Contract no.: 500345 (NMP2-CT-2004-500345)
Project acronym: ECOTARGET

Project title: New and innovative processes for radical changes in the European pulp & paper industry

Instrument: Integrated Project

Thematic Priority: NMP

Publishable Final activity report

Period covered: from 01 November 2004 to 31 December 2008
Date of preparation:19 January, 2009

Start date of project: 01 November 2004 **Duration**: 50 months

Project coordinator name: Catharina OTTESTAM
Project coordinator organisation name: STFI-Packforsk AB **Revision**: [1]

STFI-PACKFORSK

1. Project execution

Project objectives

The overall objective of ECOTARGET is to enhance the competitiveness of the pulp and paper sector (including its suppliers) in Europe while at the same time improving the eco-efficiency.

This Integrated Project (IP) intends to achieve major improvements in processing and to do it in a way that facilitates efficient deployment of results. The work is based on a set of selected break-through ideas: reduction of the energy consumption in mechanical pulping, improving raw-material efficiency by fractionation and enzymatic treatments, improvement of product properties by producing layered paper sheets, elimination of bottlenecks in the use of recycled fibres and new means of closing internal water cycles.

The goals, besides improving product quality and production economy, are to achieve improvements by at least 20% for each of the breakthrough ideas. This should be measured per unit of production, in at least one of the following target areas:

- Energy consumption (reduced by 30%),
- Wood raw material consumption (reduced by 30%),
- Fresh water consumption (reduced by 20%),
- Waste and/or emissions (reduced by 20%).

The work is performed in a series of sub-projects of high potential and high risk, directed to an industry with a large complexity and capital intensity. To perform this dedicated research, the project brings together the best and most relevant resources in the field. In addition, to maximize the probability of success, the project is manned with partners that have a high degree of multidisciplinarity.

The partners include leading industrial pulp and paper producing companies as well as companies supplying this industry with machinery, chemicals etc. The partnership also involves the major European research institutes and leading universities active in the relevant fields. Thus, the partnership allows for efficient work spanning from fundamental scientific levels to industrial implementation.

The leading idea of ECOTARGET is “More from less”, i.e. making more and better products with less use of raw materials, energy and water and at the same time reducing residues, waste and emissions. The impact can be measured along the three lines of sustainability: economic, environmental and societal. The economic impacts will primarily follow from improvements in production efficiency/production costs and quality performance.

The targets are demanding for an industry where more gradual changes are the tradition. ECOTARGET will provide the pulp and paper industry with tools to implement and comply with a range of policy statements and directives concerning sustainability, environmental actions, waste, product policy and energy from biomass. A competitive industry will help to secure employment and infrastructures (of which SMEs like forest owners, transporters, printers, converters etc., are important parts) particularly in more rural areas in Europe.

Contractors

Research institutes
STFI-Packforsk AB (STFI-PF), Sweden
Centre Technique de l'Industrie des Papiers, Cartons et Celluloses (CTP), France
Oy Keskuslaboratorio – Centrallaboratorium AB (KCL), Finland
Papiertechnische Stiftung (PTS), Germany
Technical Research Centre of Finland, (VTT), Finland
Agrotechnology & Food Innovations (A&F), Netherlands

Universities
Kungl Tekniska Högskolan (KTH), Sweden
Technische Universität Darmstadt (TUD), Germany
Helsinki School of Economics (HSE), Finland

Companies
Stichting Kenniscentrum Papier en Karton (KCPK), Netherlands
Andritz AG (Andritz PR), Austria
ARTEC System S.A. (ARTEC)., France
UMV Coating AB (UMV), Sweden
Cargill Deutschland GmbH, Germany
Holmen AB (Holmen), Sweden
Kadant Lamort SAS (LAMORT), France
Kolb Distribution Ltd (KOLB), Switzerland
LDZ, Laboratoire Dr Zesiger (LDZ), Switzerland
LLA Instruments GmbH (LLA), Germany
Metso Paper, Inc. (Metso), Finland
Sociedad Anonima Industrias Celulosa Aragonesa (SAICA), Spain
Stora Enso Oyj (Stora Enso,) Finland
UPM-Kymmene Oyj (UPM), Finland
Viochartiki S.A. (Viochartiki), Greece
Voith Paper Holding GmbH & Co. KG (Voith), Germany
Smurfit Kappa Roermond, Netherlands

Co-ordinating organization is STFI-Packforsk AB, Sweden
Co-ordinator is Catharina Ottestam, e-mail: Catharina.ottestam@stfi.se

This is the project logotype:

Project structure and main achievements

Overall IP program structure

The figure below shows the six Subprojects and the four target areas of the project. The blue marked Subprojects will develop the new process ideas. The Subproject Integration (marked in green) will evaluate results from the other Sub-Projects from a total process system point of view and perform environmental as well as socio-economic assessments.

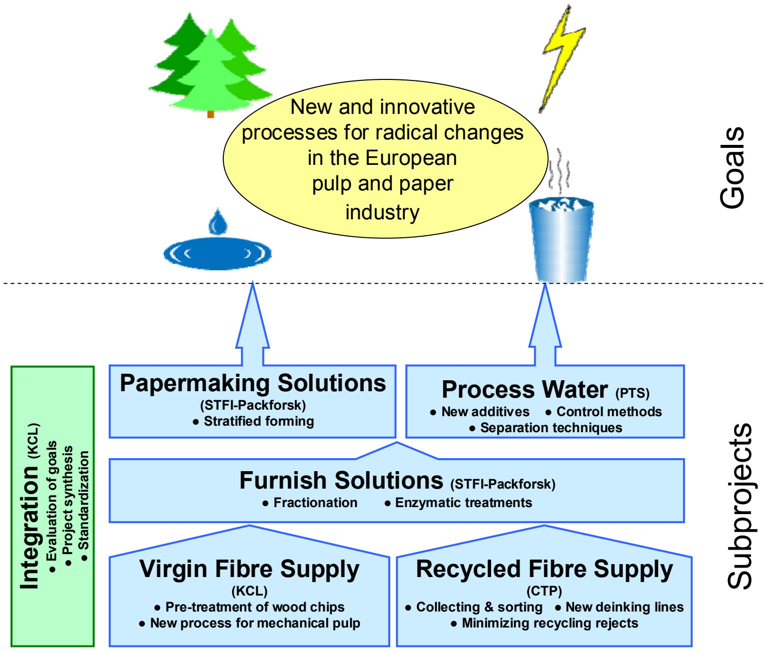


Figure: The structure of ECOTARGET with the 5 technical Sub-projects, the Integrating Sub-project and the target areas (overall objectives).

More information about the project can be found on www.ecotarget.com.

Progress and fulfilment of the IP

The ECOTARGET project, now completing its fourth and final year, has progressed according to plan. Several new technologies have been developed that will have a positive impact on the target areas and the competitiveness of the pulp and papermaking industry. Some of the processes have been implemented while some needs further demonstration or a bit more research before being implemented in industrial scale. Below follows a summary per Subproject.

SP1 - Virgin Fibre Supply: In developing a mechanical pulping concept, an 8-18 % energy reduction has been achieved by using cellulase, and a 10 % reduction with pectinase or chemical pre-treatments during this period. The evaluation of new refiner segments in mill process did not show any energy reduction, but has given some new leads for further studies created in the fundamental studies.

SP2 – Recycled Fibre Supply: In this Subproject four new sensors have been developed for identification and sorting of recovered paper. In this Subproject, demonstration trials of a new eco-efficient deinking process have been carried out during the period. There have also been activities related to up-scaling of processes defined earlier, like collection and sorting of recovered papers, use of alternative wires on paper bales made of PET instead of metal.

SP3 – Furnish Solutions: The key objective during this period has been to report and disseminate result and this has been achieved. Discussions have taken place regarding future possibilities to implement fractionation technologies and enzymatic treatments in industrial scale. A number of application scenarios have been defined and reported.

SP4 – Papermaking Solutions: The overall objective of the sub-project has been to develop and demonstrate an industrially relevant technique for stratified forming. Stratified forming, i.e. the layering of a sheet structure in the headbox, has been the dream of many papermakers. Previous attempts have generally resulted in poor layer purity. A new method called the "Aq-vane technique" has been developed in the project. By implementing this technique the possibility of raw material and energy reduction has been successfully demonstrated for the SC-paper and uncoated fine-paper.

SP5 – Process Water: New starch-based additives have been produced and tested in mill scale showing good efficiency. In this Subproject the developed measurement system has been tested in pilot-scale including analysis of requirements for later correlation signals in detrimental phenomena situations in paper mills. Pilot scale trials have been carried out testing operational requirements for most suited separation techniques for detrimental substances.

SP6 – Integration: Key objectives/milestones for this reporting period were to assess the social and economic impacts and to integrate them into environmental effects for the overall sustainability evaluation. Another aim was to evaluate the competitiveness of the technologies in different business environment scenarios. Acceptability, adaptability and economic performance have to be evaluated and interpreted together with environmental assessment results. As a conclusion, a performance profile for each technology was constructed based on SWOT analysis. The methodologies for the evaluation are finalized.

End results

The total of ECOTARGET has resulted in a variety of newly developed processes. Some of them are already on the market (sensors for control of recovered papers and new additives for process water for example), some are ready for demonstration (stratified forming of paper for example) and some will need some more research and development work before demonstration (new energy efficient mechanical pulping process for example). Since this industry has a very capital intensive structure, and needs heavy investments for new implementations, there is a certain time frame between when very promising pilot-scale results are obtained and until a larger installation has taken place. In some cases between 5-10 years, depending on the size of the investment, the timing for the mill that will implement etc. There are however so many promising results from this project that we are confident that most of the ideas will result in implementations all over Europe.

Extended summaries from the Subprojects

Below folllows more extended reports from the achievements of the six Subprojects

Sub-Project 1

The consumption of electrical energy in mechanical pulping is very large, it may sum up to over 3 MWh/t pulp for demanding printing papers. The effects of wood-chip refining parameters on fibre quality and energy consumption have been extensively studied, but breakthroughs in energy saving have not yet been achieved, because of the tight energy-quality relationship.

