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Apply Lean and Taguchi in different level of variability of food flow processing system

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Abstract

High competition in food industry forced companies to increase their efficiency and reduce their waste. The author introduces model contain steps that help in reduce variability level in food flow processing system. As (Noorwali et al., 2012) mentioned steps which includes process mapping and simulation model for investigation types of variability in food processing system. This paper is continuing these steps using lean approach, Taguchi, simulation, and correlation. Lean will be use in categories seven types of wastes in food processing .Taguchi will use orthogonal array method for design the framework that applied in the simulation models. Correlation will be applied for identify which variable affecting more in food processing.

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Keywords; Food,Correlation,Lean,Taguchi,Orthogonal Array

1. Introduction

High competition in food industry forced companies to reduce their wastes, cost, and increase their efficiency.

For achieving these objectives, lean was successfully adopted in automotive industry; the research will explore opportunities of applying lean thinking in food processing industry.

As(Venkat and Wakeland, 2006) integrated lean and simulation in car repair case study which reflect in 30% cost reduction. The lean used as map the process and reduce none-value activities. Taguchi applied as a framework for the simulation applied triangle distribution with applied all the scenarios of process delay and customers behaviors. However, there are other variables may consider such as %stopped and %blocked.

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The research will highlight lean in food. Lean enables in understanding of the process, which helps in map the process, categories waste, and apply Taguchi as a tool from lean six sigma. In addition, correlation will be applied to define the most affecting variable.

2. Lean in Food

Although, there are lots of existing methods that can deal with variability in food processing, there is no method undertaken for investigating the mixed levels of variability among the different workstation in food flow processing systems. According to (Womack and Jones, 2003), lean introduced as common Japanese approach that cause of automotive Japanese companies such as Toyota to lead the market. It mainly focuses in increasing efficiency and reduces waste.

As (Womack and Jones, 2003) defined lean as " it *is providing the way to specify value, line up value –creating actions in the best sequence, conduct these activities without interruption whenever someone requests them , and perform them more and more effectively*" .

Furthermore , as (Taj, 2008) mentioned that lean is the philosophy for improving the different procedure to increase production efficiency.

(Melton, 2005) Defined lean as the tools and techniques that help to '*banish'* waste and generate wealth in the company.

According to (Dickson et al., 2009) lean thinking is " *a set of principles and techniques that drive organizations to continually add value to the product they deliver by enhancing process steps that are necessary ,relevant ,and valuable while eliminating those that fail to add value*"

Lean can be adapted in food processing system as (Zarei et al., 2011) mentioned lean could reduce the cost and increase customer value. According to (Simons and Zokaei, 2005) the customer value means that "*understand specific requirements for specific end-customers*".

In addition, as (Womack and Jones, 2003) noted that lean thinking offers a way to indicate value, arrange value creating performances in the best sequence, accomplish these activities without disruption when someone call them and make them in more efficient way.

As (Demeter and Matyusz, 2010) stated that, "*lean production is an integrated set of activities designed to achieve high-volume production using minimal inventories of raw materials ,work-in-process, and finished goods*" .

Thus, from the above lean in food may define as a set of activities and techniques that drive companies to reduce waste and increase efficiency in order to satisfy the customers.

3. Methodology or Experimental Procedure

The model is for biscuit production line which includes 12 workstations in National Biscuits and Confectionary Company (NBCC) in Jeddah, Saudi Arabia.

As (Noorwali et al., 2012) considered characteristics of food processing system and different types of variability in food. The steps start with process map and simulation model. This paper will continue with the method steps in order to investigate more in food variability level.

The steps are lean in food by categorise types of wastes in biscuit processing system. Then, Taguchi and orthogonal array method will be applied to design the framework for the simulation models which represent the factors that affecting with food processing system. Finally, the correlation between variables will be applied to define the most impact variable. The method will be explained in detail in the following sections.

4. Waste in food

As mentioned in section 2 lean tools and techniques can help in banish wastes. Following(Taj, 2005) waste is "*anything other than minimum amount of equipment , materials, parts, and working times that are absolutely essential to production*". As (Melton, 2005) categorised seven types of wastes which lie in process, manufacturing waste, transportation waste, idle time waste, defective product waste, stock waste, motion waste.

According to (Dickson et al., 2009) , the basic lean concepts are : the insistent eradication of waste through standardisation of processes with association all workforce in process improvement.

In addition, according to (Melton, 2005) waste can simply acknowledged in all processes and advance action can acquire massive saving. Moreover, as the company reduce their waste in order to reach the minimum waste level, they implement process improvement which is the core of lean principle. Table 1 explain each type of waste with providing an example in biscuit processing system.

