automobile ; production line logistics ; production balance; solutions.

1. Introduction

As a common means of transportation-car, its production mode is the assembly line operation mode. With the saturation of the automobile car market, the production mode of the automobile manufacturing enterprises is gradually transformed into production by order. The manufacturing mode of production according to the order puts forward high requirements for the production and logistics system of automobile enterprises. The traditional system design method adopts mathematical modeling and experience. Due to the complexity, dynamics and randomness of the production line, it is difficult to model many characteristics and evaluate and optimize them. Therefore, use computer modeling and simulation technology to evaluate and analyze the production system, find bottlenecks and find out improvement measures, which can effectively avoid the waste of manpower, capital and resources.

Simulation technology dates back to the late 1940 s and developed rapidly with the development of computer technology. The advantage of the simulation system is the relative flexibility and intuition, can avoid the establishment of physical test simulation system investment, reduce the design costs, and can conduct accurate calculation and verification analysis through computer technology, to improve the feasibility of the system scheme. This paper uses Flexsim software to model and simulate a production line of a manufacturing enterprise, finds the bottleneck process in the production line through the model operation, and puts forward an optimization scheme to improve the production efficiency of the production line.

2. Auto Production Line ProcessSection Headings

2.1. Process analysis of the automobile production line

The mainstream vehicle manufacturing process in the industry, including stamping, welding, painting and final assembly, are as shown in Figure 1. And the painting link is to be the body, fuel tank, engine parts and other main parts for chemical treatment, polishing, paint and drying treatment. The coating process is responsible for spraying the white body with corrosion paint

ISSN: 2664-9640

and finish after welding. Similar to the welding installation, painting is also a highly automated process. This paper focuses on the painting link, analyzing the painting process and processing the simulation.

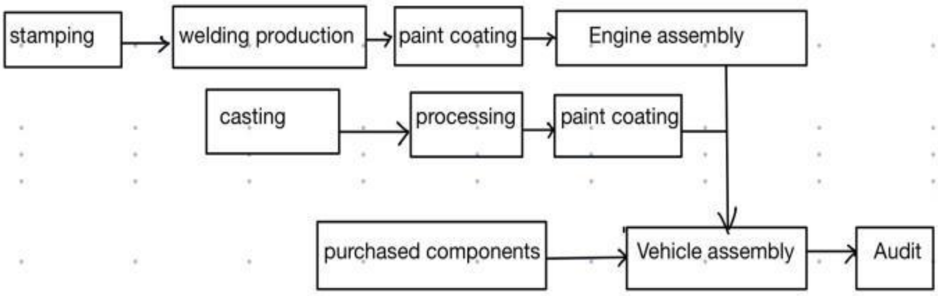

Fig 1 : vehicle manufacturing process

2.2. Production process analysis of automobile coating

Painting process of automobile production line is shown in Figure 2. When simulating the painting production line, the products in the model flow out from the generator, enter the temporary storage area, and then through chemical treatment, polishing, polishing, drying, polishing and other processes, and then enter the manual inspection and repair link, and finally to the end of the absorber. Each processes are connected by conveyor belts to facilitate the transmission of the product. During the operation of the model, if the process cannot be handled in time, there will be some blockage of the production line, which can be alleviated by increasing the number of machines of the corresponding process or adjusting the speed of the conveyor belt.

