Production Logistics Research and Demonstration based on Network Planning technique and Theory of Constraints

Zhilan Song[1] Yueyi Liu[1]

[1]Yunnan University of Financial and Economics, Kunming, Yunnan Province, China

Abstract

The Logistics of production is an important part of enterprises logistics. Whether it can be smooth is related closely to the economic benefit and business competitiveness. In order to better the efficiency, making processes of production rational and plan the layout of equipments are needed. Presently, manufacturers' design of layout and processes are made by intuitive judgments, not constraints. In this paper, theory of constraints is used to investigate the constraints of production. Then use network planning technique to analysis the critical path of process. By setting Autumn pesticides Co., Ltd. as the example to make a demonstration, hope to supply a universal methods to make the production logistics rational.

Keywords: TOC, Network planning technique, Production logistics, Demonstration

1. Introduction

Production logistics refers to the production process of transportation or transport, storage, processing, loading and the information flow. It is the bond of all aspects of the manufacturing [1]. The production logistics covers all the scope of activities and includes the whole movement needing for the materials both in space and time. And it is a process which makes materials leaves one craft to the next continually. In fact, the production logistics has formed the most important part of the process and becomes a key link.

In short, production logistics is made up of production and logistics activities. Planning of production logistics is inseparable from the consideration of the production process. From this view, three aspects of it should be needed: effect of the logistics process, capacity of the logistics equipment and layout of the factory. Only by fully taking into account the impact of these aspects, manufacturing enterprises can make logistics of production reasonable and performance better.

2. Theory of constraints

2.1. Origin and development

In the 1980s, Israeli physicist, Gedelate founded the Theory of Constraints (TOC) based on OPT. The key idea of it is the performance of the entire system is usually decided by a few factors, constraints.

In the late 1980s, TOC came into a system and gradually developed into a theory about sales rate, rather than the theory about traditional cost-oriented and methods. From 1990s, it was developing into a thinking process to solve problem (TP).which made TOC a mature management philosophy.

2.2. Effect on the production flow

TOC believes that if products can go through the production system as fast as they can, the system will achieve the balance of logistics which is difficult to reach. So TOC proposes to make the rhythm of input and constraints same to shorten the production cycle. However, it can reduce the amount of materials on the line so as to make the level of storage continuous and steady.

2.3. Assumption for application

The production logistics is affected by factors external and internal, so dose production processing, too. So it needs to be hypothesized in both.

2.3.1 Assumptions of the constraints of production logistics

There are many influence factors in and out of enterprise which not only include policies, laws, changes in the market, competitors in external, but also include staff; capital, management and some will impact the survival of enterprises. In this case, TOC can be used to help identify constraints, which is the weakest link in the whole operation.

In order to put it clear, assume that there is only some constraints existing in the internal of production system. In summary, the paper assumes that the production is the biggest constraint in the operation.

2.3.2 Assumption of the constraints of production processing

TOC believes that the utilization of resource is not restricted by its own capacity, but the constraints of the system. Namely, the capacity of the logistics system is not on the ability of maximum part, but on the minimum part.

Meanwhile, the production logistics is that materials keep moving and passing continuously. So the layout of equipment and the design of process are the key to resolve constraints.

In summary, assuming that the production processes is the very constraint of production processing.

3. Network planning technique

3.1. Basic elements

3.1.1 Network diagram

Network diagram is a model which describes the whole project task decomposition and synthesis. Decomposition refers to the division of engineering tasks. Synthesis means to solve the collaboration and coordination of tasks[2].

Drawing network diagram is the basis of network planning. Network diagram is consists of the following components:

(1) Activity. It is an independent work, job or task in engineering project. Activity is represented by an arrow lines.

(2) Event (Node). It is a point between adjacent activities in the project which is presented by ○.

(3) Line. From the starting point and goes along with the direction of the arrow to reach the end of a continuous path.

3.1.2. Time Parameters

In the whole process, it includes people, events, materials and states of motion. Those states of motion are changing into a function of time to reflect[3].

3.1.3. The critical path

By calculating the time parameters, the critical path (CP) can be founded. According to the meaning of CP, critical path has the following characteristics:

(1) The sum of all activities on the critical path is the total time for the project.

(2) Any activities on the path are the critical activities, and any delay of each will lead to postpone the whole project[5].

(3) The critical path is the longest line. So the only way to shorten the time for the entire project is to reduce the time on the critical path.

(4) The time of the CP is the shortest one to complete the project successfully.