Table 1 Types of waste in lean and case study of biscuit flow processing ((Melton, 2005), Author)

7 Types of wastes	Waste in lean	Waste in food processing
Process time	When the process take more time than expected.	After cutting process if there is a process that measuring weight and size, that will delay the process of packet assembly.
Waiting time waste	The causes of waiting time can be : • Raw material • Flow of material • Breakdown	For instance the biscuit cutting machine finish its job and waiting for new laminated sheet. In addition, the oven will wait until the cutting is finished and sometime get overheated.
Level of inventory	(Melton, 2005) Mentioned that is the storage of items or raw materials that can cost money. The cause is not understanding the process, customer demand and reacting with forecasting.	For instance, in producing cream filled biscuits, if cream is more than products needed, then the cream would take a place that needed for other material.
Transportation	According to (Melton, 2005) is moving unprocessed product from place to place and that not adding value to the customer.	Moving row materials and semi-finished products that not adding value to the customer. For example, moving cream from mixing to production line for supplying wafers producing.
Motion	No standardisations reflect in more motion that not add-value.	If there is no Slandered Operating Procedure (SOP) and work instruction for using biscuits laminating and cutter roller, then that would result in extra working motion.
Over production	(Melton, 2005) Mentioned that is produce more than demand.	When the demand is 300 packets of biscuit and the line produced 350 packets.
Defects	According to (Melton, 2005), is an error during the process and require either rework or considered as a scarp.	It is a main problem in food as some food can be recycled or rework so any mistakes in the

	process can lead to item been scarped. For instance, setting the packing machine in wrong dimensions.

5. Taguchi in food

As(Khaw et al., 1995) mentioned that , Taguchi method offers ortogonal arrayas mathematical tool that analyse the smallest number of experiments that have a large number of parameters. Thus, that would reduce time and effort.

According to (Radharamanan and Ansuj) Taguchi method is measuring variability around target performance by studying varicose types of signal-to-noise ratios.

(Pereira and Aspinwall, 1992) applied taguchi in biscuit processing for evaluating tolerance and critical parameters in process design and product. The aim of the method is to define causes of variability. The method applied in increasing moisture, dimension and weight which affected in increasing biscuit length variability. The six factors are flour type, fat weight, flour weight, water level, mixing time, and rest in mixer. The achievement was a significant reduction in biscuit length variability.

However, the method only addressed product quality, as mentioned in section 3 there are seven types of wastes may affect with process variability in food table 1. (Jafari et al., 2008) Integrated simulation model with Taguchi as they used orthogonal array L16 at four levels and run sixteen simulations with different combinations of factors to find out interactions and the main effects.

Thus, in this paper the research will apply orthogonal array method in food for biscuit processing as a case study. The model have triangle distribution in three levels of mean time to repair (MTTR) and mean time to failure (MTTF) and six factors table2.

Table 2 . Six factors in biscuit production line

Factors	MTTR	MTTF
Moisure	10,25,40	30,180,280
Speed	10,25,40	120,200,360
Low temprature	10,15,20	20,40,80
High temprature	20,40,60	100,200,300
short breakdown	10,20,40	40,140,280
Long breakdown	60,120,240	300,400,500

Therefore, 27 arrays can be implemented as shown in Table 3 .The experiment run 27 simulation models each time apply different array with adjusting cycle time.

Table 3. 27 Arrays three levels and six factors

Exp	Moisture	Speed	Low Temperature	High Temperature	Short Breakdown	Long Breakdown
1	10/30	10/120	10/20	20/100	10/40	60/300
2	10/30	10/120	10/20	20/100	20/140	120/400
3	10/30	10/120	10/20	20/100	40/280	240/500
4	10/30	25/200	15/40	40/200	10/40	60/300

5	10/30	25/200	15/40	40/200	20/140	120/400
6	10/30	25/200	15/40	40/200	40/280	240/500
7	10/30	40/360	20/80	60/300	10/40	60/300
8	10/30	40/360	20/80	60/300	20/140	120/400
9	10/30	40/360	20/80	60/300	40/280	240/500
10	25/180	10/120	15/40	60/300	10/40	120/400
11	25/180	10/120	15/40	60/300	20/140	240/500
12	25/180	10/120	15/40	60/300	40/280	60/300
13	25/180	25/200	20/80	20/100	10/40	120/400
14	25/180	25/200	20/80	20/100	20/140	240/500
15	25/180	25/200	20/80	20/100	40/280	60/300
16	25/180	40/360	10/20	40/200	10/40	120/400
17	25/180	40/360	10/20	40/200	20/140	240/500
18	25/180	40/360	10/20	40/200	40/280	60/300
19	40/280	10/120	20/80	40/200	10/40	240/500
20	40/280	10/120	20/80	40/200	20/140	60/300
21	40/280	10/120	20/80	40/200	40/280	120/400
22	40/280	25/200	10/20	60/300	10/40	240/500
23	40/280	25/200	10/20	60/300	20/140	60/300
24	40/280	25/200	10/20	60/300	40/280	120/400
25	40/280	40/360	15/40	20/100	10/40	240/500
26	40/280	40/360	15/40	20/100	20/140	60/300
27	40/280	40/360	15/40	20/100	40/280	120/400

