EFFICIENCY IMPROVEMENT OF DRIED LONGAN PRODUCTION LINE USING ECRS PRINCIPLES

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Introduction

Longan is one of the most important agricultural products that has high economic significance in Thailand. Longan has been widely consumed by both domestic and international people in form of fresh fruit or dried product. From the statistical data in 2012, the volume of exported longan products was as high as 596,418,680 kilograms, generating over 19.8 trillion THB in value (Office of Agricultural Economy, 2012). The high production areas located in the northern provinces of Thailand, including Chiang Mai, Lamphun, Chiang Rai, Phayao, Phare, Nan, Lampang, Tak, Mae Hong Son, and Sukhothai, which are 90% of total longan production area of the country. Other regions that are able to produce longan in Thailand include Chanta Buri, Loei, Nong Kai, Nakorn Phanom, and Muk Da Harn. In order to prolong the shelf life of longan, it was preserve into dried product using hot air drying technique. At present, approximately 67% of total longan products are being prepared into dried longan either skinned or un-skinned form.

This research was conduct at one of a company which produces dried longan in Chiang Mai, Thailand. Majority activity of this company was to produce the skinned air-dried longan and export to international market. The main production lines of this company were separated into two types: make-to-stock and make-to-order. The study was focus on improving make-to-order production line, which has higher priority to the company, since it effect to the satisfaction of the customer in the international market. Consequently, productivity improvement techniques such as ECRS and Motion and time study are employed to identify and suggest improving strategy to increase production line efficiency (Kasemset et al., 2014 and Makprang et al., 2014), while still preserve a quality of the dried longan.

Literature Reviews

To identify and improve the current production line; (1) motion and time study and (2) ECRS techniques are together applied in this study. The details of both concepts are briefly explained as follows.

Motion and Time Study

Motion study is a study and analysis of the motion of working parts in the production, including machine, tool, equipment, and work station, or workplace.

Principles of Motion

Motion principles can be separated into three groups, based on relations of factors, including human structure, workplace designing, and equipment designing.

(1) Human structure: is a principle which utilizes working parts of human body and use them at their most effective condition, mostly hands. Most of the time, people use their hands to do works. The human structure principle emphasizes on the equality of body parts use, for instance, the equally use of both hands. Both hands must to start and stop working at the same time, while the motion of both arms must be balanced. Furthermore, other parts of body must help support each other to reduce tiredness during working position.

(2) Workplace designing: is a principle which emphasizes on designing a workplace that allows people to do their job conveniently and effectively. It is recommended that a person must work in only one position in one spot. The tool and equipment must also be kept in their usual places, which allow users to be familiar and easily access to them when needed. Moreover, there should be adequate brightness in working place, and the color tone of workplace should be highly contrasted with the work piece, in order to reduce tiredness of eyes.

(3) Equipment designing: is considered to be an alternative way to reduce human body parts movement. The equipment should be utilized where possible, in order to reduce tiredness from work. The tools using in any work must be designed to minimize users' effort, or in the most convenient handling position; for instance, Jig and Fixture are used to help in work piece handling.

Process Chart

Process chart is a tool, which allow a user to record the production processes briefly, in order to make a later analysis easier. Marks are utilized in the process chart to clearly identify working processes, and easier to read. The recorded processes started from obtaining raw material and follow up through production line.

Signs used in process chart include "O" for Operation, "⇒" for Transportation, "□" for Inspection, "D" for Delay, and "∇" for Storage.

Flow Diagram

Flow diagram illustrates map of workplace and the locations of every related machine, with the directions of marks. The scale of map may be applied. There are two types of mark being used in the diagram.

(1) Man Type: illustrates the moving directions of workers in the job.

(2) Material Type: illustrates the path that materials used in the production are being transported.

Time study is a technique that can be applied in the production cycle, allowing the producer to gain control over production management and production yield, which are related to performance evaluation. The unit of performance indication is calculated by seconds or minutes that a person get the job done using given method (Teerawatsakul, 2009).

