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# ECO-EFFICIENCY IN MANAGING THE PULP FIBER LOSSES AND THE BROKE GENERATED IN PAPER MANUFACTURING


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# ECO-EFFICIENCY IN MANAGING THE PULP FIBER LOSSES AND THE BROKE GENERATED IN PAPER MANUFACTURING

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## INTRODUCTION

Along its existence, the pulp and paper industry has shown an enormous vitality to increase its production and to improve its technologies, in order to meet the quantities and qualities required for its products by Society. Our industry is highly dependent on natural resources (wood, water, fuels, air, etc.). As a matter of fact, it is very intimately married to natural resources, which were abundant in the past, but now are not any longer. This intimacy with using abundant resources led to a technological concept, which is not so conservative as to their use and consumption. Let's consider that nowadays, in spite of the strong awareness about rational use of water, our industry is still dependent on huge amounts of this more and more scarce resource, because almost all of our processes are wet-based. We had already and we are still to have several further environmental crises in our history. We have got through the phase of having to treat effluents in enormous quantities; we have overcome the dioxin and the potentially contaminant bleaching related panic; we are trying now to close more and more the water cycles at the mills; there are large solid waste recycling stations being established to treat our wastes; there is an acute awareness as to grow forests in a more and more sustainable way, following forest certification programs; etc., etc. However, when passing by and carefully observing how unprepared we still are in seeing the losses of natural resources, involving significant costs for our products, it is possible to feel that much is still left to be made.

The lack of profits and the so-called value destruction phase that our industry experienced in the Northern Hemisphere at the end of the 90's; the low returns for the invested capitals; the fear for business sustainability in the future and its uncertainties; the market pressures for cleaner products and processes; the greater entrepreneurs' awareness and consciousness to

the environmental aspects; the stronger and stronger presence of legislation, putting pressure on the industry and its managers by the law of environmental crimes; the non-governmental organizations more and more prepared and with their action increased by the internet; in addition to the many emotional aspects connected with the environment and our production activity: all of them are drivers to gradually improvements on the way of life at the companies. I believe that the best of all improvements was the very acceptance that we have to search for business sustainability and that it implies to have concomitantly an environmental and a social sustainability, according to the example of the excellent definition of sustainable development.

In very simplified terms, to be **eco-efficient** means to make more with less, and better, or else to use more efficiently the natural resources required for our processes and products. We depend much on this concept, since we are still, as human beings, great wasters of natural resources. Worse than that: in our professional life we do not even know how to value them in our complex production cost evaluations. For many years these resources were abundant and seemed to be inexhaustible. The abundance of something results in a wasteful behavior. For instance, in our eucalyptus and *Pinus* forests the higher the productivity, the less one becomes aware of how much wood is wasted, both in the forest and at the mills, when disposing of residues or when using more valuable wood destined for pulp production either as firewood or as energetic biomass, etc. The amount of natural resources still innocently wasted by industry - and by extension, by man - is amazing. In spite of the big improvement with regard to some decades ago, high waste and consumption of water, power, labor, oxygen, caustic soda, air, etc. should also be recorded. At the same time, we got used to generate huge amounts of solid wastes at our mills and to get along with them (bark, sawdust, ashes, organic sludges from effluent treatment stations, dregs and grits, lime sludge, pallets, wires, drums, metal scraps, etc.). We go as far as to be proud of establishing fantastic recycling units for these residues, instead of fighting against them at the origin, where the wastes are generated in our process. The vision prevailing at many mills is that these residues are inherent in the manufacturing process, they have always existed, and it is even believed that all of it has much improved. As long as we will keep the generated pollution in the water, in the air and in the form of solids, we will have to treat them and this only adds costs and does not result in any financial returns. The consequences of this shortsighted behavior in terms of eco-efficiency are a great number of process nonsenses. For instance, a major one among them is that even the most modern paper mills still recycle internally from 10 to 15% of internal broke, i.e. their machines keep producing approximately 10 to 15% of paper that will return as internal broke to the pulpers, reducing the production of saleable products in this proportion. It is hard to believe, but there are mills producing as broke even more than twice as much these figures. I wonder whether there

is business sustainability at mills that off-grade and send back to the pulper from 10 to 30% of the ready product, which huge amounts of value have been added to, and discarded later. The managers are not considering the significant costs and losses involved. This internal broke is generated at paper sheet breaks; by unnecessary removed trims; by exaggeratedly precious specifications; by attitudes of operators, cutting innocently enormous "blankets" of paper to take samples thereof, or else to remove defects that will cause some more trouble in the conversion; by mishandling paper rolls or bales, so as to damage them; by bad planning in terms of converting or paper roll shaping; etc. The internal recycling of this broke is barely seen by the administrators, it seems normal to them that this occurs. However, such internal recycling processes generate extremely high costs, reduce machine production and paper quality, increase specific consumption's, generate enormous reworks, besides impacting the environment by misuse of the raw materials (natural resources). Whenever a natural resource is misused, an associated pollution is generated. In another example, it should be considered that as well the pulp as the paper mills got used to lose about 0.5 to 2% of fibers through their effluents. Worse than that, there are cases of operators who appreciate fiber losses because they facilitate pressing the sludges generated at the effluent treatment stations. Any sludge thrown away as solid pollution is a natural resource wasted by the production process. To use fibers, the noblest pulp company product, as filtration auxiliary, is one more innocence we still put into practice. Therefore, wasting is still very high. These few among many examples of our daily life are just evidences that there are thousands of opportunities waiting for our action. When implementing a program of eco-efficiency, also called cleaner production, we will be causing behavioral changes in order to reduce the amount of residues and generating financial results for the companies. Furthermore, as motivation to work for a sounder environment is great among people, to be eco-efficient is associated with the greater motivation to generate a healthy working environment in the place where the operators spend most of their time, which is the company itself. Eco-efficiency is a strategy to reach a continued improvement of products, processes, services, working place, quality of life, and to reduce environmental impacts and production costs. It is a sustainability-oriented technique. The purpose is basically to reduce pollution and generation of residues and pollution where they are generated and not only to treat them at sophisticated treatment stations, at recycling plants or with fantastic cleaning filters. The results are a minimization of environmental impacts, a higher operational efficiency and a cost reduction. At the same time, it consists in a banner that every employee of the company likes very much to carry, as nowadays the awareness that we should work for a better environment is very spread among everyone in Society. If we want healthier, more efficient and competitive mills, one form of doing this is to include eco-efficiency in our quality improving programs of the company as a whole. For these reasons,

we will dedicate this chapter of our present **Eucalyptus Online Book** to eco-efficiency, showing basic concepts and discussing two cases of much application at the pulp and paper industry: the fiber losses and the generation of internal wasted paper.

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## LOSSES ARE WASTES OF RESOURCES AND MONEY

My highly esteemed friend and guru for the environmental subjects of the planet, our dear departed José Lutzenberger, once told to me with the naturalness of someone who knows about things: "pollution is something good in a wrong place, because of carelessness, innocence or silliness". Going on, while drinking his traditional beer, he exemplified: "this beer I am now drinking is a divine thing, which I appreciate very much. However, if I let it drop on the house carpet, it will turn at once into an undesirable pollution, difficult to remove; it will ferment and cause an unpleasant odor in my carpet for a very long time".

