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The model relationship of wastes for parameter design with green lean production of fresh water

Key words: waste, model, relationship, lean, product, water treatment

Introduction

A fresh water industry, serving the region of Banjarbaru and Banjar district with 62,205 customers in total by the end of 2015, has a service scope about 55% under the national target, which is 68%, and also the UN MDGs (Millennium Development Goals) target, that is 80% with NRW (non revenue water) average of 29%. The result of sedimentation is small water particles mixed with mud that is expelled 15 $m^3 \cdot day^{-1}$ as a result of production process with the capacity of 250 $l \cdot s^{-1}$. By seeing the condition above, an upgrade of production and service for customer by repairing/minimizing waste in the production process is needed.

Identifying waste requires certain model that can ease and simplify the problem search process and it can be done by waste relationship matrix (WRM). The advantages of this model are the simplicity of its matrix and the questionnaire that is able to cover many things and give contribution to gain an accurate result in identifying the root cause of waste Rawabdeh (2005). Lean is a continual effort to eliminate waste and increase the value adding by cutting unnecessary things so that it can give good customer value and make the process become flexible (easy to change).

Researchers observed that lean manufacturing is a must and an integral part of the manufacture principles around the world, including fresh water industry over the past few decades. In this part, lean is production principles applied most by companies that allows them to take benefit based on its application. These principles give a comprehension about why things are done and a basis to assess whether the advancement achieved is consistent with the principles within certain organization. To do repair action and minimize waste in production process that is proportional to the quality, quantity, continuity and productivity increase, lean manufacturing will influence the production process that has a goal to minimize waste. In this research, a model from WRM was developed to a relationship model among wastes according to the information in fishbone diagram with a recommendation of the most influential value for the experimental design, especially the setting parameter in the mixing process between procentage of alum, procentage of water supply, and stroke pump.

Literature review

In a manufacturing organization, value added is likely to include any activity that increases market form or product function so that the customer willing to pay. Value stream is identified for every product and defined as, "special activities required to plan well and to provide qualified product, from designing concept, inputting raw material, until delivering finished products to the customers" (Womack & Jones, 1996). It helps distinguishing value adding activities from non value adding activities for each product produced (for instance, reprocessing, scrap, waiting time).

Waste is defined as any activity of resources usage that does not give any value adding to the product. Basically, all waste occurred is closely related with the dimension of time. Method of JIT (just in time) defines seven types of waste that do not give value in the business or manufacturing process (Womack, Jones & Roos, 1990). In lean manufacturing, seven wastes are defined as (Yoneyama, Yeh & JayKuo, 2005): Defect, waiting, unnecessary inventory, inappropriate processing, unnecessary motion, transportation, over production.

Partial least square (PLS) is developed with PLS regression model (PLS-R) and PLS path model (PLS-PM) that have a reflective indicator of model – often referred as principal factor model – where the covariance of indicator measurement is influenced by latent construct or reflects the variation of latent construct. In reflective model, un-dimensional construct is portrayed by the shape of ellipse with some arrows from construct to indicator. This model hypothesizes that the change in latent construct will influence the change in indicator. The reflective indicator of model is required to posses internal consistency since all standard of indicator is assumed that all valid indicator measures the construct, thus two measurements of the indicator with the same reliability can be exchanged. Even though reliability (Cronbach's alpha) of certain construct only will be low if there is a little indicator but the construct validity will not change if one indicator is eliminated Vinzi, Chin, Henseler and Wang (2010).

Methodology

To observe the relationship among variables of seven wastes, the 60th data of respondents (questionnaire) was obtained in the production section of the fresh water company. All activities of fresh water treatment process would be identified and known for its waste of each step and also for how far the relationship between seven wastes and PLS smart analysis for the structural model of waste minimization is Anderson and Gerbing (1988), and Browne and Cudek (1993). Validity test for reflective indicator used the correlation between item score and construct score. Measurement with reflective indicator showed that there was a change on some indicator in some construct if another indicator in the same construct was changed (or taken out from the model). The measure of individual reflection is valid if the value of loading with latent variable wanted to measure is $\lambda \geq 0.5$. If one of the indicators has loading value of $\lambda < 0.5$ then the indicator must be dropped because it indicates that the indicator is not good enough to precisely measure the latent variable Henseller, Ringle and Sinkovics (2010).