ECRS principles

This technique helps generate an approach to improve productivity of the production line each character has its meaning as follows (Klomjit, 2013):

E = Eliminate: is the elimination of unnecessary processes during the production. The seven areas of detected loss in present processes, which has been eliminated, are including over-production, waiting time, unnecessary change, unnecessary job, over-stocking, unnecessary transportation, and damages to products.

C = Combine: is the combination of processes that allows the producer to save more time and energy used in the production. Some processes can be combined together; for instance, the production line used to have 5 steps to produce, which some of these steps could be done together at the same time, the processes then are being combined. As a result, the overall steps are reduced, allows the whole production process to complete faster and more efficient. This also eliminates the transit between processes that requires different tools to get the job done.

R = Rearrange: is the rearrangement of the required processes. The rearranged processes allow the production to complete faster by removing unnecessary transit to another process, or to eliminate waiting time. For example, if step 2 and step 3 in the production are swapped, it would reduce distances between production processes.

S = Simplify: is to improve the process or invent new tools that allow the production to operate more efficiently. The simplification of working processes may employ Jig or Fixture to help improving convenience and accuracy of the job, which not only reducing damages to the product, but also eliminate distances and unnecessary work.

Research Methodology

This research methodology consists of study data collection, problem identification, system design for improvement, performance measurement and conclusion (show in Figure 1)

Data Collection

This research is a study of dried longan production process, which occurs seasonally in a dried longan company in Chiang Mai. The process is emphasized on make-to-order production line, which has more complication that make-to-stock line. In the beginning, the study was focus on data collection based on factory maps, production processes, and

process activity maps of each work station, in order to clarify the current situation of the production line.

Problem Identification
The information received from the data collection process is used to create a process activity mapping to identify critical points in the production processes. There are several signs being employed to represent these critical points, including: "D" represents delays and/or waiting time, "⇒" to represent transportation of the product from one point to another. Moreover, each process is being defined using: VA (value added), NVA (non-value added), and NNVA (necessary but non-value added).

System Designing for Improvement
According to the flow chart previously created from ECRS and VSM techniques, a new flow chart is being designed to eliminate non-value added works in the process, in order to minimize waiting time, transportation, and other unnecessary works.

Performance Measurement Comparison
The results between before and after improvement will be compared based on total time, transportation distance, and total number of tasks

Results and Discussion

Data collection
According to a study, a dried longan make-to-order production process started from transporting frozen longan out from the freezer and dry the product and finish in the packaging process (as shown in Fig. 1). The first activity is called Re-dry process in which the pre-dry process kept in the frozen is transferred into oven to oven dry the longan into proper condition. Within this activity, it includes total of 13 steps of work as shown in table 1. The second part or activity 2, it started from transporting dried longan out from the oven, passing through finishing process and then going into packaging process, which include a total of 7 steps as shown in table 2. Both parts of these two activities have total of 5,151.87 minutes per production cycle, and a total of 37 km. in transportation.

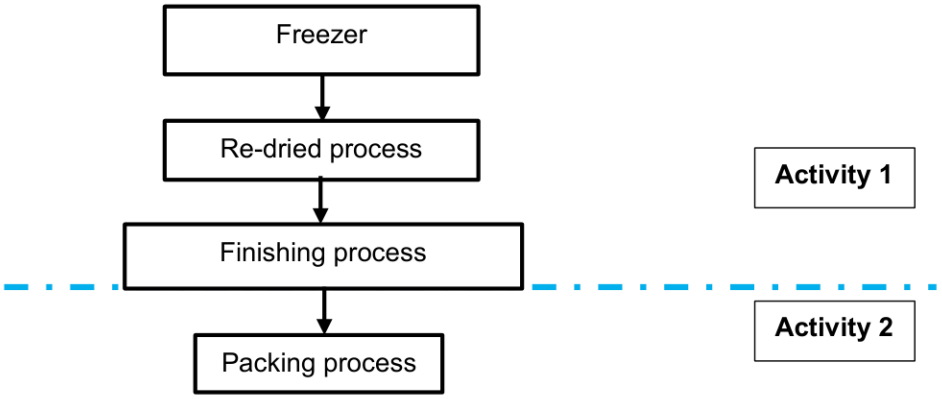

Figure 1: Process flow of make-to-order dried longan

Table 1: Current Process Activity Mapping [Activity 1]