Life is exactly like that; one is always throwing out goods things as garbage or pollution and thus contaminating the planet. One wastes good things with a frightening naturalness. Anything we are throwing away as pollution has been paid by us, and worse than that, we will pay later to treat and dispose of in a supposedly safe place. Fibers, minerals, dirty water, papers, packaging, wood sawdust, tree barks, drums, wooden sticks, little coffee drinking plastic cups, everything that is in the garbage can has a much higher cost than the simple cost of throwing away, do you agree? They are worth as not used or partially used raw material; they carry a cost aggregated by the process as power, chemicals, labor, etc.; and later they require additional costs to treat and to dispose of. It is an enormous cost, which most people are not able to see. Sometimes the companies' executives and technicians proudly say that they have fantastic effluent treatment stations and solid waste recycling and composting units at their mills. Although they have accepted to invest some millions of dollars in those stations, which proves their good environmental intentions, those people are blinded by the logic of the past, i.e. that pollution must be treated or recycled. However, pollution must be combated and destroyed in its origin, where it is generated. If there are huge garbage recycling stations it is because much garbage is generated and garbage is something good that was thrown away. I consider garbage recycling and effluent treatment to be second rank environmental measures. Recyclers exist because we throw good things into the garbage. If we avoid wasting paper, food, fibers, plastic, wood, etc.; if we adopt internal waste preventing or reusing mechanisms;

the end-of-tube treatment stations and recycling stations will be reduced and will have to treat just the really unreusable garbage without any economic value. It is always possible to reduce wastes and residues generated at the companies and in our houses as well. When someday the companies recycling our residues will complain that their activity is not yielding profit any longer, due to the lack of good quality residues, we will have reached what we actually expect: the practice of eco-efficiency.

Another seldom perceived truth is that everything we use, everything existing in the garbage can, in our houses, at our companies, everything, absolutely e-v-er-y-t-h-i-n-g, consists in natural resources. When we misuse these natural resources and generate residues and garbage, or contaminate water courses and the air, we are not only dirtying the planet, but also wasting these natural resources and exhausting the reserves of nature.

From that exposed up to now we can conclude that wastes or residues are natural resources we pay for and do not use, that we throw away and pay much more for doing this, as we will have to control the generated pollution.

In other cases, we are used to bring things to the mills without remarking we are doing it: for instance, the wires holding the pulp bales; the soil coming along with the wooden logs; the sand mixed with the limestone's; the ashes accompanying the coal, etc., etc., etc. We do not even remark we are paying for all this. They will be in excess in our processes and will turn into residues without any use. "To gain things free-of-charge", without our use for them, is also a synonym of wasting. Therefore, the traditional Brazilian popular saying that "free-of-charge even a shot into the forehead is good" as a matter of fact does not apply. I have not yet fully understood the meaning of this popular proverb, but it is certainly one more ingenuousness with environmental impact.

We have to be conscious that we can change for the better and make efforts to achieve it. Any residue reduction program begins with a good and strong cleaning and organization program. Put as many S's as you wish, call your good housekeeping program as you prefer, but please, keep your mills clean. The cleaner we are, the easier we will see our garbage, as it will begin to appear and to be noted.

The human being likes changes and to try something new. However, everyone prefers to be the very vector of change, instead of changing because the others are asking for or stimulating. Human beings change by awareness, stimulation or punishment. This is so with us, since our childhood. If the kids behave well and are not left back at school, they are given a bicycle; if they fail, they are slapped or they lose the monthly allowance for some period of time. We have to understand this logic in order to motivate the people we are working with to search for improvements and changes. We have to feel proud of our companies. A company is not a garbage can: it is not because eventually it may smell a little, due to our always used kraft process, or because it generates solid wastes or effluents

in large amounts, that it should be allowed to be dirtied. On the contrary, it should be much more endeavored to clean it and to make it beautiful and healthy. Who does not like to work in a clean, pleasant, healthy place, with green areas, with minimum environmental impact and where everybody has an interaction of respect for Nature? This means going to the environmental and by extension social responsibility. The universe is among us just as we are within it. Everything belongs to a large and complex natural system, where protection is demanded and the residue reduction is an essentiality. When we reduce wastes and residue generation, besides protecting nature and conserving the resources in a more sustainable way, we are earning money for the companies, as well as for us, in our houses.

It is starting from these premises that I will try to show in the next sections our fiber losses and our wasted paper generation under the optics of eco-efficiency. I will try to show you how to interpret these losses and how to be pro-active, finding solutions and proving that these solutions are economically, environmentally and socially viable.

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## FIBER LOSSES: UNDERSTANDING THE MANAGEMENT OF THIS WASTE

Fiber losses happen routinely, both in pulp and paper manufacturing. It is incredible that in spite of the technological advances we have reached, we go on accepting so high fiber losses in our operations as normal. There are those thinking that it is a necessary evil. There are also those not even perceiving them. The worst ones are those knowing about the problem, and doing nothing about.

Well, fiber losses happen in at least frightening proportions. Modern pulp mills consider losses of 0.3 to 0.5% as benchmarking values; while paper mills are much more "open" to these kinds of losses: they consider to be normal to lose up to 1.5 to 2% of fibers, also losing with them mineral fillers, starch, optical brightners, draining agents, etc. The situation is also dramatic at recycled paper mills, since the losses also occur at wastepaper pulping and stock preparation/screening. In such situations, a 5% or even a higher loss level may be reached. There are cases and cases, but if we consider our sector as a whole, there will be fiber loss variations ranging from 0.3 to 5%, or even higher. At many paper recycling based plants, be it as a function of the older technology, or due to the very open circuits, many fibers are lost. Thus, the raw material is ill-used and pollution increases in the form of sludges or suspended solids in the effluents. It should be remembered that lost fibers consist in paid raw material thrown away after

some value added at the mill, involving an additional cost to handle and to treat the residues and the pollution generated by them.

The fiber losses are intimately associated with water consumption of pulp and paper mills. Those mills using much water have larger effluent flows. Thus, the possibilities of throwing fibers and other valuable inputs into the effluent, among which heat, are much greater. Water is a great villain, as far as fiber losses are concerned. Fibers and water are good, even close friends, inasmuch as fibers are said to be hydrophilic ("water friendly").

Fiber loss is a waste. It can be considered to be an enormous inefficiency, either of the available technology or of the mill technical management. Many ways of avoiding fiber losses involve low cost and quick return to the invested capital. If these fiber loss prevention measures are not adopted, it is either out of ingenuousness, non-acquaintance, or incompetence, pure and simple.

Fiber losses may occur through water flows (filtrates, effluents), by the air (fiber dust, common at converting operations), or as solid residues (pieces of sheets, trims on the ground, fibrous sludges, sweeping remnants). Often, the losses dropping to the ground end up in the effluent, as the operators like very much to flush the mill with water jets, instead of using brooms. That dirty water often flows into the effluent for treatment purposes. The fibers flowing along get lost to the organic sludges.

A loss may be defined as "anything that does not add any value to the product, consisting in a waste of some resource, even of services, contributing then to an increase in manufacturing costs". Fiber losses consume resources, generate costs and residues to dispose of. As a consequence, pollution is higher and the company results will be lower.

Everything solid, which is present in the effluents, must pass through the treatment stations to be removed. Then, the fibers will go out as primary sludges, rich on moisture. In addition, they will be very contaminated with sand, soil, pitch, and residues of all kinds. In short, a material that was good turns after all into a dirty residue to dispose of.

I have seen many mill technicians looking desperately for purchasers for their primary sludges. They consider it even elegant, speak of external recycling of their residues. They accept anything for this residue, even its removal at "zero price", i.e. the purchaser just comes to take the residue, paying just a symbolic value for it, just to enable a sales note to be issued for transportation purposes.

It is curious that the purchaser is often avid for the residue, he even disputes any quantity, anxious to take everything he is able to. Such a situation suggests the loss of a very good material. The purchaser is aware of it. He is taking advantage of our inefficiency. Many mill people, even the owners, consider such a situation as normal; it is incredible, pure and simple!

The fiber losses reduce our availability of fibrous raw material for our products. They increase our residues, increase our operations with "silly

services" and add significant costs. This will be discussed later, when it will be shown how to value these residues.

