DESIGN AND DEVELOPMENT OF A DYNAMIC-ACTIVE CLOTH WASHING PROCESS

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REKABENTUK DAN PEMBANGUNAN PROSES AKTIF-DINAMIK PENCUCIAN PAKAIAN

ABSTRAK

Tesis ini menerangkan tentang tahap kecekapan suatu proses pencucian baru yang direka cipta. Suatu model makmal telah dibangunkan agar kaedah pencucian baju baru iaitu secara aktif dan dinamik dapat dikaji. Proses baru ini menggunakan prinsip cucian mekanikal di mama ia menggabungkan tindakan pulasan dan gosokan akibat tindakan hidrodinamik air dan kesan jet air untuk membersihkan baju. Pergerakan air yang komplek dan dinamik memberi interaksi secara terus antara air dan baju di mana pembersihan aktif yang lebih produksif boleh didapati. Dalam kajian pembersihan baju, jurutera menumpukan perhatian dengan mengkaji faktor seperti masa cucian, suhu, dan tindakan mekanikal untuk meningkatkan kualiti cucian. Tindakan mekanikal adalah bergantung kepada daya putaran atau kesan kacauann daripada tindakan pergerakan air terhadap baju yang dicuci semasa proses pencucian berlaku. Tujuan kajian ini ialah untuk mencari faktor utama yang mempengaruhi output cucian secara optima untuk proses cucian berkaitan. Perbandingan data antara aktif proses daripada model makmal dan pasif proses daripada mesin basuh Samsung WA91U3 dari segi keupayaan mencuci pakaian dibandingkan. Hasil data menunjukkan faktor utama yang dapat memberi kesan cucian optima kepada proses aktif ditentukan oleh masa manakala proses pasif bergantung terutamanya kepada kelajuan cucian. Kadar lunturan kotoran daripada baju menunjukkan proses cucian secara aktif adalah hampir 50% lebih baik daripada proses cucian secara pasif yang dibanding.

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ABSTRACT

This thesis describes washing performance of a new introduced washing process. A laboratory washing model is developed to simulate the dynamic-active cloth washing process. It is the mechanical washing principle which combines deflection and abrasion actions due to hydrodynamic and impact water jet working liquid to wash the cloth. Complex dynamic fluid motion creates direct interaction between working liquid and washed cloth hence produce active washing. In the washing machine research area, engineer is interested in improving the washing performance by investigating its washing time, temperature and the mechanical action that depend on motion of rotating force or agitation effect acting on the washed cloth. The purpose of this study is to find the major contributing factor to optimum washing of the washing process. Data comparison in term of the washing efficiency has been performed between the laboratory developed model and the commercial washing machine modelled Samsung WA91U3. Result shows that the most significant factor contributes to optimum washing for developed model is washing time while the commercial washing machine depends major on the washing speed. Soil removal test indicates dynamic-active cloth washing process of developed laboratory model is about 50% more efficient than the current washing machine compared.

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CHAPTER I

INTRODUCTION

Cloth cleaning aims to separate soil, odour sources and stains from fabric. It is a two-step- process which involves "get it off" and "keep it off." From the wet cleaning point of view of, this process consists of wetting a fabric and the soil, odour source or stain in order to separate the problem from the fabric. Holding the soil, odour source or stain away from the fabric is to prevent it from soiling the fabric again during the cleaning process.

1.1 DESCRIPTION OF WASHING PROCESSES

In general, cloth washing process can mainly divided into two major processes which are under influence of mechanical and chemical actions.

Mechanical agitation removes dirt from a garment by either direct force or by breaking and pulverizing dirt particles. Breaking and pulverizing results in smaller particles, which are able to leave the fabric structure more easily. These smaller particles are able to leave the fabric more easily than larger particles.

Chemical action taken place by adding certain chemicals to water can help water clean more effectively. These chemical additives are called “surfactants” because of their effects on surface tension. These chemical additives will decrease the surface tension of the water. This allows the water to penetrate the fabric more rapidly and thoroughly.

Water is a powerful solvent that can help separate certain soils and stains from fabrics. Some soils dissolve in water that is used to clean a garment. The mechanical force of water flushing can also remove some soils, even though the soils themselves do not dissolve in water.

Steaming and heating a garment also assist in separating soils and stains from a fabric. Heat can melt or soften particles. Steam can cause particles to expand or lose their electrostatic charges.

