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The Application of Quality Function Deployment (QFD) Towards The Design of Batik Coloring Machines to Increase The Value of Fading and Stains on Fabrics

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Abstract. *The aim of this study is to design a batik coloring machine using the Quality Function Deployment (QFD) method in order to increase the value of fading and stains on fabrics. It can be concluded that the results of the design of batik coloring machines according to the application of QFD have 3 rollers/cylinders and propulsion about 0.190 HP with the working concept of a sheet of cloth wrapped around the cylinder with rotation of 72.5 rpm. There are significant differences between variables in the design before and after the experiment on the batik value quality analysis of soap washing and desecration of unbleached plain cloth of Primisima type, Gamelan stamp. The average difference between before and after the experiment is 0.060 or increase to 6%, while for the analysis of batik quality test, the value of rubbing dry and wet cloth has a mean difference between before and after the experiment of 0.100 or an increase of 10%. Standard time generated from the measurement process using a machine dipping carried out by 20 batik makers has a value of 0.2701 hours/ unit with total output of 4 units/ hour, while standard time for coloring activities that uses a bucket dip is 0.5346 hours / unit with total output of 2 units/ hour.*

Keywords. *batik, coloring machine, quality function deployment*

I. INTRODUCTION

The coloring activity for dyeing process of hand-drawn batik in the batik center of Tegal City of Indonesia is generally carried out by women using a bucket or tub. The dyeing activity must be done repeatedly to produce good quality or fade-proof batik cloth. In the dyeing process, both hands of the worker go into the bucket or tub within range of about 75 cm and the body posture is stooped. The interview with the batik makers in Fitri Ayu Kalinyamat Wetan batik group in Tegal City reveals that batik coloring activity needs skill to mix the ingredients/ dyes with water, in the sense that too much thickness in the process of mixing naptol dyes with water can cause uneven coloring. The dyeing process requires energy and carefulness because the fabric must be dyed repeatedly and turned backwards so that the dye can penetrate evenly into the fabric. The cleanliness should also be maintained because hasty work attitude can cause bad quality and dirty hands also result in dirty cloth.

The process of making batik in the Fitri Ayu batik group is done through a number of processes, starting from making patterns on paper, making patterns in cloth, nyanting, isen-isen, nembok, coloring to scratching and washing. The coloring process requires 30 minutes per cloth per 1 color. In case one cloth has more than one motif, the coloring process is multiplied by the number of the color.

According to (Rizky & Trilaksana, 2015), batik process is carried out through several steps starting from motive formation, coloring/ dyeing, fixation and scratching. The dyeing process is one of determining factors of batik quality (Suliyanto et al., 2015). With regard to this, it is found that the use of naphthol dyes can improve color naphthol soap by 8% (Luthfianto et al., 2014). For dark colors and alum, it is found that the optimal condition of dyeing to obtain sharp colors are 5 and 8 times abd 11 times of dyeing, respectively (Pujilestari, 2017). High temperature can cause batik wax melted and the melting condition, in

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Figure 1. Stooping posture in batik color dyeing process in batik industry center Tegal City (Dyes are the assistance of the Tegal City Government)