Activity Mapping / Details of processes		○	⇨	□	D	∇	VA	NNVA	NVA	Transportation length (Meters)	Time (min)
1	Transport out from freezer	○						√			143.25
2	Transport in to grille		⇨					√		6,930	82
3	Put longan in grille	○						√			159.7

Activity Mapping Details of processes		○	⇨	□	D	∇	VA	NNVA	NVA	Transportation length (Meters)	Time (min)
4	Put longan in oven		⇨					√		2,304	138.8
5	Drying longan	○					√				768
6	Post-drying check			□				√			42
7	Cool- down waiting				D			√			791.1
8	Transport longan to grille-flipping point		⇨					√		3,312	73
9	Transport longan out from grille	○						√			143.64
10	Put longan in big bags	○							√		157
11	Transport big bag to silo		⇨						√	10,368	102.75
12	Wait to put longan in silo				D				√		790.2
13	Put longan in silo	○							√		540
<----------Total----------->		**6**	**4**	**1**	**2**	**0**	**1**	**8**	**4**	**22,914**	**3,931.44**
%		**46.2**	**30.8**	**7.7**	**15.4**	**0.0**					

Table 2: Current Process Activity Mapping [Activity 2]

Activity Mapping Process details		○	⇨	□	D	∇	VA	NNVA	NVA	Transportation length (Meters)	Time (min)
1	Wash, dry, polish, grading	○					√				10.71
2	Fill longan in boxes	○						√			67.2
3	Check and weight			□				√			720
4	Transfer to store area		⇨						√	14,080	17.6
5	Cool down waiting				D				√		287
6	Packing	○						√			117.92
7	Put in storage					∇		√			
<----------Total-------->		**3**	**1**	**1**	**1**	**1**	**1**	**4**	**2**	**14,080**	**1,220.43**
%		**42.9**	**14.3**	**14.3**	**14.3**	**14.3**					

Problem Identification

According to table 1, the total of 13 steps of work in activity 1 can be divided into 6 steps of operation process, 4 steps of transportation process, and 1 inspection process. In addition, there are 2 delays, 1 value added process, 8 necessary but non-value added processes, and 4 non-value added processes. The total transportation length is 22.9 km. and a total of 3,931.44 minutes were consumed in the processes.

In the meantime, when consider the process activity mapping of activity 2, as shown in table 2, it consists of 7 working steps, including 3 operation steps, 1 transportation step, 1 inspection step and 1 storing step. There is 1 delay being detected. Moreover, there is 1 value-added process, 4 necessary but non-value added processes, and 2 non-value added processes. The total length of transportation taken was 14 km and total of 1,220.43 minutes were consumed.

System Improvement

1) E-Eliminate: according to table 1, the tenth to thirteenth processes were non-value added processes, hence they could be discarded. When these steps, including put longan in big bags, transport big bags to silo, wait to put in silo, and put in silo were eliminated, the length of transportation is reduced by 10,368 meters and time consumed is reduced by 1,589.95 minutes.

2) S-Simplify: according to table 1, the eighth step was simplified by changing transport method. Instead of using big bags, the conveyor belt is employed to directly transport the dried longan from the oven to the silo. Consequently, the transportation length was reduced by 1,317.60 meters.

3) C-Combine: according to table 2, the forth to sixth steps were processes of transfer dried longan to waiting point to cool them down, which create waiting time. In response, these three steps were combined, with additional cooling fan equipped in grading process. As a result, total of 14,080 meters in transportation and 304.60 minutes of time consumed were reduced.

4) R-Rearrange: In this production line, rearrange cannot be applied due to the specification of dried longan processing step.