3.2. Basic for combining TOC and CP

TOC and CMP both emphasized the "constraints" impact on production activities. This ground makes combining the two theories possible. Another combination is they can complement each other. The network planning is only considering the logical constraints between tasks, regardless of constrains of resource among tasks, namely the CMP is used based on the assumption that the system operated on infinite resource. Therefore, if TOC can be used the network planning, it can create a better way to keep logistics balance.

4. Demonstration in Autumn pesticides Co., Ltd.

4.1. Overview of production logistics

The synthesis workshop is an important part which is not only responsible for the synthesis task of atrazine, but also providing raw materials for the mixture. Therefore, the capacity of synthesis workshop plays an important role.

4.1.1 The composition of production logistics

The production logistics mainly compose of synthesis, grinding, sanding, filling and packaging, five parts.

4.1.2. The production equipment

The main equipment of the workshop is synthesis reactor, inkjet printer, conveyors and some necessary pipeline. These devices constitute the production logistics smooth and efficient.

4.1.3 Analysis to determine critical path

Let's analysis and find the critical path based on the following specific activities. Figure 1 is process flow.

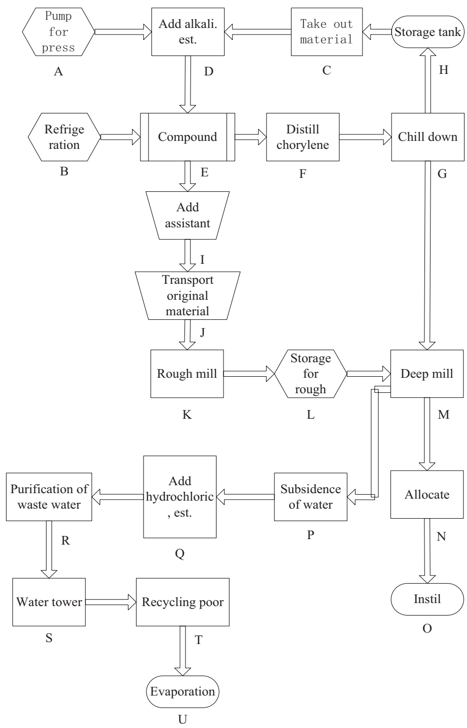

Fig. 1: Process flow.

According to practice, list each time of each activity. Show in table 1.

Draw the network diagram, and calculate the time parameters.

Activity	Later activity	Time (minute)	Activity	Pre activity	Time （minute）
A	C	5	K	L	140
B	E	30	L	M	5
C	D	20	M	N/P	240/10
D	E	156	N	O	60
E	F/I	25/20	O	——	30
F	G	5	P	Q	60
G	H/M	7	Q	R	25
H	——	360	R	S	60
I	J	20	S	T	3
J	K	3	T	U	20

Table 1: Time and relation of activities.

Formula 5 as follows:

(1) The earliest starting time of node (ES)

$$ES_j = max\{ES_i + T_{ij}\} \quad (1)$$

ES_i - The earliest starting time of node

ES_j - The earliest starting time of node

T_{ij} - Time for operation

If a node has more than one time, the maximum should be taken.

(2) The latest finishing time of node (LF)

$$LF_j = min\{LF_i - T_{ij}\} \quad (2)$$

LF_i - The latest finishing time of node

LF_j - The latest finishing time of node

T_{ij} - Time for operation

If a node has more than one time, the minimum should be taken.

(3) The earliest starting time of activity (ES_{ij})

$$ES_{ij} = ES_j \quad (3)$$

ES_{ij} - The earliest starting time of activity

ES_j - The earliest starting time of node

(4) The earliest finishing time of activity (EF_{ij})

$$EF_{ij} = ES_{ij} + T_{ij} \quad (4)$$

EF_{ij} - The earliest finishing time of activity

ES_{ij} - The earliest starting time of activity

T_{ij} - Time for operating

(5) The latest finishing time of activity (LF_{ij})

$$LF_{ij} = LF \quad (5)$$

LF_{ij} - The latest finishing time of activity

LF - The latest finishing time of node

(6) The latest starting time of activity (LS_{ij})

$$LS_{ij} = LF_{ij} - T_{ij} \quad (6)$$

LS_{ij} -The latest starting time of activity

LF_{ij} - The latest finishing time of activity

T_{ij} - Time for operation

(7) The time difference between nodes (Z_{ij})

$$Z_{ij} = LF_{ij} - EF_{ij}$$

$$Z_{ij} = LS_{ij} - ES_{ij} \quad (7)$$

Z_{ij} - Time difference between nodes

LF_{ij} - The latest finishing time of activity

EF_{ij} - The earliest finishing time of activity

LS_{ij} - The latest starting time of activity

ES_{ij} - The earliest starting time of activity

(8) The most likely time of activity (T_e)

$$T_e = \frac{T_o + T_p}{2} \quad (8)$$

T_e - The most likely time for activity

T_o - The shortest time for activity

T_p - The longest time for activity

Calculate the time of each node on the process based on the above formula and the results are shown in figure 2 and table 2.