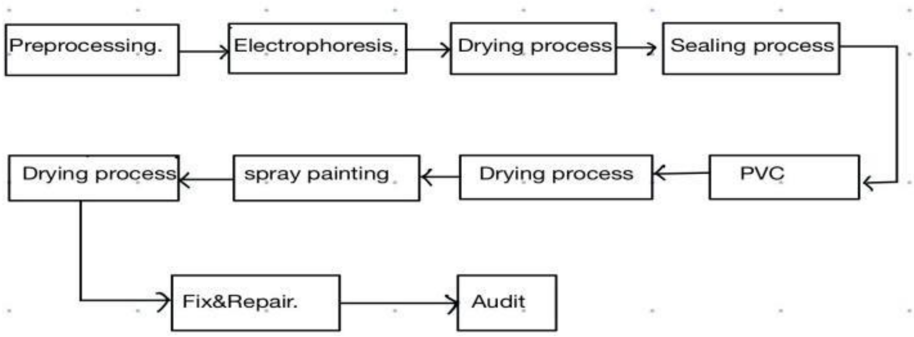

Fig2:Painting process of automobile production line

3. Simulation and optimization of Automobile Painting Production Line

3.1. Flexsim simulation software

Flexsim Simulation Software is a three-dimensional general logistics simulation software developed by Flexsim, developed in the C++ language, and supports the modeling of discrete systems and continuous fluid systems. For the automobile painting production line, it is easy to establish the process model of the production line with Flexsim, and find out the problems existing in the production according to the Flexsim operation results. Therefore, this paper uses Flexsim to establish a motorcycle painting production line model, using the version of Flexsim7.

3.2. Simulation model design and optimization

3.2.1 Simulation model

(1)Set the following simulation parameters

The rate of product entry from the welding workshop meets the normal distribution normal(50,3,0);

ISSN: 2664-9640

(2)The speed of pretreatment, electrophoresis, drying and pvc processes complies with the triangle distribution function triangular(0.5,1,1.5,0)

(3)Transfer belts 1,2, and the length of Conveyor1, Conveyor2 in FIG. 3 is L1, L2, respectively. The speed of the conveyor belt is adjustable, with V_{L1}, V_{L2}, respectively. The speed of the conveyor belt can be adjusted according to the actual situation of the production line, such as the processing capacity of each link, whether causing blockage and other factors;

(4)Other human factors are not temporarily considered in the simulation of the production line logistics system

3.2.2 Automobile painting simulation model based on Flexsim

Step 1 Establish the Flexsim simulation model of coating production line According to the coating production line model, use Flexsim preparation procedures, add entities, connect entities, and establish the simulation model diagram of Flexsim painting production line shown in Figure 3

Step 2 First set the entity parameters , According to the data collected in actual production, the rate of the product from the welding workshop meets the normal distribution noraml(50,3,0);

Second, set the parameters of the conveyor belt, the speed of the conveyor belt can be adjusted, the speed of all the conveyor belts in the setting model is 1 unit, and the conveyor belt length is 10 unit length;

Third, according to the data collected in the actual production, the processing time of preprocessing, electrophoresis, drying, pvc and other processes is as shown in the Chart1.

Fourth, according to data collected in actual production, 1000 Queen1,

Fifth, spraying (Painting) is the key and difficult process, so it is a little slower than other

The other facilities are set by default. After the above steps, the simulation model is established and the preparation procedure is completed.

Step 3: In the menu bar, click the [Execute] command. After compilation, the company produces 8h, a day so simulation time was 28800s.Set the running time to 28,800 units and click the [Run] button to start running the model. Click the [Statistics] button to output the statistical report as shown in Table 1.Also available via Dashboard is shown in Figure 4

Chart1: Processing time of each link

production processes.	CT/s
Preprocessing.	135s
Electrophoresis	103s
Drying process 1.	130s
Sealing process.	132s
PVC.	153s
Drying process 2.	141s
Spray painting.	181s
Drying process 3	181s
Fix&Repair.	222s
Audit	216s

