Design of wall mounted type power scrubber cleaning device

J. Silkson John¹*, V Thanigaivelan², M Krishna³, A Joshua ⁴

¹,²,³,⁴ Assistant Professor, Department of Mechanical Engineering, SRM Institute of Technology, Ramapuram, Chennai, India.

*Email: silksonj@srmist.edu.in

Abstract- This article presents a design scheme for a scrubber pertaining to the classes of cleaning devices for washing household utensils. The power scrubber is wall-mounted preferably near a kitchen sink and can be operated with a foot pedal for hand-free operation. The scrubbing device comes with various attachments, which could be used alternatively based on the dishwashing needs. It has been estimated that an average household utilizes almost 50 individual pieces of utensils to cook and serve food items, washing them requires huge amounts of water and is somewhat labour intensive due to the scrubbing action that is necessary to clean utensils. Though there are dishwashing machines available in the market, they are quite bulky and expensive for the common household in India, moreover they consume a lot of power and is not suited for washing single utensils and even has restrictions on the types of utensils to be washed. It has been realized by us that the utensil scrubbing is the most important task in the process. The power scrubber is a wall-mounted scrubber and is also capable of dispensing soap and in-turn reduce water usage.

Keywords- scrubber; dishwasher; design; modular; time-saving

I. INTRODUCTION

This project aims at developing a wall-mounted power scrubber to clean utensils. It is designed such that it may be used for a variety of utensils ranging from flat plates, bowls, cooking pots, spoons, forks, frying pans, cups, milk pans and glasses to water bottles with the help of scrubber attachments mounted on a circular casing consisting of gears for the washable utensil which is used to scrub one utensil at a short period of time with less labour. This makes the process very easy to use even by the elderly in the family and reduce water wastages in washing utensils, saves time and especially reduces labour on scrubbing the utensils.

Studies show that, more than 90% of current domestic dishwasher are imported and are expensive and the market penetration rate is as low as 1%, while in developed countries it is more than 70%. There are three primary limitations to the traditional dishwasher system. Firstly, the mechanism for washing by spraying of hot water & soap mix is ineffective and utilises water abundantly; secondly, there are restrictions on the type of dishes and detergents to be used, and generally causes water pollution in a large scale and finally, the dishwasher system has a small capacity and cannot clean for a long time. There has been significant efforts in removing these limitations by proposing various alternative designs based on embedded systems similar to an assembly line where each step of washing a dish undergoes
in a different module, such as washing, scrubbing, and sanitizing, etc. but these systems occupy large spaces and have been found to be non-practical for general residential purposes\textsuperscript{[1]}. Moreover, for developing a scrubber system, it was imperative to understand the interaction between the brushes and the object to be cleaned, and it was observed that brush characteristic might vary significantly using different bristle configurations. The cleaning action depends also on the stiffness of the bristles, degree of spray and filament configurations involving spacing and numbers of bristles on a tuft. Tufts with tightly packed stiff filaments, which deflected together on loading, were more effective at trapping particle than more flexible filaments\textsuperscript{[2-4]}.

Furthermore, many design patents were referred pertaining to cleaning devices, their design was carefully scrutinized and the claims made in the documents were analysed and importantly, its design features were scrutinized for its advantages and disadvantages\textsuperscript{[6-9]}. The many designs were for cleaning devices, some with, rotary cleaning heads or brushes and some with vibrating heads for scrubbing. Also, a design with water and soap dispensing along with a scrubber was looked upon carefully and the group was deeply impressed with the design and decided to incorporate the same in this project\textsuperscript{[5]}.

2. DEVICE REQUIREMENTS

The wall-mounted scrubber is pertaining to the class of cleaning devices and must be able to scrub clean the soiled utensils which are pressed against the different types of scrubber along with a spraying of water and liquid detergent mixture upon pressing of the foot pedal which activates the entire cycle of cleaning utensils. The system must be compact to be able to fit on a wall on 4 number screws near preferably a kitchen sink where dirty utensils are kept. The scrubbers are modular attachments for varying type of cleaning operations on differing utensils shapes and sizes, which are common in Indian households. The cleaning cycle comprising of spraying and rotation can be customised as per requirement with the use of the embedded IC circuit and is shown on the 5V LCD display module on the side of the device. The user ergonomics has been kept in mind while designing the product and the sequence made in such a way that anybody except small kids may be able to operate as a natural action foregoing just the scrubbing part involved in cleaning the utensils.

