PlastSep - A new technology for sorting and recycling of cable polymers

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Abstract

Cables containing the valuable metals copper and aluminium have been recycled by mechanical methods for decades and the metals are re-used. The polymers used for insulation and sheathing of cables whether it is PVC, PE, XLPE or new halogen free types are still in most cases put on landfill. Recycling of the polymers in cable waste is a complex issue. For mechanical recycling the different plastics needs first to be sorted into pure material fractions.

The Swerea IVF R&D-Program Wire and Cable has a long-term interest to solve problems related to recycling of the polymers in cable waste. One objective is to develop technology for quality assured separation and recycling of the various polymers.

Recently a process specially designed to sort cable waste or other metal containing PVC waste was installed in the cable granulation plants of Stena Recycling in Kalmar and Sundsvall. The process is called PlastSep and produces out of the metal contaminated polymer mix a polyvinylchloride (PVC) regenerate and a polyolefin (PE and cross-linked PE) regenerate with a very low metal content. The R&D-Program Wire and Cable assist the further development of the PlastSep technology for sorting of cable waste.

2. Recycling of cables

Every year large amounts of wires and cables become waste. This waste has to be taken care of somehow. The main driving force for recycling of cable waste has since long been the value of the conductor metal. Although the metals have been recycled for decades the plastics, in spite of considerable efforts, are not yet recycled commercially in any part of the world.

The total amount of cable waste produced in Sweden is approximately 40.000 tonnes per year [1]. The cable waste falls into two categories, production scrap from the cable manufactures and field cable waste from buildings, household, from the ground etc. A large part of the cable waste in Sweden is collected at the Stena’s branches all over the country. From the branches the cable waste is then sent to Sundsvall or Kalmar for processing and metal recovery.

1. Introduction

This paper describes the cable recycling situation in Sweden today and the new PlastSep process developed for sorting of cable waste.

Fig. 1 - Picture from the Stena recycling plant in Kalmar
In 2005 a Master thesis project at LiTH [2] called "The cable store of the Swedish community and its potential for increased recycling" came to the following conclusions:

- The total amounts of cables installed in the community are enormous. In the power and the communication networks the total amount of copper in cables is about 2 million tons and of aluminium 0.8 million tons.
- The amount of copper in cables not in use and thus possible to recycle is estimated to 620 000 tons. The amount of aluminum in cables not in use is estimated to 180 000 tons. The value of the metals accessible is about 25 billion SEK.
- The total amount of cables installed increases every year as only about 1/6 th of the end-of-life cables are recycled compared to the amount of cables yearly installed.

Fig. 2 - Cables installed compared to cable waste recycled in the Nordic countries - Scenario historically and in the future (Estimate by R. Neuendorff 2008).

The driving force of cable recycling is the metal value, see Fig. 3. Copper has been recycled since ancient times and aluminum recycling started in the 60-ties when it was introduced in cables. PVC compound and other plastics has low value compared the metals.

Fig. 3 - Material prices of copper, aluminium and PVC cable compound (Estimate by R. Neuendorff 2008).

The most common way to recover metals from cable waste in the developed countries is by the cable granulation process. Granulation with metal recovery has been performed in Sweden since 1973.

The cable recycling process steps:

- Pre-sorting
- Cable chopping
- Primary granulation
- Secondary granulation
- Separation metal and plastic

The pre-sorting of cable waste is most important to obtain maximum value for the recovered metal scrap, and makes further separation of the plastics easier. The waste cable is pre-sorted into different fractions before it is sent through the granulation and separation process. This to obtain as pure material fractions as possible. Pre-sorting includes the separation of long cable sections, type of insulation, conductor diameter, plated or unplated conductor and most importantly the sorting of copper and aluminium cable.

Fig. 4 - Methods for the recycling of cables (Picture by R. Neuendorff 1991).