The overall objective of **Sub-Project 1 Virgin fibre supply** was to develop a mechanical pulping concept that consumes 30% less electricity in the production of pulp at a given pulp quality level. The main raw material of the studies was Norway spruce.

The aim of **WP1.1 Chip pre-treatment** was to modify wood fibre wall chemically, enzymatically or by mechanical forces to change its internal environment in order to enhance the defibration and refining without jeopardizing the pulp quality. The approaches were

- chemical pre-treatment: acid leaching, oxalate treatment, electrochemically treated salt solutions
- enzymatic pre-treatment: cellulase, xylanase, pectinase (commercial enzymes)
- mechanical pre-treatment: plug screw Prex, Modular Screw Device, piston press
- refining in small, pilot or bigger pilot scale

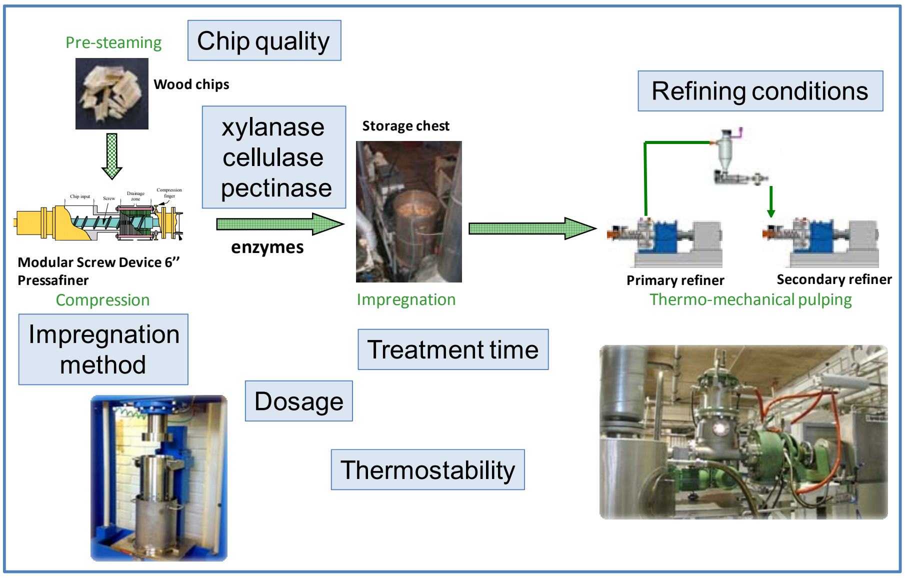


Figure x. Enzymatic pre-treatment of chips.

The aim of **WP1.2 Refining techniques** was to develop energy efficient chip refining techniques by application of more controlled energy impacts into the wood and fibres and monitoring their effect on the fibre cell wall. The main approaches were:

- Shear/compression treatment of coarse fibres or wood chips
- Clarifying the TMP refining mechanisms (plate gap mechanisms, effect of morphologically different fibres, refining conditions, etc.)
- Development of energy saving refiner segments

The partners in SP1 are: KCL, STFI-Packforsk, CTP, VTT, Holmen Paper, Stora Enso, UPM-Kymmene and Metso Paper.

Enzymatic pre-treatment of chips

The comparison of the effects of the three studied enzyme compositions (xylanase, cellulase, pectinase) showed that with the most optimal enzymatic charges, xylanase led to the best energy savings with a 25% decrease compared to the control. With cellulase the energy reduction was 20% and with pectinase only 10%. The decrease in fibre length was the main drawback of all enzymatic treatments being 25%, 10% and 8% respectively. To avoid the unnecessary fiber cutting and strength reduction caused by the enzymes the refining should be rather gentle.

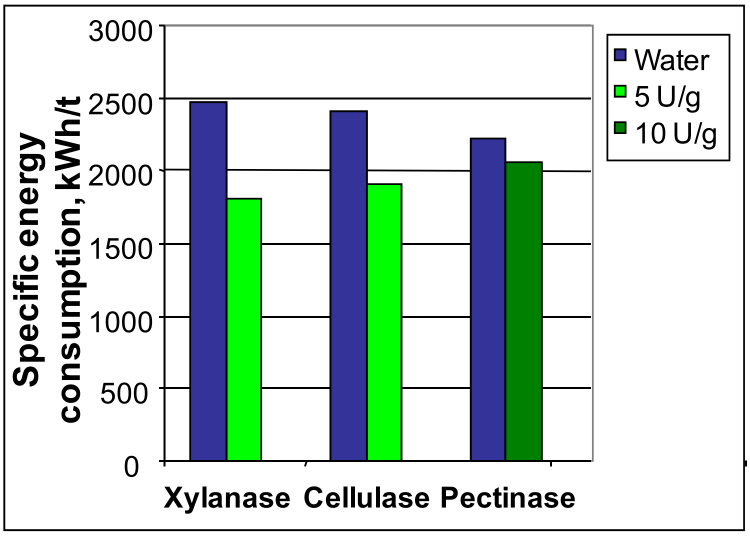


Figure x. The maximum reduction in electric energy consumption at CSF 100 ml was 25% for xylanase, 20% for cellulase and 10% for pectinase pre-treatment in pilot scale refining trials.

The cellulase pre-treatment concept was tested by several partners with various equipments, and energy reductions from 8% to 18% were shown also without fiber cutting. However, in some cases unexpectedly high enzyme charges were needed in order to get a significant effect. It must be emphasized that the composition of the commercial cellulase used is not optimized for this type of process, but was used as an indicator to show the proof of concept.

The impregnation efficiency was shown to be affected by several variables, e.g. compression and impregnation technique, chip quality, enzyme composition and molecule size, heat sensitivity of the enzyme, and refining conditions. More work is needed to optimize the process parameters properly and to show the maximum potential.

Chemical pre-treatment of chips

The chemical pre-treatment methods showed 0- 25% energy reduction in electric energy consumption of TMP refining. However, the bigger the drop the more changed were the pulp properties. E.g. the oxalate pre-treatment of the chips combined with high-intensity refining (large pilot scale) decreased the energy consumption by 25%, of which 10% was due to the intensity and 15% due to the enzyme. The pulp had remarkably high light-scattering but decreased tensile. Other methods gave only minor savings if any, but they may still have potential after further studies.

Shear/compression treatment of chips or coarse fibers

Laboratory studies of shear/compression treatment of wood chips and coarse fibre mats showed that a significant reduction of the electrical energy consumption could be achieved when shear/compression forces are used. Shear/compression treatment of coarse fibre mats showed an electrical energy reduction estimated to 25% at a given tensile index. The degree of collapse of the shear/compression treated wood chips was significantly increased at relative low energy consumption, but the effect on refining energy was minor. The concept might be potential when combined with chemical or enzymatic pre-treatment.

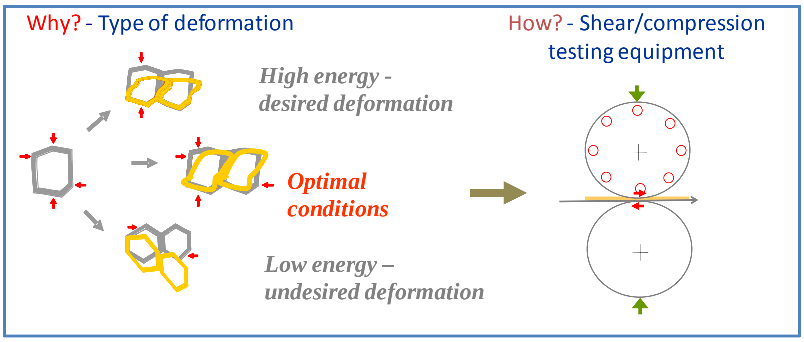


Figure x. Shear/compression treatment of wood chips.

Mechanism based segment design

New type of **refiner segments** were designed based on the new knowledge on the distribution of power consumption and fibre development in the plate gap. The segments were evaluated in both first and second stage mill scale refiner. The results did not show any significant reduction in specific energy applied to specific quality. However, the results will be utilized in future development work.

Several new equipment and methods were developed in the project. The Equipment of shear and compression (ESCO) was developed to give answers for questions like "What causes the desired development of fibers?" and "What kind of factors affect the energy consumption in refining?" Moreover, a method to calculate the power distribution in a refiner disc gap was developed. Also the new fibre characterization method is a useful tool in developing energy efficient processes. It describes the efficiency of the peeling of the fibre wall outer layers due to various pre-treatment and refining processes.

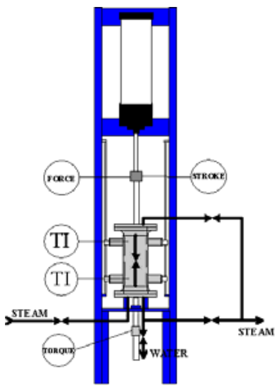


Figure x. Equipment of shear and compression.

High-intensity refining of CTMP

It has been shown in large pilot scale trials that the electric energy consumption of CTMP (certain chemical treatment conditions) refining can be decreased by 45% at given freeness by changing the refining conditions. However, the pulp properties were somewhat changed (fiber length -10-20%, tensile index -13%) and the result was not considered to fulfil the target "less electricity at a given pulp quality level".

If large energy reductions are aimed at, smaller or even bigger changes in the pulp quality should be accepted and the effects on paper making process and the applicability of the pulp for different end products should be investigated.

