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The Simulation and Optimization Research of a Filling Station Based on Flexsim

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Abstract: To simulate the actual situation of a filling station, two simulation methods are used, manual simulation and computer simulation. In addition, while comparing the results from two simulation ways, some suggests have been proposed and latter evaluated through computer simulation. Finally, the data shows that the performance in the filling station is improved.

Keywords: Computer Simulation; Manual Simulation; Filling Station; Improving Proposal; Flexsim

INTRODUCTION

Computer simulation is an applied technology that is especially useful for analyzing and solving problems. It is very popular in some industries, such as manufacturing, logistics, serving, etc[Ma et al., 2012][Liu et al., 2013]. Filling station belongs to serving industry, where the customer's satisfaction is very important, and needs to be kept relatively high with a high operating efficiency. By combining manual and computer simulation, the operation in the filling station will be observed and the results will be analyzed in this text. In addition, to evaluate and improve the performance in the filling station, comparative analysis will be taken as the main method for analysis.

There are some expected things. The goals of improving the performance and customer satisfaction can be get.

COMPUTER SIMULATION

Generally, computer simulation can be defined as the experiment on system to get some data about several objects, for some existent or unknown systems are difficult to research directly[Yang et al., 2013][Li et al., 2015]. Actually, there are some systems not appropriate to be experimented directly on for some reasons like danger , cost and indirection.

Flexsim has been chosen for use with this research because of its ease-of-use and rich functionality that allows readers to focus on simulation concepts and methods[Beaverstock et al., 2011][Zhao et al., 2012]. Flexsim including the ports for connecting other outside-software has many functions, like data matching, modeling, virtual reality display, auto-optimizing, etc. Its construction and simulation steps are shown in Figure1.

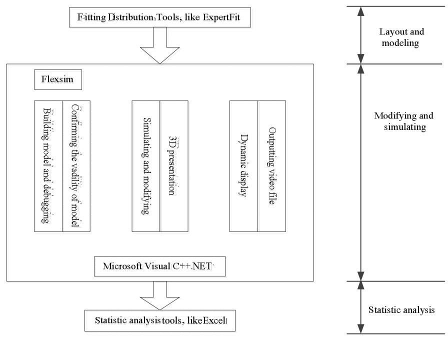

Figure 1. Construction and simulation steps in Flexsim

FILLING STATION AND QUEUING THEORY

Queuing for service in filling station is a familiar phenomenon. The queuing phenomenon exists in filling system as long as resources are in short supply, and service's supplies cannot meet the customer's demand. In addition, the bad flow and service ability performances for the serious phenomenon of queuing, excessively the long waiting time of customers or the serious waste phenomenon of service resources. Therefore, the purpose of analyzing queuing system is to balance the queuing time for customers with the idle time for services, to make both of the service performance and its operation efficiency remain relatively high[Cui et al., 2016][Zhang et al., 2015].

Some common operating parameters for evaluating a filling station include the following:

1) the utilization of service equipment, ρ

$$\rho = \text{average service time}/(\text{average inter - arrivaltime}) = \lambda/\mu$$

λ refers to the customers' average arrival rate, μ refers to the services' average service rate , namely, the number of customers enjoying service one unit time.

In reality, $\rho < 1$.

2)the customers' average wait time, W_q

$$W_q = \lim_{n \to \infty} \sum_{t=1}^{n} D_i / n$$

D_i refers to customer i 's wait time; n refers to the number of customers whose demand has been met.

3)the customers' average stay time, W

$$W_q = \lim_{n\to\infty} \sum_{t=1}^{n} W_i / n = \lim_{n\to\infty} \sum_{t=1}^{n} (D_i + S_i) / n$$

W_i refers to customer i 's stay time and equals the sum of D_i (wait time) and S_i (served time).

4) the average queuing line, L_q

$$L_q = \lim_{t\to\infty} \int_0^T L_q(t)dt / T$$

$L_q(t)$ refers to the queuing line at t time state; T refers to the total simulation hour.

5)the average line of customers in system, L

$$L = \lim_{T\to\infty} \int_0^T L(t)dt / T = \lim_{T\to\infty} \int_0^T [L_q(t) + S(t)]dt / T$$

$L(t)$ refers to the line of customers at t time state; $S(t)$ refers to the number of customers enjoying service at t time state.

The customers' average stay time, the utilization of service equipment, and the services' average service time have been chosen for use with this research.