Finally, drying can assist in soil separation as particles curl, break or change shape during the evaporation process. A dehydrated particle or cell is less likely to decompose rapidly or to attract bacteria and, therefore, is less likely to generate odours.

1.2 EFFECT OF CLEANING ON FIBERS

Fibres can be divided into two groups. There are natural fibre and man-made fibre. Each type of fibre reacts differently to the wet cleaning process. How a fibre reacts depends on a number of factors, including strength, elasticity, dimensional stability, absorbency and the effect of chemicals and heat. These factors have a clear influence on the way a garment should be handled in the wet cleaning process.

Natural fibres include:

· Wool — when wet, it absorbs 30% of its own moisture and needs to be dried flat. It needs to be washed gently to avoid shrinkage.

· Silk — it needs great care when washing as it becomes weak with water.

· Cotton — it can tolerate high temperatures, is strong when wet and washes well in the washing machine. It is absorbent and wears very well, making it suitable for work wear and soft furnishings.

· Linen — it is very strong when wet but creases easily.

Man-made fibres include:

· Nylon — it wears well and creases fall out easily. It dries quickly but is not absorbent.

· Polyester — it wears well and creases fall out easily.

· Acrylic — this fabric washes well and does not shrink. It wears well and is very light.

Fibre strength is a measure of the amount of force needed to cause a fibre to break. It is also called tenacity, and it is measured in grams per denier. Fibre strength can change when the fibre is exposed to water. Cotton and linen are the only fibres that get stronger when exposed to water. Rayon and acetates are examples of fibres that get significantly weaker in water. Polyesters and olefins, which are among the strongest of the common fibres, do not get weaker or stronger. The strength of these fibres is not affected by water at all. The effect of water on fibre strength is very important for the wet cleaner in the stain removal and cleaning stages of garment care. Because the strength of fibres can change when the fibres are wet, care must be taken when applying any force to wet fibres. For example, rayon and acetates, since they get significantly weaker in water, could be

damaged by scrubbing or harsh agitation. Table 1.1 shows the wet and dry strength of different fibres. Table 1.2 shows the resistance of different fibres to abrasion.

Table 1.1: Fibre Strength

Fibre	***Dry*** (grams/denier)	***Wet*** (grams/denier)
Acetate	1.2 - 1.5	0.8 - 1.2
Acrylic	2.0 - 3.5	1.8 - 3.3
Cotton	3.0 - 5.0	3.3 - 6.4
Linen	stronger than cotton	
Modacrylic	2.0 - 3.5	2.0 - 3.5
Nylon	3.0 - 6.0	2.6 - 5.4
Olefin	4.8- 7.0	4.8 - 7.0
Polyester	4.0 -5.0	4.0 - 5.0
Rayon	0.73 - 2.6	0.7 - 1.8
Silk	2.4 - 5.1	1.8 - 4.2
Wool	1.0 - 1.7	0.8 - 1.6

Table 1.2: Abrasion Resistances of Fibres

Acetate	fair to low
Acrylic	good to sufficient
Cotton	good
Linen	good but damaged by repeated flexing
Nylon	good to excellent
Polyester	good to excellent
Rayon	poor to fair
Silk	poor to fair
Wool	good

1.3 HISTORY OF WASHING MACHINE

In the early days, the most simplified hand-laundry used large amounts of time and labour without running water, gas, or electricity. One wash, one boiling and one rinse used about fifty gallons of water or four hundred pounds. Rubbing, wringing, and lifting

clothes are the washing process. Ancient peoples cleaned their clothes by pounding them on rocks or rubbing them with abrasive sands; and washing the dirt away in local streams. Evidence of ancient washing soap was found at Sapo Hill in Rome, where the ashes containing the fat of sacrificial animals was used as soap.

The earliest manual washing machines imitated the motion of the human hand on the washboard, by using a lever to move one curved surface over another and rubbing clothes between two ribbed surfaces as in Figure 1.1. This type of washer was first patented in the United States in 1846 and survived as late as 1927 in the Montgomery Ward catalogue. The first electric clothes washers, in which a motor rotated the tub, were introduced into America about 1900. All of these inventions lead up to what we use today. Detail evolution of washing machine is attached in Appendix I.

