Abstract

The washing machine is widely used in the present day's society for washing and drying of clothes. The *Fisher & Paykel EcoSmart GWL10* washing machine has been awarded "The America's Most Energy Efficient Washer" for this year by The Consortium of Energy Efficiency, which rates washers in the market depending on their energy and water consumption and the remaining moisture content.

Most of the raw materials used in the manufacturing process of the washing machine have considerable negative social and environmental impacts which include mass scale extraction of metals, releases of toxic gases during production and processing, contamination of land and health hazards caused in humans and animals. Therefore it is important to mitigate these effects while achieving the social requirements.

It is believed that providing a service to replace the domestic washing machine would be a feasible solution for this dilemma. A service can be introduced where all the dirty laundry will be collected on a weekly basis, washed, dried, ironed and then returned to the users after a certain number of days. It is suggested that these services be well organised and functioned as a service to the community than a business to individual service providing companies. Therefore a fixed charge for a fixed volume or number of clothes is strongly recommended.

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1.0 Introduction

Washing machine is a machine that quickly washes clothes, linens and other items. Before the invention of the washing machine, people spent hours doing their laundry by hand. Some people soaked their clothes in streams and then beat them with rocks to get out the dirt. Later, people scrubbed their laundry on washing boards. Also people on sea voyages washed their clothes by placing the dirty laundry in a strong cloth bag, and tossing it overboard, letting the ship drag the bag for hours [1]. This principle of forcing water through clothes to remove dirt has been used by people for many centuries and the modern washing machine can be considered an evolutionary advancement of this technique.

Shown beside is one of the earliest washing machines which was manual and 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 the two ribbed surfaces. This type of machines were used widely until the 19th century before the first electric clothes washers, in which a motor rotated the tub, were introduced to America at the beginning of the 20th century [1].

An early Washing Machine used in the 1850's [1]

The rapid advancement in technology has given rise to the fully automatic washing machine which is widely used in the present day's society. These machines have thousands of components and are much sophisticated and user-friendly than the ones used at early stages of development. However in order to achieve sustainability conditions, other factors such as raw materials and their sources, life cycles of materials used, efficiency, production and disposal of the product need to be considered apart from the mere development of the technology [2].

The main purpose of this report is to discuss the functionality, raw materials and their life cycles of the *Fisher & Paykel EcoSmart GWL10* washing machine. Major concerns with these life cycles from a sustainability perspective and possibilities of increasing efficiency of the machine are determined followed by a discussion on how a service could be used to replace the product and foreseeable advantages and problems encountered in implementing such a scheme.

2.0 Functionality of the Machine

The EcoSmart GWL10 is a fully automatic washing machine that has a separate set of controls to determine all of its operations. User can choose whether the machine should use hot, warm or cold water during its wash and rinse cycles, set controls to select the length of washing and rinsing time and also the amount of water entering the machine by selecting the load size [3]. Water enters the machine through hoses connected to household cold water pipes and need not be connected to a separate hot water line since its got a built in electric heating system. This machine also has a filtering

Fig 02: The *Fisher & Paykel EcoSmart GWL10* washing machine [3]

system that removes lint and automatic dispenser for bleach and fabric softeners [3,4].

Once the wash and spin cycles are completed an alarm beeps to let the user know that the laundry is ready to be taken out and further dried. This allows the user to attend to other work while the laundry's being done instead of monitoring the whole process. If unattended for more than 5 minutes power is cut off automatically thus saving energy [4].

Some of the main functions of the EcoSmart GWL10 washing machine can be listed as follows.

- Minimum water level uses only 14 gallons to further conserve water compared to the 18 gallons used by most other washing machines [4].
- Three cubic feet washing capacity helps to wash large sized loads up to 17lbs [4,5].
- This machine has five different water temperatures and sensors for accurate temperature control. This provides greater care for clothes containing raw materials such as silk and wool which require delicate handling [4,5].
- The 1000-rpm spin speed helps to dry the laundry in a quick and an efficient manner [4].