turn, causes damage on batik motifs (Pujilestari et al., 2016). The heated Batik wax will emit smoke containing gas NO2, SO2, CO, CO2, HC, H2S. The presence of these pollutants is harmful to workers' health and the environment (Latif et al., 2016). The implementation of RULA on shaking method of dyeing at Rumah Batik Komar recommends an improvement and further investigation (Pratama et al., 2015). On dyeing or coloring activities using a manual or traditional instrument (in this case, bucket), the application of REBA leads to the need of immediate repair (Siswiyanti & Rusnoto, 2018). In the meantime, the implementation of RULA on the same activities suggests immediate repair as well (Siswiyanti & Rusnoto, 2017). According to (Ma'ruf et al., 2015), the batik color dipping tool has a size of 1610 mm x 650 mm x 460 mm with a drive system of an electric motor ¼ HP, 1: 60 reducer with rotation generated of 9 rpm and 186 watts. This tool setting increases batik fabric production capacity around 5 pieces per day to 8 pieces per day and speeds up the coloring process to 30 minutes per sheet. In terms of designing batik dyeing machines, the use of two rollers of which drive rotation is 47 rpm produces 0.019 HP driving motor power. The same machine can produce the evenly colored fabric and the relatively low motor power is suitable for small batik industries (Sanjoto et al., 2016). The coloring of batik cloth can be more evenly improved by designing appropriate technology, an example of which is the application of feeder machines in small batik industries in Pekalongan. Using the feeder machines, the dyeing of batik cloth with a length of more than 2.5 m can be carried out easier with more even colors, less coloring time, improved work posture and increased sales (Irhandayaningsih, 2017). Based on the aforementioned problem description, this paper deals with the design of coloring machines in order to increase the value of fading and stains on fabrics by using Quality Function Deployment method.

II. RESEARCH METHODS

This research uses Quality Function Deployment which consists of four stages, namely planning and preparation of customer voting and the making of quality house; development of part deployment matrix; process planning matrix; and production planning matrix. The research took place at Fitri Ayu batik group which is located in batik industry center in Kalinyamat Wetan, Tegal City, Indonesia.

The tools used in this research are: 3 PVC rolls/ cylinder pipe with a driving force of 0.190 HP, the working concept of sheet cloth wrapped around the cylinder with rotation of 72.5 rpm, iron paint, digital camera and questionnaires (Siswiyanti & Rusnoto, 2018). Questionnaiare 1 is to determine attributes/ characteristics of product the user

Table 1. The characteristics of Desires / Needs for Batik Coloring Machine Customers

Primary	Secondary	Tertiary
Batik coloring machine product design	Easy to use	• Easy to operate • Easy to move • Easy to dip dye • Easy to clean and dispose of dyes
	Safe to use	• Safety of undamaged dyes • undamaged Fabric safety • Safety of dyes for processing
	Comfortable to use	• Comfort when used
	Precision	• Suitability size of tools / machines with cloth • Suitability of the shape of a tool / machine with cloth
	Good result	• Color quality, quality of quantity • Quality of time, Quality of process

Source: Results of user voting analysis

Table 2. The result of validity test

N = 20; df = 18; α = 5%

CUSTOMER'S NEED	r Satisfaction count		r Interest count	r Table	Conclusion
	Batik coloring machine	Manual batik coloring	Batik coloring machine		
Easy to operate	.628	.812	.678	0,468	Valid
Easy to move	.615	.789	.703	0,468	Valid
Easy to dip dye	.595	.796	.659	0,468	Valid
Easy to clean and remove dyes	.632	.791	.694	0,468	Valid
Safety of undamaged dyes	.603	.816	.669	0,468	Valid
Undamaged Fabric safety	.605	.831	.649	0,468	Valid
Safety of dyes for processing	.695	.773	.692	0,468	Valid
Comfort when used	.620	.806	.699	0,468	Valid
Suitability size of tools / machines with cloth	.643	.793	.657	0,468	Valid
Suitability of the shape of a tool / machine with cloth	.709	.823	.671	0,468	Valid
Color quality	.675	.826	.701	0,468	Valid
Quality of quantity	.662	.824	.660	0,468	Valid
Quality of time	.634	.823	.693	0,468	Valid
Quality process	.725	.841	.699	0,468	Valid

Source: The Analysis Results of SPSS 23.0

needs, whereas questionnaire 2 is concerned with the satisfaction and importance of the characteristics. The respondents in this study were 20 female batik makers aged between 20 and 55 years, with at least one year of experience, in good health, and are willing to participate in the research till completion.

III. RESULT AND DISCUSSION

Table 1 explains the characteristics of the users of batik coloring machines, whereas the results of validity and reliability test can be seen in Table 2 and Table 3.

