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Apply MTS-MTO & Rule Base in Food Flow Processing System

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Abstract—High competition in food forced companies to control their cost and that combine with reduce wastes and increase effciancy.The processing system of food considered as one of the most variable system because the nature of the product. The research can accomplish the goal by reduce variability in food processing system. Therefore, the research applied different steps. The steps include process map, identify different types of variability in food and in make to stock (MTS) and make to order (MTO), apply lean in food by categorize seven types of wastes in food, apply Taguchi orthogonal array, and implement Principle Competent Analysis for correlation between variables and factor to identify which variable has the most impact and from which factor the impact. This paper continues these steps as by highlighting MTS-MTO in food, existing variability measures. Minitab implemented to identify factors that affected with the highest variable. For process improvement rule base applied as an artificial intelligent tool for reduce effect of variability in the process.

Index Terms— Artificial intelligent, Food, MTS-MTO, Logic control, Principle components, System, rule base,

1 Introduction

Due to increasing competition in food industry , there is a demand for increasing efficiency and reducing wastes. Therefore, the research may accomplish this goal by reduce varibility level in food processing system.

The research will start with make to stock (MTS) and make to order (MTO) as they are strategies that commonly applied in food. Moreover, some of the existing variability measures will be highlighted in this paper in order to help for finding the proper method for reducing effect of variability in food.

In addition, the research adopted lean in food for reducing waste and increasing efficiency. As [12] started steps such as characteristics of food , different types of variability in food, process mapping ,and simulation model.

In addition,[10] continue steps by implementing lean by categories seven types of waste in food . In addition Taguchi orthogonal array method implemented combine with simulation models and then principle component implemented [11] to define which variable has the highest affect.

Moreover, the research will apply Minitab for identify which factor affected with the highest variable. Then, for process improvement rule base will be applied as an artificial intelligent tool to reduce the affect of variability in the affected areas.

2 MTS and MTO

According to[2] , in manufacturing there are a different sources of variability such as demand and arrival time , consistency of the machines , processing time , and capability of operator .

Consumers consider order response time as one of the service performance measures. The new business model use telephone/internet ordering and the requirement of a quick response service increased implementation of make-to-order (MTO) that provide production of specific demand. However, make-to-stock still needed for standard products.
Following [13] mentioned that make-to-order (MTO) products as the products with no inventory requirement. This could be due to high irregular demand products, specified products, trail products, tendered products, or very short shelf life products.

The research will highlight the definitions of MTS and MTO to understand the strategies and linked them with food. In addition, the research will compare MTS and MTO characteristics and the advantages of combination between them.

2.1 MTS definition

According to [17] make-to-stock (MTS) system is producing finished or semi-finished products and then stock them based on demand forecasts.

As [16] mentioned that under MTS management the items are produced in prediction of future orders and stocked in Finished Goods Inventory(FGI).

Moreover, [1] defined MTS strategy as “ *pre-build a standard product using efficient capacity in advance of single uncertain demand event*”.

In summary, the research here can define MTS in food according to the above definitions as producing products and stock those in finished goods inventory FGI based on demand forecasts and pulling level of inventory to increase flow in food processing system.

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2.2 MTO definition

As [17]mentioned that make-to-order (MTO) system produces only when customers demand placed.

[16], interpreted MTO process, "a *production order is released to manufacturing facility only after the firm demand has been received*".

According to [3], " *in MTO manufacturing or assembly is undertaken after the order is received as the product customized to meet the customer preferences*".

Furthermore , [1] defined MTO strategy as "*a strategy to acquire more expensive flexible capacity that can produce after observing the demand event*".

According to the above, the research can define MTO in food as the manufacture only produce product after the order has been released in order to increase product value stream in food flow processing system.

2.3 MTS & MTO Characteristics

From the definitions we may identify characteristics of MTs and MTO. Table 1 shows explains the comparison between MTS and MTO in Inventory, cost, production, demand, and scheduling.

