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Process Design for the Recycling Of Tetra Pak Components

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Abstract

The Tetra Pak packaging which was originally designed and developed for milk is widely used in the packaging of many foods and beverages. It is important to recycle and recovery of Tetra Pak's due to the different types of recyclable materials included 75% paper, 20% polyethylene and 5% aluminum. There are serious problems in recycling of composite beverage cartons that completed their lifetime and became a waste. A larger part of this packaging waste is disposed in landfills. Therefore, our priority should be performing scientific studies for management of this waste and operating with appropriate management alternatives. In this study, assessment methods and processes of waste composite drinks cartons are researched, and an alternative way is shown which separately recovers cartons, paper, aluminum and polyethylene. Tetra Pak films were cut into over 40 mm pieces, and charged to the reactor with stirring with chloroform. Thus paper, aluminum and polyethylene dissolves in chloroform. The resulting polyethylene and solvent liquid was transferred to distillation unit. The mixture of aluminum and paper remaining in the reactor was boiled and stirred until it turns into a pulp. Filtration of water is ensured by waiting the pulp on the fine sieve and the percentage of remaining solid is determined by analysis at the end of this waiting period. Thus only aluminum is remaining in the reactor. With the designed system, the waste amount of countries going to the solid waste storage areas will decrease and the protection of our environment will be provided. Tetrapak recovery will be a long-term economic investment. Recycling sector will be a step more advanced. The study will also result in allowing new technologies and reducing raw material needs.

Key words

Tetra pak, Recycle, Process design

1. INTRODUCTION

One of the most significant components, that threatens the future of the world are solid wastes. Unfortunately growing population and technological developments has resulted in an increase in solid wastes. In addition, the changes in consumption habits affect the composition of the waste.

Composite cartons which containing layers of paper, plastic and aluminum, especially preferred for storage of beverage packaging type.

There are serious problems in recycling of composite beverage cartons that completed their lifetime and became a waste. A larger part of this packaging waste is disposed in landfills. Therefore, our priority should performing scientific studies for management of this waste and operating with appropriate management alternatives.

Materials that are made by the macro-level unification of two or more materials from the same or different groups in order to merge their best characteristics or to bring out a new characteristic are called “Composite Materials.” It can also be termed as the bonding of different materials or phases of materials with the objective of strengthening each other’s weaknesses and attaining a superior characteristic [2].

The purpose of using different materials together is to increase durability and flexibility and to combine the unique characteristics of each material. The predominantly paper-cardboard composite packages known as Tetrapak are especially preferred in the conservation of liquid food products and are commonly used throughout the world.

The composite drinking cartons used in the food sector especially for long-term conservation of liquid food products are made up of 75% paper, 20% polyethylene and 5% aluminum [3].

Its layers from the outside inwards is as follows;

1. Polyethylene: Protection against external effects and moisture

2. Printing Ink

3. Cardboard: Stability / Strength

4. Polyethylene: Adhesion layer

5. Aluminum Foil: Oxygen, flavor, light and ultraviolet radiation barrier

6. Polyethylene: Adhesion layer

7. Polyethylene: Liquid sealing layer

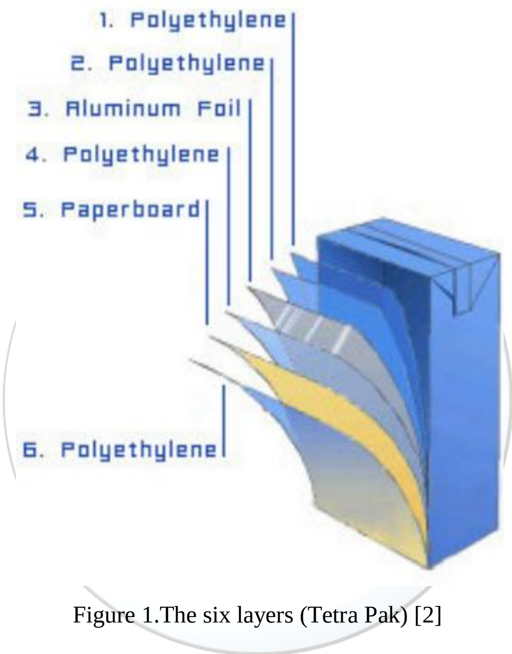

Figure 1.The six layers (Tetra Pak) [2]

Tetra Pak was founded by Ruben Rausing and Erik Wallenberg in 1951 in the Swedish city of Lund. As of January 2013, the company Tetra Pak has supplied approximately 173, 234 million packages so that 77,307 million liters of milk, juice, nectar and other products could be delivered to consumers around the world[5].