The final result of the QFD method is a product development plan located at the bottom of the House of Quality (HOQ). The QFD method covers complete processes starting from identifying problems to achieving the target of development projects through the existence of design specifications. The technical characteristic is used to measure or quantify consumer needs. The level of importance can be known based on

Table 3. The results of sampling reliability test and satisfaction (Batik coloring machine and manual batik coloring)

Item	(Alpha)	Notes
Level of importance	0,697	Reliable
Satisfaction Level of Batik Coloring Machine	0,666	Reliable
Satisfaction Level of Coloring Batik Manual	0,823	Reliable

Source: The Analysis Results of SPSS 23.0

Table 4. Part deployment matrix

Technical Requirement	Target	Critical part requirement	Machine design	Color design	Coloring process desgin	Dyeing design	Time design
Functional machine	3 cylinders (dia 3/4 ') for fabric rotation balancer	9	•		•		•
Raw material for machine makers	Electrical Motor 1/4 HP dan b, box electric	7	•			•	
Quality of dyeing	3 cylinders (dia 3/4 ') for fabric rotation balancer	6				•	•
Coloring quality	adjusted color absorbency and fabric, bubbles	5		•	•		
			determined	determined	determined	determined	determined
			144	45	126	117	135

the order of the value, namely 4.95 for the "color quality" attribute, 4.40 for the "time quality" attribute, 4.40 for the "easy to clean and dispose of dyes" attribute, 4.30 for "comfort when used" attribute, 4.25 for the "easy to move" attribute, 4.20 for the "total quality" attribute and 4.20 for the "process quality" attribute.

Part Deployment Matrix

In the part deployment matrix (see Table 4), there are 4 targets namely ¾-inch-diameter 3 cylinders for balancing cloth rotation, ¼ HP electrical motor, electric box, 3 cylinders and adjusted for color and color absorption power as well as bubble hose, with each critical part requirement 9.7, 6 and 5 with the highest score of 144 in engine design.

Process Planning Matrix

The process planning matrix (see Table 5) begins with making a map on the process of making batik coloring machine. The map is then connected with the critical part resulted from the previous matrix. There are 5 stages of the planning process, namely the process frame installation, big tub installation, lower cylinder installation, cylinder upper and electric motor installation.

Production Planning Matrix

This step is the last step to find out the actions that need to be taken to improve product design performance. The steps that require improvement can be seen in Table 6.

The analysis of Batik Coloring Machine Components

Using the QFD method, main components of Batik coloring machines affecting the quality of fabrics are found, as follow: (1) leg supporting screw is to regulate the slope of the tub to facilitate the process of disposal of dyes; (2) a small roll of cloth pressure/ load that helps the process of pressing fabric so that the liquid absorbs easily on the fabric; (3) the inventer box which is used to select the swivel/ speed; (4) the channel and faucet of the dyestuff of which