Figure 1.1: Old Manual Washing Machine (Kessler, 2008)

Automatic washing machines became popular in the 1960s. These automate the washing process by controlling the water and soap intake, draining and rotation of the drum in sequence. Different types of material can be handled by using different programmed cycles. For example, a wool wash needs a low temperature and less

agitation than a heavy soil cotton wash. Most automatic washing machines control the sequence using an electromechanical cam timer, though recently fully electronic systems based on microprocessors have become more widely available.

1.4 CLOTH CLEANING METHOD

1.4.1 Wet Cleaning

Wet cleaning is both an old method and a new method for cleaning garments. Water has been used to clean clothes for centuries. Inventors, scientists and engineers have also been working for centuries to discover new methods to clean clothes quickly and efficiently. Wet cleaning uses a wet cleaning machine, detergents, additives, stain removal agents and a specialized dryer. Basically the process can be broken down into stain removal, wet cleaning, drying and finishing.

1.4.2 Dry Cleaning

Dry cleaning treats garments in either perchloroethylene or petroleum. Perchloroethylene is the solvent used in 80% of dry cleaning plants. Petroleum is used in the remaining 20%. Dry cleaning has proven itself to be an efficient, affordable, cost effective process for cleaning a wide variety of fibres and fabrics without causing damage to garments. The primary drawback to dry cleaning is that perchloroethylene and petroleum solvents are hazardous substances.

1.4.3 Ozone Cleaning System

The Ozonated Water Continuous Cleaning System is a new process that is still being studied and under development stage. The theory behind the process is that ozone (O_3), working as an oxidizing agent, has the ability to disinfect, deodorize and bleach fabrics. Ozone can be added to water, in much the same way that carbon dioxide is used in carbonated soft drinks. Ozonated water can be combined with detergents to produce a garment that is cleaned, disinfected and deodorized.

1.4.4 Ultrasonic Cleaning

Recent research cooperatively funded by the U.S. Department of Energy and Kansas City Plant and Garment Care, Inc. determined that agitation for a continuous-flow, water-based clothes washing process could be provided by ultrasound. When clothes cleaned with ultrasound were examined, the clothes were clean enough to encourage researchers to continue developing this process. Ultrasonic cleaning works by the pressure of ultrasonic waves directed at the fabric through a solution of water and soaps. The energy from the ultrasound excites the molecules of soil and causes them to separate from the fabric.

1.5 STATEMENT OF PROBLEM

In producing quality washing, laundry industries have main considerations which strive to minimize time of washing, power, detergent and water consumption. In general, washing quality could be improved by increasing the amount of washing detergent, power, time and water used. Another issue is inefficient washing machine designs that can affect the washing performance and hence cloth cleanliness too. Mechanical action transmission from bottom actuator to wash contaminant cloth is lacking as consumers commented that hand wash is still the best cleaning method.

This study aimed to determine the optimum washing result of the active washing process which given by laboratory washing model and passive process from a commercial washing machine. Active washing is direct squeezing force and interface between washing liquid and cloth. Passive washing means indirect contact between washing mechanism which is rotor and the wash load. The soil removal effect of active washing process and passive process are compared in order to determine the best washing process. Soil removal is measurement of cloth washer degree cleaning effect to remove representative soils and stains from fabric.

1.6 PURPOSE

The objective of this study is to find out whether active washing process has better washing quality compared to passive washing type. The better washing principle should perform sufficient mechanical action on the fabrics and loosen the stain attached

into washing liquid to improve cleaning. Variables of the study include water speed, washing time and radial nozzle inclination angle. The specific objectives of this study are:

a. To design and develop the laboratory active washing model.
b. To determine the degree of soil removal rate from soiled fabric for active and passive washing process.
c. To determine the washing process which will give best cleaning effect based on factors studied.
d. To find the significant factor that influences the washing efficiency of active and passive washing process.

1.7 SCOPE OF THE STUDY

The study is limited to the laboratory washing model developed which is to be compared with the commercial washing machine of model Samsung WA91U3 depicted in Figure 1.2 and its technical specification is attached in Appendix II. The operating procedure practiced was given by its manual (AHAM HLW-1-2006). The soil test strips were in accordance to IEC60456. The supporting fabrics were 100% cotton. Water hardness which indicates the amount of dissolved minerals in the water is 500 mg/l (Ibarahim, 2006*)*. Water temperature is taken as 30 ± 2ºC.

Figure 1.2: Samsung WA91U3 Washing Machine