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ECO-CONCEPTION, RECYCLING AND LIFE CYCLE ANALYSIS IN THE CABLE INDUSTRY

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ABSTRACT

In this article we present a three-folds approach of the environmental characteristics of cables products:
At the design step, product developers use the EIME software to compare the environmental impact of various options.
During the development phase, an in-depth research is performed to provide environment friendly, non-polluting, and easily recyclable materials as well as processes consuming less energy and raw materials.
Finally, we conduct research to facilitate product recycling when cables have reached the end of their useful lives, and recycle using our dedicated facility.

KEYWORDS

Eco-Design, EIME, Cable, Recycling.

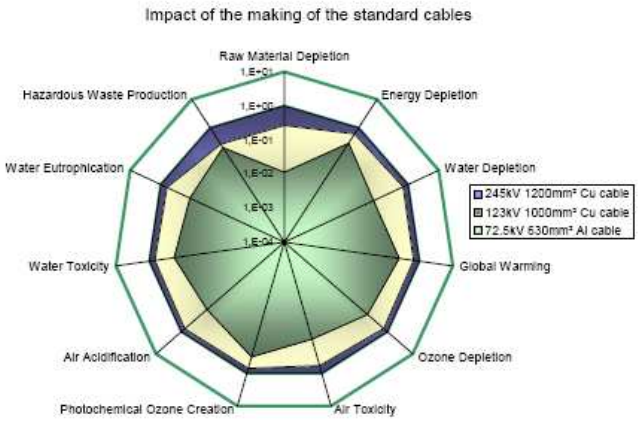
INTRODUCTION

An environmentally conscious leading cable manufacturer, developing and producing a wide range of cables, has to constantly aim at reducing the global impact of its products on the environment, over their entire life cycle.

To achieve this goal in our company, we have put in place a multi-step approach, involving Cables Design, Research & Development and Recycling.

CABLES DESIGN

Since many years we have been designing cables (1) , (2) using a reference software called EIME (Environmental Information & Management Explorer), developed by CODDE (Conception Developpement Durable Environnement) and jointly supported by famous E&E (Electronic & Electrical) industrial companies. More detail is available on http//www.codde.fr.
This user friendly tool is particularly well suited to compare various alternatives at the design step of cables. It is also useful to calculate the impact when the product is used or transported as well as when the product has reached its end of life and is recycled. These two additional considerations are not taken into account in this presentation.
The principle of the modelling with EIME lays into decomposing the product in sub-assemblies, that are then parted into simple materials and process elements, possibly linked together depending on the involved processes.
Thanks to the huge work performed by the community of users, as well as to the existing databases of well know organisms (like WTO…), databases adapted to E&E products are used to compute the impact of the product on 11 major environmental indicators, pre-defined in the software structure.
The global result is represented under the form of a radar chart that allows to easily compare results “at a glance” (Fig. 1).



Impact of the making of the different cables
Fig.1 Typical radar chart (from ref.1)

More detailed tracking of the impacts of individual parts or subassemblies of the product is possible, on one or many of the considered indicators.
As a matter of example, we report here different cases, with increasing complexity.

Application to single core automotive wire

A 0.5mm^2 single core wire, widely used in car harnesses manufacturing is probably one of the simplest possible case.
Fig. 2 shows the radar picture of the modelling results for both PVC and XLPE insulation layers.
The software takes PVC as a reference for comparison. The center point of the radar is the “no impact” point. The closer from the center, the less impact the product has on the environment.
One can easily see that the Hazardous Waste (HW) Production is significantly reduced by using PE based plastic, due to a much less creation of hazardous waste. The software gives in addition the lifetime step in which the HW is created. In this case it is found to be during the synthesis of PVC itself.

