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A Study of New Washing Process Which Combines Deflection and Abrasion Action

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Abstract. This study aimed to determine the optimum washing of laboratory washing model that design to stimulate the active washing process and passive commercial washing machine are compared in order to determine the best washing result. Variables of the study include water speed, washing time and radial nozzle inclination angle. The rotational system of an automatic washing machine has two major technical difficulties. One is the collision of the tub against the frame at the beginning of its early spinning stage. A factor that causes such instability of the rotational object can be attributed to the deflection of the liquid inside the liquid balancer due to the unbalance mass. Proposed a new washing technology and new design of the washing machine can be as a base of its new type. These machines have better outcome data; improve quality of washing process and effective use of washing liquid. New washing machine is simple design, does not have rotary parts at all and uses active process of washing process with squeezing of linens and more productive then known washing machines. Also, this machine can recycle and feed cleaned washing liquid. Additionally, in use of ultrasonic technology of washing process, new machine today will be perfect design.

1. Introduction

In the early 1800s, all mechanical washing machines appeared were hand-powered. Early models cleaned clothes by rubbing them, while later models cleaned clothes by moving them through water. Steam-powered commercial washers appeared in the 1850s, but home washing machines remained entirely hand-powered until the early 1900s, when several companies started making electric machines. The Automatic Electric Washer Company and Hurley Machine Corporation both began selling electric washers in 1907, while Maytag offered an electric wringer washer in 1911. In 1947, Bendix offered the first fully automatic washing machine, and by 1953 spin-dry machines overtook the wringer types in popularity. [1]

Nowadays, the commercial clothes washers have consisted of drums to rotate the laundry and increase its cleanliness performance. They have some common types of problems can be rectified by you itself while others might require a specialist. Firstly, the drum might create more noise than usual. This might occur due to overloading of clothes. In other instances, the drum might just refuse to rotate properly. This may happen due to several reasons. The drum consists of several small holes that act as input for the water. Some small objects like pins and hooks may get stuck into these holes. Yet another reason for malfunctioning of the drum might be the agitator in top loading machines. The agitator might have broken due to the strain of clothes or any kind or sudden tumbling mechanism. Yet another factor for improper functioning of washing machine drum is caused by the damage of the belt that connects the motor to the drum. This stops the drum from rotating. If the belt is broken or damaged the drum will not rotate until it is replaced with a new one [3]. From previous research [4-7], the use of 3D CAD software in designing the product can make the designer easier to view the model in a variety of representations and can make the simulation to the model by simulating the real condition. A new design of our washing process without using the drums can help to prevent these problems for our daily housework. Our research is to observe the best possible parameter setting for the new design washing process and investigate the cleanliness performance of this prototype. There is another study on washing machine which are using chemical reaction to define the cleanliness of washing machine such as a study on cyclodextrins [8] and sonochemical [9]. While [11] and [12] are focused on suspension design optimization. There are also some of researchers are trying to make a new model as it does in [13], [14] and [15] research.

2. Methodology

A set of standard method was used in industrial to establish a uniform, repeatable procedure for evaluating the performance of washing machine shown in figure 1. This standard provides technical means to compare and evaluate the performance of different washing machine. For this project, a standard lab testing techniques or procedures are set to compare and evaluate the cleanliness performance of the different parameter of the new design technology washing process. The parameters are including the speed of the motor, the angle of the nozzle, and the washing time. The constant parameter settings are the weight of load, weight of detergent, water volume, the changing time of valve, water temperature, conditioning cycle, and same type of soil strips. Soil/stain removal test has used to test the cleanliness performance of our new technology design of washing process. The sequences of experiment were generated by using the ANOVA software which obeying the full factorial theory in design of experiment (DOE) [16-18]. Besides, the calculation was done to define the location of center mass of the liquid in the drum to determine the best angle of water inlet by theoretical method.