The sequence of operations start from plugging the power scrubber in a 220V switch board and switching the device on after that the display will start, the, next step will be to press the foot pedal which will be connected to the IC circuit starting the spraying of water gel mixture through pump mechanism for 5 seconds and the rotation of motor shaft which will be attached to the external gear mechanism will make the scrubber move simultaneously .Thus rubbing the utensil with the help of rotating scrubbers will clean the utensil more effective and will save time and reduce water wastage.

3. EXPERIMENTAL SETUP

The device comprises of a 0.37kW DC motor coupled with a condenser to aid the starting procedure and power the on board 5V DC power regulator and a 42-pin Prototype board with IC controller and coupled to a pump for spraying the soap-water mixture and to an LCD display which shows the status of the cycle; the device is plugged to a normal household 220V power socket with proper earthing connection. The activation of the cycle can be controlled with a foot pedal for hands free switching and alternatively may be used with a proximity sensor for automatic start as soon as the utensil is brought close to the scrubbers. Furthermore, the entire cleaning cycle can be made smart by utilizing a pressure sensor beneath the scrubbing pad that automatically analyses the torque necessary for the cleaning action and modulates the speed and torque as required. The casing is made waterproof to protect all the citric components inside from splashing of water during the cleaning cycle. The isometric view of the casing is illustrated in Fig.1.
4. Components
The design consists of several key components, including: a 0.3kW AC motor, an IC circuit board (fig 6), a water-detergent reservoir, a pump, a pipe, a condenser, modular scrubber attachments (fig 3 and 4) for with rotary scrubbing pads and a water-proof casing to contain all the mentioned components.

The modular attachments are such that they may be interchangeable by easy clamping and unclamping action on the shaft that protrudes out of the device. The modular attachments are specially designed for this device and makes the device truly unique to anything available in the retail market for household purposes. The attachment comes in a variety of shapes and sizes. Various materials have been selected such as sponge, abrasive scrubber, steel scrubber, as well as nylon bristles for differing applications and utility to be used in different cleaning conditions based on the shape, size and the level of pollutants on the utensils.

The motor is selected as such that it may be able to deliver high torque required for the cleaning action on utensils. The torque and speed of the motor can be altered via the embedded circuit and is shown on the LCD display panel. Furthermore, the torque action depends on the previously discussed attachments which comprises internally of a gear system, bearings and a coupling system to the shaft. The number of output shafts depends on the type of attachment and not exceed three.

4.1. Motor

The selected motor is a high-torque, medium speed AC 3-phase motor which is housed on the device. The motor has a verified output of 0.3kW power and is controlled by a control unit. The motor shaft is connected to an external gear mechanism to use its applications for cleaning different utensils using different types of scrubbers.

4.2. IC and Development Board
An ATMEGA 42-pin IC was used on a development board to properly time and store different types of cycles. The cycle duration was programmed onto the IC circuit and was expected to prompt delay and action of the different device components like the pump and the motor as soon as actuation is detected.

**4.3. Foot Pedal Switch**

The foot pedal is a mechanical device connected to the IC circuit to start the power scrubber operations when it is pressed continuously with the pressure of the foot. To stop the mechanism of the power scrubber all we need to do is lift our foot from the foot pedal. This makes it very easy to operate and control the power scrubber.

**4.4. Pump**

Pump is a mechanical device that will move the fluid mixture of water and gel on the utensil to be cleaned before the operation of scrubbing. The pump mechanism will start when the foot pedal will be pressed.

**4.5. Gear Box**
The gearbox is the external casing of the gear arrangement that consists of four gears among which one is the drive gear connected to the motor shaft and other three gears are the driven gears which rotate on the drive gear movement. The gearbox also has the mounted three shafts on which the scrubber materials are used based on different types of utensils used.