Table 5. Planning matrix for the process of making batik coloring machines

Specification process large cylinders cylinder on motor electronics	The design of the dyeing machine	Big tub	lower cylinder	Top cylinder	Motor electronic	*Critical part requirement*	Planning process
Manual	-	0	0	0	-	Measurement process	
Meter roll	-	0	0	0	-	Tools used	
Iron the size	0	-	-	-	0	Material size	Framework Process 1
customized with design	0	0	-	-	-	Cutting method	
Hacksaw	-	0	-	-	-	Tools used	
Customized design	0	-	-	-	-	Welding method	
Electric welding	0	-	-	-	-	Tools used	
Manual	-	0	-	-	-	Assembly process	Installing a big tub 2
Painting, supporting pipes, bolts, nuts, rings	0	-	-	-	-	Tools used	
Manual	-	-	0	0	-	Assembly process	Installing lower cylinder 3
Machine frame, bulkhead tub	0	-	-	-	-	Tools used	
Manual	-	0	0	0	0	Assembly process	Installing upper cylinder 4
Lower engine frame	0	-	-	-	-	Tools used	
Manual	-	-	-	-	0	Assembly process	
Upper engine frame	0	-	-	-	-	Tools used	
Manual	-	-	-	-	-	Assembly process	
Safety cap, van belt 1,2,3	0	-	-	-	0	Tools used	
Manual	-	-	-	-	-	Assembly process	
Fasteners, bearing units	0	-	-	-	0	Tools used	
Manual	-	-	-	-	-	Assembly process	
Cylinder axle	0	-	-	-	-	Tools used	Motor electric 5
Manual	-	-	-	-	-	Assembly process	
Pulley drive cylinder	0	-	-	-	-	Tools used	
Manual	-	-	-	-	-	Assembly process	
Cylindrical pulley is driven	0	-	-	-	0	Tools used	
Manual	-	-	-	-	-	Assembly process	
Pulley motor	0	-	-	-	-	Tools used	
Manual	-	-	-	-	-	Assembly process	
Gear box	0	-	-	-	-	Tools used	
Manual	-	-	-	-	0	Assembly process	
4 inch pulley driven	0	-	-	-	0	Tools used	
Manual	-	-	-	-	0	Assembly process	
6 inch pulley driven	0	-	-	-	0	Tools used	
Manual	-	-	-	-	-	Assembly process	
Compressor, pipe bulb	0	-	-	-	-	Tools used	
Manual	-	-	-	-	0	Assembly process	
Switch, socket, cable	0	-	-	-	0	Tools used	

Source: Siswiyanti & Rusnoto (2018)

function is to facilitate the process of removing the dye and to reduce the stooping posture (Table 7).

The analysis of Standard Time per unit of Product

The normal time obtained from the measurement process, especially from coloring activities by using machine of dyes that is performed by 20 batik makers has an average value of 14.5 minutes/ unit with a performance rating level 0.95. Standard time per unit of product is 0.2701 hours/ unit so that the total output is 4 units/ hour (assuming 15% allowance value, 5% accuracy rate and 95% confidence level).

At the same performance rating level, it is found that the normal time for coloring activities by using bucket dipping carried out by 20 batik makers has an average value of 28.7 minutes/ unit. Assuming 15% allowance value, 5% accuracy rate and 95% confidence level, standard time per product unit is 0.5346 hours/ unit so that the total output is 2 units/ hour.

The analysis of the Difference Test towards the Washing of Soap and Blasphemy Test

The results of color fade-proof and soap washing value using variations in pulley diameter D100, D125, D150 and D175 are presented in Table 8.

Table 8. The analysis results of the Quality Test of Batik on unbleached plain fabrics Primisima Gamelan stamp The Value of Washing Soap and Blasphemy

Manual	D100	D125	D150	D175
4	4	4,5	4,5	4,5
4	4	4,5	4,5	4,5
4,5	4	4,5	4,5	4,5
4,5	4	4	3,5	3
4	4	4,5	3,5	3
4	4	4,5	3,5	3,5

Data source: textile evaluation lab test results of UII Yogyakarta, 2018

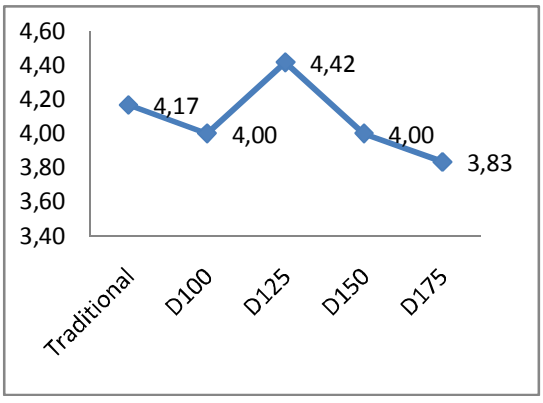

Figure 2. The average fade and stain test value

Table 9. Average, standard deviation and t test between before and after experimental design

Variable	Average	Deviation Standart	T count	*P*
Before	4.167	.2582	-1.464	.003
After	4.417	.2041		

From the normality test, it is found that all data are normally distributed. The results of t test for objects are shown in the manual machine using D125 (see Table 9), because they have the largest difference on the average after the experiment. Table 6 states that, regarding the test with respect to before and after the experiment in the sample, the probability value is 0.003 ($p < 0.05$). Thus it can be concluded that there are significant differences between the variables in the design before and after the experiment. The average difference before and after the experiment is 0.060 or an increase of 6%.