The efficient separation of the 3 components found in composite drinking cartons is done by a company named Alcoa Aluminio in Brazil using plasma technology. The facility was established in 2006 with a setup cost of 40 million dollars. After the separation of paper fibers using the hydropulping method, the aluminum and the plastic mixture is heated to 15.000°C and as a result of this process, pure grade aluminum and paraffin oil to be used in the petrochemical industry is produced. The amount of energy required in the facility to produce 1 ton of aluminum is 400-500 kWh. The plasma plant processes 8.000 tons of aluminum and plastic mixture in a year, which corresponds to 32.000 tons of aseptic material; but it is known that this method is very costly.

In Germany, the plastic and aluminum mixture is used as alternative fuel in cement kilns, functioning as a catalyst.

In the company called Corenso in Finland, the gasification method is applied. The aluminum and plastics separated from the paper fibers in the facility are sent to the Ecogas plant. At this stage, while aluminum is recovered in granular form, gas is obtained from polyethylene. The steam produced in the recycling process in gasification is used in paper production. The facility, which began operation in 2001, processes 85.000 tons of carton boxes a year; of which 50.000 tons comes from Germany, a couple of thousand tons comes from Holland, and the rest comes from Finland.

The first method used in the recycling of composite drinking cartons was the particle board method. The boards manufactured from processing the product without separating it into its components (thermal compression) were used in furniture, civil construction, and packaging industries. In later years, the recycling of paper (hydropulping) began, in which the paper fibers that constituted 75% of the composite drinking cartons were recovered. The remaining polyethylene and aluminum parts left after the composite drinking cartons undergo hydropulping is subjected to plastic product transformation, energy recovery, pyrolysis and plasma technologies; but the cost of these technologies are quite high, and the processes are complex.

Nowadays, the collected tetrapaks are accumulated in certified collection and separation facilities, in landfill areas, or burned in cement plants.

With this project, the paper, aluminum and polyethylene in waste tetrapaks shall be recycled, and the recovered materials shall be used to reduce the raw material needs of various facilities. Thus, the natural balance shall be protected against the increase in consumption that rises in parallel with the increase in human population.

At the same time, with the selling of the recovered materials as raw materials to related facilities, businesses be able to ensure high levels of energy saving. There are many establishments that can utilize paper, aluminum, and polyethylene as a source of raw material.

MATERIALS AND METHODS

Tetrapak films are cut in approximately 40mm sizes, and a 2 gr sample is mixed in a reaction flask with 40 ml (1 to 20) of chloroform in 65^{o}C for 2 hours. As a result of this process, paper, aluminum and polyethylene dissolved in the chloroform is produced in the flask. The dissolved polyethylene in the chloroform is transferred to the distillation unit, and solid polyethylene is obtained after the solvent is evaporated. As the solvent condensed in the distillation unit can be re-used in the reaction flask, its continuous use makes it economical. Water is added (1 to 20) to the aluminum and paper left in the reaction flask to be boiled and mixed until it turns into paper-mache (pulp). The paper pulp is separated from the aluminum by watering and filtering it. The paper pulp is then placed on a fine sieve to allow the water to filter down; after the waiting period, the solid material content percentage is determined with analyses. Similar to the solvent, the re-use of the water is possible and is used when necessary. Thus, only the aluminum remains in the reaction flask.

RESULTS AND DISCUSSION

Experiments were performed in SuleymanDemirel University and it is altitude is over 1065 meter and so atmospheric pressure is over 674 mm Hg. So boiling point of the water is over 96,5 ºC. So dissolution of composite compounds takes more longer time than expected. Separation of all aluminum part from paper takes over 2 hours. After all aluminum separates from paper this means all polyethylene is dissolved. After this stage, the pulp is separated by filtration from polyethylenecontainingchloroform. After evaporation of chloroform 0,36 grams of polyethylene was obtained. In the literature it has been reported that tetra pak includes over 20 percent of LDPE. [1]. 0,36 gran is about %19 percent and it is consistent with the literature. After evaporation % 92 of solvent was recycled.