6. Results and dissection

Table 4 and figure 1 shows results of the simulation models after applying Array 27.

Table 4. The average results of 27 simulation models

%Waiting	%Blocking	%Stoppages	%Working
10.05	29.58	19.82	40.54
13.98	13.52	23.96	48.53
7.65	6.06	23.09	63.20
6.76	8.00	19.64	65.60
4.67	4.97	15.66	74.70
12.88	10.46	21.69	54.97
5.22	4.66	24.84	65.29
4.49	8.83	23.59	63.09
11.72	14.73	14.88	58.66
8.70	9.17	24.09	58.04
9.04	8.91	14.30	67.75
13.12	13.85	13.78	59.25
8.42	6.88	17.64	67.06
7.63	8.73	11.19	72.46

6.87	4.66	19.42	69.05
12.24	12.78	25.09	49.89
6.27	13.36	14.65	65.72
11.32	11.46	12.67	64.55
7.16	7.26	17.62	67.96
5.75	5.38	18.54	70.34
6.50	9.18	15.98	68.34
7.24	8.79	21.45	62.52
9.58	10.02	23.80	56.60
7.12	20.37	11.96	60.56
7.17	23.18	17.13	52.52
6.24	16.60	11.41	65.76
8.64	24.98	10.83	55.56

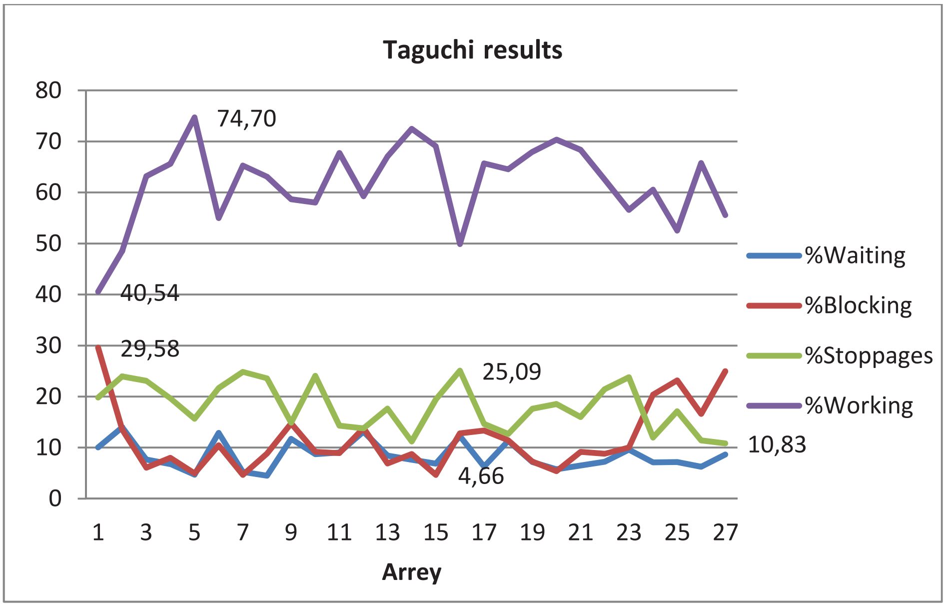

Figure 1.The patterns between four outputs.

Applying correlation for the simulation results table 5 shows that %waiting and %blocking affecting more in biscuit flow processing system.

Table 5. Correlation matrix (Pearson (n))

Variables	%Waiting	%Blocking	%Stoppages	%Working
%Waiting	**1**	0.292	0.093	-0.629
%Blocking	0.292	**1**	-0.333	-0.715
%Stoppages	0.093	-0.333	**1**	-0.350
%Working	-0.629	-0.715	-0.350	**1**

7. Conclusion

After introducing lean in food and highlighting seven types of wastes. The paper applied Taguchi as a framework in the simulation model. From the correlation results we can find that %waiting and %blocking consider as high variables. Thus, the research might apply some of mathematical and statistical equations to minimise the percentage of error in the next paper.

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