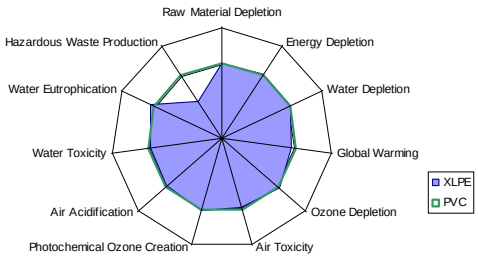


Fig.2 Comparison of the impact of XLPE & PVC used for single wire automotive cables

Application to cables for the petrochemical industry

The modelled cables are used in the field of oil & gas industry. In this example the objective is to compare a new design of cable called "Hypron" using an alternative solution to standard lead cover sheath.
This alternative solution is based on a triple layer coverage using Aluminium Tape + High density Polyethylene and Polyamide.
Considering the material used, it appears that this triple layer design has much less environmental impact than the design using lead, especially for raw material depletion (Fig.3)

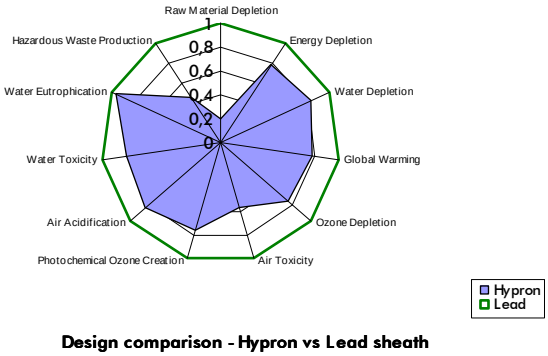


Fig.3 Comparison of cables containing lead and new Hypron cables for onshore oil & gas applications

CABLES RESEARCH AND DEVELOPMENT

The second step of the approach is to carry out Research & Development on new materials and processes in order to reduce the environmental impact of cable manufacturing.

Avoid VOC emission

Some energy cable are protected with a braid covered by a varnish. Until now, this varnish was a solvent-based two-components system.
In order to prevent atmosphere from Volatile Organic Compounds (VOC) emission, the R&D team has developed new formulations using water instead of solvents. These new systems are designed to fulfill all the technical (flexibility, chemical resistance, friction…) and productivity requirements. In addition, they have allowed to reduce the coating thickness by a factor of two.

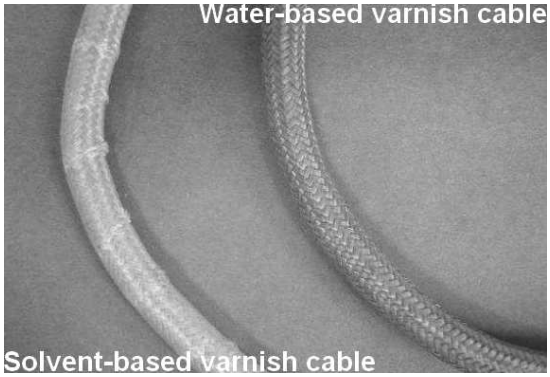


Fig 4 : Cables using solvent-based and water-based varnish.

The new cables combine high performances and quality. The switch from the solvent-based to the water-based system allows an overall reduction of solvent emission in the atmosphere of 1.2 ton/year for this type of cable.

The EIME software described above has been used to compare the environmental impact of the new varnish with the previous one. The results presented in the figure 5 are based on a 1.1kV – 120mm² cable.
Both cables are compared using similar production processes.

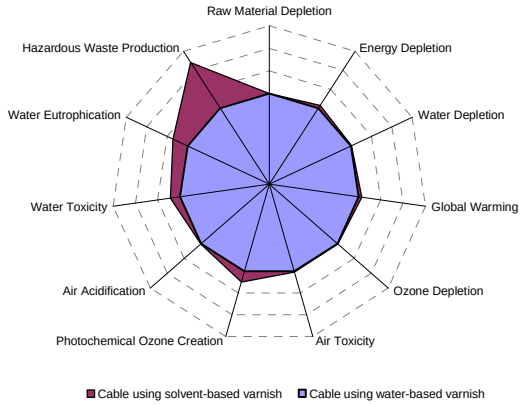


Fig 5: Comparison of the environmental impact of cables using solvent based or water based varnish.

It is observed that using the water-based varnish decreases the environmental impact of cable manufacturing. The decrease is particularly noticeable concerning hazardous waste production, due to the limitation of VOC produced.

Reduce use of toxic additives and corrosive vapors

European regulators are now striving to enhance building safety by creating new standards and directives such as the upcoming Construction Products Directive (3). The CPD will affect the cables that are mandatory to be used in any new construction.