3.0 Materials used and their sources

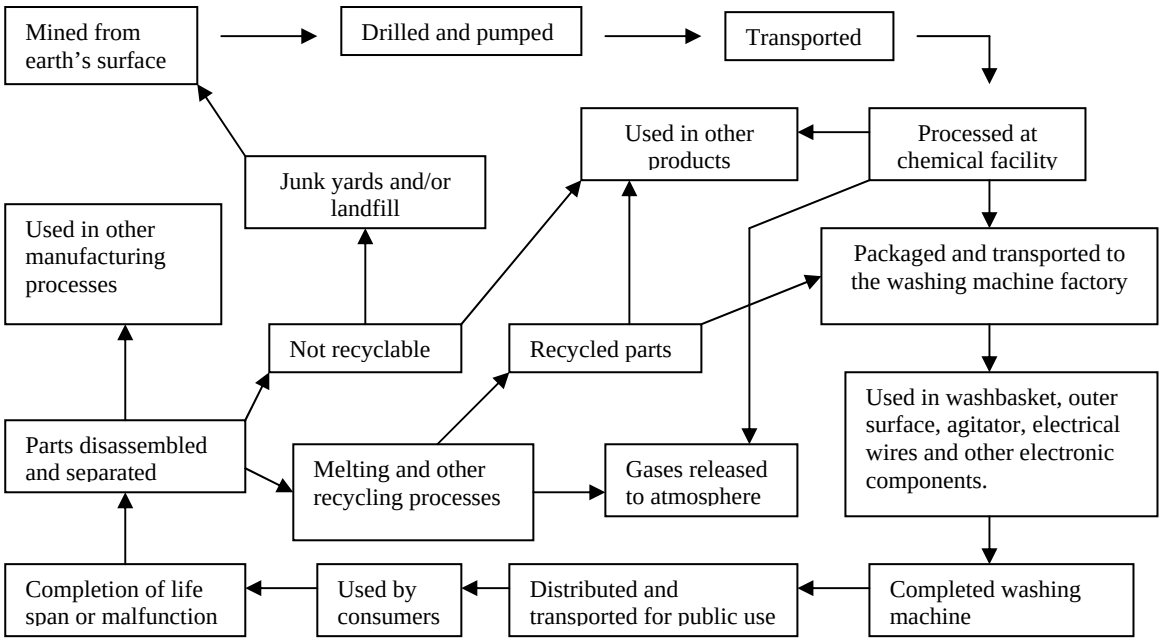
Most of the materials used in fabrication of the machine and their sources are listed in Table 01. However it should be noted that all the parts and relevant fabrication materials are not listed herein due to the lack and unavailability of such finer details.

Part of the Machine	Material(s) used	Source(s)
Washbasket (or inner tub)	Stainless steel, mild and heat-treated steels	Ores
	Aluminium alloys	Bauxite ores
Lid and Outer surface	Polypropylene	Crude oil
	Rust-proof toughened plastics such as ABS	Crude oil
Agitator	Hardened plastic	Crude oil
	Metals (mainly steel and copper)	Ores
Motors	Copper, iron	Ores
Electronic controls (Timers, relays, transistors, water and temperature controllers etc.)	Semi-conductors	Silicon
	Metals such as copper, and aluminium	Ores
	Fibreglass	Crude oil
Hoses and water leakage insulators	Rubber, plastic	Crude oil