Conclusions

- Several of the activities within SP1 have indicated energy reduction of 10-25% to be possible at least if a slight reduction of the pulp properties is allowed. However, the energy saving potential has not yet been proven in larger scale.
- Even close to 50% energy reductions were shown to be possible if more or less changed pulp quality is accepted.
- The project has substantially increased the understanding of the refining mechanisms and this knowledge will be utilized in the future development of refining process.
- The further development of the ideas and added effect of applying several of the developed approaches is likely to increase the energy savings significantly.
- The most economical way to implement the enzymatic and mechanic pre-treatment techniques is in connection of a major rebuilding or with the case when new lines are planned to be build.
- Decreased electric energy consumption of TMP refining means also reduced steam heat recovery and therefore increased need of supplementary fuel for paper making process or steam savings. The choice of supplementary fuel is critical in terms of air emissions and the environmental performance of the technology. Instead of oil (increased air emissions) other alternatives like wood residuals should preferably be used.

Sub-Project 2

The overall objective in SP2 was to develop new process solutions towards increasing the recycled fibre utilisation rate and consequently reducing the energy consumption in the paper industry since the production of recycled/deinked pulps require much less equivalent energy compared to virgin pulps. The process solutions developed in SP2 also led to direct savings in raw materials, energy and waste. The partnership included 2 research institutes (CTP & PTS), 4 papermakers (Holmen, KCPK, UPM & Viochartiki &) and 5 suppliers of sensors (ARTEC, LDZ & LLA), equipment (Kadant-Lamort) and chemicals (Kolb).

WP 2.1: Recovered paper sorting and quality control by sensor development

The objective was to develop new sensors to replace the human controls of recovered paper performed in recycling and deinking mills by automatic RP control systems, in order to get the specified RP quality (EN 643 grades) with less unwanted components and consequently to improve paper quality and reduce the rejects. Five new sensors were investigated to control most relevant RP raw material characteristics.

A first sensor based on Nuclear Magnetic Resonance (NMR) technology was investigated and prototype was built and tested by ARTEC in order to measure the moisture content of whole RP bales and get consequently a real average value without sampling. Promising results were obtained with very wet RP samples, but the difficulty to get correct values in the relevant RP humidity range led to drop this technology after the second project year. The moisture control task was taken over by specific development achieved with the NIR sensors.

Two sensors were developed for the control of recovered papers delivered loose, i.e. deinking grades (1.11) to be controlled on conveyor belts.

Fig.1: NewsMag sensor (CTP/Techpap)

Fig.2: Unusable materials sensor (PTS/LLA)

CTP developed the NewsMag sensor, based on Image Analysis, for the control of the ratio of newsprint and magazines. Successful tests were performed in UPM deinking mills (fig.1). The new sensor also gives the amount of board in the deinking furnish. It is marketed by Techpap.
PTS developed, together with LLA, a sensor based on Near Infra Read (NIR) spectroscopy for the detection of unusable materials including non-paper (plastics, textiles, wood) and paper (boards, flexo printed newspaper, etc.) components. A first lab prototype (fig.2) and a full-scale version were built and evaluated. The new sensor is ready for marketing.

Two sensors were also developed for the control of recovered papers delivered in bales, i.e. RP grades used in packaging paper recycling mills.

Fig.3: MONITOR sensor (CTP/Techpap)

Fig.4: SmartNose sensor (LDZ/CTP)

CTP developed the MONITOR sensor, based on NIR spectroscopy, for the control of RP bale core drilling samples. Long-term trials were performed at KCPK and other Ecotarget partner recycling mills. Moisture content and unusable materials are measured accurately. A portable and an automatic core drilling version (fig.3) are marketed (and already sold) by Techpap.
LDZ developed, together with CTP, the application of the SmartNose mass spectroscopy unit (fig.4) to the analysis of various RP volatile compounds. The new system offers fast detection of chemicals like Phthalates and DIPN, which are prohibited for food contact applications.

WP 2.2: Simplified and new deinking line structure

The objective was to develop new processes, equipment and process layouts to achieve more eco-efficient deinking, i.e. with less energy and rejects, as deinking lines have become quite complicated to meet deinked pulp (DIP) quality requirements, especially for high-quality grades (SC, LWC) where the potential to increase the use of recycled fibres is high (fig.5). The innovations were developed at pilot or industrial scale, including demonstration in mills.

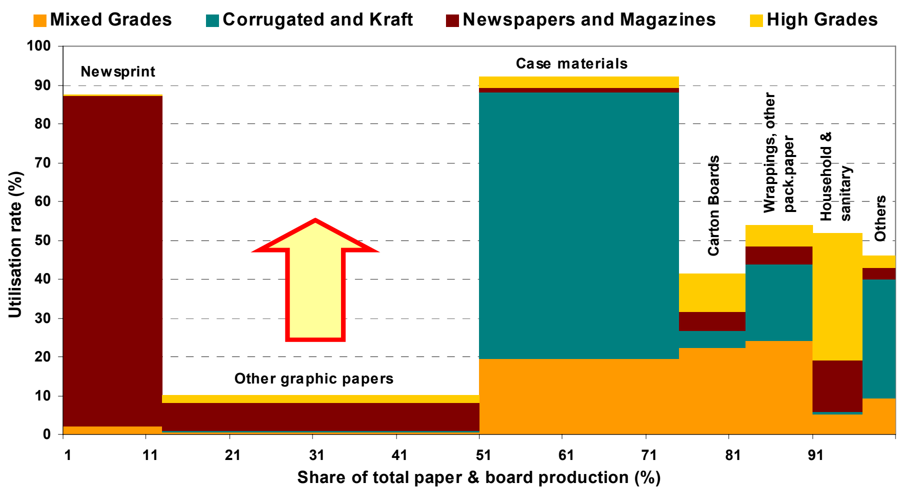


Fig.5: RP utilisation by paper grades in CEPI countries in 2007

Pulping, the first deinking process step, required rationalisation of the different functions, i.e. efficient defibering and ink detachment while minimising contaminant and ink fragmentation to improve their subsequent removal. The optimisation of all the pulping parameters (fig. 6) performed at CTP on pilot scale with wood-containing and wood-free raw materials showed the possibility to save 30% energy, using short pulping time. Concerning pulping chemistry, new deinking chemicals were developed by Kolb and tested at the Viochartiki mill with PTS.

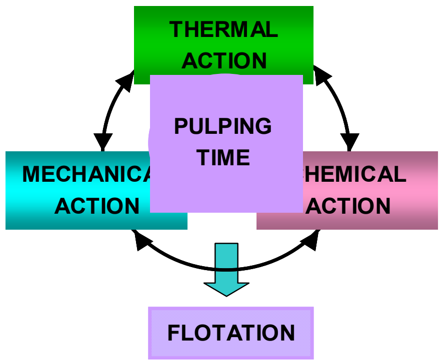


Fig.6: Pulping parameters

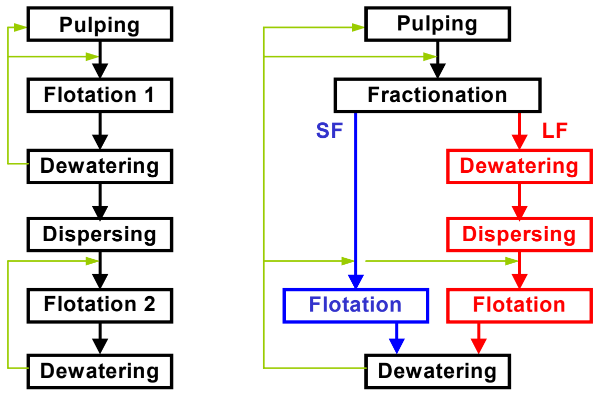


Fig. 7: Standard 2-loops vs. new single loop deinking

To simplify conventional two-loops deinking processes, PTS has investigated recombination of the deinking process steps (figure 7) and shown that fractionation with one-step single-loop flotation and hot-dispersing limited to a long-fibre fraction would save 17% of total DIP line energy consumption and increase the yield from 85% to 90%, for newsprint application. Some additional bleaching chemicals are required to compensate for the reduced flotation capacity.

New simplified low-energy equipment has been developed by Kadant-Lamort (fig. 8). With 3 stages in one single equipment energy savings > 50% can be achieved at fine slot screening while the use of low-pressure injectors in a multistage flotation cell saves 25 to 30% energy.

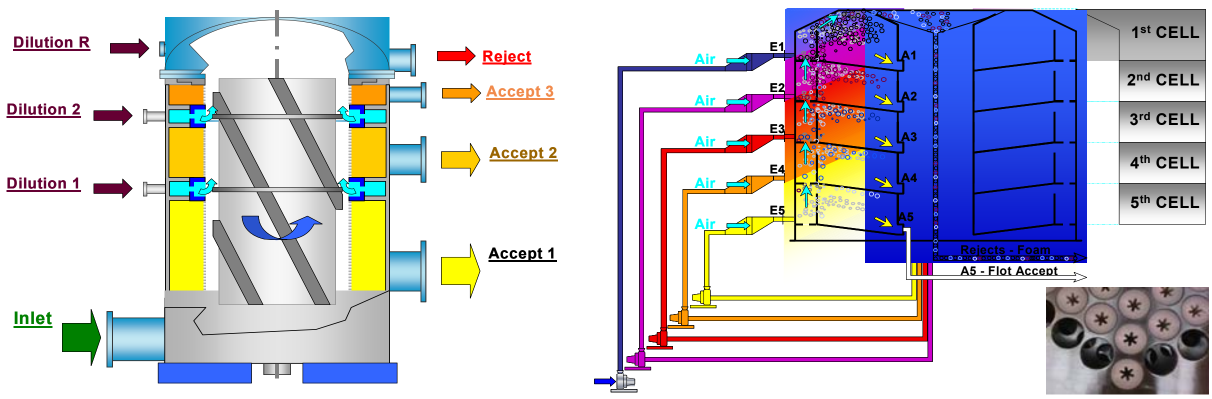


Fig.8: ScreenOne pressure screen and MAC Cell with new injectors (Kadant-Lamort)

A large part of the research at CTP in WP2.2 was devoted to the reduction of flotation losses, with focus on the control of surface active substances which were shown to have detrimental effect on the flotation selectivity. A method to establish surfactant balances in deinking mills and a process to remove surfactants through process water flotation were developed. The new process has been patented and demonstrated in different deinking lines at UPM and Holmen. Flotation losses can be reduced by 10 to 30%, while maintaining high deinking efficiency.