ISSN: 2664-9640

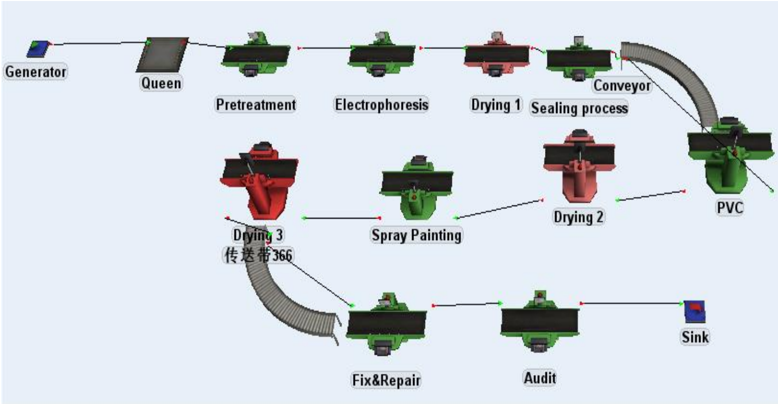

Fig 3: Simulation model diagram

Table 1:Running Statistics from the model

Object	idle	busy	blocked	generating	empty
Generator	0. 00%	0. 00%	0. 00%	100. 00%	0. 00%
Queen	0. 00%	0. 00%	0. 00%	0. 00%	1. 18%
Pretreatment	0. 34%	35. 81%	0. 00%	0. 00%	0. 00%
Electrophoresis	7. 26%	0. 00%	36. 16%	0. 00%	0. 00%
Drying 1	2. 15%	0. 00%	26. 97%	0. 00%	0. 00%
Spray Painting	3. 79%	94. 97%	66. 00%	0. 00%	0. 00%
Drying 3	3. 33%	0. 00%	9. 53%	0. 00%	0. 00%
Sealing process	2. 20%	33. 15%	26. 30%	0. 00%	0. 00%
Conveyor	0. 00%	0. 00%	95. 88%	0. 00%	4. 02%
PVC	2. 09%	30. 30%	22. 65%	0. 00%	0. 00%
Drying 2	2. 83%	0. 00%	28. 31%	0. 00%	0. 00%
Conveyor 2	0. 00%	0. 00%	94. 26%	0. 00%	5. 66%
Fix&Repair	3. 97%	0. 00%	0. 00%	0. 00%	0. 00%
Audit	7. 31%	0. 00%	0. 00%	0. 00%	0. 00%
Sink	0%	0%	0%	0%	0%

3.2.3 The Problems Analysis in the Production Line

(1) The equipment utilization rate of the production line is much different, and the production line is seriously unbalanced.

(2)The line has high utilization.

(3) The production line is available in a too high number of products. The excessive accumulation of products takes up a lot of space, so the cost is wasted.

(4) operator utilization, long idle time and personnel redundancy.

(5) also shows the spraying schedule of 94.97% and the production efficiency of only 30.14%. The blocking rate of 66% leads to a certain degree of obstruction in the subsequent processes.

(6) The blocking rate of both conveyor belts is about 95%, resulting in free time in subsequent processes and lower efficiency than expected

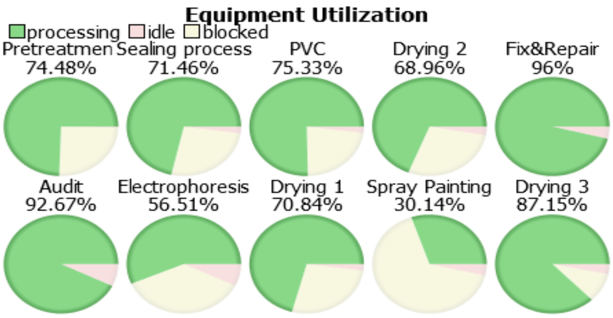

Fig 4:Equipment Utilization via Dashboard

3.2.4 Optimization scheme:

Scheme I : It is simple to add a temporary storage area, which can also reduce the blocking rate of the original link lines of the original temporary storage area, but it is difficult to improve the rate of spraying, because in the existing production conditions, the rate has reached a higher level. That is, if the spraying rate cannot be increased. Then this method is unfavorable for the subsequent operation.

Scheme II:①It can be seen that the bottleneck link of the whole automobile painting production line is the spraying link. Therefore, the spraying process needs to be optimized. According to the blockage of the spraying link, a processor (Spray painting 3) to the spraying link of the coating production line can not only solve the accumulation problem in the temporary storage area, but also improve the number of vehicles spraying per unit time. But while increasing the equipment, the relevant supporting personnel should also be added.