Filtered aluminum-paper mixture started to boil with 40 mL water. About 2 hour's paper start to divide to its fibers and being a pulp. Following this step, the paper is diluted by addition of water and a miscible fluid consistency. The liquid paper pulp filtered from aluminum with 10 mesh size filter. After filtering and drying 1,52 gram of paper pulp was obtained. In the literature it has been reported that tetra pak includes over 75 percent of paper [4]. 1,52 gran is about %76 percent and it is consistent with the literature.As in [6], they pyrolysis tetra pak composite for to obtain aluminum and they obtain about %7 of aluminum from waste tetra pak. In this study 0,12 gram aluminum obtained and it is %6 of the total weight and consistent with the literature.

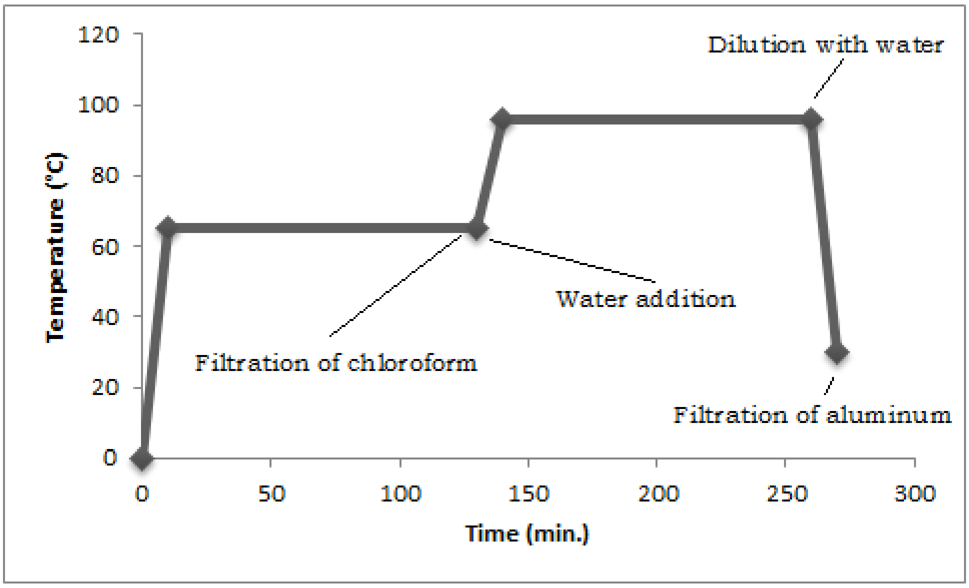

Figure 1. Process steps of tetra pak recycling

Figure 1 shows the details of Tetra Pak recycling process. As seen from the figure recycling process is easy to application. It takes about 4 hours to separate all compounds of the composite and all solvents are recyclable.

Figure 2 shows the disassembled components of the composites. First picture (a) is polyethylene, second picture (b) is dried paper pulp and third picture (c) is recycled aluminum.

Figure 2.Separated components of Tetra Pak

CONCLUSIONS

Tetrapak films were put in reaction with chloroform under heat and pressure. The products of this reaction were paper, aluminum, and polyethylene dissolved in chloroform. Polyethylene was easily recovered in the distillation unit, and the chloroform from the distillation unit was re-used in the system. High-grade aluminum and paper were obtained by introducing water to the reaction flask. It was concluded that in terms of obtaining high-grade Tetrapak components, use of chloroform under heat and pressure was an interesting method as it resulted in requiring less duration and reaction times. Thus, the Tetrapak package that consisted of starting materials with different compounds was easily recycled. As a result of recycling, the damage to the environment and pollution due to increasing consumption habits will be prevented.

At the same time, with the selling of the recycled materials as raw materials to related facilities, businesses be able to ensure high levels of energy saving. There are many establishments that can utilize paper, aluminum, and polyethylene as a source of raw material.

The greatest reason why paper and carton (cardboard) manufacturers prefer recycled paper as raw materials is because they are able to obtain the cellulose necessary for paper for much cheaper. The paper that will be obtained in the envisaged project is in the form ofpaper-mache (pulp), which will be a reason for preference as it will not require any additional pulpification.

Aluminum, on the other hand, is used in many different industries in the manufacturing of millions of different products. Aluminum production from recycled aluminum required 95% less energy in comparison to aluminum production from raw materials. When 1 kg of aluminum is recycled, 8 kg of bauxite mineral, 4 kg of chemicals, and 14kWh of energy is preserved. When all these are considered, the importance of aluminum recycling is evident.

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