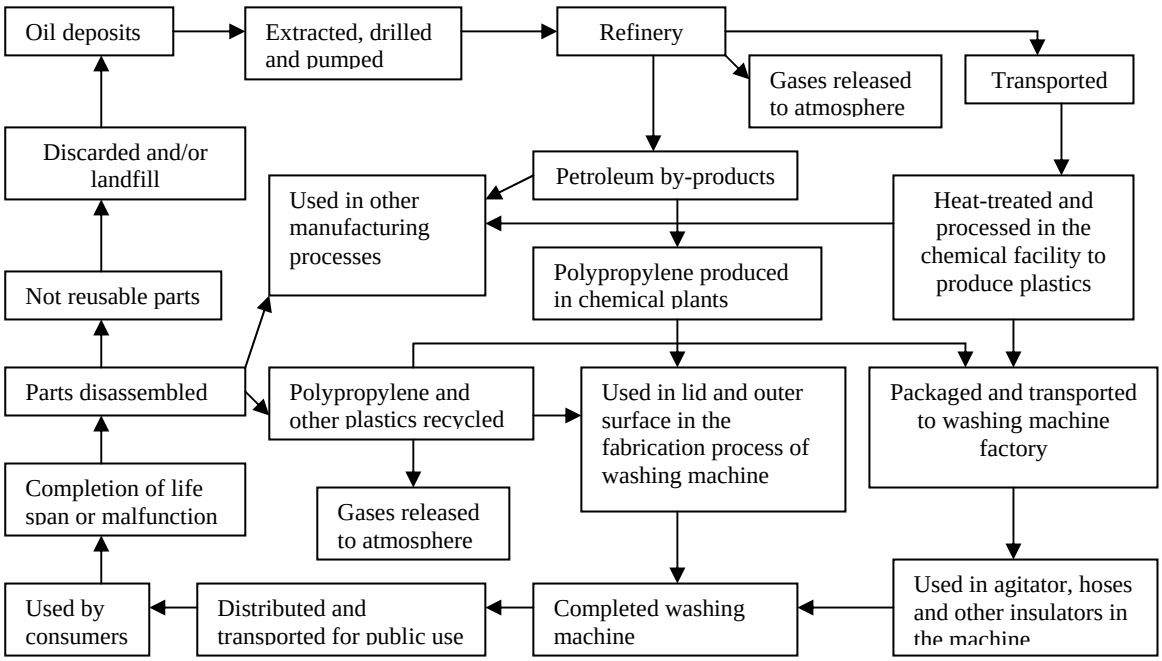
***Table 01*:** Materials used in fabrication of the washing machine

4.0 Life cycles of the raw materials used (more than 10%)

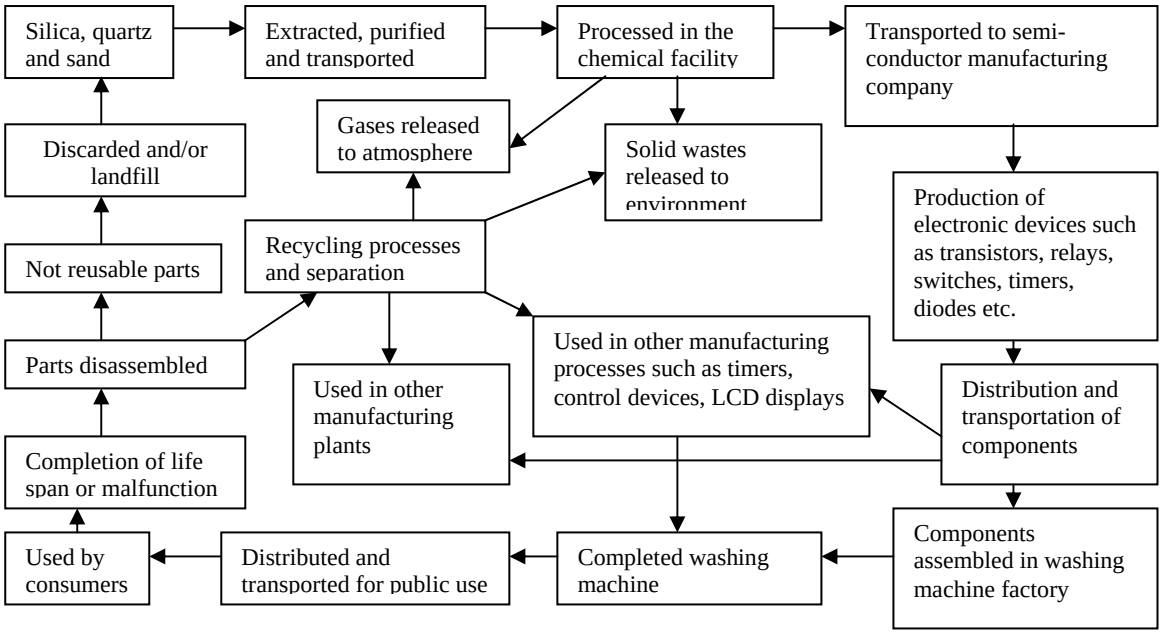
4.1 Life cycle of Stainless steel, copper and aluminium