After using ECRS technique, the improved flow process activity mapping can be represented as Table 3 and Table 4

Table 3: Process Activity Mapping after improvement [Activity 1]

Activity Mapping / Details of processes		○	⇨	□	D	∇	VA	NNVA	NVA	Transportation length (Meters)	Time (min)
1	Transport out from freezer	○						√			143.25
2	Transport in to grille		⇨					√		6,930	82
3	Put longan in grille	○						√			159.7
4	Put longan in oven		⇨					√		2,304	138.8
5	Drying longan	○					√				768
6	Post-drying check			□				√			42
7	Cool- down waiting				D			√			791.1
8	Transport longan to grille-flipping point		⇨					√		1,994.40	73
9	Transport longan out from grille	○						√			143.64

Activity Mapping Details of processes	○	⇨	□	D	∇	VA	NNVA	NVA	Transportation length (Meters)	Time (min)
<----------Total----------->	**6**	**3**	**1**	**1**	**0**	**1**	**8**	**0**	**11,228.40**	**2,341.49**
%	**46.2**	**33.3**	**11.1**	**11.1**	**0.0**					

Table 4: Process Activity Mapping after improvement [Activity 2]

Activity Mapping **Process details**		○	⇨	□	D	∇	VA	NNVA	NVA	Transportation length (Meters)	Time (min)
1	Wash, dry, polish, grading	○					√				10.71
2	Put longan in boxes	○						√			67.2
3	Check and weight			□				√			720
4	Packing	○						√			117.92
5	Storing					∇		√			
<---------Total--------->		**3**	**0**	**1**	**0**	**1**	**1**	**4**	**0**	**0**	**915.83**
%		**60.0**	**0.0**	**20.0**	**0.0**	**20.0**					

Performance Measurement Comparison

The comparison of existing and the proposed system is illustrated in Table 5

Table 5: Comparison of before and after improvement

	Before	After	Difference	% Reduction
Total distance (meters)	36,994.00	11,228.40	25,765.60	69.7%
Total time (min)	5,151.87	3,257.32	1,894.55	36.8%
Total Number of tasks	20	14	6	30.0%

Conclusion

This study emphasized on make-to-order dried longan production line in one of dried longan manufacturer in Chiang Mai, Thailand. The process starts from transfer frozen longan out from freezer and pass through drying process and finishing step before going to the packaging process, there are total of 20 processes included. The total production time was 5,151.87 minutes per production round, and total of 36,994 meters of total transportation length.

According to the process activity mapping, all of the processes were divided in to two activity group. The first section includes the processes from transfer frozen longan out of freezer to silo filling. This section contains total of 13 work steps; 4 of which were non value added and not necessary processes. Hence, ECRS technique was applied in order to improve efficiency in production. The technique was applied by removing the tenth to thirteenth steps, which could eliminate 4 working stations. Moreover, in the eighth step, the process has been simplified by equipping conveyor belt to replace big bags transferring, in order to minimize transportation time and delays. In the second section, the processes include transferring dried longan from silo to packaging process. There were total of 7 work

steps, 3 of which created unnecessary waiting time, including the forth to sixth steps, which is the processes of transferring dried longan to waiting point until cool down, then transfer them back and put in boxes. As a result, these three steps were combined in accordance with an equipped cooling fan in grading machine. This combination allows the transportation and delays in the production to be eliminated.

From employing ECRS and VSM techniques, the total of 20 working steps were reduced to 14 steps (30% reduction). The total transportation length was reduced from 36,994 meters to 11,228.40 meters (69.7% reduction). Therefore, these reduced steps allow the organization to save energy consumption in transportation by approximately 13,000 THB per annum (calculated from fuel consumption per distance unit), and reduce labor cost by 367,290 per annum (calculated from numbers of employees to labor costs in one production). Furthermore, the time consumed in the production were reduced from 5,151.87 minutes to 3,257.32 minutes (36.8% reduction), leading to the reduction of production lead time from 3 days to 2 days. This allows the factory to acquire an additional one day per annum, which can be calculated equally to an opportunity to generate additional 1.37 million THB each year.

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