The test of empirical model and goodness of fit was done on variable measurement (outer model) by checking on the estimation value of loading critical point (critical ratio – CR) that is significant towards trust degree which is of 95% or $\alpha = 0.05$. Discriminant validity was measured by seeing the AVE (average variance extracted) value and the recommendations of it are AVE value should be greater than 0.50 and composite reliability value should be greater or equal 0.70. Data assumption of distribution free was evaluated using R^2 for dependent construct, Q^2 test for predictive relevance, t-statistic with significance of degree on every path analysis (Michael & Andreas, 2004). To see the relationship between green manufacturing and waste, (Deif 2011) see in Figures 1 and 2 the process of modification of green Taguchi of fresh water production process developed with the integration of lean manufacturing and parameter settings for waste minimization is shown on Figure 2.

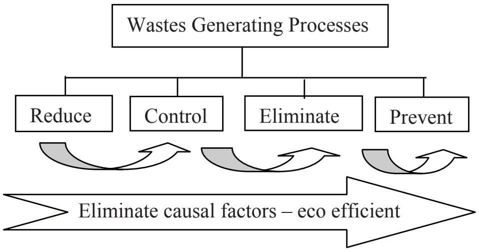

FIGURE 1. Green manufacturing and wastes

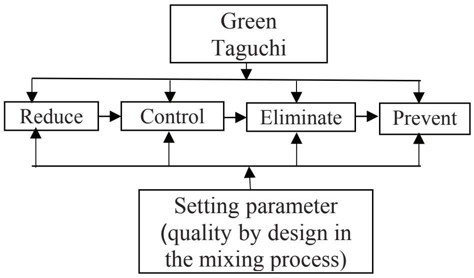

FIGURE 2. The green Taguchi model of fresh water

Results and discussion

Process added was followed by parameter setting (Ross, 1996; Duque & Cadavid, 2007) which required time, material and re-processing. Parameter setting done was in mixing process which consists of percentage of alum, water supply discharge and pump stroke in the installation of fresh water treatment. The result of composite reliability shows

TABLE 1. The value of waste composite reliability and AVE (average variance extracted)

Seven wastes	Cronbach's Alpha	Composite reliability	Reliability	AVE	Validity
Defect	0.786	0.860	reliable	0.607	valid
Waiting	0.721	0.877	reliable	0.745	valid
Motion	0.746	0.872	reliable	0.612	valid
Transportation	0.846	0.892	reliable	0.774	valid
Over production	0.919	0.958	reliable	0.728	valid
Over processing	0.816	0.889	reliable	0.920	valid
Inventory	0.828	0.898	reliable	0.736	valid
Minimize waste	0.841	0.887	reliable	0.781	valid

satisfying value that was above 0.7. An indicator could be stated as valid if the loading factor is above 0.5 towards the construct headed. These are the values of loading factor, valid AVE and composite reliability on output in Tables 1 and 2.

In Table 1, it can be seen that all values are above 0.7 which denote that the relationship among wastes influenced the overall waste minimization in fresh water treatment Roy (2001). In Table 2 an indicator is valid if it has a loading factor above 0.5 to the intended construct, in the table all indicators are valid.

The relationship among wastes in Figure 3 shows the relation between *x* and *y* variable. Figure 3 shows the relationship between *x* and *y* variable that portrays waste and what influences it. The quality of influence of over processing was the highest so that re-process of parameter setting was needed to upgrade the fresh water quality (Abdullah et al., 2009; Ling et al., 2017). The process of parameter setting was suggested to improve the production process which is more environmentally friendly Dieleman and Huising (2006). This is the equation track diagram of output result of structural PLS waste.

