Eco-design of water purification equipment for domestic use

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Abstract

Though a lot of water purification equipments are used in Japan and collected by the suppliers after u sage, they are not adequately recycled or reused due to the high cost of reproduction.

We investigated the feasibility of three proposed equipments (cartridge) to construct a new recycling system, considering all through the cost of production and recycling, and environmental load.

As a result of analysis, application of polypropylene as main cartridge material was found to be the best one for establishment of fundamental purpose.

1. Introduction

In these days, since the tap water quality is lowering, various kinds of water purification equipment have been placed in many houses in Japan. In general, activated carbon and hollow fiber are applied for adsorption and filtration of pollutant substances in cartridge type equipments. Those cartridges should be renewed every 0.7 year according to the guideline of health and welfare. After renewal, the old cartridges are collected and wasted in landfill area without reuse or recycling. But most of the landfill area is already occupied, and new landfill area is very difficult to be developed. The one way system of production - consumption - disposal is now approaching to its limitation. Moreover, much attention should be paid to energy and resource saving because of their exhaustion.

In this paper, we did feasibility studies concerning the eco-design of a water purification equipment (cartridge) for domestic use. On the basic analysis of present type of cartridge, three types of eco–designed cartridge were proposed. They were compared from the viewpoint of energy cost and others. Through such studies, a new type of water purification cartridge with low energy cost of production and easy recycling structure will be introduced to correspond to an eco-friendly society.

2. Problems of present type of water purification equipment

2.1. Structure of present type of cartridge

Typical structure of present type of water purification cartridge is shown in Figure 1. The cartridge consists of two housing cases (ABS resin), two plates (ABS resin), granular activated carbon, two sheets of unwoven polypropylene fabrics (first and second filter), hollow fibers (Polysulfone:PS), potting material for hollow fiber bundle

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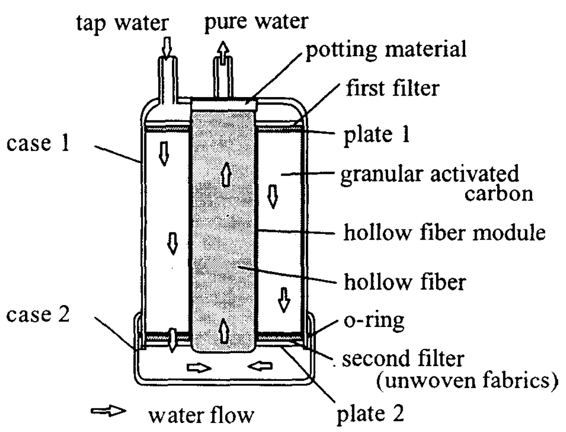

Fig.1 Structure of present cartridge

(urethane resin), a module case of hollow fiber bundle(ABS resin) and an O-ring(NBR).

Hollow fibers have two main roles of removal of iron rust included in tap water and removal of bacteria that generate in the activated carbon bed in the cartridge.

2.2. Amount of disposed cartridges and problem analysis

Because over one fourth of household of Japan (12 million households) are now applying water purification cartridges, 17 million cartridges are collected at the renewal time and disposed in the landfill area every year. The reason for cartridges not to be recycled is the high cost of breakage, separation, recovery of the same material and so on. When being burned, exhausted gas treatment of ABS and PS will require much cost to avoid HCN or SO_2 discharge. A new structure with easy breakage or easy recovery is required for the recycle system that should work with low production cost and low environmental load.

In order to propose a new structure, production cost analysis of the present type of cartridge was attempted from .the viewpoint of energy consumption. As is shown in Fig.2, around 90% of the production cost consists of casing material and hollow fiber material. As a result of the cost and factor analysis, it was found that alternative structures should include change of materials of casing and hollow fiber.

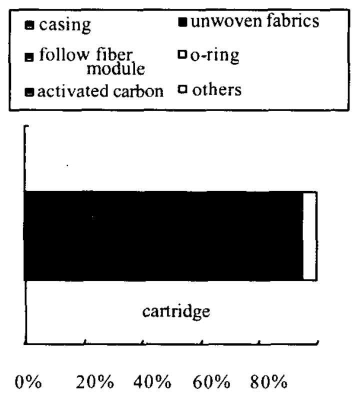

Fig.2 Energy consumption for production

3. Proposals of alternative structure

3.1. Proposals

Following three types of alternatives were proposed and analyzed.

1) Change of casing materials to stainless steel
2) Application of propylene as a common material for cartridge
3) A type without hollow fibers

3.2. Analysis of proposed alternatives

1) Change of casing materials to stainless steel (semi-permanent casing)

Long-term usage of the cartridge can be expected by applying stainless steel (SUS) as casing materials with the same structures of other parts as before, where the casing would be semi -permanent, for example, for 10 years. In this case, the energy consumption decreases 0.5% every year (totally 5%)(Fig.3). But the load to landfill area is not so small since other parts would be renewed and disposed as before. In addition, much quantity of small metal powders will be generated on the production of casing, which will lead to pollution of working area. Therefore, no much effect seems to be expected in this case.