Table 1 illustrates a comparison between MTS and MTO characteristics[6]; [17]; [14]; [1]; [13]; [15])

	MTS	**MTO**
Inventory	[6] Considered MTS system as a "push" system that has high level of inventory.	[17], MTO system removes finished-goods stocks as the order dispatched to the customer after produced. In addition, [6] mentioned that MTO system is considered as a "*pull*" system that minimise inventory level.
Cost	[14] As MTS is producing in high capacity, the cost of product is low. However, [17], make-to-stock (MTS) is become expensive in large number of products.	[1] Noted that using MTO flexible system in production lines helps to reduce the expenses of extra costs.
Production	[1] Operating in MTS system help to increase production utilization by run production lines for long term in high capacity as the plan will be for produce to stock.	MTO has flexibility in product mix to produce high range of products as it produced after the order released. However, the production schedule is more variable.
Demand	[13] MTS products depend on forecasting by knowing in advanced how much should be produced. In addition, as [16] mentioned that the MTS benefit is to enable immediate reactivity to external demands.	[6] The demand will be as the customer's requirements instead of forecasts.
scheduling	[15] Mentioned that the main key performance in scheduling of MTS products is *throughput*.	[15] The main key performance in scheduling of MTO products is *on time delivery rate.*

From the above, the research found that the combination of both MTS and MTO in food flow processing system may increase the following:

1) Meet customer requirement; the changing of demand may increase due to many factors such as weather. Meeting the demand is important as the customer will not buy not need it product. In addition, lean principle specifies value can be applied for increase customer fulfillment.

2) Improve optimization in capacity planning; reduce waste ad increase efficiency. Lean perfection might applicable for improve optimization.

3) Reduce cost; due to high competition in food market cost reduction can give competition advantage.

4) Reduce level of inventory; increasing inventory may increase time and material wastes. Lean pull might be applied for reduce inventory level.

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5) Improve scheduling utilization; MTO flexibility with MTS forecasting may increase scheduling utilization.

Therefore, from identifying MTS and MTO and highlight their characteristics and the advantages of combination between them in food, the research identified types of variability in food and MTS-MTO as [12] :

1) Correlation between products.
2) Change in customer demand.
3) Changeover time.
4) Weather change.
5) Uncertain due date.

The research will measure the effect of each factor in increasing variability level in food processing. The research will highlight existing variability measures in food in the next section.

3 THE EXISTING VARIBILITY MEASURES IN FOOD PROCESING SYSTEM

There are many measures that commonly used in measuring variability of food processing system; the research will highlight some of them in the following:

3.1 Mixed Integer Program (MIP)

[8] Used MIP for planning and scheduling and classified large number of products into product families. They applied Discreet time approach for inventory and backlog cost, continues time approach with sequencing for scheduling of families, lot-sizing for scheduling products. Mathematical modeling applied for i.e.: lot-sizing and timing constrains and common resources constrains. The results were:

- Control changeover carryover and crossover
- Increase recourses utilization.

In addition, [7] applied Mixed Integer Programme (MIP) for yogurt lot sizing problem for product families in packing stage. The target was Increase yogurt packing capacity by investing in new fruit mixer that may increase the flexibility of packing machines. In addition, there are problems in changeover between some products. They crossbreed between discreet-time and continues-time mathematical models.

Thus, the model shows that 7.6% improvement after adding fruit mixer and the inventory cost is lowered by12.2%.However, the model only focused in adding facilities to increase flexibility and reducing the cost, reducing variables such as changeover time and product mix and overcome of them should be considered for increase the efficiency level.

3.2 Algorithm for scheduling complex multipurpose batch process (MILP)

According to [9] the MILP is restructuring algorithm for improving non-optimal schedule or updating current schedule by repetitively discharging and repositioning a small number of jobs.
[5] Developed formulation that performing inventory mass balance by applying individual continues time grid and that allowing process event to take place at any time with different tasks duration.
Moreover, MILP was implemented successfully real case studies in order to control machine breakdown and labor change .The MILP framework is depends into four abstractions:

1) Sequencing decision and managing of allocation separately.
2) Represent problem by offering each task process that may give the task sequence at any utilized resources item.
3) Use a unique set of binary variables to explain the proceeding task sequence for uniform handling of discrete resources.
4) Accomplish partial-rescheduling scheme until reach the optimum improvement.