The implementation of all the WP2.2 innovations in the virtual RCF-TMP-LWC case mill defined in SP6, would lead to 16% electricity and 30% steam savings, and to a 20% reduction of the flotation losses with a corresponding increase from 71.5 to 75.5% of the DIP line yield.

WP 2.3: New technologies to reuse recycling rejects

The objectives was to develop new solutions to reduce the rejects generated during recycling, with focus on 2 main tasks, i.e. the reduction of coarse rejects by different approaches and the recycling of DIP coating pigments in surface treatment applications.

KCPK has developed a waste hierarchy approach to reduce the recycling rejects, starting with prevention of waste. Best RP collection and sorting practices were identified to generate less rejects and alternative solutions to replace the metal wire used for RP baling were developed. PET wires were shown, after mill trials (fig. 9), to offer clear advantages including less rejects and the possibility to recover energy from these rejects, as well as improved personnel safety. Industrial implementation of PET baling wires has started in the Netherlands and Germany.

Fig.9: Mill test of PET RP baling wires

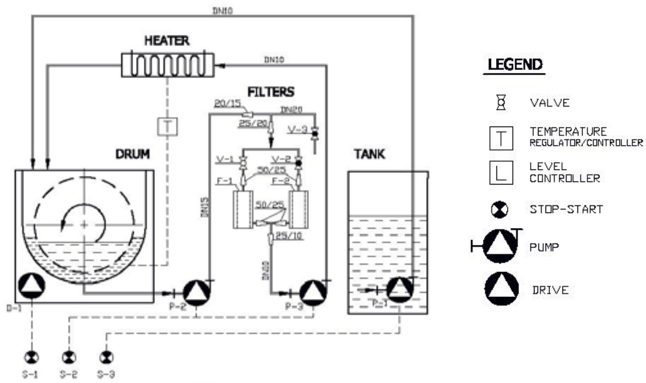


Fig. 10: The "Reject Treater" installation (KCPK)

Most of the research effort at KCPK has then been devoted to the characterisation and reuse of coarse rejects from packaging paper recycling mills. The "Reject Treater" concept has been developed on small pilot scale (fig. 10) to recycle most valuable fibres. Full-size equipment has been designed, patented and is ready for construction for a recycling mill.

The possibilities to develop real recycling of coating pigments, i.e. to reuse DIP pigments in paper coating instead of "down-cycling" these pigments in the base paper, were investigated at CTP. Mechanical separation and grinding processes as well as bleaching and enzymatic treatments were tested on mill samples. DIP pigments with more than 70% brightness were recovered from the last deinking loop process water and tested for coating applications. Up to 10% DIP pigments could be incorporated in coating under-layers, e.g. with curtain coating, which would lead to a 20% reduction of LWC deinking line rejects (fig. 11).

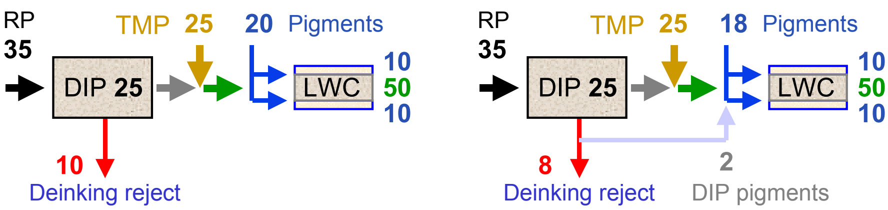


Fig.11: Example of maximum recycling of DIP pigments in coating

Sub-Project 3

The papermaking process is based on wood fibres characterised by a significant variation in their morphological properties. Fractionation according to fibre properties has therefore always been high on the agenda coupled to the goal to be able to "use the right fibre for the right purpose". The use of enzymes has for a long time been looked upon as a promising tool in papermaking having a large potential to modify fibre properties. Up till now, the progress has, with a few exceptions, been slow.

Fractionation based on fibre wall thickness and fibre modification through enzymatic fibre surface modification are despite their obvious potential, presently not much used. Obstacles are low fractionation efficiencies and the absence of a clear demonstration of the value of novel fibre surface treatment processes. These areas have been addressed by **Sub-Project 3.**

The overall objective of **Sub-Project 3 Furnish Solutions**, has been to maximise the use of a given fibre raw material in terms of materials efficiency as well as energy and water consumption by the use of fibre fractionation and/or enzymatic treatment of the fibres.

The Sub-Project has been effected through two Workpackages:

- WP3.1 New fractionation technologies.
- WP3.2 New fibre properties through enzymatic treatment.

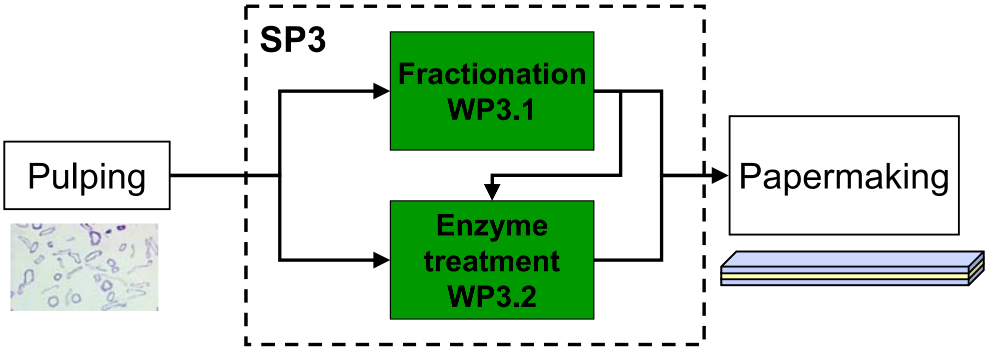


Figure 1. The layout of the approach of SP3 Furnish Solutions.

The partners of theSP3 have been: STFI-Packforsk, CTP, KTH, VTT, TU Darmstadt, A&F, Holmen, Voith Paper and Smurfit Kappa Roermond.

WP3.1 New fractionation technologies

The objective was to evaluate/develop three different fractionation technologies which fractionate the fibres with respect to fibre wall thickness and fibre flexibility.

Three novel fractionation ideas were explored. The technologies were modified and tested in laboratory scale. The emphasis was to improve the selectivity of separation with respect to fibre wall thickness and fibre flexibility. With an efficient separation it would be possible to use different fibre fractions in different layers/products.

The fractionation technologies that were studied were:

- A novel hydrocyclone
- A modified rotary cleaner

- A novel screen bar design

These experimental studies were assisted by modelling work which is common to all three processes

- Modelling of a centrifugal flow field

Fractionation by a **novel hydrocyclone design**, see *Figure 2*, resulted in a fibre fractionation with a much less pronounced thickening of the course fraction. As a result the fines do not accumulate to the same extent in the fines fraction, thus avoiding a dramatic deterioration of the dewatering properties (much higher SR value). Much less efforts are thus required for dilution/thickening processes of the fine/coarse fraction.
The CFD calculation showed that an optimal inlet geometry is crucial for the evenness of the inlet flow. An even flow field is supposed to be a prerequisite for a good fractionation result.

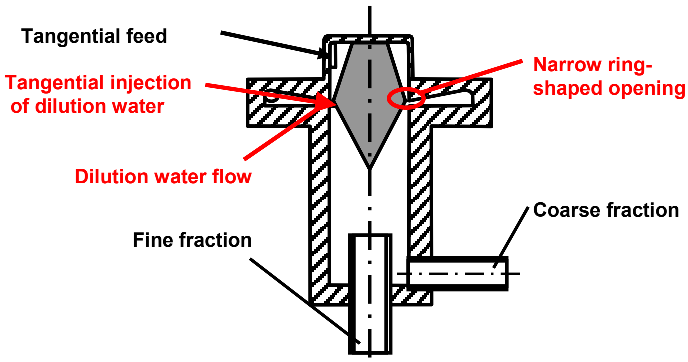


Figure 2. Geometry of the novel hydrocyclone.

In the work with the **modified rotary cleaner**, see *Figure 3*, a cleaner prototype was modified to deliver three pulp fractions (a heavy fraction, a light fraction and a middle fraction that was recirculated). To better control the centrifugal separation of fibres, a water layer was introduced along the rotary drum wall. The trials showed clear differences between the heavy and light fractions with respect to the sheet properties which offer new possibilities to develop various new fractionation concepts.

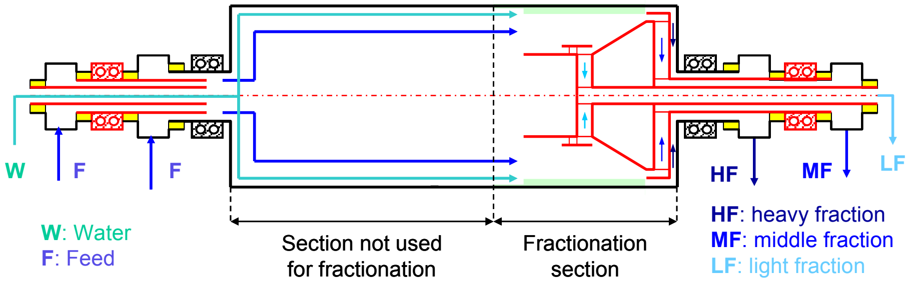


Figure 3. The modified rotary cleaner.

In the third part of the project **a novel screen bar design**, see *Figure 4*, a number of new designs were tested. The screen bar is manufactured by a rapid prototyping that enables every possible shape to be tested. It was shown that it was possible to fractionate pulp into fractions containing flexible fibres and stiff fibres, respectively, with the new technique.

Figure 4. The novel screen bar design.

WP3.2 New fibre properties through enzymatic treatment.
The objective was to improve the drainage and dewatering properties of virgin and recycled fibres with the help of enzyme treatment.