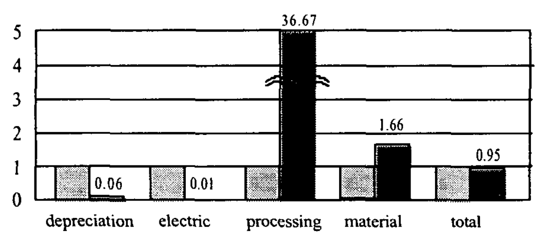

Fig.3 Result-1 SUS casing

2) Application of a common material for all parts of cartridge (except for adsorbent)

Materials of casing, hollow fiber, hollow fiber module, plate and unwoven fabrics are polymeric ones, though not the same at present. As the second alternative, we can apply the same materials to those parts. The common material selected is Polypropylene(PP). When PP is applied as common materials for the cartridge, almost all of the materials except for granular activated carbon would be recovered. In this case, separation of PP and activated carbon is not so difficult. After being broken and separated, the recovered PP would be recycled as fraction of new cartridge materials. It could be also recycled chemically or at least thermally. Even in the last case, reduction of toxic gas generation would be expected. Moreover, production energy cost was estimated to decrease by 2% a year(Fig.4).

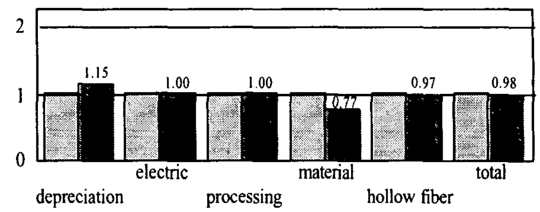

Fig.4 Result-2 Common material

While, the thickness of the casing by applying PP as the material should increase because the strength of PP against pressure is not high.

3) Structure without hollow fiber filter

A quite different alternative structure is given in Fig.5. In this case, instead of application of hollow fibers two electrodes are placed in a cartridge with ABS resin of casing material as before. In general, as bacteria have minus charge on their surface, it is possible to kill them by breaking the metabolism on the plus electrode surface. The applied electric potential of 1.5V is so small that the energy consumption for sterilization is not large. As activated carbon, it is desirable to use fiber type one. In addition, a sensor is necessary to detect the start point of water flow and to add the electric potential. In this case, separation of casing material and fiber type activated carbon seems easier. However, production energy cost was estimated to increase by 22% a year.

Considering the increase of production energy, the third alternative is not so good one.

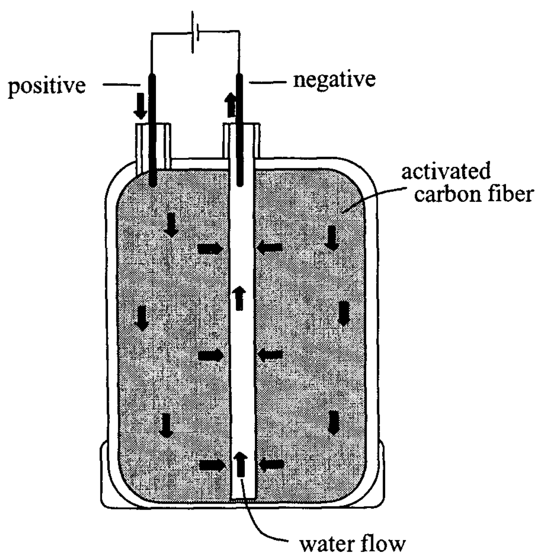

Fig.5 Sterilization by electrodes

4. Discussion on a Selected Cartridge

As mentioned above, application of PP as a common material for all parts of a cartridge is preferable as an eco-design alternative from the viewpoint of production energy cost and environmental load.

When the new cartridge is commercialized, however, the following problems should be taken into account:

1) Separation of resin and activated carbon
2) Fouling of PP hollow fiber surface
3) Treatment of used carbon
4) Selection of potting reagent for PP hollow fiber
5) Design of a new chemical recycle system
6) Identification of additives in the base PP material

5. Conclusion

Eco-design of water purification equipment (cartridge) for domestic use was investigated. Through the analysis from the viewpoint of production energy cost and environmental load, application of PP as a common material was found preferable.

The analysis is not sufficient at present. It should be done more precisely according to the LCA procedure. But such an analysis will give us a new way for eco-design of chemical substances or materials. Though so far, most of the chemical products have been produced aiming to obtain high functionality, the eco-design concept is now a new guideline forhigher technology.