[4] Applied mixed integer liner program (MILP) model for production scheduling problem and synchronize lot-sizing in yogurt production line in Greece. They plan was improving product and process sequence and manage inventory level as the requirement demand. They divided variables into two types:
Continues variables:

- Product quantity
- Utilization
- Inventory level

Binary variables:

- For each products indicating producing product in the particular day.
- For each possible transition for each changeover taking place or not.

Thus, their results were reducing the cost of production and increasing machine utilization. However, the model only applied in production scheduling problem. There is process flow problem such as machine breakdown and setup time need to be overcome in order to minimize lot-sizing and increase machine utilization. In addition, there are other factors might need to be covered i.e. high process waste.

4 RESEARCH METHOD

The steps for reduce the affect of variability in food flow processing system are:

1) Process mapping.
2) Simulation model.
3) Types of varibility on food processing system.
4) Lean seven types of wastes categories.
5) Taguchi 27 Array.
6) Principle components.
7) Rule base analysis.

Some of the above steps already published i.e. [10] ,[11] ,[12],. The research will summerise these steps and then continue with the new approach.
The model applied in biscuit production line in National biscuit and confectionary company (NBCC).As [10] there are three levels of variability and we have four variables , the research applied Taguchi orthogonal array 27 .Table 2 [10]

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shows the results of Taguchi 27 array for biscuit production line. The results include four variables %waiting, %Blocking, %Stopping, %Working.

Table 2

27 Arrays for biscuit production line[10]

%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

After finalize the result , the research apply Principle Component Analysis table 3 for find out which factor affecting more in increasing variables.

Table 3

correlation between variables and factors[11]

	F1	F2	F3
%Waiting	-0.756	0.159	0.635
%Blocking	-0.775	-0.542	-0.327
%Stoppages	-0.133	0.958	-0.253
%Working	0.963	-0.178	0.201

Thus, table 3 results shows that %waiting and %blocking have the highest correlation with factor 1. Thus, %waiting and %Blocking need to be reduced in order to reduce variability level in biscuit production line.

4.1 Problem Statement

For identify the factors that affect with increasing the highest variable, Minitab applied as figure 1 shows that the factors affecting waiting. The highest affected factors are moisture, speed, low temperature, and short breakdown.

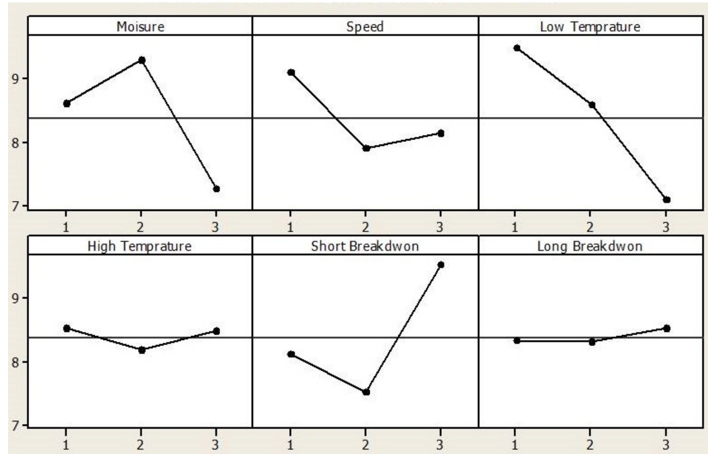

Figure 1 The factors the affecting with waiting

From the Taguchi orthogonal array results as Figure1 shows that waiting is affected by factors. The most affected factors are:

- Speed; affected in two work stations :
  - Cooling conveyor; cooling conveyor speed is 2.8 m/sec which increase waiting in the next processes such as aligning and packing. The solution is to apply rule base to increase conveyor speed to match the stander which is 4m/sec.
  - Packaging 1; Packaging 1 conveyor speed is 1 m/sec which increase waiting in the processes. The solution is to apply rule base to increase conveyor speed to match the stander which is 3m/sec.
- Low temperature; affected in packing machine1 as the sealing temperature is 62◦ which cause bad sealing and that increase waiting in packaging1. The solution is to set machine temperature to 56◦.
- Short breakdown; affected in two workstations :
  - Packing machine 2; sensor is not working which affect in increase waiting in packaging 2. The solution is to adjust sensor to 0.05.
  - Packaging 2; packing fingers out of timing (15 pack/min) which cause of increase waiting in the process. The solution is to increase packaging fingers to 20 pack/min.