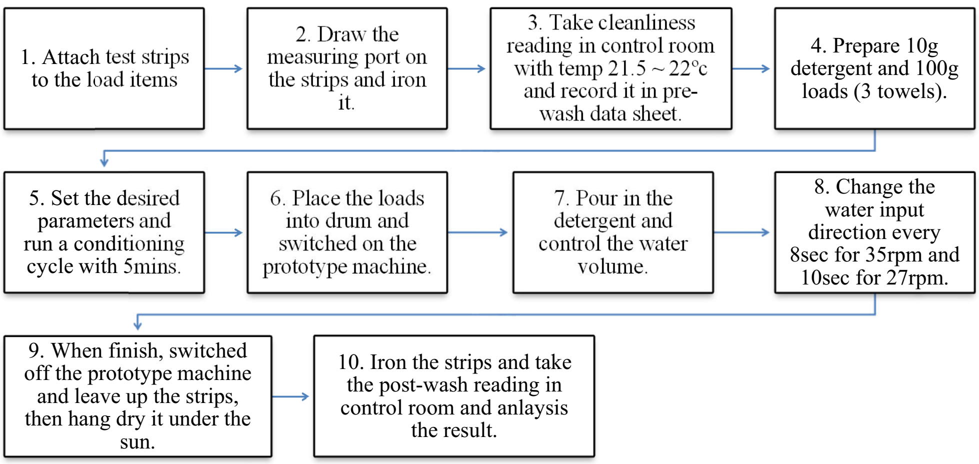
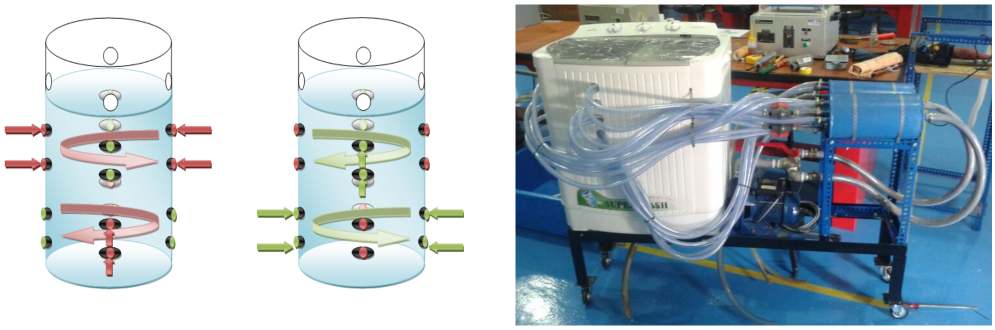


Figure 1. Process Flow

For the step-8, the water direction changed in regular sequence to create the squeezing effect for the washing process of cloths. For testing in 35rpm, the water direction changes in every 8sec. For testing in 27rpm, the water direction changes in every 10sec. The figure 2a shows the water flow direction that generates the rotary motions of fluid and figure 2b shows the prototype of washing machine.



a) Water Flow Direction b) Prototype of new washing machine.

Figure 2. Water flow

The parameter setting for the analysis in our thesis are washing time, washing speed and water nozzle angle. Therefore, the controllers of nozzle angle in water inlet and controller of washing speed are adjustable used to change the desired setting for testing. The constant parameter settings are water temperature, weight of detergent, volume of water, power supply. The nozzle angle in the model is flexible for different desired testing angle from 50°to 70°. The bottom valve is fully close during the experiment and it is used to release water in the drum when experiment finished. The water level remark is used to maintain the constant water volume for testing. The water outlet is used for water output and to prevent the water over flow problem. Motor is pumping in the water to the drum. The speed controller used to adjust the washing speed. The controller switch to 40° is used for 27rpm and switch to 90° is used for 35rpm. The frequency controller is used to control the input of water form green nozzle or red nozzle. Hence, create the squeezing effect for the washing process [19-20]. Different speed of motor will have different frequency of the input water. For 35rpm, water level constant when valve changes at 8sec per cycle. For 27rpm, water level constant when valve changes at 10 sec per cycle. The flow meter also installed to observe the flow rate of system.

3. Results and Discussions

Table 1 is the data used for ANOVA analysis. 2^3 factorial is used in the analysis with the 2 replication and 2 block form. 16 runs are generation under design of experiment theory. The response 1 cleanliness (%) value is the calculated value of CSt in the previous section table. The Model F-value of 6.85 implies the model is significant. There is only a 1.06% chance that a "Model F-Value" this large could occur due to noise. Values of "Prob > F" less than 0.0500 indicate model terms are significant. In this case A, B are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve the model. The "Pred R-Squared" of 0.3344 is not as close to the "Adj R-Squared" of 0.7452 as one might normally expect. This may indicate a large block effect or a possible problem with the model and/or data. Things to consider are model reduction, response tranformation, outliers, etc."Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. The ratio of 8.659 indicates an adequate signal. This model can be used to navigate the design space.

The Normal Plot is a normal probability plot that we have used before. The effects estimates are plotted versus their corresponding normal scores, which are the normal percentiles expressed as standardized units. The straight line fit through the points is not a least square fit as used in simple linear regression. The line is a function of the mean and standard deviation of the plotted points. If the plot points from the effect estimates are normally distributed, the points will tend to approximately follow this line.

IOP Conf. Series: Materials Science and Engineering **864** (2020) 012145 doi:10.1088/1757-899X/864/1/012145

Table 1. Data of Washing Machine for ANOVA Analysis

Run	Block	Factor 1 A. Water speed Litre per second	Factor 2 B. Washing time minutes	Factor 3 C. Nozzle angle degree	Response 1 Cleanliness %
1	Day 1	0.14	12.00	50.00	0.324747
2	Day 1	0.14	8.00	70.00	0.204701
3	Day 1	0.14	8.00	50.00	0.285539
4	Day 1	0.18	8.00	70.00	0.292262
5	Day 1	0.14	12.00	70.00	0.290661
6	Day 1	0.18	12.00	70.00	0.363343
7	Day 1	0.18	12.00	50.00	0.38961
8	Day 1	0.18	8.00	50.00	0.197421
9	Day 2	0.18	12.00	70.00	0.357585
10	Day 2	0.18	8.00	70.00	0.164474
11	Day 2	0.18	12.00	50.00	0.41239
12	Day 2	0.14	8.00	70.00	0.128027
13	Day 2	0.14	8.00	50.00	0.167926
14	Day 2	0.14	12.00	70.00	0.184373
15	Day 2	0.14	12.00	50.00	0.303125
16	Day 2	0.18	8.00	50.00	0.215987

Normal Plot helps to pick out effects that deviate from the normal lines. The following Half-Normal plot and Normal plot shows the positive effect or negative effect of each factor to the variability of the response. The plot of the effects suggests that factor B and C have significant effects.