Enzyme treatments were screened with respect to fibre and papermaking properties. Different enzymes, both commercial and experimental, were used to study the mechanism of enzyme aided dewatering. Special emphasis was devoted to measurements of drainage and dewatering properties and dissolution of carbohydrates.

The activities included enzymatic treatment of TMP pulp to change the drainage properties, addition of xyloglucan (XG) to the sheet to increase the strength properties as well as mill trials using enzymes in the process to enhance the dewatering (recycled fibres), see *Figure 5*.

Virgin mechanical pulp fibres

Cellulase and hemicellulase treatments with commercial and experimental strains (VTT):

- Fibre properties
- Drainage and dewatering
- Sheet properties
- Dissolution of carbohydrates

Xyloglucan adsorption (KTH):

- Adsorption of XG
- Adsorption of modified XG
- Surface sizing using spraying techniques

Recycled fibres (A&F and Smurfit Kappa)

Cellulase treatments with a commercial strain:

- Lab studies on selection of enzyme
- Modelling of water network
- Mass loss and COD measurements
- Optimisation of dosing
- Mill scale trials
  - Drainage, dewatering and sheet properties

Figure 5. Main activities carried out in WP3.2.

Different commercial enzyme preparations and purified cellulases and hemicellulases were used to study the mechanisms of enzyme treatments and to determine the optimal enzyme preparation for different modification goals. Laboratory hand sheets were prepared and analysed with respect to sheet properties. The effects of the enzymatic treatments were followed through measurements of pulp properties and lab scale forming, pressing and drying studies.
The results showed that the drainage properties of the TMP pulp were enhanced by enzyme treatment but the strength properties were reduced. The strength properties were however possible to regain by adding xyloglucan to the paper surface.

Enzymes treatment trials using recycled fibres were also carried out on a mill scale. The results showed that the enzyme treatment had a significant effect on the dewatering. Further long term mill trials are, however, necessary to confirm these results and to identify the full benefits of the enzyme treatment.

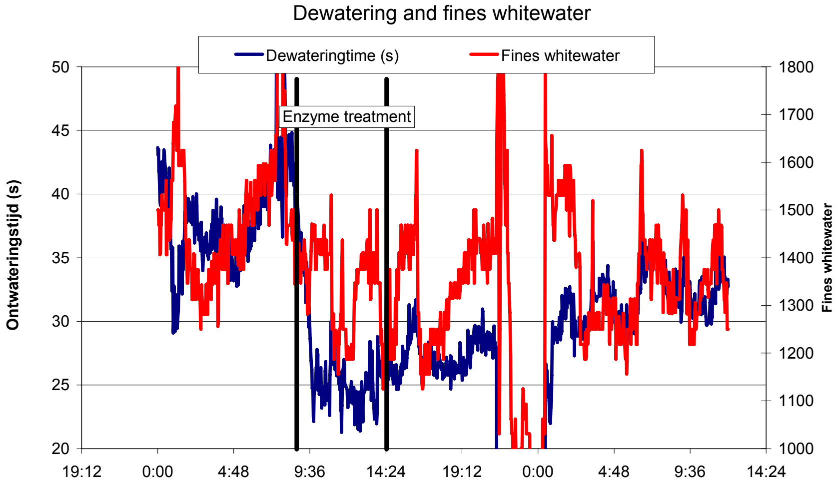


Figure 6. The effects of enzyme treatment on dewatering in the paper machine.

Sub-Project 4

The overall objective of the sub-project "Papermaking Solutions" has been to develop and demonstrate an industrially relevant technique for stratified forming. Stratified forming, i.e. the layering of a sheet structure in the headbox, has been the dream of many papermakers. It gives possibilities to design the sheet structure according to product specification without using complicated machine layouts with several forming units. The introduction of the stratified forming in the paper and board making process has so far been obstructed, as sufficiently good layer purity could not be achieved. The conventional design, where the material (pulp) streams are separated by vanes/lamellas leads to uncontrolled mixing at the end of the vane and poor layer purity, see Figure 1. In the figure a new method of reducing the detrimental mixing effects is illustrated. A passive thin layer of water is injected between the pulp streams through a hollow vane. Small scale mixing between the liquid layer and the pulp flows will still occur, but the large scale mixing between the two neighbouring pulp flows/layers will be significantly reduced.

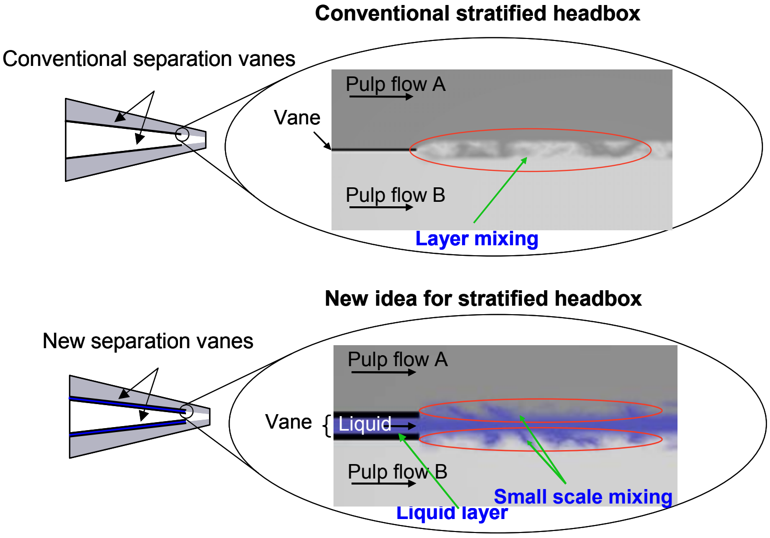


Figure 1. The principle of conventional stratified forming (top) where the layers are separated by vanes/lamella and the new idea (bottom) where hydrodynamic layer mixing is reduced by adding a third stream of liquid. The technique is called Aq-vanes or Aq-lamellas.

In order to reach the overall target the sub-project has had the following goals:

- To develop missing knowledge regarding fibre suspension flows related to stratified forming.
- To develop the new technique for stratified forming.
- To develop methods and equipment for evaluation of the stratification techniques.
- To compare the new technique with state-of-the-art, in laboratory scale as well as in pilot-scale.
- To demonstrate the effect of the new technique and stratified forming in general with the respect to the target areas.
- To evaluate the economical and environmental aspects of stratified forming based on the new technique.

In order to reach these goals the work in the sub-project has been divided into three research and technical development work-packages, 4.1, 4.2 and 4.3.

Work-package 4.1 has been devoted to generate needed knowledge on the physics of multi-phase flow with fibres. This knowledge was considered imperative in order to solve fluid dynamic related problems to stratified forming. This has been achieved through the following activities.

- *Active hydrodynamic control of fibre orientation*. The possibility to actively control fibre orientation in the final paper sheet will be exploited.
- *Hydrodynamics and mixing layers in stratified forming*. The effect of fibres on the mixing between the layers will be studied.
- *Control of hydrodynamic instabilities of the headbox jet*. The stability of the headbox jet has shown to be of major importance with respect to layer mixing. By performing this analysis the receptivity can be studied and detrimental mixing prevented.

These activities have generated several pieces of important knowledge that have been implemented in work-package 4.2.

Work-package 4.2 has been focused on performing research targeted at a technology for industrial implementation of stratified forming. In order to achieve this methods and equipment for evaluation of the new technique and its potential have been developed. In addition, a laboratory former for cost-effective screening of ideas has been developed. This equipment has been used to screen many different scenarios and also used by participating industry within the project.

Within the work-package the Aq-vane technique has been refined. Initial results clearly showed that the layer purity could be significantly improved. However, these results also show that successful stratification is not only a result of layer purity. In addition a concentrated effort was made to achieve good layer homogeneity, i.e. the ability of a top-layer to cover a middle-layer. This effort has paid off, which is illustrated in Figure 2.

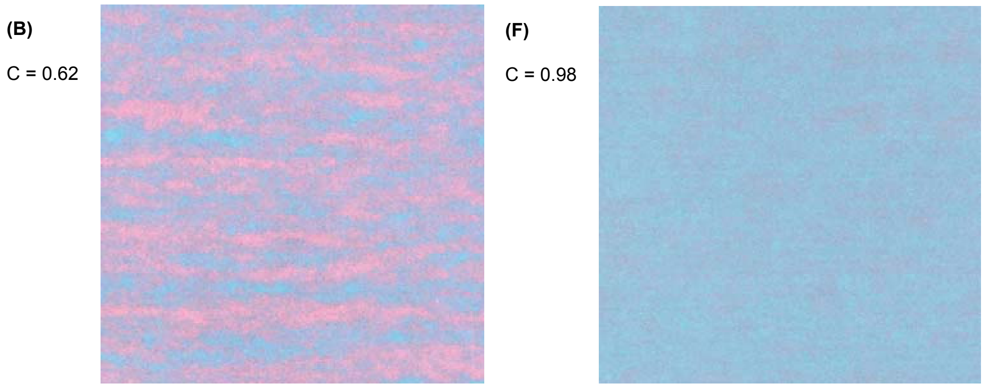
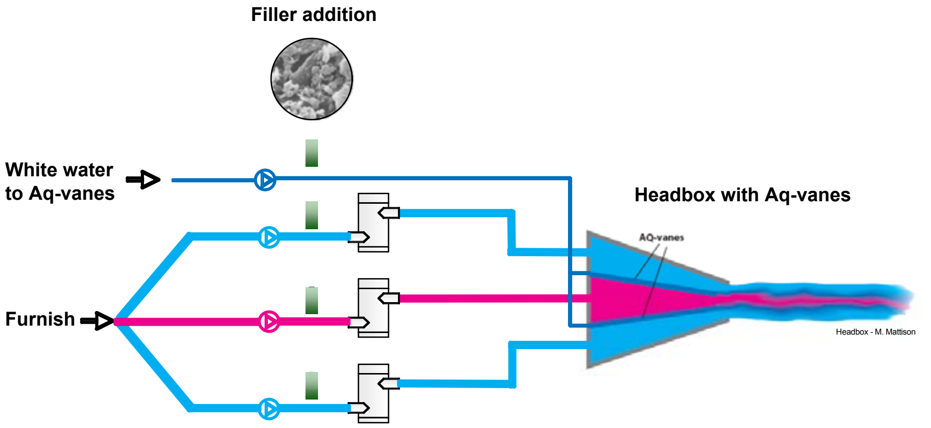


Figure 2. Images of the surface of stratified samples where the middle-layer was dyed red and the top-layers were dyed blue. Coupled to the images the analysis using a developed methodology for determination of the level of coverage power, C, is shown where C=1 represents total coverage. Left image represents state-of-the-art and right image the newly developed technique.