Therefore, the research identified each factor and area of affecting with defines the problem and the suggesting the solution that shows in table 4.

Table 4

Summary of affected factors and the required improvement

Variable	Affected Factors	Work station	Problem	Improvement

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Waiting	Speed	Cooling conveyor	Lower conveyor speed 2.8 m/sec	Increase conveyor speed 4m/sec
	Low temperature	Packing machine1	Bad sealing 62◦	Set machine temp 56◦
	Short Breakdown	Packing machine2	Sensor not working	Adjust sensor 0.05
	Speed	Packaging1	Lower Conveyor speed 1m/sec	Increase conveyor speed 3m/sec
	Short breakdown	Packaging2	Packaging finger out of timing 15pack/min	Increase packaging finger to 20pack/min

4.2 Rule base implementation

As the problem identified, for process improvement the research applied rule base in order to improve each process that affected with factors. Figures 2-6 shows rule base applied in affected areas such as cooling, packing, and packaging as the follwoing:

1) **Cooling conveyor;** figure 2 shows implementation of rule base for reduce waiting. The condition include if operation time is equal and more than five, then set cooling conveyor speed to 4m/sec, MTTR = 20, and MTTF=87.

Cooling conveyor = waiting
On Breakdown
IF cooling conveyor. Operation time ≥5
Then set conveyor speed = 4m/sec
And set MTTR = 20
And set MTTF = 87

Figure 2 Rule base in cooling conveyor

2) **Packing machine 1;** figure 3 shows implementation of rule base for reduce waiting. The condition include if operation time is equal and more than two, then set sensor = 0.05, MTTR = 30, and MTTF= 87.

Packing macine1 = waiting
On Breakdown
IF packing machine1. Operation time ≥2
Then set Sensor = 0.05
And set MTTR = 30
And set MTTF = 87

Figure 3 Rule base in packing machine1

3) **Packing machine 2;** figure 4 shows implementation of rule base for reduce waiting. The condition include if operation time is equal and more than two, then set machine temperature = 56, MTTR = 35, and MTTF= 89.

Packing machine 2 = waiting
On Breakdown
IF packing machine2.Peration time ≥2
Then set machine temperature = 56
And set MTTR = 35
And set MTTF = 89

Figure 4 Rule base in packing machine2

4) **Packaging 1;** figure 5 shows implementation of rule base for reduce waiting. The condition include if operation time is equal and more than three, then set conveyor speed to 3m/sec, MTTR = 20, and MTTF= 80.

Packaging1 =waiting
On Breakdown
IF Packaging. Operation time ≥3
Then set conveyor speed = 3 m/sec
And set MTTR = 20
And set MTTF = 80

Figure 5 Rule base in packaging1

5) **Packaging 2;** figure 6 shows implementation of rule base for reduce waiting. The condition include if operation time is equal and more than three, then set packing fingers to 20 packets/min, MTTR = 25, and MTTF= 85.

Packaging2 = waiting
On Breakdown
IF Packaging2.Peration time ≥3
Then set Packaging finger = 20 packets/min
And set MTTR = 25
And set MTTF = 85

Figure 6 Rule base in packaging2

4.3 Rule base results

Applied rule base reduced the effect of factors in variables at the affected areas. Table 5 and 6 shows the comparison between the results of the simulation model before and after rule base implementation.