MODELING AND SIMULATION OF A FILLING STATION

Background

（1）The filling System

The filling station includes a filling equipment 'A'[Ma et al., 2012]. If the filling equipment is busy, customer must wait. Through simulating, the average queuing line, the average processing time and the utilization of service equipment should be figured out.

The system state parameters include Q（t）referring to the average number of customers who are waiting for filling at t time state and A （t） referring to the state of filling equipment at t time state (1 means busy; 0 means idle).

（2）System Data

1) Customers randomly arrive at the filling station. Arrival information is showed in table 1 .

Table 1 Arrival information

Time between arrivals (unit: minute)	Probability	Cumulative probability	Random number
1	0.25	0.25	01～25
2	0.40	0.65	26～65
3	0.20	0.85	66～85
4	0.15	1.00	86～00

2) Service information on the equipment 'A' is presented in table 2.

Table 2 Processing time on the equipment 'A'

Processing time (unit: minute)	Probability	Cumulative probability	Random number
2	0.30	0.30	01～30
3	0.28	0.58	31～58
4	0.25	0.83	59～83
5	0.17	1.00	84～00

2) The following arrival schedule table3 is set up based on the data provided above.

Table3 Time between arrivals and relative processing time (unit: minute)

Customer member	1	2	3	4	5	6	7	8	9	10	11	12
Random number of arrival		26	98	90	26	42	74	80	68	22	48	34
Random number of processing	95	21	51	92	89	38	13	61	50	49	39	53

Customer member	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Random number of arrival	45	24	34	63	38	80	42	56	89	18	51	71	16	92
Random number of processing	88	1	81	53	81	64	1	67	1	47	75	57	87	47

Modeling and Simulation

Manual Simulation

（1）The following table4 is set up based on the table1, 2and 3 provided above.

（2）Results

1）The average queuing line: 337/26=12.96（min）;

2）The average processing time: 89/26=3.42（min）;

3) The utilization of service equipment 'A': 89/89=100%.

Computer Simulation

（1）Modeling and Modifying

1）Layout and Connecting

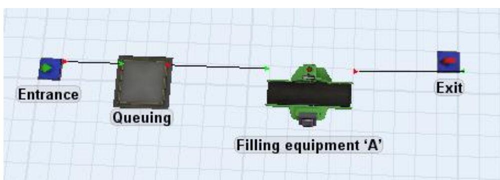

Figure2. Layout and connecting

2）Settings of Model Based on Table 4

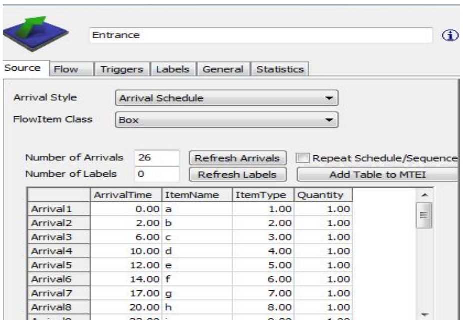

Figure 3. The setting of ‘entrance’

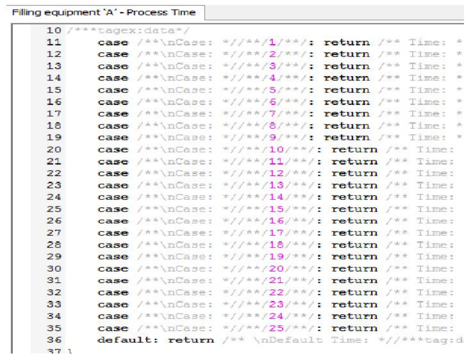

Figure 4. The setting of ‘filling equipment ‘A”

Table4 Manual simulation schedule (unit: minute)

Customer member	Random number of arrival	Time between arrivals	Arrival time	Random number of processing	Time for beginning to serve	Processing time	Time for stopping serving	Queuing time
1		0	0	95	0	5	5	0
2	26	2	2	21	5	2	7	3
3	98	4	6	51	7	3	10	1
4	90	4	10	92	10	5	15	0
5	26	2	12	89	15	5	20	3
6	42	2	14	38	20	3	23	6
7	74	3	17	13	23	2	25	6
8	80	3	20	61	25	4	29	5
9	68	3	23	50	29	3	32	6
10	22	1	24	49	32	3	35	8
11	48	2	26	39	35	3	38	9
12	34	2	28	53	38	3	41	10
13	45	2	30	88	41	5	46	11
14	24	1	31	1	46	2	48	15
15	34	2	33	81	48	4	52	15
16	63	2	35	53	52	3	55	17
17	38	2	37	81	55	4	59	18
18	80	3	40	64	59	4	63	19
19	42	2	42	1	63	2	65	21
20	56	2	44	67	65	4	69	21
21	89	4	48	1	69	2	71	21
22	18	1	49	47	71	3	74	22
23	51	2	51	75	74	4	78	23
24	71	3	54	57	78	3	81	24
25	16	1	55	87	81	5	86	26
26	92	4	59	47	86	3	89	27
∑						89		337

