WP5

List of relevant parameters affecting the recyclability performance and sustainability of selected products for LCA

INTRODUCTION

Eco-design solutions of paper products affect different parameters of the recycling process for the stock preparation and production of new paper products. Different results in terms of recycling parameters and levels consequently affect the environmental performances of the recycling itself, for instance in terms of emissions or energy consumptions. These environmental outputs are used for the calculation of the overall environmental sustainability by mean of LCA approach.

According to EcoPaperLoop *Position Paper on the scope and system boundaries of life cycle assessment to be used in the project*, particular focus is given to the characterization of the end-of-life recycling phase of selected products.
The available data and methodology for LCA at the beginning of the project allowed the impact assessment of different end of life scenarios on the overall LCA, for instance paper recycling versus incineration, or recycling in different paper loops, like the effect of downgrading of a product from a higher quality recycling loop to a lower quality recycling loop for the production of a different paper grade.

In the present work it is reported the further study regarding the assessment of different levels of recyclability in a similar quality recycling loop (e.g. graphic products recyclable in the graphic paper loop but with different levels of deinkability), as this was not available at the beginning of EcoPaperLoop. The main objective of the work in the present deliverable is to provide quantitative links between different levels of recyclability, as obtained from laboratory results for deinkability and recyclability and related environmental impacts to be used for the calculation of end-of-life phase of the LCA.

PRINTED PAPER PRODUCTS

Here it is reported the strategy to provide quantitative relations between the results from laboratory deinking tests and the most relevant environmental impacts in a standard industry recycling process, as one of the main results of WorkPackage 5 activity.
Specific aspects and consideration regarding graphic paper recycling and deinkability are reported.

BACKGROUND

Laboratory deinking tests are performed according to the available method Ingede 11 (2012), which evaluates three quality parameters of the deinked pulp and two process parameters:
- Quality parameters: Luminosity, Colour shade, Dirt specks
- Process parameters: Ink elimination, Filtrate Darkening.

It was already available a standard scorecard for the assessment of deinkability behaviour; five main parameters plus deinking yield are analysed and a score is given for each parameter, resulting in a total product score and rating (3 level of rating are given: good, fair or poor).

Deinking results are affected by different manufacturing features and design solutions of the printed products, e.g. type of paper and inks used, printing technology, post-treatments.
Based on the experience and available knowledge and according to the time frame of the project it was agreed that the most significant deinking parameters to be taken into account for the scope of this study are the Luminosity and the Dirt Speck content of deinked pulp. These two parameters are the most important quality indicators for the deinked pulp and if their desired quality is not achieved, some additional operation in the recycling process are needed, thus increasing the overall environmental impact of the production.

Considering a standard deinking plant, it was supposed which additional operations are needed to achieve the necessary deinked pulp quality when luminosity and/or dirt specks results don't match the standard average acceptable range, or possible avoidable operations when they are better than the average acceptable range of results.

The objective of the deinking process is to achieve the necessary deinked pulp (DIP) quality at the highest possible yield with the lowest possible energy consumption and chemical dosage. As a background for this study, it was considered the case of a standard 2 loop deinking plant in Europe, producing graphic newsprint paper using typical mixtures of ONP and OMG from household collection which is the most important raw material for deinking today. It was supposed a raw material of paper for recycling made of 50% ONP and 50% OMG. About 70,8 million of tons of paper for recycling is used for the production on newsprint in the CEPI countries, with an utilization rate of paper for recycling in the total newsprint production of more than 90%. It was considered the state of the art for the different stages of a standard deinking plant with two-loops deinking:
- pulping: high consistency pulping.
- screening and cleaning: standard machines for mechanical separation of contaminants, with fine screening up to 0,15 mm slots and possible additional centrifugal cleaners.
- deinking: two loops flotation, with a standard number of installed processes, using typical alkaline chemistry and ink collector.
- dewatering and thickening
- dispersing: possible additional dispersing stage.

LUMINOSITY (Y)

In the case of offset or rotogravure printed products, unsatisfactory levels of luminosity can be ascribed to different reasons, among the most important are the bad in detachment from fibres during pulping and the ink re-deposition on the fibres during pulping or reaction time.

The highest luminosity can be obtained at defined process conditions, the better it is.

Three products categories are considered as standard raw materials for the above mentioned deinking standard process, offset newspapers, uncoated and coated magazines, all including flyers of the same product category.