Work-package 4.3 has had the purpose to make industrially relevant demonstration of the feasibility and impact of stratified forming. This has been made in the form of three demonstrators where stratified forming using the new technique has been implemented in pilot-scale using the EuroFEX pilot paper machine. The three demonstrators that have been evaluated are SC-paper, fine-paper and a generalised liner. For the generalised liner demonstrator only one initial attempt was made. The focus in this trial was to investigate the possibility to improve sheet delamination resistance (Z-strength or Scott-Bond). The results showed no clear effects.

The work with the SC-paper demonstrator has shown that the use of Aq-vanes can give significantly improved product properties such as formation and strength without detrimental effects on process properties such as retention. This can be utilised to produce a sheet using less fibre raw material but with more fillers such as e.g. clay or calcium carbonate. The process used and the impact on a model SC-paper mill can be found in Figure The pilot-scale produced paper was also subject for coating, but web width caused major problems for pilot-scale coating. Nevertheless, no differences between the stratified paper and reference paper could be observed.

The fine-paper demonstrator has focused in the implementation of fractionation (SP3) in the context of stratified forming. Fractionation has been performed on a conventional fine-paper pulp composition. The obtained fine- and coarse-fractions have been used to produce a layered structure giving improved surface roughness and bulk (bending stiffness). This can be utilised to produce a sheet using less fibre raw material without detrimental effects on product properties.



	SC-paper	Adv. dosage	Improvement	
Production [t/year]	450 000	450 000	0	
Fibre [k€/year]	103 500	97 740	+5 760	➡ 6%
Energy [k€/year]	37 350	31 230	+6 120	➡ 16%
Energy [GWh/year]	1 152	959	194	

Figure 3: The concept of filler stratification using the Aq-vane technique (top). The impact on a SC-paper mill where filler content has been increased from 35% to 45% (bottom).

Thus the possibility of raw material and energy reduction has been successfully demonstrated for the SC-paper and uncoated fine-paper cases. The results clearly show a potential for producing the same functionality using less fibre raw material. As shown in Ecotarget sub-project 6 this is the most straightforward way to reduce energy consumption.

Sub-Project 5

WP5.1 Additives

Work package 5.1 “Additives” was devoted to develop new additives to decrease the build-up of dissolved and colloidal organic substances in the white water system of paper machines. Lower concentration of such material in the process water system enables the papermaker to further close up the water system which results in reduced water consumption and savings of energy and production costs.

The work started by laboratory pre-tests of the efficiency of a number of cationic polymers (synthetic as well as starch-based). The tests were used as reference and used as an input to the further work with the polymers. After a thorough evaluation of the results, a decision was taken to focus on starch-based additives. The development should lead to new starch-based additives that remove organic material with a high efficiency, that are easy to use and handle, that are cost efficient and sustainable.

A number of new starch-based products was produced by partner Cargill in small scale and was tested in the partner laboratories. One main issue to elucidate was their ability to neutralise anionic material and another issue was their ability to coagulate colloidal materials to remove COD. To ensure a wide field of application of the new products, the tests carried out by the partners covered different white waters containing different classes of detrimental material. As sources for the detrimental material, filtrates from pulps of different origin (mechanical pulps, DIP, coated broke) were used. Based on the results from the tests, new generations of modified starches were developed step-wise. Each generation/modification was evaluated by lab tests giving input to the further modifications.

In parallel, the production technology to produce new starches in larger scale was developed. An important aspect was the stability of the process as it must give the starches produced the same properties throughout the whole production. Work was also carried out to develop and/or apply new analytical methods to better characterise the starch-based product.

In this development process three “generations” of modified starches were produced in small scale and some of them also in large scale for mill trials.

The laboratory results showed that two of the new starches of the 3rd generation were highly efficient with respect to removal of organic dissolved and colloidal material from white water. The results showed *e.g.* that they removed significant amounts of COD (25-30 %) from white waters originating from unbleached or bleached TMP fibres. The results for the other white waters tested were similar. Also the production technology was developed and these starches are now possible to produce in larger amounts in pilot scale based on a new production technology.

A limited mill trial in one of the partner mills gave results that clearly support the development of the product. It was established that the new product could be easily dissolved in full scale and that the practical application was without problems. The mill trial also made clear that the application focus should be on coagulation and COD reduction in low consistency process waters.

The potential of the new product is quite large and based on the encouraging results with regard to COD reduction and coagulation capacity Cargill has decided to continue the project as an internal project.

Concluding remark: The ECOTARGET project has been a success and given a very good foundation for the further work which we anticipate will lead to a complete development of a new cost efficient product with good performance.

WP5.2 Control methods
Work package objectives

Controlling detrimental substances (e.g. stickies, deposits, anionic detrimental substances) to increase process stability in papermaking has been tackled in **WP 5.2.** Available measurement systems have served as a basis for establishing advanced measurement system. Simultaneously, appropriate measurement, analysis, and simulation methods have been searched for and investigated as a basis for a monitoring system to stabilise the process chemistry (e.g. stickie/deposit formation and charge measurements (i.e. cationic demand/zeta potential)

Progress during period Nov. 2004 - Oct. 2005

The following deliverables of the work done have been produced:

D 5.2.1a Compilation of existing and available measurement methods referring to present knowledge.

Progress during period Nov. 2005 - Oct. 2006

For controlling and monitoring of detrimental substances in process waters advanced level correlation analysis of new on-line complementary measurements has been carried out. A process state comparison tool to study operational efficiency has also been developed. This has been done in co-operation with the UPM case mill. To detect detrimental substances in process waters new NIR and surface tension measurement devices have been tested.

The following deliverables of the work done have been produced:
Two presentations of WP5.2 results were given in the Public Ecotarget Workshop in Delft, January 2006.

Public report: Control of detrimental phenomena in papermaking,
D 5.2.1b Detection of detrimental phenomena with lab-scale measurement systems
D5.2.1c Causality between detrimental phenomena and process operation
D5.2.1d A draft for complementary measurement system and refining of process data for process control
D5.2.2 Assessment of forward-looking complementary measurement and monitoring system including knowledge management on the basis of present knowledge, existing process data and process modelling (specification of knowledge management).
D5.2.3 Suggestion and draft testing of advanced/forward-looking measurement principles in lab-scale (pilot-testing in later stage) including requirements for new system for later correlation signals with detrimental phenomena in paper mill.

Progress during period Nov. 2006 - Oct. 2007

In this period the developed measurement, simulation, and analysis tools were integrated in a toolset, where they can be jointly used for gaining a more comprehensive view of the detrimental phenomena. The toolset was applied to the case mill data.

The following deliverables of the work done have been produced:

D5.2.3 The final version of Suggestion and draft testing of advanced/forward-looking measurement principles in lab-scale (pilot-testing in later stage) including requirements for new system for later correlation signals with detrimental phenomena in paper mill.

D5.2.4a Draft Advanced use of on-line process data, including calculated sensors to reveal detrimental process states.

One presentation of WP5.2 results was given in the Public Ecotarget Workshop in Poland, October 2007.

Progress during period Nov. 2007 - Oct. 2008
In this period the application of the developed toolset to the case mill data was completed, and the applicability of the toolset was evaluated.

The following deliverables of the work done have been produced:

D5.2.4b Final version of Advanced use of on-line process data, including calculated sensors to reveal detrimental process states

D5.2.5 Final Report Evaluating Field Test Results .
Final presentations of WP5.2 results are presented in the Public Ecotarget Conference in Stockholm, 12^{th} - 13^{th} Nov., 2008.

Concluding remarks:
Ecotarget WP 5.2 has studied cause-effect relations regarding operational practices, the quality of process waters, and detrimental effect. A toolset has been implemented for detailed study of this area. This toolset includes both measurement techniques that supplement mill instrumentation and tools for extracting useful information from measurement data.

The developed toolset has been applied in the analysis of detrimental effects at a case mill. The results from the different analysis techniques in the toolset supplemented each other and together provided a more comprehensive understanding of the complicated phenomena being studied. The tools supplemented each other also in another way, as they exploited and further refined each other's outputs.

As the work was carried out, process changes were proposed to the mill. Some process changes were implemented, which reduced the detrimental effects. The results serve as proof for achieving the Ecotarget goals.

WP5.3 Separation techniques
The goal of WP 5.3 “Separation Techniques” is to remove detrimental substances such as unavoidable micro stickies and anionic trash from the process water streams with high efficiency. In the first step an extensive systematic assessment and evaluation of the micro stickies and anionic trash load was performed in the process water system of our partner (reference) mill. The comprehensive database of all relevant parameters of the reference mill enables the calculation of water and mass balances and provides the paper mill with further valuable information for optimising their processes beyond the aims covered by SP5. Simultaneously the test methods for measuring micro stickies were investigated to choose the appropriate method(s). In the following the IPST Method (Δ-TOC), INGEDE Method 6 (precipitation method) and the Pitch Counter Method from BASF were selected for the determination of micro stickies.