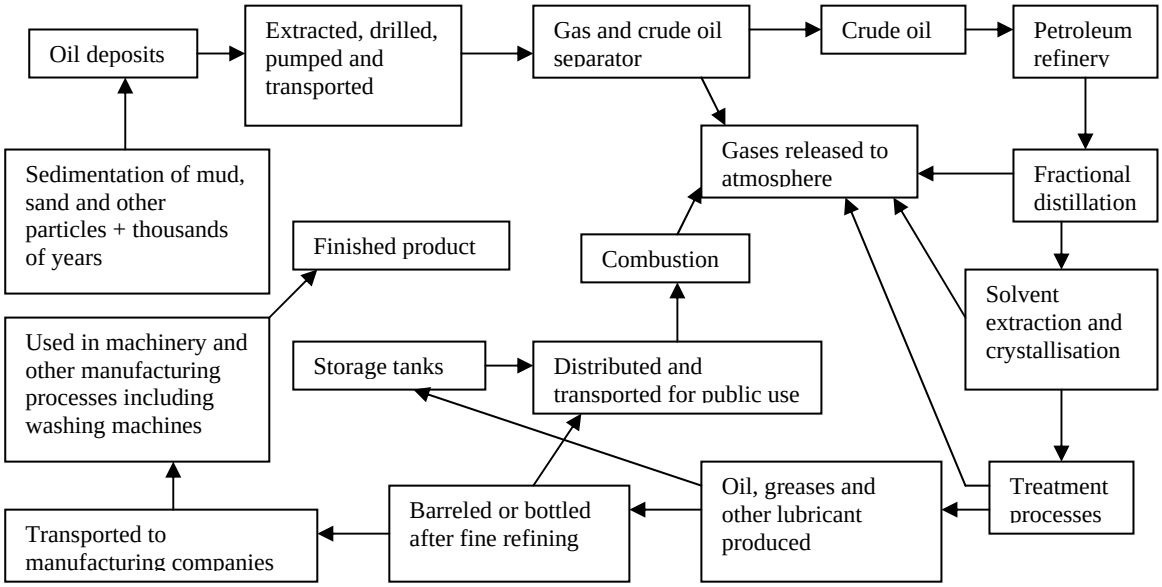
4.2 Life cycle of Synthetic rubber, hardened plastics and other insulators



4.3 Life cycle of Silicon



4.4 Life cycle of oil, grease and other lubricants used



5.0 Major concerns with the life cycles of the raw materials used from a sustainability perspective

5.1 Stainless steel, copper and aluminium

All these metals are extracted from the earth's surface and are generally mined on a large scale basis. They take hundreds of years to get accumulated and form a metal ore thus there is a risk of running out of them due to mass scale extraction.

Aluminium dust particles may be released into air during processing stages which might be absorbed through the gastrointestinal tract and lungs and get deposited

mainly in the skeleton, liver and brain. Although the metal has a low toxicity level, long-term inhalation of dust particles can cause lung fibrosis, affect the functionality of the nervous system and cause skeletal disorders [6]. Inhalation of copper dust can cause liver and kidney failure while chromium dust generated during stainless steel production can adversely affect the skin and kidneys [6,7]. Metals particles and other poisonous gases released during production and manufacture can get deposited on earth's surface and also get precipitated under water, enter food chains and cause many disorders not only in humans but also in many other animal species [8]. These health issues require considerable attention and medication thus requiring extra resources for treatment.

Refining and processing of alumina and copper generate carbon dioxide which is a green house gas [6,7]. Mass scale release of CO_2 into atmosphere could result in an increase in global temperature, change in rainfall patterns, rise in sea level and also adversely affect the balance of many ecosystems.