The critical path for the synthesis workshop is shown by shadow in Figure 3.

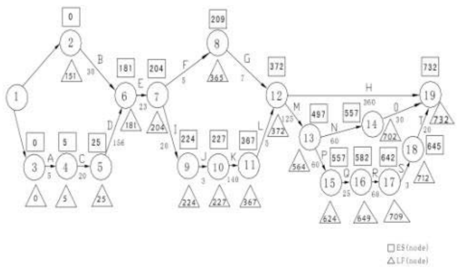

Fig. 2: Time of nodes.

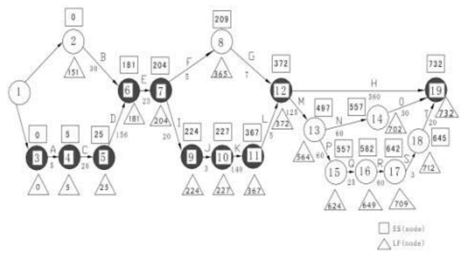

Fig. 3: The critical path.

Activity	T	ES	EF	LS	LF	Z	CP
A	5	0	5	0	5	0	√
B	30	0	30	151	181	151	
C	20	5	25	5	25	0	√
D	156	25	181	25	181	0	√
E	23	181	204	181	204	0	√
F	5	204	209	360	365	156	
G	7	209	216	365	372	156	
H	360	372	732	372	732	0	√
I	20	204	224	204	224	0	√
J	3	224	227	224	227	0	√
K	140	227	367	227	367	0	√
L	5	367	372	367	372	0	√
M	125	372	497	439	564	67	
N	60	497	557	642	702	145	
O	30	557	587	702	732	145	
P	60	497	557	564	624	67	
Q	25	557	582	624	649	67	
R	60	582	642	649	709	67	
S	3	642	645	709	712	67	
T	20	645	665	712	732	6a7	

Table 2: Time for activities.

So, the critical path is 3-4-5-6-7-9-10-11-12-19.

4.2. Constraints on the critical path

4.2.1. Layout of factory unreasonable

In the rush hour, for example, storage of finished products is too difficult for the distance between workshop and warehouses is too long so as to the storage of finished products can not be stored timely. Figure 4 is the current layout of factory.

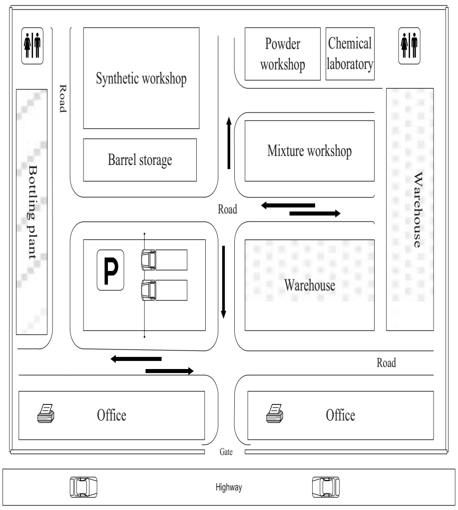

Fig. 4: Layout the old site.

4.2.2. Layout between each process irrational

During the production, pipeline transports liquid are too circuitous to convey raw materials on time. Moreover, environmental protection equipments are far away from the workshop so as to the polluted water can not been cleared quickly. The specific layout is shown in Figure 5.

4.3. Measures to solve the “constraints”

Taking consideration of expanding factory in 2011 some suggestion are proposed to the blueprint.

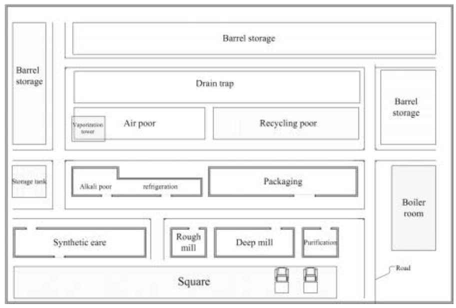

Fig. 5: Layout of old synthetic workshop.

4.3.1. Make the factory layout reasonable

(1) Make full use of two highway built around the factory. One road is mainly used for transportation of finished products, and the other is used for raw materials.