The Analysis of Different Tests towards Rubbing Tests of dry and wet fabrics

The results of dry and wet cloth rubbing fade-proof values which use variations in pulley diameter D100, D125, D150 and D175 are provided in Table 10.

It is found that all data are normal distributed. The test for difference used is paired sample t-test applied to the D125 (for the reason that they have differences in the mean on the average after the experiment, see Table 8).

Table 11 states that, regarding the test with respect to before and after the experiment in the sample, the probability value is 0,000 ($p < 0.05$). It can therefore be concluded that there are significant differences between the variables in the design before and after the experiment. The average difference before and after the experiment is 0.100 or an increase of 10%.

Table 10. The analysis results of the quality test of batik on unbleached plain fabrics primisima gamelan stamp the value of rubbing dry and wet cloth

Manual	D100	D125	D150	D175
3,5	3	3,5	3	4
3,5	3	4	3,5	3,5
3	3	3,5	3,5	3,5
3,5	3,5	3,5	3	3,5
3,5	3,5	4	3	3,5
3	3,5	3,5	3	3,5

Data source: textile evaluation lab test results of UII Yogyakarta, 2018

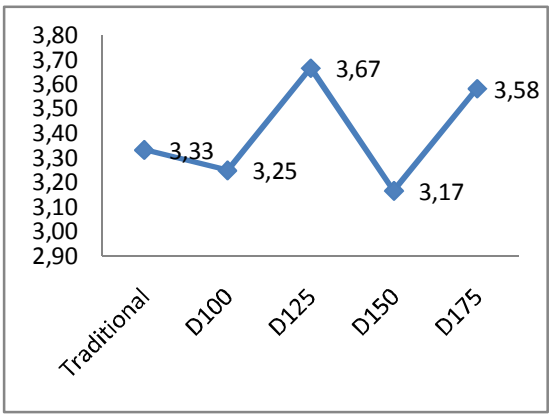

Figure 3. The Average Value of Rubbing dry and wet cloth

Table 11. The average, standard deviation and t test between before and after design

Variable	Average	Deviation standart	t count	*P*
Before	3.333	.2582	-3.162	000
After	3.667	.2582		

IV. CONCLUSION

From the results of data processing and data analysis that have been conducted, it can be concluded that there are 14 attributes of ergonomic interests as the source of ideas for designing batik coloring machines, namely easy of operation, easy of transfer, easy of dyeing, easy of cleaning and removing dyes, the safety of the dyes is easily not damaged, the safety of the fabric is not easily damaged, the safety of the dyes to be processed, the comfort when used, the suitability of the tools/ machines with the fabric, the suitability of the machine / fabric, color quality, quality of quantity, quality of time, process quality.

Based on the Analysis of batik quality test on unbleached plain fabric Primisima Gamelan stamp has TLW Value on Soap Washing and Blasphemy, it can be concluded that there are significant differences between the variables in the design before and after the experiment. The average difference before and after the experiment is 0.060 or an increase of 6%.

Regarding unbleached Plain Fabric Primisima Gamelan stamp has TLW Value towards dry and wet cloth rubbing, it can be concluded that there are significant differences between the variables in the design before and after the experiment. The average difference before and after the experiment is 0, 100 or an increase of 10%.

From the measurement process using machine dye performed by 20 batik makers, it is found that the normal time has an average value of 14.5 minutes/ unit.

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