Table 5
Results of the simulation model before apply rule base

		Before				
Work station	Work station	%wr	%wait	%Stop	%block	Thro
1	Mixing	58.25	0.00	38.34	0.00	39006
2	Cutter	10.25	0.01	50.08	38.44	17877
3	Laminator	14.92	32.17	2.91	48.25	17729
4	Cutter roller	4.08	19.23	2.42	74.02	17729
5	Baking	43.77	5.07	39.40	6.74	17570
6	Cooling	19.42	47.00	10.44	20.85	16893
7	Aligning	9.53	34.67	43.24	12.56	16560
8	Packing1	2.92	18.12	74.43	4.19	7611
9	Packing2	2.96	18.92	74.43	4.19	7762
10	Packaging 1	3.85	52.65	42.88	0.00	6696
11	Packaging 2	4.01	52.37	42.98	0.00	6975
12	Recycle	7.42	7.42	3.65	0.00	4299
	Avg	15.11	23.97	35.43	17.44	14726

Table 6
Results of the simulation model after rule base applied

		After				
Work station	Work station	%wr	%wait	%Stop	%block	Thro
1	Mixing	58.25	0.00	38.34	0.00	39006
2	Cutter	9.85	0.01	50.08	38.88	17186
3	Laminator	14.34	30.81	2.91	50.27	17045
4	Cutter roller	3.92	17.74	2.42	75.69	17044
5	Baking	42.10	4.45	39.40	9.23	16891
6	Cooling	18.67	36.72	22.93	19.47	16244
7	Aligning	9.17	31.85	43.24	15.74	15927
8	Packing 1	2.92	14.60	77.78	4.34	7615
9	Packing 2	2.73	14.14	77.78	4.34	7160
10	Packaging 1	3.84	46.57	48.98	0.00	6699
11	Packaging 2	3.70	44.99	50.72	0.00	6435
12	Recycle	7.13	7.13	3.65	0.00	4131
	Avg	14.72	20.75	38.19	18.16	14282

4.4 Variables improvement

Figures 7-11 shows the comparison of variables before and after rule base implementation.

- **Working;** by applying logic control working was slightly decreased due to slow of the process as shown in figure 7.

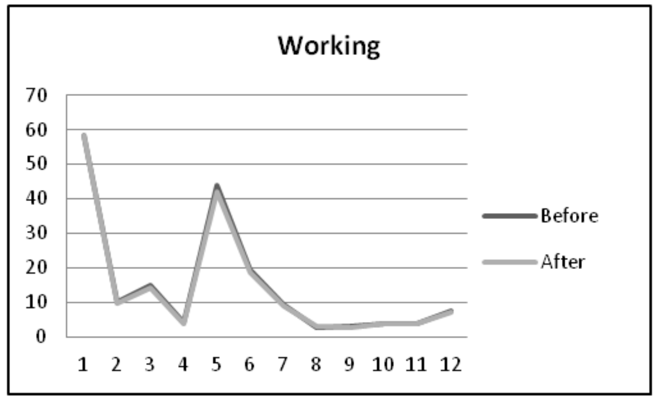

Figure 7 comparison of working before and after rule base

- **Waiting;** by implementing logic control waiting was decreased and the process was improved as shown in figure 8.

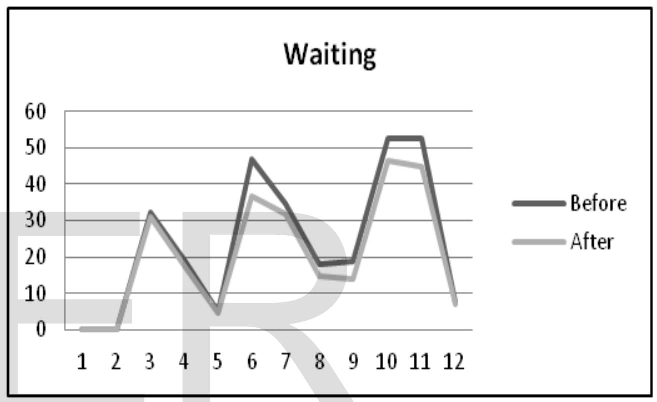

Figure 8 comparison of waiting before and after rule base

- **Stopped;** by implementing logic control the process was getting slower and stopped was slightly increased as shown in figure 9.