Meanwhile, the experimental design of L9 Taguchi method was made as part of the information and recommendation gathered from the value of over processing of structural model in treatment process. It was to optimize the parameter setting of the mixing process for the quality upgrade of fresh water in the water treatment plant (WTP), which was designed to produce quality water complying with drinking water. The water treatment processes performed in WTP are water supply, pre-sedimentation, mixing process (coagulation + flocculation), sedimentation, filtration, chlorination, storage and distribution). Performance characteristic and parameter value of the product were identified by using optimal parameter of the process. In Tables 3 and 4 shows three controllable factors of process were examined, namely: PAC (poly aluminium chloride) or alum, water supply and pump stroke. The mixing time denoted respectively assigns three levels for each controllable factor. An L9 orthogonal array was developed. The levels in Table 5 and Figure 4 indicate that they were 5, 10, and 15 for water supply with the debit water of 5, 10,

TABLE 2. The test of validity among wastes

Indicator	Defect	Waiting	Motion	Transportation	Over production	Over processing	Inventory	Minimize waste
*X*11	0.824							
*X*12	0.801							
*X*13	0.737							
*X*14	0.750							
*X*21		0.874						
*X*22		0.893						
*X*31			0.965					
*X*32			0.786					
*X*41				0.965				
*X*42				0.863				
*X*43				0.729				
*X*51					0.937			
*X*52					0.981			
*X*61						0.907		
*X*62						0.854		
*X*63						0.794		
*X*71							0.816	
*X*72							0.910	
*X*73							0.862	
*Y*11								0.813
*Y*12								0.851
*Y*13								0.760
*Y*14								0.730

*X*11: correction; *X*12: optimization; *X*13: repair; *X*14: rework; *X*21: idle time; *X*22: The readiness of the tools when needed; *X*31: employee/technician movement; *X*32: movement made to see the tools; *X*41: the stream of fresh water material; *X*42: part stream; *X*43: information stream; *X*51: the capacity of operating tools; *X*52: the input of fresh water; *X*61: non value added; *X*62: non value added; *X*63: non value added; *X*71: JIT; *X*72: supplier/water resource; *X*73: collector/storage; *Y*11: energy; *Y*12: mixing process; *Y*13: the quality of raw water; *Y*14: maintenance schedule.

15 and pump stroke of 15, 20, 25. With the L9 array, only nine tests run instead of full experiment conducted for three controllable factors on each level. The details of the L9 experiment are shown in Table 4 on the section of optimization and condition. In Taguchi method, quality characteristics are categorized into the larger-the better, nominal-the-best, and smaller-the-better types. The goal of this study is optimum parameter setting of factors (percentage of alum, water supply, pump stroke). There are nine experiments will take place on different parameter. Let us next interaction network process mixing in Figure 4 for