According to the available deinkability database, built from Ingede with the results of many laboratory deinking tests over the last years, the following luminosity values can be taken as average results for the selected product categories:
- Offset newspapers (including flayers of similar product category):
Average Y = 53,1 %.
- Coated magazines (including flayers of similar product category):
Average Y = 79,4 %.
- Uncoated magazine (including flayers of similar product category):
Average Y = 63 %.

If the luminosity Y of a tested product is lower than the average value for the category, the Luminosity should be increased. There are different options depending on specific plants, but generally the most common action is to increase the chemical dosage → high chemicals consumption.
The following data about average chemicals consumption are considered, based on oven-dry paper furnish:
Sodium Hydroxide: 0,5% w/w
Sodium Silicate: 1,0 % w/w

If the luminosity Y of a tested product is higher than the average value for the category, a possible reduction of the deinking process can be assumed, e.g. avoiding the second flotation loop → less energy consumption.
The following data about average energy consumption of the stock preparation system are considered:
Specific electricity consumption: 300 kWh/ton

The quantitative variation in the chemicals consumption and electricity according to Luminosity will be analyzed and reported in the Report regarding the Sustainability software tool.

DIRT SPECKS

In the case of offset or rotogravure printed products, unsatisfactory levels of residual dirt specks content can be ascribed to different reasons, among the most important are the bad ink detachment from fibers during pulping and the presence of post-treatments like UV varnishes or other special coatings that are not fragmented properly during the pulping.

The lowest dirt specks content can be obtained at defined process conditions, the better it is.

The same products categories as for Luminosity are considered: offset newspapers, uncoated and coated magazines.

According to the available deinkability database, built from Ingede with the results of many laboratory deinking tests over the last years, the following dirt specks values can be taken as average results for the selected product categories:
- Offset newspapers (including flayers of similar product category:
Average A_{50} = 631 mm^2/m^2 (A_{250} = 153 mm^2/m^2)
- Coated magazines (including flayers of similar product category):
Average (A_{50} = 490 mm^2/m^2) A_{250} = 251 mm^2/m^2
- Uncoated magazines (including flayers of similar product category):
Average (A_{50} = 458 mm^2/m^2) A_{250} = 185 mm^2/m^2
A_{50} is the total area of specks larger than 50 µm equivalent diameter; A_{250} is the area of specks larger than 250 µm equivalent diameter. The parameter in brackets is given for information, but it is not used for the present scope.

In order to decrease the dirt specks content, there are different options depending on specific plants, but generally the actions with their related environmental impacts are:
i) to increase the energy for the dispersion stage → high energy consumption.
ii) to add an additional dispersion stage → high energy consumption.

If the product has a content in dirt specks lower than the average level, a possible reduction of the energy for the dispersion stage can be assumed → less energy consumption.

The quantitative difference in the electricity consumption according to Dirt Specks will be analyzed and reported in the Report regarding the Sustainability software tool.

CONCLUSION:

The **most important environmental impacts for printed graphic products** are the ones related to **chemicals and electricity consumption**, which affect the selected impact categories for LCA.

Quantitative variations in the chemicals and electricity consumption with respect to average values, according to Luminosity and Dirt Specks results, will be integrated in the LCA calculation and consequently in the Sustainability software Calculator.

PACKAGING PAPER PRODUCTS

Here it is reported the strategy to provide quantitative relations between the results from laboratory recyclability tests and the most relevant environmental impacts in a standard industry recycling process, as one of the main results of WorkPackage 5 activity.
the scope and objective of the study is totally similar as described for graphic paper. The main goal is to find a correlation between some critical parameters resulting from recyclability tests and environmental impact indicators for LCA.

Specific aspects and consideration regarding packaging paper recycling are reported.

BACKGROUND

Laboratory recyclability tests are performed according to the EcoPaperLoop method developed and validated in the project, named Recyclability Test for Packaging Products.
The method evaluates three main process parameters of the stock preparation for recycling:
- Coarse Rejects: content of non-paper components or difficult to disintegrate materials, which are separated in the first operation.
- Flakes: content of smaller impurities like small plastic parts and primarily fibre bundles, which have to be removed in fine screening.
- Macro-stickies: content of tacky particles mainly due to adhesive used in the packaging product, with specific attention to the fragmentation behaviour during the recycling process.

The assessment Scorecard for evaluating the parameters obtained with the EcoPaperLoop method is not available yet and possibly it will be finalized by the end of the project.