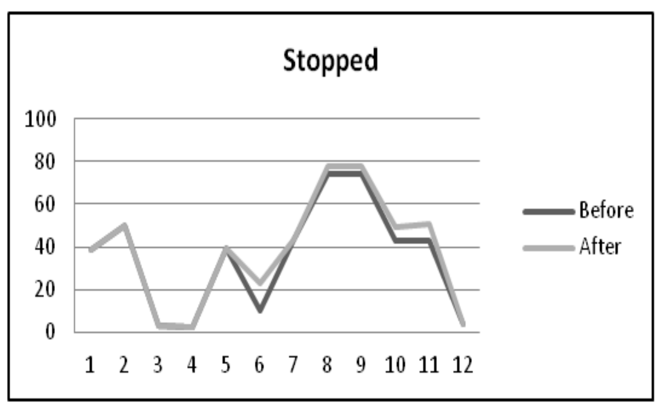

Figure 9 comparison of stopped before and after rule base

- **Blocked;** implementation of logic control reduce blocking slightly in packing areas as shown in figure 10.

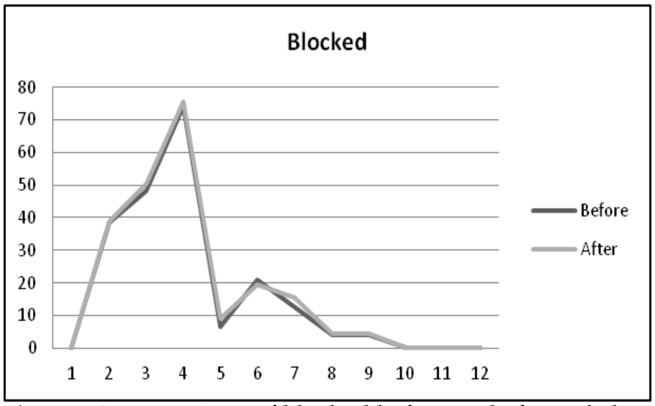

Figure 10 comparison of blocked before and after rule base

- **Throughput;** due to implementation of logic control, throughput was slightly increased as shown in figure 11.

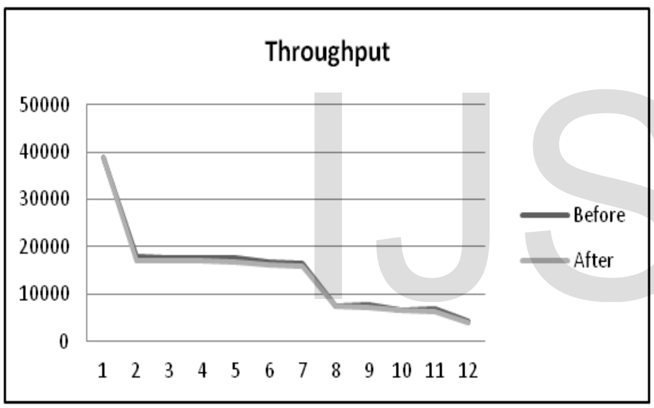

Figure 11 comparison of throughput before and after rule base

4.5 Process improvement

1) **Cooling conveyor;** the results from table 2 and 3 shows that waiting in cooling conveyor reduced from %47 to %36.72 and in aligning reduced from %34.67 to %31.85. However, Stopped in cooling conveyor increased from %10.44 to %22.93.

2) **Packing machine 1 ;** the results from table 2 and 3 shows that waiting in packing machine 1 reduced from %18.12 to %14.60 and in packaging1 reduced from %52.65 to %46.57. On the other hand, Stopped in packing machine1 increased from %74.43 to %77.78.

3) **Packing machine 2 ;** the results from table 2 and 3 shows that waiting in packing machine 2 reduced from %18.92 to %14.14 and in packaging2 reduced from %52.37 to %44.99. However, Stopped in packing machine2 increased from %74.43 to %77.78.

4) **Packaging 1;** the results from table 2 and 3 shows that waiting in packaging1 reduced from %52.65 to %46.57. On the other hand, Stopped in packaging1 increased from %42.88 to %48.98.