Although most of the metallic parts used in products are recycled, some parts are disposed of by means of landfill or incineration [9]. When metals are incinerated CO_2 emissions occur while landfills result in contaminated soil and water conditions. For example when metals are used in landfills, they may react with acidic and/or basic elements found in soil and produce toxic solutions [8,10]. Also some alloys are not biodegradable thus contamination processes will take place over a long period of time.

All these metals are corrosive. They react with oxygen and water in the atmosphere and form oxide layers causing malfunction of the product at times [9]. This further increases the use of metals since more machines will need to be manufactured to meet the demand. Also some corrosive layers can be quite poisonous and affect the wellbeing of humans. For example, the action of acidic water on copper and brass, can have significant long-term health effects on children including impaired intellectual development [7].

5.2 Rubber, fibreglass, hardened plastics and silicon

Handling and fabrication of plastic resins can result in the generation of vapours and dusts. Dusts resulting from sawing, filing, and sanding of plastic parts in post-moulding operations may cause irritation to eyes and the upper respiratory tract [6].

Emission of various toxic and greenhouse gases in the production of these materials is of great environmental concern. Some of the gases emitted are Carbon Dioxide, Sulphur Dioxide, Methane, Nitrous Oxide and Sulphur Hexafluoride [8]. These gases cause acidic rain, increase in temperature, health concerns in humans and animals, change in weather patters and many other irregularities.

Direct contact with chemicals used in manufacturing and other treating processes can cause asthma, affect the central nervous system and reproductive system and cause irritation in lungs, eyes, nose, and throat. For example inhalation of phenyl glycidyl ether gases used in producing hardened plastics and synthetic rubber can seriously affect the male reproductive system and the maximum allowable limit is only 1 part per million parts of air for an eight-hour work shift [11,12].

Inhalation of silicon particles, used in fabrication and manufacture of semiconductor devices used in electronic devices can cause breast, uterine and cervical cancer. They can also cause other problems in the lungs and respiratory system [6]. Hundreds of people who used to work in the Fabrication Department at National Semiconductor Corporation, Scotland, being affected with respiratory diseases in 1998 is exemplary [13,14].

6.0 Ways of reducing material use in the life cycle

6.1 Recycling material

The most feasible option to minimise material use in the life cycles would be by means of recycling as many parts as possible. Aluminium, stainless steel and copper are recycled on mass scale at present although certain parts are disposed of due to their inseparable and complex nature. The manufacturing companies should make arrangements to recover their parts from the disassembling companies thus making the recycling process more efficient.

Aluminium is fully and repeatedly recyclable and can be recycled over and over without any degradation or loss of its innate characteristics. These processes take less than 5 per cent of the energy needed to make the metal from bauxite and other sources [15]. Most of the metal components come with a special identification code nowadays so that the disassemble companies know where the parts need to be sent for recycling processes. However it is still important to increase the efficiency of the recycling plants and minimise wear and tear of machines used.

6.2 Wastage minimisation

Wastage needs to be minimised to achieve maximum use of the mined metals. These metals take hundreds of years to form into an extractable deposit thus more care is needed in the extraction, transportation, treatment and other manufacture processes.

6.3 Alternative materials and products

Finding alternative, biodegradable products will also help cut down on the material use. With the advancements in new technologies new alloys could be developed which in turn could be used in production and fabrication of washing machines therefore replacing metals and reducing amount of metal extraction. For example researchers are looking at replacing silicon with optical fibres at present which do not have any of the complications or environmental and health hazards silicon does [16].

7.0 How efficiency of the product can be improved

Fisher & Paykel EcoSmart GWL10 washing machine has been named as the America's most energy efficient washer for this year and awarded 5 stars by The Consortium of Energy Efficiency, which rates washing machines in the market on three main factors, Energy Factor, Water Factor and Remaining Moisture Content [4]. Although it is very efficient compared to most other washers, its efficiency can be further improved by following means.