When we reduce our process fiber losses or broke generation at paper manufacturing, we obtain a series of environmental, social and economical advantages, such as:

- Reduction in manufacturing unit costs (both fixed and variable costs),
- Better raw material utilization,
- Less environmental impact, due to lower utilization of natural resources (wood, pulp, water, kaolin, calcium carbonate, electric power, steam, etc.),
- Lower water pollution,
- Lower solid waste generation,
- Reduction in environmental liabilities,
- Greater facilities to meet requirements of the environmental control agencies,
- Lower needs of dumping areas (landfills) to dispose of the garbage,
- Lower involvement of the operating personnel in emergency operations,
- Less workers' stress,
- Higher esthetic beauty of the mill, which will be always cleaner and better organized.

There is an enormous series of reasons for fiber losses. They are almost always the same for any kinds of wastes occurring at the industrial plants. In another chapter of this virtual book we will further discuss the concepts of eco-efficiency and cleaner production. However, at this moment it is important for us to know that the main causes for the fiber losses are concentrated in the technology we have available (technological age and quality), as well as in the use of this technology by the mill personnel (management and operation).

The commonest operating causes for fiber losses are as follows:

- Operation failures and upsets,
- Vital equipment shut-downs,
- Badly operating machines, or operating above their capacity, or poorly maintained machines,
- Unsuitable working method (badly concatenated, badly executed, badly planned operations, etc.),
- Lack of training or commitment of the operating staff,
- Lack of indicators and goals regarding the losses, to indicate the actions to reduce them.

Losses decisively affect the productivity indicators of the mill. Both the fiber loss and the wasted paper generation impair productivity at several of its indicators, such as:

- Use of fibrous raw material per ton of produced pulp or paper (specific consumption will be higher),
- Use of water ($m^3$/adt),
- Use of power (kWh/adt),
- Operating efficiency of machines,
- Utilization of worked hours (labor) per ton of end product,
- Production unit costs,
- Higher environmental costs.

For all these reasons it is very important to quantify, to value and to understand the impacts of fiber loss and broke generation on the process. Which are the lost amounts? Where are they occurring? What are the causes? How could we prevent them from occurring further? What is the payback of our investments to solve the problem? It is very important to define goals, responsibilities and courses of action. Thus, we will get out of the conformity of accepting these important losses as being a "necessary evil" or as "something normal and inevitable".

In my opinion, even the best values in terms of benchmarking, something around 0.2 to 0.3% of fiber loss, are still too high. It is like discarding 0.2 to 0.3% of our most valuable raw materials or products to the garbage can. In the case of a pulp mill, it would be something like throwing away one tree, which was planted to turn into pulp, at every 300 or 500 trees that would be consumed.

The loss reduction basically refers to a continuous improvement of the industrial process or to a search for technologies of better eco-efficiency, because, as it was already seen, losses are a synonym of inefficiency and pollution generation.

When we lose something because our inefficiency, we do not spend more money just to make up for the losses. Many other costs add up to it, increasing our costs and reducing our margins of profit. This happens in several ways, as follows:

- Higher raw material use,
- Higher effluent treatment costs,
- Higher needs of capital for construction of effluent treatment stations and landfills of larger dimensions,
- Higher costs to handle losses concentrated in the form of residues to dispose of,
- Costs of environmental liabilities to manage for ever,
- Costs of licenses, bureaucracy, etc.

In addition to this all, the lower production that may occur associated therewith also implies higher fixed unit costs per ton of manufactured product. The overall fixed costs increase as a function of the need to manage the garbage. The saleable production decreases due to the process losses

occurring. Consequently, as the fixed unit cost is a ratio between both, increasing the numerator and reducing the denominator, it means that we will be losing on both sides. The variable unit cost also increases for two reasons: as a function of the lower production and of the higher consumption of inputs (fibers, pulping and pumping power, etc., etc.). In general, the losses also demand a higher amount of work by people whose work is to handle and to dispose of the losses. It would be much better to pay to them to prevent such losses, do you not agree? In short: losses, inefficiency, incompetence, inadequacy, incapacity, obsolescence, etc. are very associated words, as well as fibers, wasted paper and water consumption at the mills are also associated with each other. When we reduce fiber losses, wasted paper (broke) and water consumption we are improving our mill. We are also improving the environment and the happiness of the company's personnel will be greater, because stress will decrease and the pressures caused by the wastes will be lower.

To quantify, to measure and to segregate the losses are very important ways of understanding the problem and planning corrective and preventive action. These quantifications should preferably involve the physical losses of inputs, power, etc., plus the monetary losses. How much did it cost in addition? How much did we fail to gain? Historical comparisons, benchmarks and goals are important manners of showing our evolutions and of challenging our staff to look for solutions. The personnel involvement and commitment should be stimulated. Nevertheless, to quantify something it is not enough to want to start measuring, without knowing how and what. It is necessary to define a sampling plan that should be well representative of our situation, i.e. situations occurring in the normal routine, as well as on emergency occasions, when we lose much more. It is necessary to have reliable equipments and methods of analysis. It is necessary to be able to distinguish fibers from other suspended solids. It is necessary to be able to distinguish recoverable fibers from almost colloidal fibrils or fines dispersed in the effluents. Therefore, before starting foolishly, trying to measure everything and at all points, it is better to stop for thinking, in order to see the critical points, to establish the sampling procedures and routines, as well as the measuring methods. It should be remembered that fibers in general get lost in water flows. Therefore, correct flow and consistency measurements are vital. After everything has been planned and evaluated, it is very important to calculate the physical and economical losses. Thereafter, solutions should be proposed to prevent them.

The very first step to be taken in this quantification process is to have a well-accepted method to measure fibers in the effluents and in the channels, piping flows, etc. There are different ways of trying to measure lost fibers:

- By the primary sludge quantification at the effluent treatment station. This quantification is a partial one, since a part of the fibers gets lost in

the receiving water body (river) in the form of suspended solids. In addition, sludges contain many contaminants interfering with the quality of the analysis, such as fine sand, clay, mineral fillers, rust scales, paint pigments, pitch, etc.

- By quantifying the raw effluent coming to the effluent treatment station (by the flow and by the concentration it is possible to determine the lost dry fiber load). In this respect there are also sources of imprecision, since there exist many other kinds of solids in the general effluents, such as rests of wood, leaves, soil, etc. The flows are also rather variable, which makes it difficult to have a suitable average calculation.
- By the sectorial effluent segregation, where significant losses of fibers are occurring. This method is much better, but it requires flow meters to be installed for the sectorial effluents. However, these meters are simple to construct and they are not many. For this reason, when proceeding in this way, we will not only measure values, but we will know more precisely the sources and causes of the losses.

Segregation of fiber containing effluents is very important for a better understanding of the problem. It also allows establishing specifications of maximum losses per sector, which should be managed by the operators. Thus, the operator should pay attention not only to his production and quality goals, but also in order not to reach the maximum limits of fibers allowed in the effluents. It should be remembered that at present, with the companies certified by ISO 9000 and 14000, any nonconformity must be explained very well by the causing area. Thus, the responsibility increases, as well as the results improve.

Regardless of where we find it convenient to measure the fiber losses, it should be always taken into account that the fibers must be distinguished from the mineral content of the solids measured. Pure cellulosic fibers are poor in ions and ashes (from 0.2 to 0.4% dry weight basis). Values exceeding these figures result from sand contamination, mineral fillers, etc.

Through segregation it is also possible to know the champion areas in terms of wastes. As they will certainly feel provoked by this knowledge, they will tend to react, both in operation and in searching for more eco-efficient technological solutions (new investments in preventive measures, new technological improvements, new ways of collection and internal recycling of the losses, etc.).