Due to their intrinsic property of radicals trapping during materials combustion, halogenated additives into a polymer matrix are widely used in the industry as efficient fire retardant systems. Unfortunately, in case of fire, halogenated additives will generate a lot of acidic and dense smoke. In addition, the incineration of end-of life PVC cables will generate a large amount of dioxin in the atmosphere.

Fig.6 Fire safety cables used in fire evacuation systems

In this context, a complete range of Halogen Free Fire Reaction materials was developed in order to provide cables with a very high fire performance as well as low smoke emissions, leading to a much better visibility during evacuation and fire-fighting operations. In case of fire, Halogen Free Fire Reaction cables cause minimal corrosive damage to the equipment and steel/concrete structures, thus reducing expensive replacement, cleaning, and secondary pollution . On the other hand, such cables do not release dioxin or acid gas by incineration like standard building cables used up to now.

Protect earth resources

More than half of the total cable materials in volume is made of plastic obtained from transformation of fossil resources, whose stock is constantly decreasing and price increasing.

Research is currently carried out on potential materials based on renewable resources, that could replace standard polymer. Such materials can be based on starch, coming from potatoes, rice or corn (Fig. 7) , on cellulose, etc.

To be effective, this approach implies a specific evaluation of bio-based polymers available on the market, as well as development of new systems including bio-materials but also fillers and additives. In order to prevent environmental pollution, a specific focus is given on the origin and on the toxicity of those fillers and additives. The use of non-toxic and natural components is particularly looked at.

Fig.7 Corn as a base material for cables insulation?

CABLES RECYCLING

Cables can be complex products, made of metals, surrounded by several layers of various types of plastics, such as PolyVinyl Chloride (PVC), standard or cross-linked PolyEthylene (PE and XLPE respectively), rubbers… As a cable manufacturer, we are concerned by what further becomes scraps and purges out of cables manufacturing, and we want to take this into account in our environmental management. An excellent review of "end of life considerations" is given in ref.(4).

A preliminary step has been to reduce the volume of scraps produced during the cables manufacture, by improving the various processes. Recycling as well as valorization of the remaining waste products has been taken into account.

Cables are made of copper or aluminium, which are easily recyclable, but also of plastics, that can be blended or co-extruded during the process of cable elaboration.
The work carried out on cables recycling focuses both on metal and plastics and is divided into four domains:

- Materials separation techniques
- Materials compatibility
- Polymers valorization
- Plastics recycling

Materials separation techniques

The waste issued from the cable manufacture is collected, sorted and grounded in order to separate copper, aluminum and various categories of plastics.

At the end of each grinding line is a densimetric separator, which is a vibrating device, inclined, with a blower underneath and an air extractor on the top. It allows separation based on the existing differences in density between non-ferrous metals and plastics.

The separator usually delivers three different streams of material:

- clean copper particles, considered as a secondary raw material,
- a mixture of copper and plastic which is fed back to the grinders for a second passage through the separator
- plastic particles containing a certain amount of copper

This third stream passes through a further metal / plastic separation phase using an electrostatic system, known as HAMOS (5). The basic principle used here is the difference in the charging ability of copper and plastic within an electrostatic field.
At the output of this "cleaning" process, only a few percent of residual copper remains, which has been reduced to its minimum following the results of an optimization study. Each parameter is monitored and adjusted as a function of the cross-section of the copper wire in the starting cable. Currently, the residual proportion is well below 3 %.
Despite this considerable improvement of the residual metallic inclusions content in the plastic, it is still not suitable for being reused directly in the manufacture of cables. This is why new improvements are evaluated. Particularly, the use of more effective processes, such as water tables, flotation baths or hydro-cyclones is currently considered. The tests and validation of these new equipments have started.

Polymers compatibility

Polymers such as PVC, PE and rubbers are currently recyclable independently. The main difficulty lies in treating mixed polymers
Today, a major category of plastics obtained after cables recycling is a blend of PE and PVC. Because they are not compatible, the mix has low mechanical and thermal properties.
Work has been carried out to improve the compatibility in order to obtain a final system with better properties. It has been demonstrated that among various compatibilisers tested, some of them can lead to the improvement of mechanical properties such as tensile strength and elongation at break, ultimately allowing to avoid the costly separation step before materials valorisation.

Polymers valorisation

During the recycling of manufacturing waste and old cables, more than 3200 tons of particulate - i.e. 80 % of the plastics - have been recovered in 2006 (Fig.8). The trend is showing a continuous growth, raising interest for materials valorization.

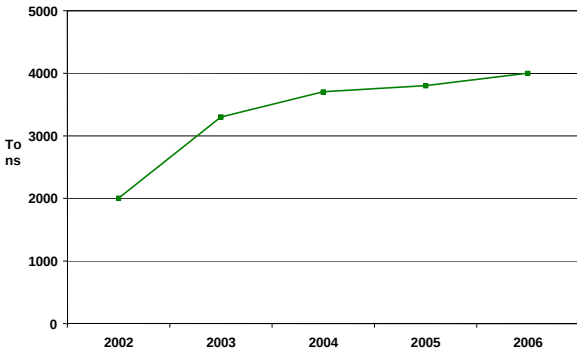


Fig. 8 – Plastic scraps production from cables recycling in the 2002 – 2006 period

The families of polymers produced by grinding are shown in Fig.9. They can be used in the manufacture of finished products like pavement edging for mix and rubbers, additives for bituminous products, road sign bases …

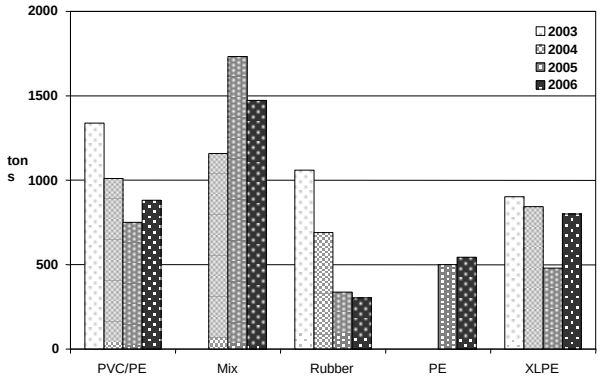


Fig.9 Various families of plastics obtained from cables grinding

Plastics recycling

Re-using these polymer purges and scraps produced during cables manufacturing in new applications has been investigated as well.

For this purpose, it is essential to both characterize the various polymer sources, and have a detailed knowledge of the constituents and properties of the polymers resulting from cable recycling. Some intrinsic properties of plastics (mechanical strength, hardness, elongation strength), the percentage of residual metal, the percentage of non-metallic impurities, the composition of the mixes, and the presence or absence of additives are key factors that will determine the type of application and recycling process.

The Research Center in collaboration with the French National Environmental Agency (ADEME) and the Center for studies into the recycling of plastic materials (Ceremap), has explored the potential and the utilization limits of each family of polymers to be recycled. This study addresses three broad types of processing: compression molding, extrusion and injection molding;

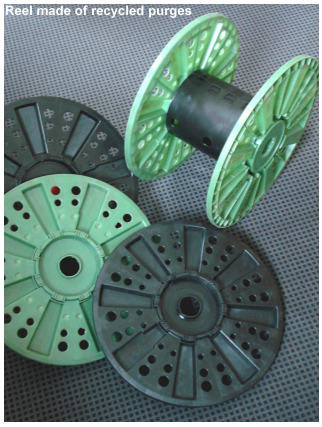


Fig. 10 Cable reels obtained from recycled materials

Various prototypes have been made as well as and various kinds of objects in order to validate the feasibility of the

various types of recycling. Accessories, and particularly cable reels (Fig. 10) have been produced, based on blended materials made of recycled polymer added to virgin one. Ratios of up to 75% of recycled polymer have been introduced, and the final material is usable in standard injection process.

CONCLUSION

A three-folds approach has been developed to ensure an optimized management of the environmental impact of cable products . First, the cable design operation is performed with the support of the EIME life cycle software Then, R&D proposes materials alternatives with lower impact for cable manufacturing. Finally a unique cables recycling unit provides an end of life treatment which ensures the best re-use of the materials resources.

Acknowledgments

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