Recyclability results are affected by different manufacturing features and design solutions of the paper based packaging products, e.g. type of paper used, plastic or foil lamination, surface treatments like coating, varnish or wax application, additives used in the stock preparation, type and amount of adhesives.
Based on the experience and available knowledge, the most significant recycling parameters selected for the scope of this study are the coarse rejects and macro-stickies of recycled pulp. These parameters are the most important process indicators for the recycled pulp and if their level is too high, some additional operations in the recycling process are needed and/or more waste is produced, thus increasing the overall environmental impact of the production.

Based on a standard technology plant for the most common packaging paper production, it was supposed which additional operations are needed in the stock preparation when coarse rejects and/or stickies results are over the standard average acceptable range, or possible avoidable operations when they are lower than the average acceptable values.

The objective of the recycling process is to achieve the necessary pulp quality and properties at the highest possible yield with the lowest possible energy consumption.

As a background for this study, it was considered the case of a standard plant in Europe, producing corrugated board papers, both linerboard and fluting, using typical mixtures of paper from recycling from household collection. This mixture principally consists of used corrugated board and other paper and board packaging of various qualities.
It was considered the state of the art for the different stages of a standard technology plant :
- pulping: from low to medium consistency as used for liner and fluting
- deflaking (optional): fine disintegration of fibre bundles in a deflaker, e.g. disk screen
- screening and cleaning: standard machines for mechanical separation of contaminants, with fine screening up to 0,15 mm slots and possible additional centrifugal cleaners.
- dewatering and thickening
- dispersing (optional): possible additional dispersing stage.

COARSE REJECTS

Unsatisfactory high levels of coarse rejects can be ascribed basically to the presence of plastic lamination of wet strength resistance papers, which are not able to be separated in the pulper conditions and they are separated as coarse fragments on the screen. The coarse rejects are normally disposed as special waste to incineration, landfill or other destinations, so the higher is the amount of coarse rejects, the higher is the amount of waste to be handled and disposed. As a consequence of a high level of rejects, the recycling fibres yield decrease and more raw paper for recycling is necessary.

Coarse rejects is the most important parameter affecting the recycling operations.

Two product categories are considered as standard raw materials for the above mentioned recycling standard process, corrugated boxes and folding boxboards.
The average recycling values for these product categories are obtained from the database of packaging products recyclability developed in WorkPackage 3.

The following coarse rejects values can be taken as average results for the selected product categories:
- Corrugated boxes:
Average CR = 4,0 %
- Folding boxboard:
Average CR = 1,0 %

If the coarse reject CR of a tested product is higher than the average, an additional amount of reject is accounted as waste production to be disposed.
If the measured value for the coarse reject il lower than the average, a minor amount of reject is accounted as recycling waste to be disposed.

Quantitative variations in the waste production according to Coarse reject will be analyzed and reported in the Report regarding the Sustainability software tool.

MACRO-STICKIES

Unsatisfactory high levels of macro-stickies in the pulp stock are determined by the presence of high amount of un-soluble adhesive particles below a certain particle size, which are potentially difficult to be separated in standard fine screen units.

Normally the stickies are efficiently separated in the fine screen units of recycling plants when their size diameter is higher 2 mm; the little they are, the most difficult is their separation, with the possibility that some particles pass through the pressure screens. Therefore the macro-stickies area of the particles fraction below 2000um of equivalent diameter are evaluated in the present scheme.

The lowest macro-stickies content can be obtained at defined process conditions, the better it is.

The same products categories as for Coarse Reject are considered: corrugated boxes and folding boxboard.

According to the database of packaging products recyclability developed in WorkPackage 3, the following values for macro-stickies area <2000um can be taken as average results for the selected product categories:
- Corrugated boxes: average MSA = 2630 mm^2/kg
- Folding boxboard: average MSA = 5090 mm^2/kg

If the amount of Macro-stickies is higher than the average value for the category, the amount of stickies should be reduced. In order to decrease the amount of macro-stickies, there are few options and generally it can be limited to operations intended to better separate the adhesive particles or disperse them if they have small size:
i) to add more effort in the screening stage → higher electricity consumption in the process.
ii) to add a dispersion step → higher electricity consumption in the process.

If the product has a content in Macro-stickies lower than the average level, a possible reduction of the energy for the screening and/or dispersion stage can be assumed → less energy consumption.

Quantitative variation in the electricity consumption according to Macro-stickies content will be analyzed and reported in the Report regarding the Sustainability software tool.

CONLUSION:

The **most important environmental impacts for packaging products recycling** are the ones related to **waste production and electricity consumption**, which affect the selected impact categories for LCA.

Quantitative variations in the waste production and electricity consumption with respect to average values, according to Coarse Reject and Macro-stickies results, will be integrated in the LCA calculation and consequently in the Sustainability software Calculator.