It must become very clear that in any optimization and fiber loss reduction process the worst of all situations is to send fibers to the landfill (or to the river without any treatment). The manager must have a measurement of this loss daily. Rather than that, he must always go to the treating station or to the landfill, in order to see what is being sent thereto. In many cases, he will be surprised at what he will see. The slightly better solution is to gather the whole fibrous sludge generated at the effluent treatment station, to press it or to centrifuge it and to sell it to a third party. It would be an

external recycling, which tends to mislead one about what is really happening, because one fails to see the loss as a problem, since it does not accumulate at his home. Thus, we are deceivingly solving the problem or getting rid thereof. The only advantage we will have thereby is that we will not be using the landfill. Yet our inefficiency will be maintained.

Any definitive solution should be located in the very place of the loss, i.e. where it has its origin. It is there the fibers escape and try to flee to the effluent. Therefore, it is at those points we must concentrate our efforts. It is in the origin of the problem that it must be solved. "It is to pull up the evil by the roots", as the old popular proverb reads. By looking for the origin of the problem, it will be easier to find its causes: is the problem occasional or constant? Is it caused by poor maintenance? (pumps leaking stock through the gaskets, tanks drained by valves presenting leakage, etc., etc.).

To lose fibers, to lose ready paper, to lose electric power, to lose water, to lose inputs, are synonyms of bad operation and incompetent management. Not to measure this is even worse. It means to be blind to the problem, to think everything is O.K., sometimes stating this with a certain vanity and prepotency. This kind of behavior must be found, clarified and corrected.

In short: we must segregate, quantify, monitor, evaluate in a reliable and precise way, and propose solutions and action through our creativity, responsibility and competence.

Simultaneously to the fiber loss management, we must also manage the water (its qualities and quantities). Water clarification and fiber recovery are intimately associated. When we filter an effluent or a water flow we will be recovering the fibers and improving the quality of that water. That water which was classified as effluent can be converted into recovered water and have new opportunities in the industrial process. A flow of an effluent with 500 ppm of fibers can be converted into reasonably clean water, containing about 25 to 30 ppm of solids. This can be achieved in the place the contaminated water is being generated. Then the recovered water can return victoriously to the process.

The advantages we obtain when solving the problem in the generating area, recovering fibers and creating new opportunities for reusing the water, are as follows:

- Usable fibers will be back to the process (they were being lost, thrown away),
- There will be good recovered water, ready to be used again,
- The need of clean water will be reduced (less need of river water and treatment at the water treatment station),
- The need of steam to heat water will be reduced, as in general hot water is lost,
- The flow of effluent to be treated will be reduced,
- The primary clarifier, which in many cases is always operating above the limit and letting many solids go ahead, will be relieved.

- Etc., etc.

Therefore, my friend, the solution does not consist in finding a use for the primary sludge, like many people are doing or thinking to do. The solution consists in trying to prevent the fibers in all possible ways from leaving towards the effluent station clarifier or primary air flotation clarifier.

The fiber losses vary from mill to mill, machine to machine, operator to operator. Hence the need of an individualized evaluation, case by case, for better understanding, positioning and course of action definitions. In many cases we discover the need of installing a filter, training better some operator, changing the gasket supplier, training better a maintenance operator, installing a protective system against accidental spillage, etc., etc.

Another problem faced when wanting to recover the fibers at the end-of-the-pipe, i.e. starting from the primary sludge of the effluent treatment station, is the fact that there the fibers are already dirty, contaminated. They will be useless for nobler uses. They will be dirty with all kinds of contaminants, almost impossible to clean and purify. Whereas, when the loss recovery is carried out in the very area which is losing the fibers, they will have the same quality as those in the process. Therefore, they can return without any problem to the points where they were being lost.

Let's take an example of fiber loss by the acid and alkaline pulp bleaching effluents. Such fiber losses occur in the pulp washing operations. If we do not filter the fibers to recover them, we may lose about 0.4 to 0.8% of the bleaching production. With a simple filter as e.g. a thickener with a screen of 80 to 100 mesh, we can recover from 85 to 95% of these fibers, absolutely good fibers to return to the point where they were escaping, i.e. from the fiber line again to the bleaching line itself. Therefrom, they will be able to resume their course to turn into the end product. If we let these fibers go to the primary clarifier, they will become pollution, dirty, ugly, almost useless fibers. They may end up as sludge on the landfill. It is an injustice against them. At the most, they may become corrugated board medium or some second-grade sanitary paper. Even when thinking of purifying or fractionating the fibers of a primary sludge, in order to remove the fibers from the remaining contaminants, we will be carrying out an operation of low eco-efficiency. Once more, do not let good stock or good fiber go to the effluent. It means to condemn them to an unhappier end.

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## RECOVERING OUR FIBERS

When we speak of recovering our fibers, we are in fact thinking of two things:

First: to avoid, to prevent those fibers from trying to or escaping from the process. This is achieved with suitable maintenance of the equipment, with conscientious operators, motivated to avoid throwing good stock away. Through the suitable analysis of the process, it is also possible to define the best practices to prevent water from flowing out, taking good fibers to the effluents. For example: if a stock chest often overflows, it is throwing stock on the floor and/or to the effluent. By a simple balance of inlets into this chest and outlets from it, it is possible to understand the reasons for these lacks of control and to act accordingly. Which flows enter that chest and in which fiber concentrations? With which regularity and how often? We will be able to understand the dynamics of these flows, whether they are constant, eventual, emergency flows, etc. Starting therefrom, we can plan a course of action to avoid overflows and fiber and water losses, such as: discipline in sending water to that chest; water segregation; separation of more concentrated from less concentrated water flows, establishing different destinations to them; installation of a fiber recovery filter for the fiber richer water flows; installation of an auxiliary tank for spills, distinguishing occasional spills from continuous and routine water flows; closure of some fiber-rich water circuit; etc.

It is very common that the operators have to work with open system, in order to drain organic and inorganic contaminants from their system ("trash"). Thus, they try to purge undesirable elements, such as "inorganic garbage", "ionic garbage", pitch, stickies, etc. Nevertheless, when carrying out the purging, they throw good fibers away, which follow the water flow being discarded. Therefore, if something must be purged, a way to avoid losing fibers should be studied. Let's use the intelligence to do this, O.K.?

Second: to recover fibers trying to escape by the effluents, which would flow towards the general effluent, turning later into our undesired primary sludge. For this purpose, we can make available to ourselves of several fiber recovery means, such as filters, air flotation devices, screens, decanters, clarifiers, etc. All of them are useful, have their typical efficiency and result in a recovery of at least 60 to 70% of the fibrous material. In optimized situations, fiber recovery reaches percentages above 95%, which is wonderful, is it not? In spite of these charming figures, the best is still to prevent fibers from trying to escape from the process, once again by solving the problem in the origin of the loss. Let's remember that the problem must be killed where it happens.

Therefore, our first mission is to discover the secrets and riddles of the losses and the mysteries causing our process to lose so many fibers. If deficiencies of the processes, the equipment or the operators are concerned, we should then act wisely with regard to them.

Recovered fibers must be reincorporated into the process, where it is possible to reincorporate them intelligently. If unbleached fibers are

concerned, they should enter the fiber line at a point, which allows them to pass through the bleaching process. If contaminated fibers are involved, they should pass again through the screening process, while if the fibers are clean they should return to the point of origin. And so on.

If at the same time as we recover fibers we clarify and recover water, we must also find a good use for that water, as well as look with creativity at the process and find the best alternatives. Let's give here a piece of advice. The prime responsibility for reusing recovered fibers and water belongs to the area that is losing them. In other words, if a good fiber and good water are being lost in the pulp screening process, they should be preferably reintroduced at that point. We should not keep transferring our inefficiency to other areas, is it clear?