（2）Running and Observing

1）The average queuing line, as shown in figure 1-5;

2）The average processing time, as shown in figure 1-6;

3）The utilization of service equipment ‘A’, as shown in figure 7.

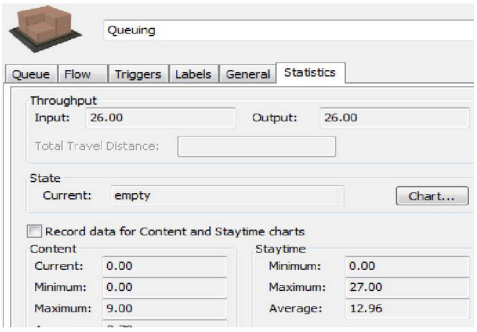

Figure5. The average queuing line

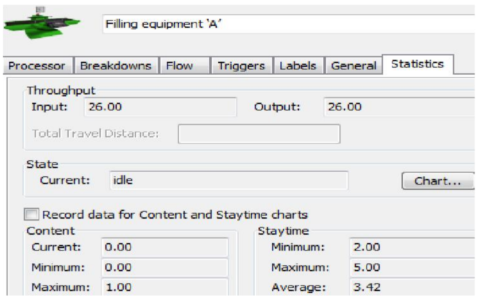

Figure 6. The average processing time

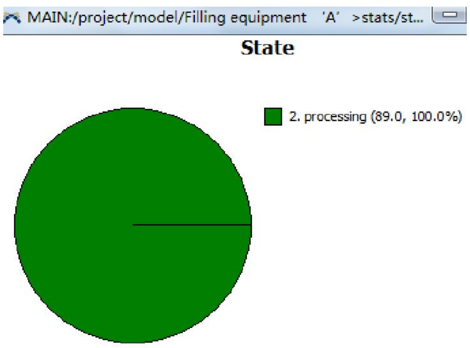

Figure7. The utilization of service equipment ‘A’

4）Result

1）The average queuing line is 12.96（min）.

2）The average processing time is 3.42（min）.

3）The utilization of service equipment ‘A’ is 100%.

Analysis

The following table 5 is established based on the results above.

Table 5 Comparative analysis on the results above

	The average queuing line	The average processing time	The utilization of service equipment ‘A’
Manual simulation	12.96 (min)	3.42（min）	100%
Computer simulation	12.96 (min)	3.42（min）	100%

It is obvious that the data from two different simulation methods are extraordinary same. But the data itself should be analyzed further. The service equipment ‘A’ is always busy for its utilization is 100%. However, the whole efficiency of the filling system is low as the average queuing line is 3 times as much as the average processing time. In this situation, the customer’s satisfaction must be pretty low as well. To improve this situation, another service equipment should be added in.

Prioritization Scheme

Introduction

Adding service equipment ‘B’ in the filling system. There are two equipment for serving and it is be expected that equipment ‘A’ will be the most utilized and equipment ‘B’ the least for when equipment ‘A’ is busy, equipment ‘B’ will be used. Again, the average queuing line, the average processing time and the utilization of service equipment will be focused on.

The data of equipment ‘B’ include the following and other agents’ data are as same as the former.

1）B（t）refers to the state of filling equipment ‘B’ at t time state (1 means busy; 0 means idle);

2）Service information on the equipment ‘B’ is represented in table 6;

3）Time between arrivals and relative processing time are shown in table3.

Table 6　Processing time on the equipment ‘B’

Processing time (unit: min)	Probability	Cumulative probability	Random number
3	0.35	0.35	01～35
4	0.25	0.60	36～60
5	0.20	0.80	61～80
6	0.20	1.00	81～00

Evaluation

（1）Manual Simulation

The following table7 is set up based on the table1, 6 and 3 above.

1) Results

① The average queuing line: 11/26=0.42（min）;

② The average processing time: