In balance with nature

From frog to prince

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From frog to prince

"The ugly frog has been transformed into a prince."

This is how an experienced consultant described the transformation of the Swedish forest industry. An outmoded, environmentally hazardous industry, has been converted into a modern environmentally adapted industry. It has become an industry of the future, using the sun as its source of energy, that is engaged in activities which, in the highest degree, are adapted to the natural ecocycle.

Many people can claim the credit for giving the frog his transforming kiss. A critical environmental movement and demanding consumers have had a considerable impact. So have well informed government authorities who have steadily stiffened their requirements.

But it is the industry itself that has done the work. Capable researchers and dedicated engineers and operating personnel have ensured that emissions are reduced, while management and shareholders have made the decisions and taken the risks. During the past 20 years, the Swedish forest industry has invested some 20 billion kronor in environmental measures. Processes have been improved, energy consumption has been reduced and purification facilities have been made more effective.

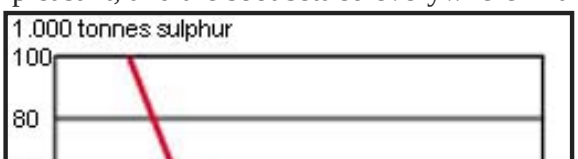
Joint research in the industry

The Swedish forest industry started systematic environmental activities at the beginning of the 1960s. Much of the work has since then been carried out jointly within the industry. STFI, the Swedish Pulp and Paper Research Institute, has played a central role. IVL, the Swedish Environmental Research Institute, was founded in the 1960s, and SSVL, the Swedish Forest Industry Water and Air Research Foundation was established in 1970. These organisations helped to compile comprehensive background material to serve as a basis for practical environmental measures.

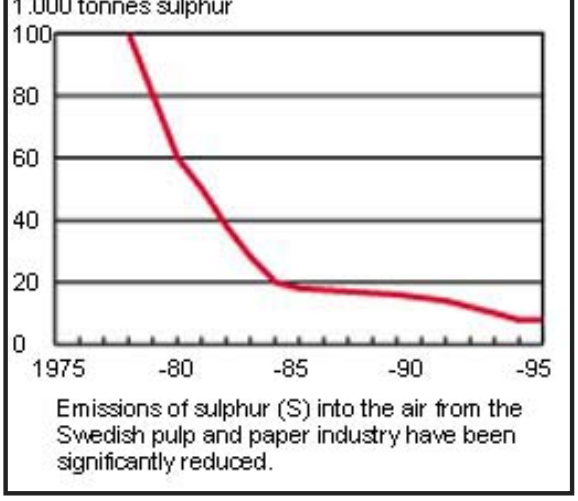
The forest industry's environmental work has always been characterised by an open approach, and within the industry there has been a continuous exchange of information and experience. New research discoveries have been quickly passed on to the industry, and new techniques for reducing environmental impact have been developed in co-operation with equipment and chemicals suppliers. Ever since the 1960s, Swedish suppliers have been providing decisive input for the development and installation of new environmental equipment and methods in the forest industry, both in Sweden and abroad. Through the work within SSVL, companies in the forest industry have developed the practice of working closely together in the environmental field. The results were also made available to the environmental authorities. Even though differences of opinion are inevitable from time to time, a common view on the fundamental issues has been established.

Serious environmental hazard

In the 1960s the forest industry suffered from serious environmental problems. Mills had been built without any consideration for how the surroundings would be affected by their operations. In most cases, chemical recovery at sulphite pulp mills, internal fibre recovery and sedimentation ponds - which are taken for granted today - simply did not exist. Smoking chimneys spewed out dust and sulphur dioxide in immense quantities. The smell was unpleasant, and the soot settled everywhere in the mills- vicinity.



Water courses were also severely affected.



Emissions of sulphur (S) into the air from the Swedish pulp and paper industry have been significantly reduced.

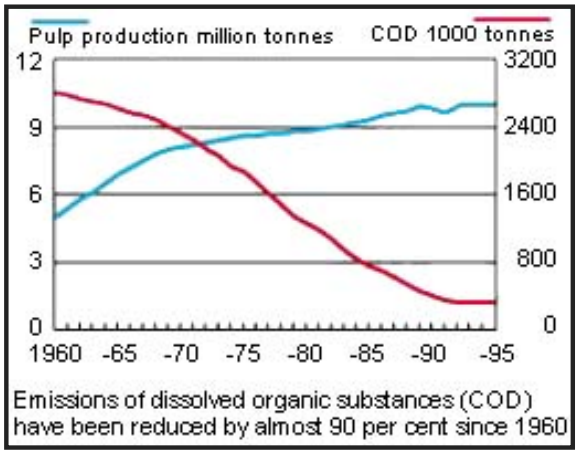
The effluent from the pulp mills contained large quantities of chemicals and wood residues. Where there was little water circulation, fibre banks started to spread over large areas. In many places the water lacked oxygen. Malodorous hydrogen sulphide built up and the fish died.

The authorities as well as representatives of the industry realised that this situation could not continue. If the industry was to survive, this negative trend had to be broken.