5) **Packaging 2;** the results from table 2 and 3 shows that waiting in packaging2 reduced from %52.37 to %44.99. However, Stopped in packaging1 increased from %42.98 to %50.72.

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6 CONCLUSION

MTO and MTS are commonly used strategies in food. The research identified types of variability in food processing system. Then, the research highlighted the exits variability measures in food. In addition, pervious published method steps have been summarized.

From rule base we can find that there were and improvement of process after implement rule base in waiting affected factors in different areas. In addition, as the result of implementation, waiting is decreased in all work stations.However; stopping was slightly increased in some workstations.

Therefore, apply artificial intelligent tools rule base in food flow processing system could reduce factors affect with variables. Thus, that could decrease variability level in food processing system. Although, there are many methods applied in food processing, rule base applied in bottleneck areas and reduce of each factor. For future work, Autonomous could be applied in food flow system for continues improvement.

REFERENCES

[1] Cattani K, Dahan E and Schmidt G M 2003 Using Make-to-Order Production Layered on Make-to-Stock Production to
Hedge Against Uncertainty

[2] Chang K-H and Lu Y-S 2010 Queueing analysis on a single-station make-to-stock/make-to-order inventory-production system *Applied Mathematical Modelling* 34 978-91

[3] Claycomb C, Dröge C and Germain R 2005 Applied customer knowledge in a manufacturing environment: Flexibility for industrial firms *Industrial Marketing Management* 34 629-40

[4] Doganis P and Sarimveis H 2007 Optimal scheduling in a yogurt production line based on mixed integer linear programming *Journal of Food Engineering* 80 445-53

[5] Ierapetritou M G and Floudas C A 1998 Effective Continuous-Time Formulation for Short-Term Scheduling. 1. Multipurpose Batch Processes *Industrial & Engineering Chemistry Research* 37 4341-59

[6] Kaminsky P and Kaya O 2009 Combined make-to-order/make-to-stock supply chains *IIE Transactions* 41 103-19

[7] Kopanos G M, Puigjaner L and Georgiadis M C 2010 Optimal production scheduling and lot-sizing in dairy plants: The yogurt production line *Industrial and Engineering Chemistry Research* 49 701-18

[8] Kopanos G M, Puigjaner L and Maravelias C T 2011 Production planning and scheduling of parallel continuous processes with product families *Industrial and Engineering Chemistry Research* 50 1369-78

[9] Mendez C A and Cerdá J 2004 An MILP framework for batch reactive scheduling with limited discrete resources *Computers & Chemical Engineering* 28 1059-68

[10] Noorwali A 2013 Apply Lean and Taguchi in Different Level of Variability of Food Flow Processing System *Procedia Engineering* 63 728-34

[11] Noorwali A 2013 Apply MTS-MTO and Principle Component in Food Flow Processing In: *International Conference in Production and supply chain management* (Rome,Itlay

[12] Noorwali A, Khalil R and Stockton D 2012 Investigating Types of Varibility on Food Flow Processing System In: *International Confrence on Manufacturing Research* (Aston University Birimingham Aston Business School)

[13] Soman C A, Pieter van Donk D and Gaalman G 2006 Comparison of dynamic scheduling policies for hybrid make-to-order and make-to-stock production systems with stochastic demand *International Journal of Production Economics* 104 441-53

[14] Soman C A, van Donk D P and Gaalman G 2004 Combined make-to-order and make-to-stock in a food production system *International Journal of Production Economics* 90 223-35

[15] Wu M-C, Jiang J-H and Chang W-J 2008 Scheduling a hybrid MTO/MTS semiconductor fab with machine-dedication features *International Journal of Production Economics* 112 416-26

[16] Youssef K H, Van Delft C and Dallery Y 2004 Efficient Scheduling Rules in a Combined Make-to-Stock and Make-to-Order Manufacturing System *Annals of Operations Research* 126 103-34

[17] Zaerpour N, Rabbani M, Gharehgozli A H and Tavakkoli-Moghaddam R 2008 Make-to-order or make-to-stock decision by a novel hybrid approach *Advanced Engineering Informatics* 22 186-201