Fibers may be lost in all places where they are present. If they are present in the black liquor, for instance, when sending that liquor to the evaporation and the boiler without previously filtering it, we will be losing fibers. They will end up becoming a poor fuel instead of noble pulp. If fibers are flowing out with the bleaching filtrate and we do not prevent them therefrom, they will flow directly to the effluent treatment station and will turn into primary sludge. In other words, the game of the loss is a very quick and dynamic one. If we play the fool or if we do not pay the due attention, we will lose the game, with no chance of a return match. A fiber that has gone away hardly comes back in the same state of quality. Furthermore, if today everything is O.K., without any losses, this does not mean that tomorrow it will be alike. Any hole in a thickener screen will already start draining fibers away from where they should remain.

Let's list in the following the commonest points of fiber losses of an industrial pulp and paper process. I will imagine an integrated pulp and paper mill having also a deinked secondary fiber based paper-machine. Thus we will encompass all main fiber waste possibilities.

The main losses occur in two types of stock flows:

- High flows and low concentrations: bleaching filtrates, black liquor for evaporation, pulp drying machine effluent.

- Low flows and high concentrations: white water purging from the pulp or paper forming and drying machine, purging from hydrocyclone screening, sludge floated from secondary fiber de-inking, stock preparation effluent (broke pulping and screening).

As a matter of fact, in both situations we lose a lot of fibers. In case of low fiber concentration effluents (40 to 100 ppm), flows are very large and consequently the losses may become high in terms of lost load in kg/day;

whereas for small and fiber concentrated flows (250 to 4,000 ppm), losses also end up being high due to high concentration.

Fiber losses often occur at the following points of a mill like that described above:

- Black liquor for the recovery area;
- Along with the digestor rejects and unbleached stock screening shives (2 to 7% of the dry weight corresponds to fibers);
- Bleaching filtrates;
- Pulp screening and washing effluent;
- Water purging from the web forming and drying machine;
- Machine wet section suction box vacuum pump water;
- Stock preparation area;
- Broke pulping and preparation area;
- Wet press dewatered water purging;
- De-inking sludges;
- Sludge pressing at the effluent station;
- At tank or line overflows and drainage, where the flows contain fibers.
- At gasket, seal, joint, valve leakage, etc., etc.

The total amount of all these losses is perverse and may reach, as it has already been seen, values ranging from 0.3% (best pulp manufacturing situations) to 2 through 5% (integrated paper mills and recycled paper mills). The papermaker producing recycled paper pays for his wastepaper, spends power and work to pulp it and to screen the stock, but with his operations he is very prone to lose many fibers. All of us agree that losing 5% of the fibers is too much, is it not so? But after all, this is real life at many mills of this type. When that papermaker purchases the wastepaper which is the source of his fibers he pays for it on a dry weight basis, whereas when he disposes of the sludge to the landfill he pays to transport a water rich wet weight. In such situations a dry fiber ton easily corresponds to 2 through 5 wet tons or to equivalent volumes in cubic meters. Let's remember that the amounts of lost fibers vary from case to case, depending on technology available, maintenance applied, operating care taken and on the company's management. Management is fundamental for this all: it is management that will motivate, show the ways, provide resources for more effective action to prevent these important losses, etc.

Any of the previously mentioned areas may be a great fiber loser. It should be remembered that the higher the purged water amounts, the higher the possibilities of losing fibers. <u>Unfortunately, operators like very much to purge, a verb very used and practiced at our mills</u>.

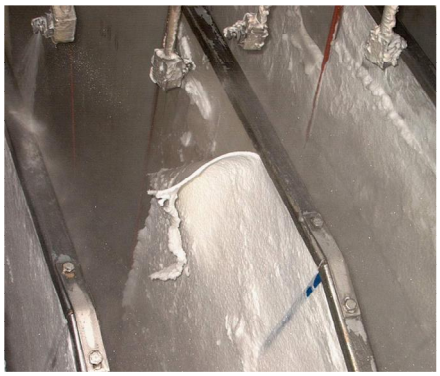
An important consideration to be remembered is that the measurements of these losses should be carefully done, trying to understand

how much is the loss in terms of fibers and of other kinds of solids (mineral fillers, sand, etc.). COD (Chemical Oxygen Demand) and SS (Suspended Solids) measurements do not show alone the fiber values. They are associated, but do not measure just fibers. The fiber COD to fiber weight ratio is approximately 1:1. This means that in case of a suspension consisting just of water and fibers, with 1 absolutely dry milligram of fibers in 1 liter of water, its COD will be approximately 1 ppm. If 1 milligram of starch, expressed as oxygen, is put into this suspension, the COD will rise to 2 ppm, but there will be 1 mg/L of fibers and 1 mg/L of starch, is it clear?

It should be also considered that COD and fibers have same numerical values when the fiber COD is measured. However, they have very distinct meanings. The fiber COD has a value as lost pulp, while the COD value of the fiber containing effluent has an even more negative value, corresponding to the treatment cost of this COD at the effluent treatment station. Fibers have a high value on the market; however, sludge originating from fibers and from COD has no positive economical value: on the contrary, it only means additional costs. An extremely important thing to consider it that most COD of the raw effluents (not filtered at COD measurement) of a paper mill is due to the presence of fibers. This also occurs at many pulp mills.

Raw effluents of recycled paper mills have extremely high COD concentrations, which is due to fibers and other kinds of oxidisable organic compounds, such as starch, anilines, inks, glues, very thin fibrils, etc. Those effluents also contain much mineral filler, sand, etc. The wastepaper is often very contaminated. When fibers of this kind of effluents are recovered, ways of purifying and separating the fibers from these undesired contaminants must be found. There are efficient systems to recover and purify recovered fibers. Clean fibers are much more valuable than dirty and contaminated fibers. Sand removal, washing and even bleaching these recovered fibers add value to them.

An additional comment: <u>white water of a paper-machine should be never considered as an effluent</u>. It does not deserve this "status". Purging white water rich in fibers, glue, mineral fillers, dyes, optical brighteners, etc. to the sewer should be considered as an operational crime. If the operator has excess water or wants to clean his system from organic trash (pitch, stickies, slime, dissolved colloids), he could have at least a filter system to remove the fiber stock and release just dirty water to the effluent: a plain thing, which is sometimes forgotten. It may be with the use of a "save-all" system, a static screen, plain things that any mechanical workshop might make at very low costs. Have a look at some simple examples listed below, very common at more modest mills. In their simplicity, these systems help the companies improve their results and reduce their wastes. It is much better to have something simple, reaching efficiency levels of 60 to 80%, than to bid farewell to the fibers going away.


Fiber recovery systems

I would like to tell you a singular situation I have experienced. During the period of time I have worked for Riocell (a Brazilian bleached kraft pulp mill), the effluent treatment of the company was extremely sophisticated. It consisted of several steps, up to a tertiary stage with aluminum sulfate clari-flocculation. The primary treatment consisted of several steps, as follows: pH control, sand removal and decantation. The final effluent COD was just above 100 ppm, very good for effluents of similar mills. Curiously, as the treatment started operating, in 1983, it was noted that only the primary treatment removed about 40% of the raw effluent total COD. We were astonished at such efficiency. We began ingenuously to conjecture hypotheses to explain such a high efficiency: were heavy decantable molecules concerned? Organic auto-flocculation? pH effect? Organic fibrils? I was definitively naive or even blind to these huge amounts of lost fibers. Much to our surprise, as we began to study better this sludge and its solids, we noticed that over 95% consisted of fibers lost by the mill, at several points detected. The mill had mixed recent and modern installations with other older ones, with not so closed systems. It also had a paper-machine that was used to lose a considerable amount of fibers. The final effluent of the mill was extremely good; after all it was a result of a primary, a biological secondary and a tertiary clari-flocculation step. All this yielded a wonderful final effluent, among the best ones all over the world, and blinded us to the intermediate steps. We started immediately after discovering the fiber losses a process of cleaner production and eco-efficiency, aiming to reduce the losses and sludge generation, in order to relieve the solid waste recycling station. The tertiary sludge filter operators were those who complained. The fibers facilitated filtering that sludge. Yet, let's acknowledge, my friends, fibers are too valuable to become a filtration aid, there is no sense in using fibers for this purpose. There are much more efficient and inexpensive polymers for doing this; even wood sawdust may be used for this task in a better and cheaper way. The most

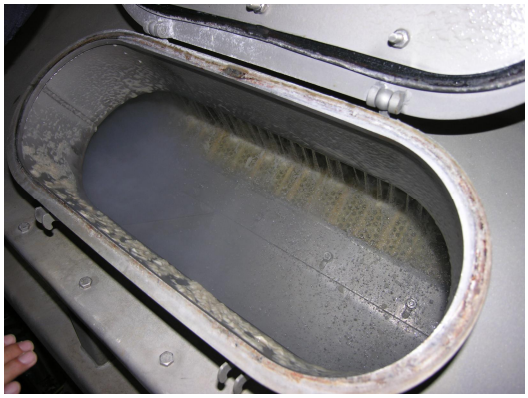
valuable product of our pulp mill (fibers) must be prevented from being used as filtration aid, do you agree?

Other interesting experiences to be reported are those concerning equipment purchased by some people for fiber recovery. We have already seen all sorts of things in this papermaking world, but it is the under or the over-dimensioned equipment purchases that surprises most of all. There are many cases of companies purchasing huge air flotation clarifiers to recover some few fibers from flows with very low concentration. There are those who in spite of having static screens in operation let everything passes and do not recover anything. There are still the primary clarifiers crowded with fibers due to excess primary sludge. You have certainly seen this already in your professional life. It should be observed that in all these situations the problem could be solved by looking for problem origins. If there are low concentration flows, in general they are formed by several mixed flows. It would be sufficient to find the most concentrated ones and to recover the fibers in them, before mixing all water flows with each other and getting an extremely high low concentration flow. If there is a high fiber load in the primary decanter, it is better to solve the problem where fibers are being thrown away, rather than to let the poor decanter be flooded with fibers up to the top.

Let's see in the following an example of it:

Clarifier overloaded with fibers and the fibrous sludge generated

In view of that, I recommend to all mills having primary clarifiers overloaded with fibers to carry out a careful analysis of the causes and to solve them at the origin of the problems. For pulp mills, installing filters in the sectors used to lose fibers (bleaching, screening, drying machine, black liquor flowing out from the digestor) will allow projecting primary clarifiers with considerably reduced dimensions. The primary clarifiers at the WasteWater Treatment Plants (WWTP) should be as small as possible. The fibers should not go there to be sacrificed. The solution is in the areas, not in the primary treatment, do you agree? If anyone of the readers has an overloaded primary treatment, he should be its doctor, relieving its burden. Look for the point at which the fibers are being lost and cure the clarifier. Do it right away because the payback is excellent.




Fiber filter for bleaching filtrate

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## FIBER RECOVERY STRATEGIES

The fiber recovery strategies at pulp and paper mills are divided into three groups:

- Preventive: consist in preventing the fibers from going out to the effluents, via suitable and conscientious maintenance and operation;
- Corrective: consist in eliminating traditional fiber loss causes (leakage, overflows, drainage, etc.);
- Recuperative: consist in using fiber recovery equipment in flows where they are being lost.

In all situations the strategies should focus on:

- More effective, quicker and higher quality maintenance;
- Proper operation of usually fiber wasting equipment, such as hydrocyclones, washers, etc.;
- Fiber recovery equipment effectiveness;
- Fiber rich water purging and drainage;
- Indicators of operating quality for vital equipment (for instance: hydrocyclone consistency, primary cleaner rejection level, water returns, specific water consumption per ton of product, etc.);
- Accumulation of harmful contaminants in the white water system;
- Mass balances to identify inlets and outlets of these vital systems. Improvement of measuring processes and the corresponding automation.

- Development of clear goals, shared with the operating areas in regard to sectorial fiber losses, not only focusing company's global loss. To speak of global losses dilutes responsibilities, so that nobody feels guilty or responsible. Everything that is global may finish with a "pizza" (or some sort of undue commemoration like that) and there will be nobody to be blamed directly for. Nobody will feel humiliated for making their wastes when operating their machines. This is too bad; lack of responsibility is the usual consequence.

The following objectives should be pursued at the strategies for water conservation, fiber recovery and circuit closure at the pulp and paper mills:

- Maximum fiber retention in the process;
- Maximum water recovery and circuit closure;
- Maximum attention in the operations, so as to avoid unsuitable situations representing fiber and water losses;
- Maximum attention at emergency shutdowns and accidents, which always result in higher losses;
- To have efficient water and fiber loss recovery systems (spill collection systems);
- To have efficient measuring and monitoring systems;
- To segregate waters and effluents, interpreting the flows and their qualities;
- To separate the hydrocyclone rejects, in order to treat them separately. Thus, it is possible to recover some good fiber, and besides, these rejects will not contaminate a larger and cleaner effluent of that area.
- Maximum cleanliness and organization in the mill areas. I consider temerity wanting to manufacture white paper of competitive quality at a dirty mill, carelessly operated in regard to its cleanliness.

### – Preventive action

- Constant attention to the filter screens (washing drums, etc.) and to the belts fastening these screens, in order to prevent fibers from passing to the vacuum zone through holes or through openings. It should be remembered that every screen initially receives the stock and a layer begins to form, that increases retention and filtration. This is one of the great disk and drum filter characteristics.
- Constant attention to the hydrocyclone stock consistency, which should range from 0.4 to 0.5% for a good operation. Too high a consistency means overload. To allow pushing the whole stock through the hydrocyclones, the operator eventually raises the consistency. Two

options exist: either to purchase one more hydrocyclones set or to reduce the rejection rate of the pressurized screens preceding the hydrocyclones. This option relieves the dry stock flow to the hydrocyclones and allows operating at lower consistencies. This is only feasible when no efficiency loss occurs at stock cleaning by the screening devices, i.e. the dirt level of both stock and pulp or paper sheet has to be monitored.

- Forming machine wire evaluation as to holes and cleanliness. Maximum fiber retention on the wire should be striven for, without causing load and production loss problems. Closer wires increase fiber retention, reducing fiber losses.
- Constant attention should be paid to the screening rejects (composition, reusable fiber proportion, consistency, etc.);
- Constant attention should be paid to the web forming machine white water quality and quantity. When purging of this water is scheduled and there are no recovery systems, maximum retention on the machine wire should be striven for, in order to reduce stock losses.

### – Corrective action

- Extremely strong emphasis on maintenance and on the materials used for maintenance. For instance, bad quality gaskets or seals always cause fiber losses, as shown by the following examples:

Fiber losses caused by joint and gasket breaks
(you should know this; these are current facts in our mills operations)

## – Fiber recovery action

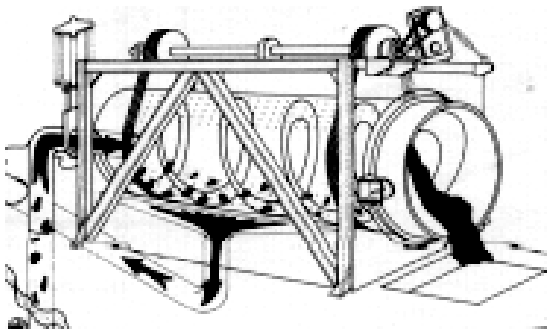
Any fiber recovery equipment should have some basic characteristics. Such apparatuses have double function: to recover fibers and water. Therefore, the requirements concern these two particular subjects, as follows:

- Good water cleaning efficiency;
- Good reusable fiber retention capacity;
- Ease of operating and cleaning;
- To occupy a small space in the area;
- To be capable of recovering fibers and water in flows and concentrations that may vary considerably and quickly (operating flexibility);
- Low cost;
- To be capable of providing high consistency to the fiber stock being recovered, in order that these fibers return to the process without overloading the system with more water.

The fiber or solid recovery efficiency (in case of paper mills with high mineral fillers, where it is also desired to retain the valuable fillers) ranges from 60 to 95%. Even very simple filters show good fiber efficiency, as fibers are easily screenable. After all, this is the basic principle of paper manufacturing, i.e. fiber retention on a wire (or screen).

There are several types of filters or screens. Their use depends on the fiber concentration in the water to be treated and in the flows to be sent to them. The drainage characteristics are also important. Very refined, fibril rich and high swelling capacity fibers are more difficult to be filtered or to be screened. Thick stock drains badly and is more difficult to form the filtering pre-layer.

We know that most filters are based on the principle of a pre-layer formation with the fibers themselves. At operation beginning, still without the layer, retention of fibers is not so high. Upon the fiber layer formation, retention and recovery rates increase considerably. It is the case of thickeners with layers and disk filters. Other filters are basically screens, allowing water and thin solids to pass through and holding the fibers (thickening filters, “side hill” type static screens, mechanical filters, etc.).



Simple filter for fiber screening
Source: Rodrigues, J.F., 2005



Filters and screens for fiber recovery
Source: CBTI

There exist other more sophisticated filters (micro-filters) for smaller particles, when the aim is to retain small dimension fibers and fillers, as those of calcium carbonate, kaolin, etc.

For the commoner filters, clarified water flows out with relatively low suspended solid concentration (50 to 80 ppm). Those suspended solids consist of fibrils, mineral fillers, etc., whereas when a super-polished water is desired, solid concentrations of 30 to 40 ppm can be achieved. The COD levels of those water types are also considerably low, ranging from 40 to 100 ppm. This is due to the presence of diluted or of very small dimension organic compounds (fibrils, extremely thin fines, starch, etc.)

Besides the filters, another way of fiber recovery consists in using air flotation clarifiers, the effectiveness of which is based on formation of fiber flocks mixed with ascending air bubbles in a suspension. The fibers are taken to the water surface and collected for reusing. Clarified water can be also reused.


Air flotation clarifiers

Air flotation clarifiers are very common at paper mills, rather than at pulp mills, because the unrefined pulp mill fibers are more easily filtered or screened than the refined paper mill fibers. For this reason, paper mills have elected air flotation clarifiers as their commonest fiber recovery methods. As well air flotation clarifiers as "side hill" screens or mechanical filters are abundant at paper mills due to their good performance. At recycled paper mills all of them are extremely common.

Flotation is an efficient system, but it is also subject to losses. Auxiliary chemicals are used to improve its performance, which aim to suit air bubble size and abundance.

To be considered as efficient, an air flotation clarifier must:

- Occupy little mill room;
- Be easy to install and to operate;
- Be able to raise to the water surface the solids someone wants to separate (fibers, ink pigments, mineral fillers, etc.);
- Produce a suitable consistency sludge;
- Have low operational costs (auxiliary chemicals, maintenance, cleaning).

The efficiency of separating fibers and other solids will depend on:

- The air flow;
- The water and sludge feeding and outlet flow;
- The suspension concentration or consistency (the higher the concentration, within certain limits, the better the separation);
- Bubble size;
- Rejection rate of liquid along with the fibers.

Air flotation clarifiers are also considerably used for de-inking recycled broke stock. Although similar to those for fiber recovery, they have some differential characteristics. In case of pigment separators, soap or surfactant is used to enhance bubble formation, whereas coagulants and flocculants are

used for water clarification and fiber recovery to increase fiber flock size and thus facilitate their raising by the ascending air bubbles. Let's imagine that there are rigid controls and conditions must be suitable for a good separation efficiency.

There are also fiber thickening and recovery situations where screw type thickening presses are used. They are not so common, but they are used to thicken fibrous sludges. They may have variable efficiency, according to the raw material type. They perform considerably well when conditions are suitable, i.e. occupy very little room, are noiseless and consume little power. At the end, an optimum consistency sludge is produced, a great advantage of this system.


Fibrous sludge presses

The traditional drum dewatering presses are common for fibrous sludge pressing. A reason for mills having them and avidly operating them is that the fiber losses may be high.


Fiber rich primary sludge dewatered by drum presses
Paper mill primary sludges are 70 to 80% organic (fibers) and 20% mineral

Practically, all separating equipment (air flotation clarifiers, screens, cleaners, filters, dewatering presses, etc.) depends on design and operating process characteristics to have a suitable performance. For its efficient operation much attention should be paid to the following:

- Hydraulic flows (attention to design flows – the closer to them the higher the efficiency);
- Operating consistencies;
- Operating pressures;
- Dilutions;
- Equipment cleaning;
- Rejection rate control;
- Rejects or accepts quality control;
- Stock freeness;
- Water temperature: it affects considerably the superficial tension (and dewatering and flotation);
- pH also may affect the fiber swelling capacity and hydrophilicity.

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## ECONOMICALLY VALUING THE FIBER LOSSES

It should be clear once more that any residue getting lost means a waste of natural resources, labor and the rich money of the company. Therefore, that residue has an economic value that in most cases is not to neglect. The process managers are often unable to see the whole savings they can have by solving the problem and go on getting along with it. If the company loses, everyone loses, inclusive the environment. The mill workers lose as well, since if the company has a lower yield it will not be so willing to share more with the employees.

For any residue losses the quantification is very similar, although a certain practice is required to find out all losses.

For the purposes of a numerical example let's have recourse to the hypothetical example of a pulp mill losing fibers in several of its sectors. Our hypothetical exemplifying mill manufactures 1,000 air-dry tons of white market pulp per day. Its average daily fiber losses were estimated to be 0.8% of the production, i.e. 8 adt/day. These lost fibers go to the primary treatment and there they are captured as primary sludge by approximately 95%. Therefore, about 7.6 adt/day of fibers become primary sludge at 25% of consistency. In practical terms the weight of the resulting pressed primary sludge in daily average values will be 27.4 wet tons. This value should correspond to approximately 25 $m^3$ of pressed sludge per day.

Some assumptions will be required for this calculation, but they will be perfectly compatible with reality at the time this chapter was written:

- Dry white pulp net selling price: US$ 700.00/adt

- Variable pulp bleaching, screening and drying cost: US$ 65.00/adt. This is the only variable cost to be given for these recovered fibers, which will produce very inexpensive market pulp bales, because all costs incurred prior to bleaching had already been paid (wood, chip production, cooking, washing, liquor recovery, etc.). What it comes to the scene is that this money spent to produce the lost fibers was being thrown away.

- Cost of opening and maintenance of a cubic meter of a landfill: US$ 6.00/$m^3$

- Cost of primary treatment and cost of pressing, removing and handling the primary sludge: US$ 4.00/$m^3$

In case the technological solution for recovering these fibers at the very point they are generated allows a recovery of 85% of what is being lost at present as primary sludge, there will be a considerable amount of additional fibers within the process and a much lower amount of fibers lost as primary sludge. We will achieve a higher production for the same consumption of wood entering the mill. Our specific consumptions – almost all of them – will be slightly reduced. The economic value may vary a little as a function of the location these fibers have been recovered and reintroduced into the process, but the gains will continue to be outstanding.