The Swedish Environmental Protection Agency was set up at the end of the 1960s, and a new environment protection act was passed. The Environmental Protection Agency exerted intense pressure on the industry. To be granted a licence to continue their production activities, companies were compelled to limit emissions to strictly established threshold values. The conditions of the licence stipulated a time limit, and every time the licence was re-applied for, these threshold values were lowered further. The decisions were based on what was considered technically feasible, ecologically necessary and economically reasonable. In principle, this still applies today.

The Swedish model

Initially, the forest industry's environmental conservation work focused on the most glaring environmental problems, in other words, emissions which affected the immediate vicinity of the mills. The first target was to reduce emissions of fibres and oxygen-demanding substances that were the cause of the destruction of all life in the water and at the bottom of the lakes around the mills.



Emissions of dissolved organic substances (COD) have been reduced by almost 90 per cent since 1960

At an early stage, the forest industry opted for a strategy of purifying at source, rather than "end of the pipe" that is to say, they attempted to prevent pollution by making improvements to the processes. Only when these measures were insufficient was biological and chemical purification of the waste water used.

Since the development of new, improved processes represented pioneering work, it was frequently encouraged by the Environmental Protection Agency. Even though results were not always immediately evident, it is now generally agreed that the Swedish model for environmental work has been very successful.

Decades of development work

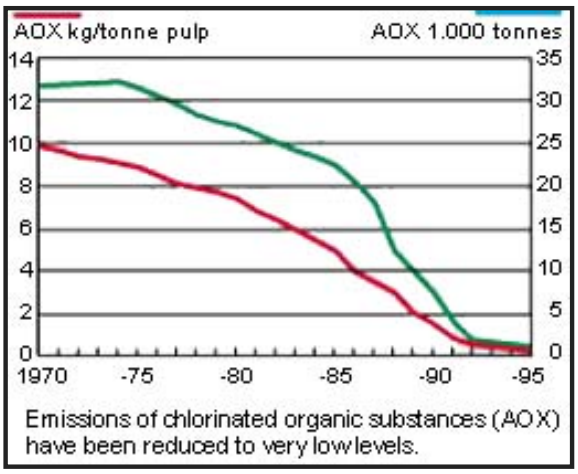
Pulp cooking and bleaching methods have developed enormously since the 1970s, with dramatic reductions in emissions as a result. Decades of research and development work, in which Swedish researchers and companies have had considerable influence, has led to new, environmentally adapted cooking and bleaching methods.

Throughout, the main principle has been to reduce the lignin content of the pulp by means of extended cooking and bleaching with oxygen prior to final bleaching. Once the lignin content has been reduced, the pulp is easier to bleach and the need for bleaching chemicals has been steadily reduced. The developments up to the present day are illustrated in the figure below.

Pioneers in oxygen bleaching

At the beginning of the 1970s the first full scale installations of oxygen bleaching were introduced in Sweden. As pre-bleaching with oxygen significantly reduces the lignin content, this almost halves the need to use chlorine gas in the final bleaching stage. The pioneers were Gruvåns Bruk and Aspa Bruk who were among the first in the world to adopt this new technique. Other Swedish mills followed suit and for the past few years oxygen bleaching has been in use at all Swedish sulphate pulp mills.

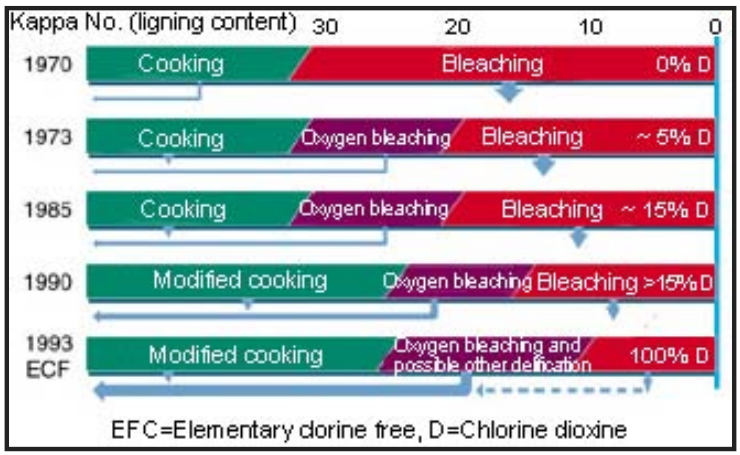
Chlorine dioxide replaces chlorine gas



By the middle of the 1980s oxygen bleaching had become an established technique. Emissions of chlorinated organic compounds had been reduced to some 5 kg AOX/tonne of pulp compared with around 10 kg in the 1970s. The proportion of chlorine dioxide was successively increased during the 1980s while the use of chlorine gas was further reduced. Chlorine dioxide is a considerably milder bleaching agent from an environmental point of view since it does not create highly chlorinated organic compounds. The need for chlorinated bleaching agents was further reduced during the 1980s with the introduction of reinforced and pressurised alkali stages in which hydrogen peroxide and oxygen could be used.

The formation of AOX was also lowered by the introduction of low multiple chlorination, in which the proportion of chlorine used is very low in relation to the kappa number. This method also eliminates the formation of dioxins in the bleach plant.

Bt this point the major environmental clean-up had been completed. Compared with their competitors in other countries, Swedish companies had low emissions - but high costs for their environmental measures. At that time, the cost of producing one tonne of pulp was 100-150 kronor more than in the main competitor countries and the market was not prepared to pay more for products from mills with low emissions.



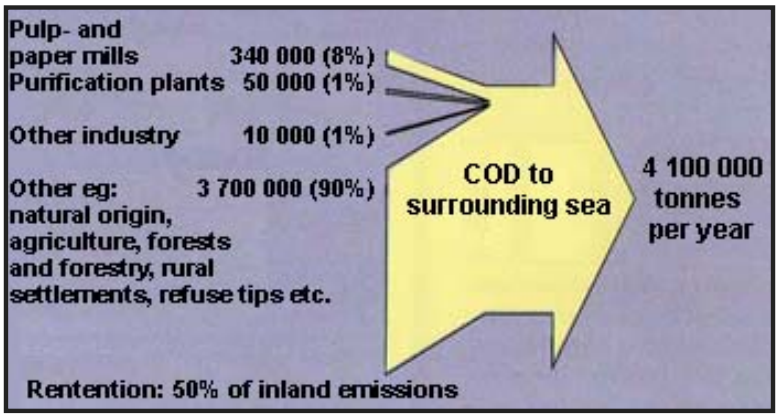
The methods used for delignification and bleaching of sulphate pulp have developed rapidly. The use of oxygen bleaching and modified cooking, for instance, now make it possible to exclude the use of chlorine gas and, in some cases, also of chlorine dioxide.

A green market

Many people within the industry therefore felt that we had gone as far as was possible at the time. However, the collective pressure from government authorities, environmental opinion and the market would compel the industry to take further measures. 1985 was a tumultuous year with three main events accelerating developments.

Firstly, forest industry researchers themselves observed during the course of an SSVL project, that the biological effects of the emissions from two particular pulp mills were greater than had been expected. The Environmental Protection Agency soon confirmed these results with similar ones from an investigation in the vicinity of a third mill, where fish were also found to have been harmed. The results received considerable publicity in both Swedish and foreign media. The same year also saw reports that researchers had discovered measurable quantities of dioxins, a highly toxic group of substances, in the sludge outside an American pulp mill.

The chlorine debate was now in full swing. In "Paper and the Environment", a book which attracted much attention, Dr Göran Bryntze summarised the arguments against chlorine bleaching. Swedish Greenpeace and the Swedish Society for the Conservation of Nature were also keenly engaged in the debate. This course of events made a reaction from politicians and environmental authorities inevitable. The licences made for subsequent years involved even tighter restrictions on chlorinated emissions. Sweden became a front-runner in the "race against chlorine".



The proportion of total emissions of oxygen demanding substances (COD) emanating from the pulp and paper industry has declined as a result of process improvements, reduced water consumption and an extensive variety of purification measures.

Environmental adaptation accomplished - chlorine phased out

The chlorine debate gave rise to fundamental changes in market conditions in many countries. In Germany, Sweden's largest market for pulp, intense demands were made for "low chlorine" and then "chlorine free" products. Other countries followed Germany's example.

After some hesitation, the industry reacted vigorously to these new challenges. The process and product development which followed at the beginning of the 1990s can only be described as exceptional. New processes which radically reduced emissions of chlorinated substances were introduced at all the mills. That this could happen was the result of the intensive efforts of numerous researchers and companies over a long period of time to make the processes more environmentally friendly.

The method that had the greatest impact, which came to be known as modified or extended cooking, was introduced at the end of the 1980s. At the beginning of the 1990s extended cooking had become an established technique and research was focused in developing even more sophisticated types of process. Super-Batch and ITC cooking, for example, were

introduced by many mills.

In the new processes even more lignin was removed at the cooking stage, which further reduced the need for bleaching. This created the possibility of introducing bleaching methods that are even more friendly to the environment, such as peroxide and ozone bleaching, as well as bleaching with extremely small amounts of chlorine dioxide. Chlorine gas was completely removed from the process and is no longer used as a bleaching agent by any Swedish pulp mills.

Breakthrough for ECF and TCF

These internal measures have been complemented at many mills by various types of biological purification treatment. Emissions of oxygen demanding substances have been greatly reduced. Emissions of chlorinated substances, measured as AOX, have on average been brought down to 0.2-0.3 kg per tonne of pulp - a level that no one would have dreamed of just five years ago.

Modern cooking and bleaching methods have also altered the chemical composition of the chlorinated substances. Highly chlorinated substances have been eliminated. The chlorinated pollutants in today's emissions have a far lower environmental impact than those in emissions in the 1970s.

In recent years, technical developments have made it possible for the mills to bleach pulp without using chlorine gas (this is known as ECF - Elementary Chlorine Free), and even without the use of chlorine dioxide (known as TCF - Totally Chlorine Free).

All these environmental measures have involved heavy investment, but at the same time, they have generated advantages in the market. Both ECF and TCF pulp have been launched with great success on the increasingly environmentally aware market. Swedish companies are among the leading producers of these types of pulp.

To sum up, the Swedish forest industry has been transformed in a few decades from an environmentally hazardous to an environmentally adapted industry. Most of the environmental problems have now been solved or virtually solved. Emissions of sulphur, oxygen demanding substances and chlorinated pollutants have been reduced by more than 90 per cent since the 1970s.

Why bleach?

Wood is made up of fibres bound together by lignin. To produce pulp, the wood has to be broken down so that the fibres are separated. This can be done by chemical means, by cooking the wood with various chemicals. Or it can be done mechanically by grinding the wood.

However, no pulp process can completely separate the fibres without damaging them. Pulp can also contain impurities of different kinds, such as bark and resin residues. Bark residues cause dark flecks in the paper and resin can cause both a smell and a taste.

Unbleached sulphate pulp contains a small percentage of lignin, which gives the pulp a dark brown colour. This lignin residue cannot be released by cooking without seriously impairing the characteristics of the pulp. To produce a clean, white chemical pulp that can age in a stable way - which is a prerequisite for many paper products - the pulp has to be bleached with substances that removes the lignin. During bleaching, impurities are also eliminated and the brightness is raised to the level required for the intended paper product.

Source: MoDo

Modified cooking

Swedish research resulted in the development of new ways of cooking pulp to a very low lignin content (low kappa number) during the 1980s, while retaining strength and pulp yield. The methods were known as modified or extended cooking. These processes are used today at most Swedish sulphate pulp mills.

The processes reduced the need for bleaching chemicals and therefore made a valuable contribution to the reduction in emissions of chlorinated organic substances (AOX) by the pulp industry. Other emissions are also being reduced.

Modified cooking can be used for either continuous cooking (MCC) and batch cooking (such as Super-Batch). Isothermal cooking (ITC) is a further development of modified continuous pulp cooking.

Source: Swedish Forest Industries Association

Life cycle assessment

The market's demands for "environmentally friendly products" are becoming increasingly rigorous. To assess different products from an environmental point of view, an overall view is necessary. Nothing is gained if improvements in one area are offset by changes for the worse in another part of the chain. Generally speaking, paper products - made from renewable raw materials in environmentally adapted processes, and capable of being recycled - are manufactured in an environmentally sound way.

Life cycle assessments (LCA) are a tool for evaluating the total environmental impact of a product "from cradle to grave". A standard methodology is much needed and is now being developed in the form of an international standard with ISO, the International Standardisation Organisation.

Environmental labelling

Environmental labelling is mainly intended as an aid for consumers who wish to select products that do not harm the environment. Environmental labelling can therefore also be used as a method of encouraging producers and the trade to invest in more environmentally adapted products.

The Nordic Swan label and the Bra Miljöval (Good Environmental Choice) symbol sanctioned by Swedish Society for the Conservation of Nature are the best established systems in Sweden. Within the EU, a flower is used as an environmental symbol.

The dioxin problem is solved

At the end of 1986, scientists in the USA issued a warning that the effluent from mills producing bleached chemical pulp could contain chlorinated dioxins and furans. Traces of these toxic substances were also found in pulp and paper products.

This prompted the Swedish forest industry to begin investigating effluent and products from Swedish pulp mills. Their results showed that the pulp industry was only responsible for a small proportion of the total emissions throughout the country. Research also showed that the minute traces of dioxins which could be found in paper products did not represent a hazard to health.

Despite this, wide-ranging research and development efforts were made to eliminate the formation of dioxins in the pulp process. At the beginning of 1988, researchers were able to present practical solutions, and it was not long before the mills were putting these results into practical effect. For many years now, bleached pulp is produced at Swedish mills without any dioxins or furans being formed in the process.

ENVIRONMENTAL STATUS

Many of the forest industry's environmental problems have already been solved or are well on the way to a solution.

PROBLEM	CURRENT SITUATION
Fibre emissions	Solved
BOD emissions - deoxynenated water	Solved
Sulphur dioxide emissions	Almost solved
Odours	Unsolved but greatly improved
Oil consumption	Minimised
COD emissions - demanding substances	Much has been done, some work remains
Chlorine emissions - organically bound chlorine, AOX	Much has been done, possibly solved
Chlorate emissions	Solved
Dioxine formation in processes	Solved
Nitrogen oxide emissions	Low emissions
Nutrient salt emissions (nitrogen and phosphurus)	Unsolved
Metal emissions	Uncertain whether this is a problem
Chemical additives	Situation unclear, research underway

The closed bleaching plant

The forest industry is now pushing ahead with its environmental activities. The long-term goal is for the entire industry to be managed in total harmony with nature. This requires a "closed" or emission free mill.

The factor preventing the process from being closed was the bleaching plant, since conventional wisdom said this was impossible to close. The chlorinated effluent from the bleaching plant was too corrosive to be recycled back into the process since it could damage the equipment.

Now we have another situation. The new chlorine-free bleaching methods generate flows that can be returned to the process. During the last few years one Swedish sulphite pulp mill has introduced a closed-process at its bleaching plant and several sulphate pulp mills have advanced plans along the same lines.

Proving that it can be done

The success of these Swedish mills is of great international significance. Concrete examples are now available that bleaching plants can be closed. This has removed the most serious obstacle hindering progress towards ecologically balanced production of pulp and paper.

In this perspective, the breakthroughs achieved represent a landmark for the entire industry and its environmental work. It is also likely that a new market force has been created.

Advances - one step at a time

The process and internal purification methods required to close a bleaching plant are still at an early stage of development. New advances are constantly being reported, and equipment and methods are expected to develop rapidly. Behind the good results of recent years lie research and development activities going back many years. Numerous forest companies, universities, research institutes, machine suppliers, chemical companies and consultants have played their part in this development for decades.

The work has been expensive and has absorbed a great deal of time. The forest industry is extremely capital intensive and the introduction of new techniques always involves serious risks. New processes and new equipment have therefore been meticulously tested, firstly in laboratories and pilot plants and then in full-scale trials at various mills.

The ideas and equipment that have stood the test have gradually become standard in modern mills. Oxygen bleaching, extended cooking, reinforced and pressurised alkali stages, the replacement of chlorine gas with chlorine dioxide, and ozone and hydrogen peroxide bleaching are all examples of this.

Sulphite pulp mills were pioneers

An important landmark was passed in 1991, when the sulphite pulp mill in Domsjö became the first in the world to introduce closed TCF bleaching. The closing of the process involved recycling some 90 per cent of the bleaching chemicals and wood residues. The volume of emissions of oxygen demanding substances and other pollutants has been reduced dramatically.

It is not surprising that a sulphite pulp producer should be a pioneer. As sulphite pulp is relatively bright and easily bleached, it is easier to develop a chlorine-free, sulphite process. The type of process introduced at Domsjö was a combination of extensively modified cooking, pre-bleaching with oxygen, and final bleaching with hydrogen peroxide alone.

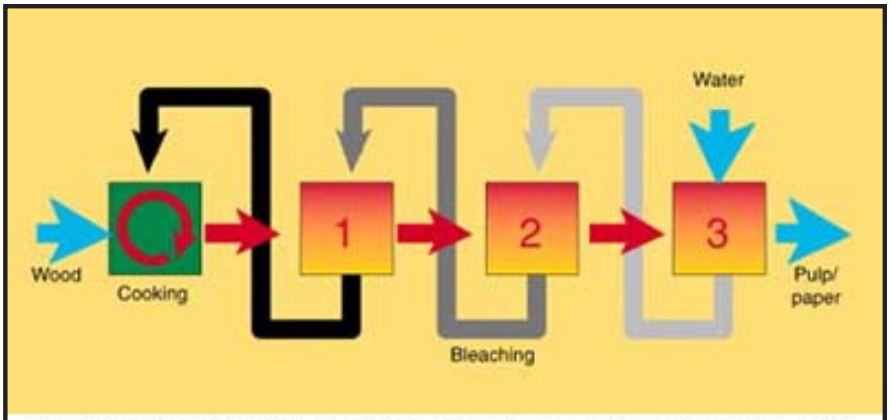
Sulphate pulp mills followed suit

The lessons learned at Domsjö have been used by producers of sulphate pulp, which is much more difficult to bleach. The first sulphate pulp bleach plant to be closed is the line for hardwood pulp in Husum, where a closed process is now used for recurrent week-long periods.

However, softwood pulp is Sweden's main export product. Closing a large softwood pulp bleaching plant, while still being able to meet the rigorous demands of the world market for production reliability and quality, is the real challenge. This capability is now available in the form of the new chlorine gas-free ECF and TCF processes. Once chlorine gas was no longer in use, and the use of chlorine dioxide had been phased out or reduced to a minimum, the problem of recycling bleaching effluent into the process became more manageable. Bleaching effluent can be returned to the recovery unit for the cooking chemicals where it can be evaporated and incinerated or treated separately in a similar way.

Heavy investment needed

Swedish pulp mills have chosen different types of process in their endeavours to close their bleaching plants. In most cases, they have changed over to totally chlorine free bleaching (TCF), although certain mills are running trials of closed ECF processes.



The principles behind closed bleaching. Instead of releasing process water after each stage in the bleaching process, it is pumped back into the preceding stage and used as washwater. Finally, it is evaporated and incinerated.

Common to all the mills whose goal is to "close" their bleaching process is that they must have complete control of all the stages in the production chain from the forest to the finished pulp. Rigorous demands are made regarding the freshness and quality of the raw material and harvesting therefore needs to be planned in great detail so that the right wood is harvested at the right time.

In most cases, it will be necessary to modernise other parts of the fibre line, such as the digester house, oxygen bleaching and pulp washing, before the bleaching process can be "closed". It is also often necessary to renovate the woodyard, the woodroom and the chip handling system. Since the burden on the chemical recovery system increases when the process is "closed", this system may also need modernising and additional capacity. Extremely advanced computer systems are also required - as well as qualified personnel - to operate the sensitive system.

The build-up of high concentration of metals and other substances which can damage the equipment and disrupt the process remains the most difficult problem to solve when a bleaching process is "closed". Attempts are made to prevent this by diverting the most hazardous flows of effluent and treating them in various types of internal purification facilities, known as kidneys.

Swedish forest industry takes the lead

The trials of closing processes at Swedish sulphate pulp mills have been successful, even though there may be some way still to go before the agreed goals have been reached. Water consumption, which may be regarded as a measure of how far the process has been closed, has in many cases been reduced by 75-95 per cent. Consumption of almost 100 cubic metres of water per tonne has been reduced to only 4-5 cubic metres at some bleaching plants. Emissions of chlorinated substances have been eliminated and emissions of oxygen demanding substances (COD) have been sharply reduced.

To sum up, these Swedish cases demonstrate that techniques and methods are available to allow pulp bleaching plants to be closed. In most cases, however, extremely heavy investment will be needed, not only in the bleaching plant, but also in other sections of the fibre line. Since all Swedish sulphate pulp mills have introduced oxygen bleaching and most of them use modified cooking, the Swedish pulp industry is in a very strong position in relation to many of its international competitors. It is very likely that closed bleaching in the future will become the norm within the Swedish pulp industry.

What is meant by "closed" or "emission-free"?

The terms closed and emission-free are not altogether accurate. A pulp mill can never be run without any emissions at all. Experts expect that even with a completely closed process, a few cubic metres of water per tonne of pulp must be added to the process.

What we really mean by closed is that the plant creates no environmentally hazardous emissions. All the substances included in the process are re-used or treated so that they cause no harm to nature when they are released into the surroundings.

Chlorine-free is not an absolute requirement

In general terms, it is easier to close a TCF process since it is totally free of chlorine-based chemicals. With the latest techniques it is hoped that ECF pulp mills using small quantities of chlorine dioxide could also introduce closed bleaching processes. This method is currently undergoing full-scale trials at a Swedish sulphate pulp mill.

"Kidneys" - internal purification facilities

New purification technology, using equipment known as "kidneys" has markedly improved our ability to close bleaching processes. A kidney is a kind of internal purification unit with the function of dealing with metals and other substances alien to the process, which are introduced along with the wood. In a conventional system, such substances are washed out in the effluent, but in a closed process the metal content can become so high that it disrupts the process. To prevent this, the most harmful effluents are separated and treated specially in a kidney. Kidneys are now being developed that are based on techniques like filtration, electrolysis or precipitation. Different types of kidney will probably be needed at different stages of the process.

The vision becomes reality

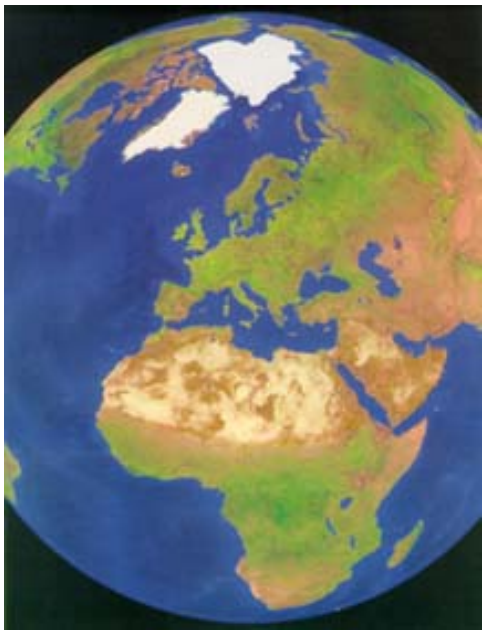
AIt is possible to manufacture pulp and paper in a way that is in complete harmony with nature.

This is the principle upon which a group of Swedish researchers who are investigating pulp and paper mills of the future have based their work. After consultation with STFI, they have drawn up guidelines for how a system of ecologically balanced production of pulp and paper could be realised.

Initially, this was mostly a vision, but over the past few years, these ideas have become concrete. Technological developments, especially relating to the closure of processes, have advanced far faster than anyone could have imagined.

The basic idea underlying the research is the same as that shown in the figure of the forest and forest product ecocycle. The important pieces in the puzzle are: sustainable forestry, environmentally adapted production, recovery of materials and energy, and a positive carbon dioxide balance.

A global view



Researcher Per-Olov Lindblad, one of the driving forces, emphasises the global character of the challenge.

- For decades, man has been over-exploiting this planet's resources. To break this trend we have to return to ecocyclical use of natural resources, used in harmony with nature.

- Bringing about such changes represents and immense challenge, one that is not alleviated by rapid population growth. Tomorrow's systems for using resources have to be adapted to the ecocycle, but they must also be capable of supplying about 10 billion people with food, energy, shelter and so forth. Wise use of the world's forests is one aspect of the solution of this problem.

Without harmful emissions

The heart of an ecologically balanced production system is a pulp and paper mill where the most advanced technology available, now and in the future, is employed in all stages of production. Researchers now take it for granted that such a mill will be closed cycled. In the long run it is not feasible for industry to generate emissions that harm the environment, even though the quantities are being steadily reduced.

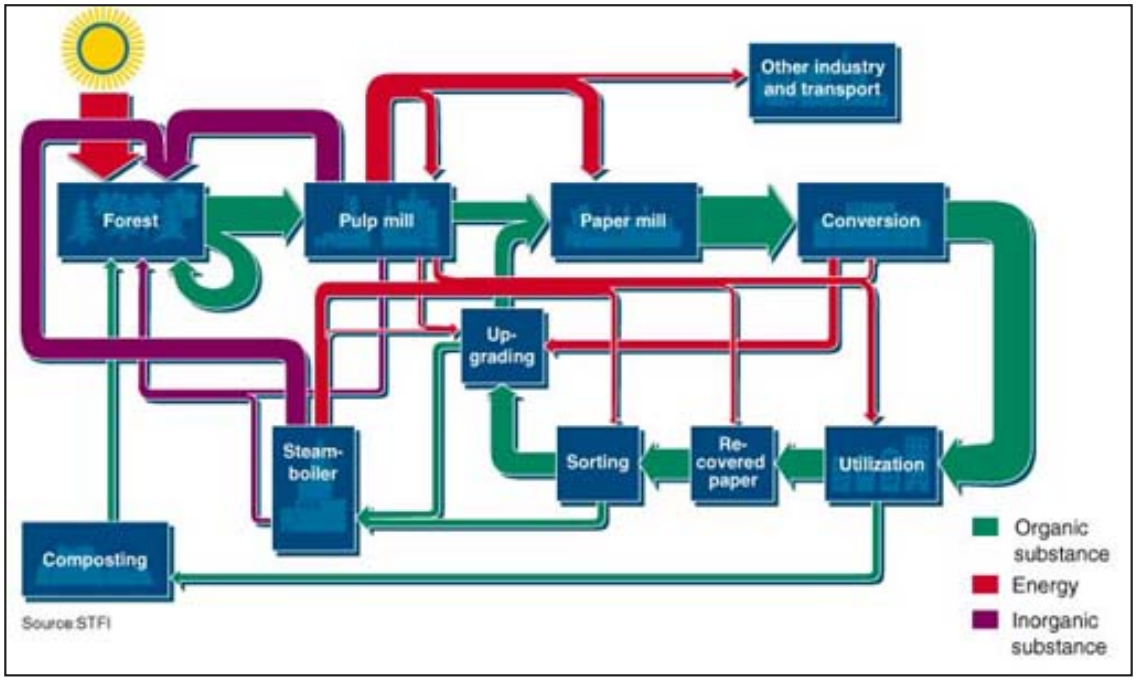
At the same time, any scientist knows that a mill that is totally free of effluent is an impossibility. A pulp mill that uses thousands of cubic metres of wood and water every day must necessarily create some effluent. The goal agreed therefore is to have mills that do not create environmentally harmful emissions. Some effluent must be allowed, but only in quantities and forms that can be sustainably included in a natural ecocycle.

Everything is dealt with

It is not possible to isolate such a large, heavy industry as the forest industry from its surroundings. When we refer to closed processes we therefore have to broaden our perspective. An ecologically balanced system must include all the stages of production from the forest via the pulp mill, to use of the products by consumers of industry, handling of waste, recovery of energy, composting and so forth. You have, as it were, to leave the mill site if you are to create a functioning ecocycle. Only by adopting this approach, believe scientists, will you be able to bring the entire production chain into harmony with the ecosystem.

This holistic approach is illustrated in the figure alongside. The pulp and paper industry is part of a natural ecosystem. What comes into the factory is energy from the sun in the form of wood along with some water. What comes out, apart from the products, is energy in the form of heat that may be used by the rest of the community. Everything else is contained within the ecocycle. The raw material, wood, is used to the full. Whatever is not converted into pulp becomes useful by-products or energy. The ash, which contains minerals and nutrients, is returned to the forest. Used products are for the most part returned to the paper mill as recycled fibre while remaining amounts become energy. Even the emissions of carbon dioxide from processes and products belong to the larger ecocycle which is maintained in balance as long as the forest is managed sustainably. Nothing is left where it can harm the environment, all waste products are put to use.

Vision on an ecologically balanced circuit



The Swedish Pulp and Paper Research Institute's (STFI) model for ecologically balanced production of pulp and paper has aroused international interest.

International attention

This model for ecologically balanced pulp and paper production was presented by STFI as early as 1992. The ideas, which have been briefly outlined here, have attracted worldwide attention at scientific conferences.

What makes this model so interesting is that most of the technology already exists, while the technology that does not yet exist, is under development. As described in the previous chapter, the essential problem - the closing of bleaching plants - has already largely been solved. Sights are now set on the closed cycled mill, and there are good grounds for believing that by the year

2000, several of the pulp mills in Sweden will be totally closed. Finnish industry is also progressing in the same direction, as are some North American producers.

Naturally, further research and development are needed in a number of sub-areas. Cooking can be made even more selective and bleaching methods can be further refined. Computerised control systems can certainly become even more advanced, so that the entire manufacturing process can be optimised. In the forest itself, new technology for determining fibre quality and new logistical systems can be introduced to ensure that the raw material for the new sensitive processes will be the best possible.

Even those ecocycles that extend beyond the confines of the mill will be developed. Collection and sorting of waste paper will be developed so that the right fibre is always used for the right final product. One urgent task is to find new chemical additives and fillers that are more suitable in the ecocycle. Many of today's types of paper contain large quantities of filler that cannot be recovered, which causes considerable problems in connection with recycling and incineration. To master these remaining difficulties is a great challenge for researchers and technicians in the industry, but the task is by no means insurmountable.

Surplus energy

One force behind the introduction of closed processes is their ability to generate large amounts of energy. A sulphate pulp mill today can already be made more than self-sufficient in energy. Integrated mills have for some time supplied their paper mills with energy. An alternative use for the surplus energy is to heat homes via the local district heating network. Surplus energy from a pulp mill can also be used to generate electricity.

In environmental terms this is an ideal solution. The energy produced by a pulp mill comes from those parts of the wood that are not converted into pulp, mainly bark and recovered spent cooking liquors. It is also totally bio-fuel based. The carbon dioxide resulting from this incineration does not cause any overall increase in the atmosphere, nor does it contribute to the greenhouse effect. In principle, a modern sulphate pulp mill is a completely solar powered industry, which can also help to reduce the use of depletable sources of energy, such as oil, coal and gas.

In the mill of the future, the volume of energy produced can be considerably increased. Closed processes require the use of less water by the mill. Process water has an elevated temperature, which facilitates efficient extraction of energy.