②Increase the length of conveyor 2 to 10 units .Based on the above scheme, comparing scheme 2 saves a lot of capital investment for enterprises, but the possibility of realizing scheme 1 is small, so the following mainly adopts schemeII for simulation. The optimized model is shown in Figure 6.

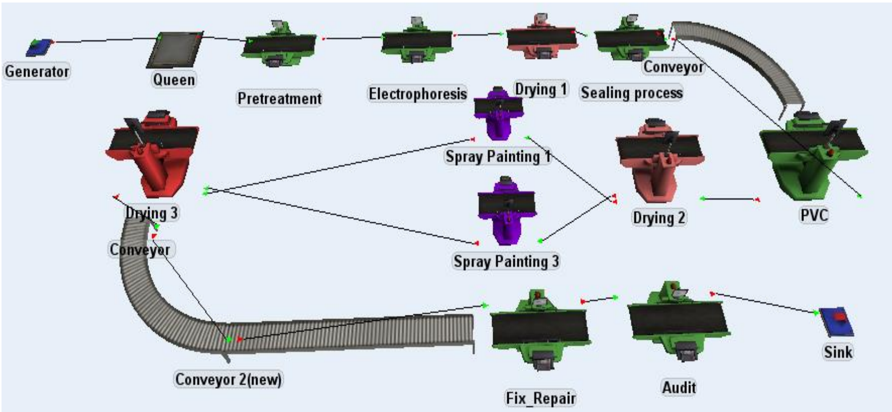

Fig 6 :Optimized model diagram

Table 2 :Equipment Utilization of the updated model

Object	idle	busy	blocked	generating	empty
Gnerator	0. 00%	0. 00%	0. 00%	100. 00%	0. 00%
Queen	0. 00%	0. 00%	0. 00%	0. 00%	1. 18%
Preteatment	0. 00%	33. 14%	15. 08%	0. 00%	0. 00%
Electrophoresis	80. 01%	74. 24%	22. 28%	0. 00%	0. 00%
Drying 1	80. 01%	0. 00%	16. 34%	0. 00%	0. 00%
Spray Painting 1	80. 02%	78. 53%	8. 66%	0. 00%	0. 00%
Drying 3	80. 03%	73. 58%	15. 29%	0. 00%	0. 00%
Spray Painting 2	0. 00%	77. 95%	34. 97%	0. 00%	84. 35%
Conveyor 1	80. 06%	0. 00%	24. 89%	0. 00%	4, 72%
Sealing process 1	80. 06%	73. 26%	15. 89%	0. 00%	0. 00%
PVC	0. 00%	72. 78%	11. 11%	0. 00%	84. 32%
Drying 2	80. 07%	73. 43%	12. 33%	0. 00%	35. 66%
Conveyor 2(new)	80. 05%	0. 00%	14. 64%	0. 00%	0. 00%
Fix&repair	80. 08%	0. 00%	7. 07%	0. 00%	0. 00%
Audit	80. 09%	0. 00%	0. 00%	0. 00%	0. 00%
Sink	0. 00%	0. 00%	0. 00%	0. 00%	0. 00%

Set the same parameters and run the model, output the optimized statistical report such as Table 2 and state pie via Dashboard in Figure 7.

ISSN: 2664-9640

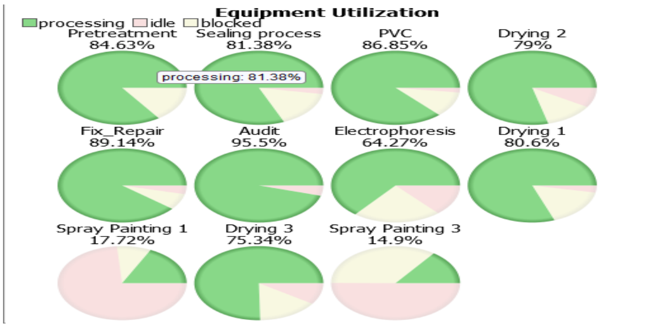

Fig 7: Statistics from updated model

3.2.5 Results analysis:

①Analyze the data in Table 2, except two processes (Conveyor1 Conveyor2 blockage and slightly low work efficiency）, the remaining processes are basically balanced