Even though this machine is a top loader, it does not fill up completely with water. It mimics a front loader and uses up to 40% less water than a regular top loader but further

research on the machine has shown that this could be increased up to 50%. This difference would mean less water and energy consumption [3,4].

The current, maximum spin cycle of the machine runs at 1000 rpm. This can further be increased using more efficient motors reducing drying time as well as energy costs by up to 30% when compared with the present maximum spin speed [3,4,5].

The spin cycle generally makes a loud noise at the beginning. This is due to considerably high friction between the agitator and the stainless steel shaft connected directly to the brush-less DC motor [3,4]. Introducing alternative materials with less friction could help to overcome this situation and keep noise levels at a minimum.

8.0 How a service can be used to replace the washing machine

The many advantages the washing machine has provided to the society are beyond controversy. Yet the social and environmental hazards caused during manufacture, processing, fabrication and other stages of the machine cannot be ignored by any standards. Therefore it is quite important that these impacts be mitigated while achieving the human requirements.

Pick up and delivery type laundry services are already in existence although not widely used. Collecting dirty laundry on a regular basis, washing, drying and ironing them and then returning to the owners is how such a service generally functions. Laundry is placed in a separate bag with appropriate user identification methods to avoid mix up of clothes between different users.

When many domestic washing machines are in use, the energy, water and resource consumption would be much greater than using a few machines with higher washing capacity. Therefore if the government can make agreements with companies to provide a laundry service where laundry will be collected once a week, washed, dried and ironed and then returned after a fixed number of days, a great amount of resources can be saved and energy and water consumptions minimised. A fixed rate should be introduced for a fixed volume or number of clothes so that it would be a service to the community rather than a business. It would also avoid competition between service providers.

8.1 Advantages of this service

The washing machines used by the service providers will need to be designed with larger washing capacities. Since a fewer number of washing machines would be required compared to the many domestic washing machines used at present, there will be a reduction in metals and other raw materials used in the manufacturing process.

More clothes will be washed in one cycle thus reducing amount of water and energy consumed. For example washing machines X and Y will consume more water and energy than a larger washing machine used with the combined loads of X and Y.

Waste water from the service providing companies will be easy to analyse, treat, purify and recycle since major contamination constituents would be quite similar unlike from different households. For example waste water from a household could come from many places and activities such as toilets, kitchen, washing, shower and

so on contributing to a mixture of constituents making purification and treatment harder processes.

8.2 Foreseeable problems in implementing the service

The major concern would be the reluctance shown by washing machine manufacturing companies. The present designs will need to be redesigned to accommodate larger washing capacities while maintaining low water and energy inputs. Such redesigning processes could be quite costly and time consuming

Implementing this service on a large scale would not be quite feasible while domestic washing machines are in use. Domestic washers will need to be collected though an organised scheme so that they can be disassembled and possible parts reused and recycled.

A special way of identifying clothes will be required since clothes from many households will be washed in the same cycle. An organised code system is recommended in this regard.

Working out a reasonable load per household could be quite a task since it depends on many factors such as number of people living, season of the year, age of inhabitant and hygiene practises of the people. This will need to be pre-determined using an appropriate methodology.

9.0 Conclusion

The washing machine has greatly influenced people's life styles by providing easy means of washing clothes and drying them out to a considerable extent. It not only saves time and amount of water used but also helps the user to wash and dry clothes with a lot of ease due to its fully automatic nature.

Most of the raw materials used in the manufacturing process of the washing machine have unacceptable social and environmental impacts in their life cycles. Therefore it is quite important to mitigate these effects and also look at other possible alternative materials while achieving the functionality of the product.

Due to the many drawbacks in various stages of washing machine manufacture, alternative options of washing need to be looked at. A service can be provided where dirty laundry will be collected on a weekly basis, washed, dried, ironed and then returned to users amidst some feasibility problems. It is believed that by providing such a central service, material use and water and energy consumption patterns could be minimised to a great extent. Although implementation of such a service could be a daunting task at present, it could be one of the few available options to maximise the use of limited amount of resources available and save them for the future.

(2754 words)

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