(2) Divide the factory into three parts

Test area is located in the center of the work, which makes setting information between workshop and test part easily. The location of raw materials warehouse is in the back which is convenient to transport materials to the workshop. Moreover, located in this area, make materials convenient to management since the raw material is flammable, explosive, and poisonous. The new factory layout of each functional area is shown in Figure 6.

4.3.2. Distribute workshop equipment and process rational

In order to achieve the objective of improve efficiency of workshop; the machines of it are replaced.

(1)The workshop is divided into two parts; the first part is the production area, including the synthesis, packaging.

Another part is the effluent disposal area, including cycling pool and vaporization machine.

(2) Move the boiler room off the packing room, which is close for providing heating to the synthesis workshop.

(3)The workshop has small working areas to loaf and unload the large number of products per day.

New workshop's layout is shown in Figure 7.

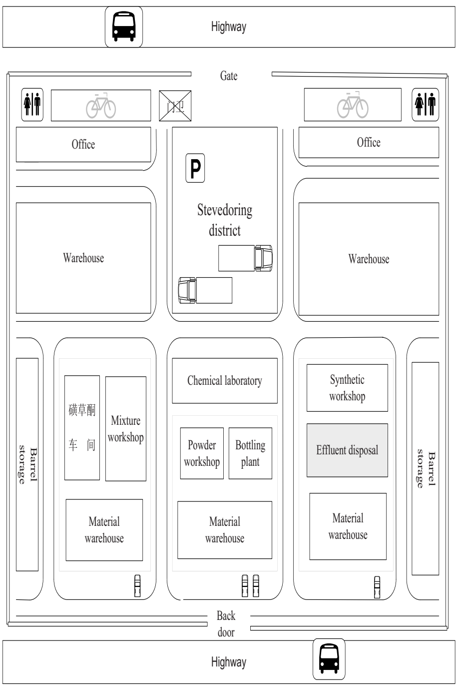

Fig. 6: Layout for new site.

4.4. Expected results of measures

Production logistics is an important component of modern logistics and is also an important factor which affects production. Better production logistics management can shorten the production cycle and educe the number of raw materials in the warehouse. Thus, according to measures, the new plan can achieve the following expected results:

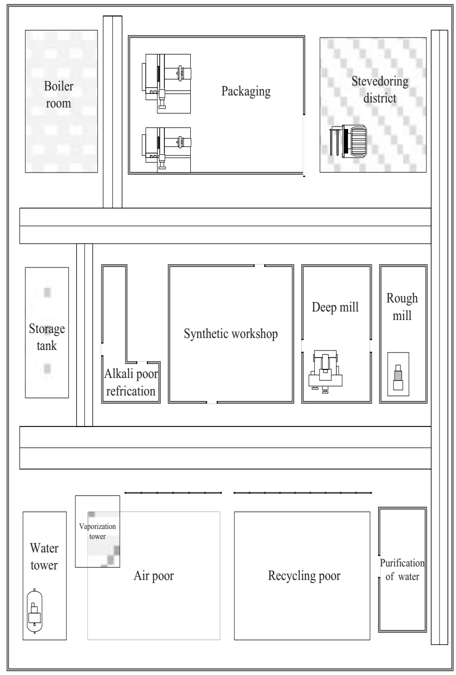

Fig. 7: Layout of new synthetic workshop.

(1) Using the new layout will reducing the time of materials in the pipelines and roads, which is expected to shorten the producing, cycle 10%, 1-2 hours.

(2) Re-planning the location of the wastewater purification will reduce the time of waste water entering in the filter equipment and extend the evaporation time.

(3) Shorten the distance between warehouse and 1-2 hours of transporting production. Making full use of the advantages of two roads let transport raw materials and finished products easier.

5. Conclusions

Production logistics is the shortcoming of many manufacturers. Enhancing the ability of production logistics can both meets market demand quickly and create value highly. In this paper, setting Autumn pesticides Co., Ltd. as evidence to demonstrate TOC and CMP, try to find a method to solve logistics questions. Moreover, this approach is also applicable to other companies. Moreover, the method is still inadequate for the study is limited. However, this article makes a specific application of TOC and provides a method can extend to all areas.

References

[1] Liu Xiaohui. Information management for Logistics.2006, (1):P146
[2] Hu Xinsheng. Method of analysis for Logistics Management, (2)2005:P204~205
[3] Hu Xinsheng. Method of analysis for Logistics Management, (2)2005: P211~215
[4] Robins. Management.2003.(7):P240
[5] Chen Qiurong. Ma Shihua, Operation Management.2007.(2):P389-390