Another graphical tool for evaluating effect estimate is the Pareto chart for effects as shown in figure 3. Pareto chart is useful presentation of the relative size of the effects that helps determine which effects are most significant. There are two different t limits plotted on the graph - based on the Bonferroni corrected t and a standard t. These limits are re-calculated and thus will change as terms are added or removed from the model. These t-limits are only approximations to the 5% risk level.

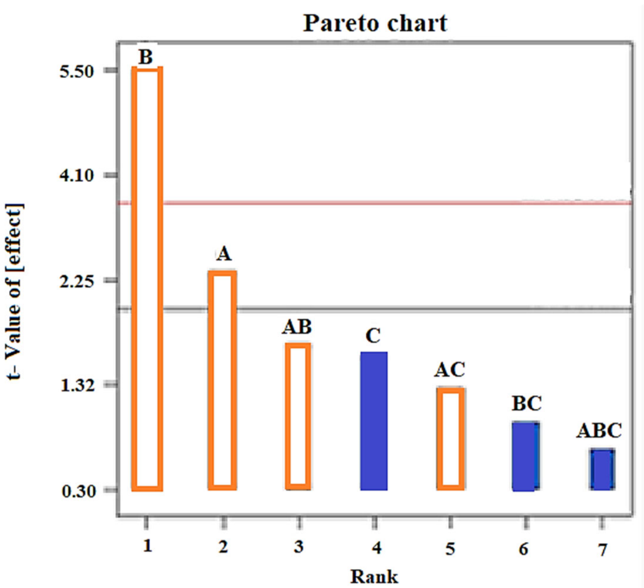


Figure 3. Pareto Chart

IOP Conf. Series: Materials Science and Engineering **864** (2020) 012145 doi:10.1088/1757-899X/864/1/012145

Here's the process to follow if using this pareto graph to pick effects.

1. Select those effects that are obviously larger than the others.
2. Effects that are now above the Bonferroni Limit are almost certainly significant.
3. Effects that are now above the T-Value Limit are possibly significant and should be added if they are not already selected.
4. Effects that are below the T-Value limit are not likely to be significant.

The selected optimum parameter setting by ANOVA analysis is washing speed = 0.09l/s, washing time = 12 minutes, nozzle angle = 0°. The desirability = 0.098. Besides, total 25 solutions generated by ANOVA can be used for the parameter setting base on the desired value of desirability and with the constraints on maximum cleanliness.

4. Conclusion and Commercialization Potential

In this project, a new technology and design of the washing machine which does not have rotating drum and actuator is introduced. The new idea is transfer pressure of the fluid right to rotary motions of the fluids that can be used for squeezing and washing process of the clothes. The calculation and analysis is applied when evaluate the optimum parameter. Design of experiment theories are used to generate the experiment progress sequence and analyze the experiment result.

By comparing the highest cleaning score (CSt) result, the percentage improvement shows that laboratory washing machine is 47% better than washing machine model WA91U3. The optimal parameter setting are washing speed = 35rpm (0.09 litre/s), washing time = 12 minutes, nozzle angle = 0°. If the water speed fixed at 27rpm, the best parameter setting are washing time = 12 minutes and nozzle angle = 0° also to get the better performance with cleanliness = 50.49%.

By referring to the result of comparing ratio, we found that the improvement of cleanliness vs. water speed is 18.355% and the improvement of cleanliness vs. washing time is 32.67%. It shows the washing time more affecting the cleanliness result than water speed. It also prove that the analysis diagnostic plot generated by ANOVA which showing the most significant factor is washing time and second is the water speed. To conclude, this project done successfully with the output of optimal parameter setting are washing time = 12min, water speed = 35rpm and nozzle angle = 0 degree. This new technology design washing process gives 47% improvement compare to washing machine model WA91U3.

The new design of washing process consists of high commercialization potential. This is because the new technology is help to reduce one of the parts - rotating drum or actuators in the washing machine. At the same time, the problems that created by rotating drum and actuator are solved. Besides, the manufacturing cost of washing machine also can be reduced due to less one part used. On the other hand, the manufacturer company can gain more benefit by using investing our new design technology. In addition, this new design gives 47% better performance than commercial product. This means the new washing process can performance better and can increase the good feedback from customer or user Hence, the reputation of company will increase and public more truthful to the company product Therefore, our new design technology is having strong commercialization potential in the market.

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