②Compared with Table 1, the data in Table 2 were somewhat improved, the busy rate of the processor decreased by about 20%, and the blocking rate of each process was also well relieved. The maximum blocking rate for the entire process is 34.97%, compared with the initial maximum blocking rate(95.91%), which decreased by about 60%.The blockage of the overall process is basically solved. At the same time the busy rate of the whole coating process processor basically reaches the balance (about 75%).The conveyor belt load is also at a better level. Meanwhile each link processing rate increased by around 10% compared to the previous figure, especially the spray painting link, almost half but the processing rate remains normal.

3.2.6 Line balance analysis

Line balance is load analysis of the line. It is a technical method to reach balance of each process(operation time is as close as possible)by adjusting the load distribution between processes. And finally eliminate various waiting waste phenomena thus improving the overall efficiency of the production line.

The balance of the production line is measured by production beats that match the following formula

$$T = \frac{T_a}{T_d} \tag{1}$$

T Production Beat for Demandc ;

Ta (Time available) min/d ;

Td refers to Customer Demand Time item/d

$$CT = \delta \times Max（T_i） \tag{2}$$

$$T_i = T_h + T_m - T_b \tag{3}$$

$$T_i = \sum_{i=1}^{n} \frac{T_i}{n \times CT} \times 100\% \tag{4}$$

CT for the production beats ; δ is the beat fluctuation factor ;

Tm is the machining time for each process

Tb is the parallel processing time of manual and machine in each process

Formula (4) Calculation formula of the production balance rate

By formula (1), the production beat depends on the longest process, which means that , the time of the production bottleneck station is the spraying painting link. We roughly achieve the line balance by optimizing the

4. Conclusion

This paper simulated and optimizes the production system according to system modeling steps. First, the automobile production line process, especially the coating process with simulation and optimization model based on Flexsim software. We found the bottleneck of the automobile painting production line logistics system, according to the model simulation calculation results. By increasing the spraying painting processor and adjusting the parameters, optimizing the painting production line model twice, the efficiency and smoothness of the automobile painting production line reached an ideal level. Simulation and optimization using Flexsim software effectively improve the production efficiency.

References

[1] Fabio Sgarbossa, Eric H. Grosse, W. Patrick Neumann et al. Human factors in production and logistics systems of the future[J] Annual Reviews in Control, 2020, 49

[2] Lin Yu,Guo Jie. Efficiency improvement method research about the assembly line based on JIT ［J］. Industrial Engineering and Management,2012,17(3) : 124-128.

[3] Seleim A,Azab A,AlGeddawy T. Simulation methods for changeable manufacturing ［J］. Procedia CIＲP,2012 (3) : 179-184.

[4] ］Chen Li-hong,Hu Da-wei,Xu Ting. Highway freight terminal facilities allocation based on flexsim

[5] Information on: http://www.weld.labs.gov.cn

[6] Ceng Qing-xun,Jiang Xiao-bo,Tan Zhen,et al. Leakage test efficiency promotion based on the flexsim rear axle assembly

[7] Peng Jun. Mixed production line balancing and optimization based on flexsim ［J］. Modular machine tool ＆ automatic manufacturing technique,2014(9) : 140-143.

[8] Wang Chuan-lei,Li Lei,Liu Hong-wei. Simulation and optimization of the logistics operator of a production line based on flexsim ［J］. Logistics Sci-Tech,2011,30(8) : 58-60.

[9] Yi Shu-ping,Guo Fu. Fundament of Industrial Engineering ［M］. Beijing: China Machine Press,2007: 186-188.

[10] Ye Xiao-su,Cai Yong. The research of the line balancing under the lean production ［J］. Mechanical ＆ electrical,2009, 38(11) : 58-59.