The first step in reducing the size of the cables is the chopping. Then the granulators reduce the size of the material further and the insulation material can be separated from the metal. The plastic and metal granulates are then fed to a fluid bed that is slanted in two directions. The material enters from the rear of the fluid bed, and the mix is fluidised by air, lighter particles are lifted higher than heavier ones. Consequently, the heavier metal particles move up the fluid bed, while the lighter particles of plastic float down slope. The fluidised bed separator produces two fractions: a clean metal product and a plastic fraction. The plastic fraction is contaminated with metal particles, from 1-6%.
The cables contain several different polymers: PE, cross-linked PE, HFFR (Halogen-Free cable compound), PVC, and rubber compounds, see Fig. 6.

The cable polymers need to be recycled of environmental reasons but there are also economical driving forces for recycling. Landfill of polymers is in principle not allowed in the EU countries from 2008 but continues still due to lack of alternatives. The landfill cost in Sweden is 1 SEK/Kg and rises. Energy recovery is an alternative for polymer waste free from chlorine. But waste incineration has a gate fee of more than 0.5 SEK/kg in Sweden. PVC contains chlorine and is therefore very expensive to incinerate. The best alternative for PVC is material recycling. Increasing polymer prices makes also recycling more attractive.

3. PlastSep for sorting of cable plastic

The various techniques available for the separation of plastics are based on material properties like differences in density, magnetic, electric, chemical or optical properties. The most common technique used by the cable recycling industry is gravimetric separation in water. The separation follows a sink/float proceeding, were material with low density, like polyolefin’s, can be separated from material with higher density, like PVC.

Watech, a company in the NKT group in Denmark developed the Plastsep process, originally designed for separation of certain mixed plastic waste streams. The Plastsep process separates mixed polyolefin/PVC waste into a “light plastic”, a “PVC plastic” fraction and simultaneously separates metals (aluminium, copper, iron and steel) from the mixed plastic waste. The process is based on separation in water with a certain amount of detergent. With this technology remaining metals (copper and aluminium) in the plastics can be separated and recycled which increased yield compared to conventional cable waste recycling, from 95 % to about 99.5 %. Thus the purity and value of the plastic fractions also increases. The process steps are shown in Fig. 7.

The plastic fraction is sent to a sink/float separator; barrel containing water and small amounts of wetting agent. The density of the water solution (1.00 g/cm3) is higher than the density of PE and cross-linked PE (0.92 g/cm3), but lower than the density of PVC (1.39 g/cm3). A paddle wheel moves the material down and forward and the lighter PE fraction floats to the surface while the heavy fraction, containing PVC sinks. The PE fraction is sorted out while the heavy fraction is sent to a vibrating wet separation table. Here the remaining metal is separated from the PVC and sent away to be melted and recycled. It is possible to separate more than one heavy plastic fraction on the wet separation table if the density difference is large enough.

Stena Recycling has recently installed Plastsep plants for separation of cable plastics in Timrå and Kalmar, see Fig. 8 and 9. The Plastsep plant in Timrå has the highest capacity, with three sink/float tanks and three wet-tables.
The light plastic fraction consisting of PE and/or cross-linked PE can depending of cable input be recycled into new polymer compounds to be re-used in cables or in other applications (mechanical recycling) or be used as fuel (energy recycling) if free from chlorine (PVC). Cross-linked PE can be recycled mechanically by pulverizing and compounding with LLDPE or HDPE.

The heavy plastic fraction, if it consists of PVC compound with high quality, can be melt-filtrated and recycled into new PVC compound to be re-used in cables or in other applications. If the PVC compound is mixed or of low quality it can be used for example in molded traffic products.

4. Conclusions

- The amount of cable polymer waste increase every year and needs to be taken care of. For a sustainable community it is necessary to recycle the cable polymers.

- With the PlastSep process a PVC fraction and a polyolefin fraction with low metal content can be produced. The remaining metals (copper and aluminium) in the plastic fraction can be separated and recycled which increased yield compared to conventional cable waste recycling, from 95 % to about 99, 5 %.

- The light plastic fraction from the PlastSep consisting of XLPE and PE, depending of cable input and mix, can be transformed into new polymer compounds to be re-used in cable applications (material recycling) or be used as a fuel (energy recycling).

- The heavy fraction from the PlastSep consisting of PVC, depending of cable input and mix, can be transformed into a new PVC compound to be re-used in cable applications or be used as a mixed plastic in for example molded traffic products.

5. References