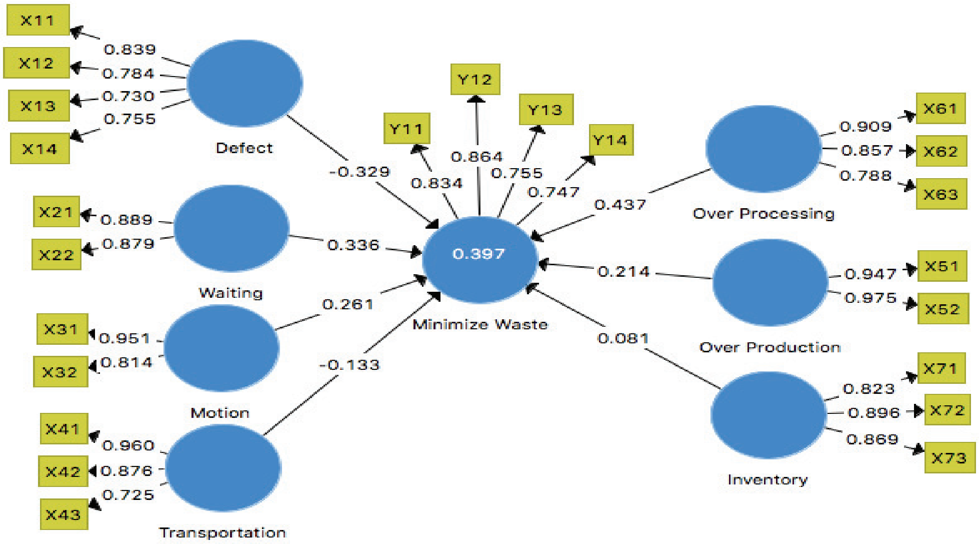

FIGURE 3. The relationship among wastes in structural model

TABLE 3. Level factor

Parameter	Code	Level 1	Level 2	Level 3
Concentrated alum [% ppm]	A	5	10	15
Water supply [$l \cdot s^{-1}$]	B	5	10	15
Pump stroke [%]	C	15	20	25

TABLE 4. Taguchi L9 orthogonal array

Run	Control factor and levels		
	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

design, minimization and interception waste by Kuo and Smith (1998), Wang and Smith (1995) and El-Halwage, Hamad and Garrison (1996).

Recapitulation and conclusions

The focus in this study was to investigate the potential of waste and the researcher can obtain the relationship among wastes describing how strong the contribution of each waste towards the decrease of waste in fresh water treatment with the optimal setting parameter. The information obtained is that the over processing value that was of 0.437 was higher than others which were the contribution of *X*6.1, *X*6.2 and *X*6.3. Over processing value influenced the parameter setting in the mixing process between percentage of alum, water supply, and pump stroke in the installation of fresh water treatment (Table 5). Para-

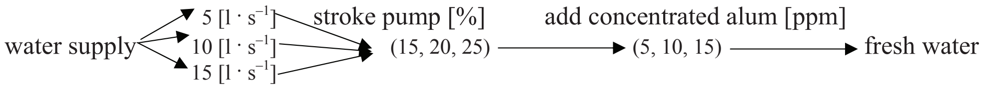

FIGURE 4. Structure process mixing for example setting

TABLE 5. Mixing process L9 orthogonal matrix

Concentrated alum [% ppm]	Water supply [l·s^{-1}]	Pump stroke [%]
5	5	15
5	5	15
5	5	15
10	10	20
10	10	20
10	10	20
15	15	25
15	15	25
15	15	25

meter setting was required to obtain an optimal mixing process to determine a level that is in accordance with the quality standard of fresh water. Table 2 showed that loading factor gave values that are above the suggested value which is of 0.5. The smallest value was 0.729 which is for *X*43 indicator. It means that the indicator used in this research is valid and has fulfilled the convergent validity.

Model relationships between waste is required to know what factors most influence on the process of water treatment through the mixing process, because water treatment is influenced by the conditions in the river flow upstream as input water supply, turbidity factor is the most important in the process of water treatment. Therefore the water quality is well maintained according to standards of health will require setting parameters to obtain optimal mixing process between percentage of alum, water supply and pump stroke. The composition and level of the mixing process adjusted to the level of turbidity of water supply from the river, the optimum setting is obtained by combining the above three factors to reduce turbidity levels. Decreased levels of turbidity will affect water quality and preserving the environment in the upstream and downstream and minimize waste in the water treatment process.

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Summary

The model relationship of wastes for parameter design with green lean production of fresh water. Lean manufacturing is about eliminating waste including the seven traditional, this writing suggested an observation on no value added of seven wastes influencing the process of fresh water production. The relationship value among waste was statistically verified to create an approach for continuous improvement action. Thus, the main goal of this research is to develop a methodology of relationship among wastes and eliminate them. In relationship among wastes, it could be known that the high value indicating how often it happened in the production process gave direct cause in the system of fresh water treatment. A recommendation to reduce the highest value of waste is by doing improvement on parameter setting to obtain an optimum mixing model between water supply, alum and stroke pump with Taguchi method. The interaction of relationship among these seven types of waste can be portrayed using fishbone diagram and a relationship model among wastes using PLS smart (partial least squares). The final relationship model with the highest value of waste was analyzed using off-line quality control to upgrade the quality of fresh water used as the basis to eliminate waste and find out the optimal parameter of mixing process in accordance with the health standard.

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