After finishing deliverable 5.3.2 which deals with the state-of-the-art removal techniques for anionic trash and micro stickies, it becomes clear that especially the forward-looking techniques like pressure and membrane filtration should be investigated and improved. Nevertheless, the first laboratory trials were performed also on the conventional dissolved air flotation (DAF) removal technique. The data obtained from lab-scale trials serve as reference for treatment trials with pressure and membrane filtration which were performed only in pilot scale. The laboratory trials were also used for a screening of various chemical additives which should be used for further optimisation in pilot trials. By DAF the best results were obtained with a dual organic polymer system consisting of a polyethylenimine (high cationic charge, high molecular weight) as coagulant (dosed first) and a branched polyacrylamide (low cationic charge, high molecular weight) as flocculant (dosed second). Turbidity of the process water was removed by DAF treatment with chemicals up to 95 %, Δ-TOC in a range between 35 % - 80 % and anionic trash between 35 % - 70 %. In contrast, a single stage process with membrane filtration (RotoStream^{RM}) reaches for all three parameters significantly improved removal rates between 96 % - 98 % for turbidity, 90 % - 95 % for Δ-TOC and 80 % - 85 %

for anionic trash (see **figure**). In this case membrane openings of 20 nm for the RotoStream[RM]treatment were used. In the single mode pressure filtration process (RotoFilter) openings between 2 µm and 60 µm were applied.

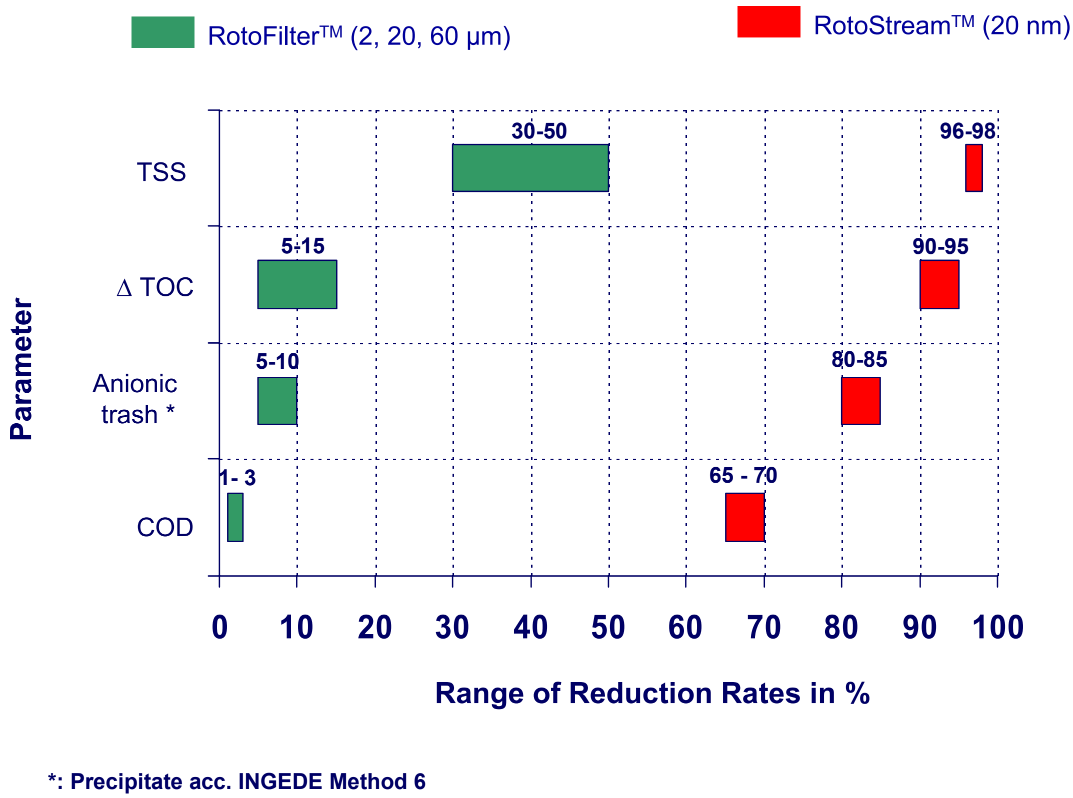


Figure: Reduction rates of process water from a newsprint mill for single unit operation

In the following three pilot scale trials both units were tested in series as dual mode operation, partly in combination with the application of chemical additives to improve flocculation before the pressure or membrane filtration processes. The comparison of the results indicated, that the use of pressure filtration, performed with RotoFilter, does not result in a significant reduction of the micro sticky related parameters (Δ-TOC and anionic trash), unless a suitable cationic flocculation chemical is added to the feed stock. By this measure detrimental substances can be agglomerated by the flocculant. Depending on the size and stability of the flocs and the size of the filter basket openings it is possible to separate them from the process water. The results obtained in two stage processes, set up with RotoFilter (1. stage) and RotoStream[RM] (2. stage), which had been performed in the 1st and 3rd series of pilot trials, indicated, that pressure filtration as a pre-treatment prior to membrane filtration was of no further improvement to the removal efficiency of membrane filtration. Membrane filtration, performed with RotoStream[RM], proved to be the most sufficient device in concern to the separation of total suspended solids, micro stickies and anionic trash from process water.

The superiority of membrane filtration for the removal of detrimental substances from process water is unquestionable. Treatment of white water with new process technologies is the most promising location for these new processes. The reduction of micro stickies measured as Δ-TOC can be increased to about 90 % with the RotoStream[RM] process compared to no measurable separation efficiency for DAF and disc filter. For measuring micro stickies with the Pitch Counter Method, the RotoStream[RM] process can achieve a reduction rate of 80 % to 90 % compared to reduction rates for DAF and disc filter between 20 % and 30 %. For dissolved COD no reduction was observed for the RotoFilter technologies with pore sizes larger than 20 µm. This can be explained with the method for measuring dissolved COD detecting particles smaller than 0.45 µm.

Scientific and economic considerations have to decide on the particular pore size of the membrane, which is to be used. In total offers membrane filtration a very good potential for the separation of micro stickies measured as pitch, Δ-TOC or anionic trash and deliver a process water quality which is significantly improved. This will help to reduce the over-all fresh water consumption of a paper mill and should improve paper machine efficiency by less web breaks.

Sub-Project 6

The aim of KCL participation in the ECOTARGET project was the integration of the research results and the development of an assessment framework for competitiveness and sustainability evaluation of the new technologies. KCL coordinated the work of Subproject 6 Integration, and was responsible of Work package 6.2 Project synthesis. Other partners in the subproject were Helsinki School of Economics (HSE), VTT and STFI.

The four year integrated project ECOTARGET (2004 – 2008) aimed at supporting the European pulp and paper industry with innovative new processes, from making pulp to paper. The process ideas developed within ECOTARGET aimed at reducing the volume of at least one of the four target areas: Wood raw material, Energy, Water, and Waste & Emissions. Each idea should have a potential of 20-30 % reduction in one or several of these target areas. The task of SP6 was to evaluate the results of other subprojects in a total paper mill system and in the more general business environment in respect to the targets of the ECOTARGET project.

During the project, information on environmental, economic, technical, social and regulatory aspects related to new technologies was gathered. The competitiveness of the technologies was defined to consist of four main dimensions:

- The environmental performance of the technology is based on the use of resources, on the amount of emissions into air and water, and on the amount of waste produced during the paper production process. Possible impacts on the environment and on human health are other important indicators.
- The acceptability dimension includes components linked to environmental and social values and attitudes of the society.
- The economic performance of the technology refers to its ability to maintain the revenue flow and profitability of the production.
- The adaptability of the technology is closely related to the economic performance and to the production technology of the pulp and paper companies.

Specific indicators were chosen to describe the performance of a technology in each of the dimensions. A competitiveness assessment framework was developed as a tool for gathering information and integrating the results. The results of the evaluation were presented and summarized in the form of performance profile of the technologies. Qualitative approach was applied and SWOT analysis was used as the main method. Methodology development was conducted as a cooperation of KCL and HSE.

In addition to methodology development, an essential part of KCL's work consisted of the environmental assessment of the technologies. Environmental loads and use of resources were defined implementing life cycle assessment (LCA) method. This covered the value chain from forestry to paper mill gate. Environmental indicators were studied both at mill level and trough the life cycle of products. KCL-ECO LCA software and KCL EcoData database were utilized, and a total of 18 case studies were calculated. Life cycle inventory, life cycle impact assessment and carbon footprint calculation were included in the analysis.

To highlight the possible opportunities and threats related to the paper business environment, future business scenarios were created by HSE. The scenarios present possible future developments within the years 2015-2020. The five paper business scenarios are called:
1. The Never Ending Growth
2. Towards Efficient Models & Solutions
3. Business as Usual
4. Sustainability Challenge
5. The Climate Change Rules the World

In the final phase of the project, the competitiveness of the ECOTARGET technologies within the future business scenarios was evaluated by KCL and HSE. In the final assessment, 11 technologies were included. Full-scale evaluation was conducted for 10 technologies. The evaluation was based on the information provided by the technology developers in SP's 1-5 and research conducted in SP6.

The performance of the technologies was evaluated in relation to three reference mills that represented typical mills with respect to technology, use of raw material, energy consumption, water consumption and emissions. The reference mills were:

- TMP-LWC mill, assumed location Sweden
- TMP-LWC-RCF mill, assumed location France
- Fine paper mill (unintegrated), assumed location Germany

Based on the evaluation, all the technologies seemed to bring about improvements in one or more of the original four target areas. Two of the technologies were estimated to achieve the original target: 20% reduction in Water consumption. Many of the technologies were estimated to achieve reductions in electricity consumption. Biggest savings in purchased electricity were 24% and 19%. However, as a consequence, the need for supplementary fuel increased. As the reduction of energy consumption is a very important target, the challenge seems to be, how to achieve reductions in electricity and fuel use simultaneously.

A positive trend was that based on the evaluation, several technologies achieved reductions in the target area Waste & Emissions. A remarkable share of emissions and waste created during paper's life cycle are related to energy production and consumption. As a consequence, energy profile utilized in the evaluation has a significant impact on the results. Thus the results might change depending of the assumed location of the mill. Another important factor is the choice of supplementary fuel.