4.6. Coupling

The coupling for the modular attachment to connect to the main body was made to be a spring action-coupling device. The coupling was machined in two parts out of two steel rods differing in size. The design of the coupling was selected among numerous other types as to enable easy engagement and disengagement of the scrubbing apparatus, which is modular and inter-changeable in nature.

5. DESIGN OF WALL MOUNTED POWER SCRUBBER

5.1. Design Overview

The main approach for this design was to develop a device that eliminates the exhausting task of scrubbing which is crucial for cleaning a messy utensil. In addition, the device allows for substantial preserving of water and detergent, which is otherwise wasted in typical dishwashing sequence by hand. The operation sequence is strategically designed to maximise ergonomic satisfaction of the user operating the device.
5.2. Design Presentations

Fig.8 Exploded View of Machine with Attachment-1

Fig.9 Machine with Attachment-1
6. OPERATION OF DEVICE
When operating the device, the user begins by taking the soiled utensil from the kitchen sink and pouring a little water just as to wet the dishes. The user brings the dish near to the device’s scrubbers which is mounted near the sink and presses the foot pedal starting the pump mechanism of spraying the water gel mixture for 5 seconds after which the rotary action of the motor starts, rotating the scrubbers attached to the gear box connected to the motor shaft and then presses the dish and rotates the dish based on the sides of the utensil to clean to cover all the sides of the dish in contact with the rotating scrubbing pads of the device. The user then lifts his leg from the pedal when satisfactory level of cleaning has been achieved.

7. RESULT AND DISCUSSION
Our aim while designing and fabricating the wall-mounted power scrubber was to eliminate the limitations of a conventional dishwasher while still delivering on the low cost, so that it affordable by masses at a fraction of price of a conventional dishwasher. It was designed for a one to one dishwashing hence, any type of utensils could be scrubbed and the laborious task of scrubbing dishes was eliminated. The following limitations were targeted:
• Overall water consumption per cycle
• Time required for washing dishes
• Versatility of utensils that could be used
• Overall fatigue caused by scrubbing utensils
• Compact size of the machine
• Reduce overall cost to a fraction and make it affordable.

To test the above mentioned factors, the machine was tested with reference to Bosch Dishwasher with 12-place setting capacity and also compared to conventional hand-washing. Same number of utensils were used while testing in all three modes considering the maximum capacity of the Bosch Dishwasher and they were:

• 1 Kadhai (5.5ltrs)
• 4 Dinner plates (12 inch)
• 2 Quarter plates (8.5 inch)
• 1 Pressure cooker (3.5ltrs)
• 1 Milk pot (1.5ltrs)
• 1 Cooking pot (3.5ltrs)
• 1 Tea pan (2ltrs)
• 1 Serving pot (2ltrs)
• 2 Heating glass bowls (900ml)
• 8 Bowls (180ml)
• 4 Coffee mug (270ml)
• 10 Table spoons
• 4 Forks
• 4 Ladles/Serving spoons
• 1 Plastic container (500ml)
• 4 SS/Glass tumblers (250ml)

Graph 1: Water consumption per wash cycle
A conventional Bosch Dishwasher with 12 place capacity retails for around Rs.45000. The overall cost including material, labour and fabrication cost was Rs.15000 for building the wall-mounted power scrubber. The cost could heavily be reduced with improvisation in manufacturing process and through mass-manufacturing practices to almost Rs.8000 per piece. Even in such a scenario, the machine could be retailed at Rs.12000 that is only a fraction of the price for a conventional dishwasher provided with the functionality that is most essential, scrubbing.

Graph 2: Comparison of time consumed per wash cycle

Graph 3: Comparison of power consumption

Graph 4: Comparison of approx. retail prices

8. Conclusion

Overall, the response from household workers were quite good and they were happy to see such a product at an affordable cost that gets the job done. They were impressed at the functionality and versatility of the machine at the price range and understood the utility of the machine within no time. We got very positive response from also those who saw the machine in action and are ready to spend money on the machine and buy one for themselves.

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