Moreover, the industry has now reached the point that everyone hopes will be the next main technical leap forward - the recovery boiler is about to be replaced by a new gasification technique that can generate considerably more energy. Such a process of black liquor gasification is now being tested at AssiDomän's cartonboard mill at Frövifors.

If this gasification technique does not meet expectations, other alternatives exist. A new generation of boilers which make much more efficient use of energy, are under development.

Fantastic opportunities

If one considers the situation as a whole, it becomes obvious that the forest industry will have fantastic opportunities in the ecocycle society of the future.

- The decisive factor is that the forest industry is based on a renewable raw material and that its products really help to improve the quality of life. Paper is the bearer of knowledge, culture and information, paper products help to improve hygiene and convenience, and packaging conserves resources. It is likely that only 10-15 per cent of the sustainable yield from the earth's forests, excluding rain forests, is needed to supply the entire population of the world with paper in adequate quantities, - says Per-Olov Lindblad.

This production can take place in a solar powered industry, an industry that is not only self-sufficient in energy, but can also generate immense quantities of energy for the rest of the community.

- The world needs an attractive model for a sustainable supply system in ecological balance. The Swedish forest industry is uniquely placed to become such a model, - says Per-Olov Lindblad.

Environmentally adapted transportation

The forest industry is Sweden's largest source of road, rail and sea freight. The transport industry is also a major source of a variety of emissions, noise pollution, land encroachment and so forth. To attain ecological balance, the industry has to strive to reduce the environmental impact of transport. Road transport in particular has been the subject of attention, due to its adverse effects on health and its output of emissions that exacerbate the greenhouse effect.

The ability of the forest industry to select the most environmentally friendly and cost-effective means of transportation requires detailed knowledge of the actual emissions as well as their effects. Work has begun to raise levels of awareness and the aim is to formulate a common environmental policy for the entire industry. Environmentally adapted transportation using the latest technology is the aim.

Research moves on

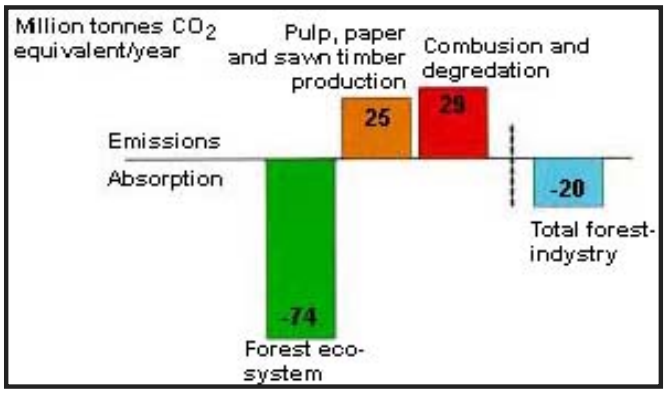
An extensive research project that is intended to identify the remaining technical solutions for a totally closed pulp mill in the early years of the 21st century has begun. The project is being funded by Sweden's Foundation for Strategic Environmental Research, MISTRA, and by research grants from the industry. The project is co-ordinated by Dr Peter Axegård and is based at STFI.

The general goal of the project is to propose technical solutions for the production of pulp and paper that will minimise environmental impact. It includes examining what energy production could be technically and ecologically feasible at such a mill.

Initially, research is being carried out within three sub-areas: development of extended cooking, development of "kidneys" and research into the pulp industry's energy potential. Eventually, the possibility of closing the processes at paper mills will also be investigated.

The forest absorbs carbon dioxide - the circle is closed

Paper, wood and other forest products contain carbon. This carbon has been absorbed by trees at the point in the ecocycle where carbon dioxide is used in photosynthesis. When forest products have been used and become waste, the carbon is released and returns to the atmosphere in the form of carbon dioxide. This occurs regardless of whether the waste is incinerated or allowed to biodegrade in the composting process. The carbon dioxide in the atmosphere is absorbed once more by the growing trees and is converted via photosynthesis into new wood. In this way the ecocycle is closed and the forest products themselves do not add to the risk of the "greenhouse effect" and changes in the climate.



The Swedish Environmental Research Institute, IVL, has estimated that the forest industry currently absorbs greenhouse gases amounting to some 20 million tonnes of carbon dioxide equivalents per year. This net absorption is due to the build-up in forest bio-mass. This increase in the total stock of wood in Swedish forests is expected to continue for the next 50 years. In the longer term, balance is expected to be achieved between the emission and absorption of carbon dioxide in the forest.

Counteracts the greenhouse effect

In addition to the carbon dioxide created by the degradation of forest products, carbon dioxide is also emitted from the production processes at the mills, in transportation and other technical operations. A large proportion of these emissions is also taken up in the natural ecocycle since the forest industry's energy consumption is largely based on the combustion of biofuels such as bark, liquors and other wood residues. The carbon dioxide emissions from fossil fuels are also balanced by sustainable forestry methods which assimilate carbon dioxide and convert it via photosynthesis into new material and new fuel for the growth of new trees. In this way, forestry, seen overall, does not contribute to the greenhouse effect. In fact, the forests in Sweden absorb more carbon dioxide from the air than the quantities emitted in the production processes and when waste products are incinerated or biodegraded. This all helps to offset the greenhouse effect.