In the target area Wood raw material, biggest reductions achieved were 10% in mass based evaluation and 15% in surface area based evaluation. In addition, 3% reduction in the use of recovered fibre was achieved. In general, reducing the use of raw materials improves environmental performance. The goals in the target area were very challenging, and the original target (-30%) was not achieved. However, a potential for further reductions was noticed.

The competitiveness of the technologies was analyzed in the framework of five future scenarios. Two of the scenarios emphasized eco-efficiency, energy efficiency and even carbon neutrality of the technologies. Considering the environmental performance evaluation, a couple of the technologies had rather advantageous position even in the most challenging scenario. The other technologies also seemed to have several positive features in their competitiveness outlook, but they also seemed to encounter unfavorable developments in terms of competitiveness. Based on the scenario outlook, it is likely that bigger improvements in environmental performance are required in the future.

The acceptability of individual technologies is largely determined by their environmental performance. In addition to the technologies' impact on resource efficiency, one of the key indicators in evaluating the acceptability of a technology was its ability to reduce greenhouse gas emissions (GHG's). Carbon footprints (including fossil GHG's) were calculated to illustrate the impacts. The attempt of ECOTARGET to develop less energy intensive processes is clearly on the right track, since energy efficiency and low-carbon energy supply will continue to play an important role. As a consequence, even small reductions in energy use and GHG emissions can be considered positive with regards to the acceptability of the technologies. Unfortunately, in many of the ECOTARGET cases, the carbon footprint reduction remained rather small.

Affecting the acceptability and adaptability of the new technologies, an analysis was conducted (by WP6.3) on the potential harmful health and safety impacts of the new technologies. In general, no remarkable risks were reported. Few remarks were made related to minor environmental or occupational health risks. In many cases, the questions related to work and product safety were difficult to evaluate, and need further investigation in the future.

In order to be truly competitive, the technologies should be feasible also in terms of economic performance. Based on the economic evaluation (conducted in WP6.1), all the technologies might contribute to cost savings. However, the savings potential in only three cases may rise over five percent compared to reference mill annual costs. Considering the savings potential and the investment cost estimates for each technology, it seems that the payback time of a potential investment in most of the technologies may be estimated under two and a half years, and in most cases even clearly under one year. Generally, such payback times are considered acceptable in most businesses. In addition to economic performance, the adaptability of the new technologies may be further promoted by the fact that the technologies are applicable both as retrofit and greenfield.

According to the scenario outlook, the technologies' economic performance in terms of specific savings seems to develop positively in all scenarios, despite of radical rise in input costs and the costs of externalities (CO_2 emission trading). Thus, the new technologies seem to be competitive in terms of cost efficiency in the future. On the other hand, the future trends in markets and product demand may prove less favorable to some of the technologies.

To conclude, the original targets of the ECOTARGET project were very challenging and ambitious. It can be argued that achieving the original goals would require even more radical innovations. It is likely that several technologies would be needed at the same time to achieve the original reduction targets. However, many of the evaluated technologies showed potential and positive improvements, and thus the achievements of the ECOTARGET project are a step forward. It is also important to remember that the evaluation was based on estimations and on current development phase of the technologies. Thus, the results are indicative in nature.

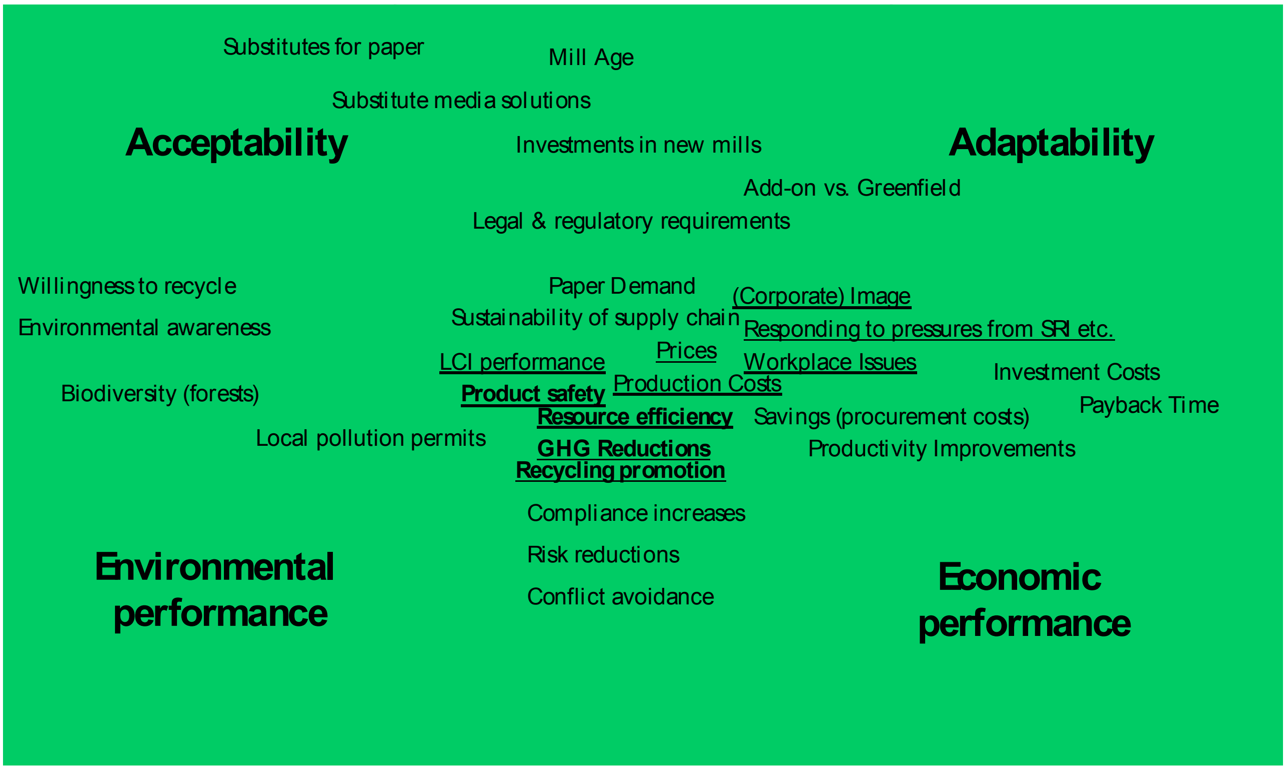


Figure. The indicators as building blocks in the performance profile

The other aim of this sub project; developing methodological tools for the evaluation of economic, technical, environmental and social impacts and for integrating research, was carried out successfully and demonstrated within this project, like explained above. Sustainability assessment methodology developed in Ecotarget project can be generally applied when evaluating processes, products, technologies or services.

The evaluation results provide useful information both for the industry and for the technology developers, considering different aspects of sustainability and competitiveness, taking into account possible opportunities and threats related to the future business environment.

2. Dissemination and use

ECOTARGET Final interactive presentation.
This presentation will be found on the web-site www.ecotarget.com
Presentations from the Final conference 12-13 November, 2008, in Stockholm, Sweden, www.ecotarget.com

Newsletters

February 2005
June 2005
February 2006
August 2006
February 2007
August 2007
February 2008
August 2008

Conferences and workshops

Open Conference, 10-11 January, 2006 in Delft, The Netherlands
2 nd open workshop, 11 October, 2006, in Munich, Germany*
3rd open workshop, 16-17 October, 2007, in Słok, Poland

Technical reports

D1.1.11 Enzymatic pre-treatment of wood chips for energy reductions at mechanical pulp production - A review

D1.1.2 Specific impact of enzyme impregnation on energy consumption
Subtitle: Eveness of impregnation of wood chips with enzymes

D1.2.5 Shear and compression behaviour of fibre beds formed by spruce and pine fibres

D2.1.4a NewsMag: online estimate of the amount of newsprint, magazine and board inside furnishes for deinking lines
Presentation to Symposium

D2.1.4b Brown quality grade: The NIR spectrometry, a high-performance technique to qualify the grade of recovered papers and boards
Presentation to Symposium

D2.1.6 Use of the Near Infra-Red Spectroscopy for direct control of recovered paper bales
Sensor industrial implementation Report

D2.1.7 Use of the Near Infra-Red Spectroscopy for direct control of recovered paper bales. Sensor installation, utilisation and maintenance

D2.3.7 Evaluation of potentials of recovered paper collection and process management for prevention / influencing the composition of coarse rejects

D2.3.6 Feasibility of implementation of pilot plant for reuse of solid rejects on the side of a paper mill

D2.3.8 Design of reject treater. Pilot plant installation – design and performance

D3.1.7 Modelling of the flow field inside a novel hydrocyclone using CFD (computational fluid dynamics)

D4.1.1 Visualisations of the mixing process using the new technique

D4.1.2 Deliverable reference number and title : Data from both experimental sept-ups

D4.1.3 First results regarding global modes in the headbox D4.1.3

D4.1.4 Results regarding mixing in the jet/wake D4.1.4

D4.1.5 Measurements of fibre orientation close to a solid boundary at elevated Reynolds numbers

D4.1.6 Results showing the interaction between headbox geometry and jet stability

D4.1.8 Measurement and control of fibre orientation in a headbox

D4.2.2 Potential of new stratification technique

D4.2.5 Deliverable reference number and title : One full evaluation of scenario in lab-scale

D4.2.5 Appendix

D5.2.1a Control of detrimental phenomena in papermaking Compilation of existing and available measurement methods referring to present knowledge

D5.2.1b Detection of detrimental phenomena with lab-scale measurement systems

D5.3.2 Assessment report on current sticky and trash removal techniques in water loops (filtration, fixation, micro flotation, hydrocyclone) including suggestion of forward-looking technology or current technology to be improved

D6.1.1 Description of the reference paper mills for ECOTARGET project

D6.2.2 Definition of the methodology to assess the environmental, social and economical effects and competitiveness of the new technologies in changing business environment

D6.3.3 Standardization