Let's then imagine that the fiber recovery filters we intend to install have an efficiency designed to recover 85% of these fibers. In our hypothetical case these fibers will be deposited again into the stock chest for bleaching. This means that they will undergo a new bleaching and screening process and thereafter will be dried. Let's estimate a loss in weight of 5% of these fibers in these operations, which will escape the effluent or lose organic matter in the reactions.

In short, there was the following:

- 7.6 adt of pulp fibers lost as primary sludge

- These 7.6 adt/day correspond to 6.84 odt/day (oven dry)

- Through the filtration stage that we intend to implement as a measure to recover fibers lost at present at the primary sludge we will be able to return to the process 85% of these 6.84 odt/day, i.e. 5.81 odt/day.

- During bleaching, screening and drying operations we will lose 5% in weight of these fibers and the new recovered fiber balance will be 5.52 odt/day. This weight will correspond to a production gain per day, without any great operating troubles.

- There will be 5% loss of recovered fiber weight, a part of which will be converted into dissolved COD in the new bleaching process and a further part will consist of new fiber losses at screening. These fibers will remain in a closed loop, as a part of them will be recovered again, but we will not calculate this now, in order to simplify calculations.

- The 5.52 odt/day of the new production achieved will correspond to 6.13 adt/day of bleached pulp baled for the market. Then, there will be a gain of 0.613% in tonnage produced, which is not at all bad for an investment of a few thousand dollars in filters to recover the fibers in some sectors of the mill.

- Let's suppose now the total investment in filters to be US$ 400,000.00 and the operational expenses to keep these filters in operation and in good maintenance condition to be US$ 0.50/adt of the total production of the mill. As a matter of fact, this will slightly rise our end product in price, but we will see in the following calculations whether or not the gains will repay this.

Finally, our mystery will be clarified and solved based on the following calculations:

- Net selling value of the 6.13 adt/day:

  6.13 adt/day x US$ 700.00/adt = **US$ 4,291.00/day**

- Additional value spent in bleaching, screening and drying these 6.13 adt/day:

  6.13 adt/day x US$ 65.00/adt = **US$ 398.45/day**

- Amount of primary sludge that will not be any longer generated and sent to the landfill:

5.81 odt/day : 0.25 (consistency) = 23 odt/day or approx. 25 $m^3$/day

- Value saved with handling this primary sludge that will not be produced any longer

25 $m^3$/day x US$ 4.00/day = **US$ 100.00/day**

- Value saved with disposal of the sludge to the landfill, so that no useful landfill volume is consumed. Let's consider that the sludge consistency of 25%, when stabilizing on the landfill will increase to 50%. The sludge will lose a certain amount of water until stabilizing on the industrial landfill. Therefore, the useful volume it will occupy will be 12.5 $m^3$/day.

12.5 $m^3$/day x US$ 6.00/$m^3$ = **US$ 75.00/day**

- Daily fiber recovery filter operation value:

(1,000 + 6.13) adt/day x US$ 0.50/adt = **US$ 503.06/day**

There are evidently other values that will change in other areas of the process. Attention should be always paid to them. Where are our changes causing effects? Of what kind are they? Do they involve more or less costs? Will any new and significant change occur due to filter installation? For instance, some different expenses should be incurred at the effluent treatment plant. They may be better in the primary treatment; or worse when using a polymer to press the secondary sludge, etc. This should be also placed on this balance, in order to solve this mystery. We will not do this in our example, but you would be well advised to look very well for what will happen to your process changes, even if they are so simple as those we are reporting. All relevant alterations must be identified and be technically, economically, environmentally and socially valued. When I say socially, I am concerned with knowing whether our change will have some effect on the workers' operating conditions or living surrounding communities, for the best or for the worst. In our present case, it will affect those handling sludge losses, as some of them may have nothing more to do and thus lose their jobs. Residues are always used to generate some additional labor requirements. When this is solved at the source, it is possible to eliminate the need for that work. It is interesting to have these people preferably relocated within the company. In case we fire them, the search for eco-efficient solutions by employees is discouraged.

Now coming back to the final calculations:

- Additional sales: **+ US$ 4,291.00/day**
- Additional bleaching, screening and drying costs: **- US$ 398.45/day**
- Savings resulting from dispensing with handling and disposal of the sludge: **+ US$ 175.00/day**
- Higher operational costs due to filter operation: **- US$ 503.06/day**

**Final balance in US$/day:**

+ 4,291.00 – 398.45 + 175.00 - 503,06 = **+ US$ 3,564,50**

As the total investment in purchasing and installing the filters was estimated by the engineering team to amount to US$ 400,000.00, the approximate payback for this technological solution would occur within:

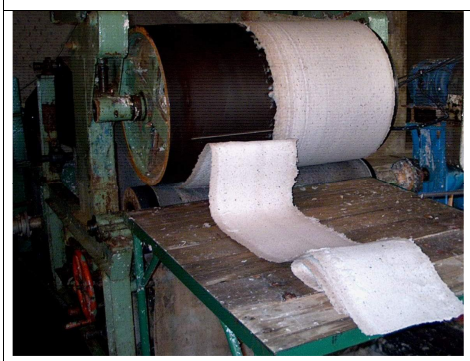
400,000.00 : 3,564.50 = **112.2 days**

This means that already on the 113$^{th}$ filter system operating day, i.e. less than 4 months, it would be already paid and yields the net amount of US$ 3,564.50/day to the mill. This is wonderful, is it not? Where is the mill manager who would not be motivated to make such an investment?

Just one more recommendation: equipment exists at a mill to yield results: environmental, economical and/or social nature. Therefore, should you need a technical solution in your company, make simple calculations like this one. Where is the manager who would not pay much attention to a report like that one written by you? Where is the shareholder who would not stir on the chair when seeing an additional daily net gain of US$ 3,564.50? In one year this corresponds to approximately 1.2 million dollars. It means 1.2 million dollars of higher net result for the company, which at the end of the year will have a higher pulp production by approximately 2,100 additional tons, just resulting from the recovered fibers. With a higher production and same overall fixed costs, the unit fixed costs will decrease without a shadow of a doubt. And this will be achieved without dismissals or cuts in training programs or in the amount of coffees served. The margins of contribution will increase, as well as the EBITDA ("Earnings Before Interest, Taxes, Depreciation & Amortization"). Financially and technically it is a success not so difficult to achieve.

Having easily solved our mystery, let's now go over to the next step, which would be negotiation and dialog within the company, in order that the mysterious fiber "theft" can be definitively solved. It is up to you to do it...

Meanwhile have a look at this gallery of photos of fibers being either lost or recovered:

| | |
|---|---|
|  | Primary sludge at a recycled paper mill |
|  | Fibers being pressed for outside recovery |
|  | Fibers that were used to escape, but soon began to be recovered |
|  | Primary sludge or process fiber loss press |

| | |
|---|---|
|  | Disk filter to recover suspended solids and fibers |
|  | Lost fiber being swept from the ground |
|  | Fiber losses via hydrocyclone rejection |
|  | Recovered fibers feasible to be reintroduced into the industrial process |

| | |
|---|---|
|  | Pressed sludge from a paper recycling mill |

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## BROKE GENERATION AT PAPER MILLS

Broke, sometimes referred to as internal broke, may be defined as the paper which is off-graded - as unsuitable for sale - inside the mill itself which has produced it. As a matter of fact, it is a product out of specification or a paper produced during an anomaly of the process. It will require an expensive and problematic reprocessing, demanding a new supply of inputs and using again the machinery capacity to be re-manufactured. It is therefore a rework that all paper mills carry out, all of them, without exception. Thus, it is an important loss at all paper mills all over the world. There is wasted paper sheet in all paper manufacturing operations, from the moment the stock of pulp and additives was transformed into a web. There is broke generation at the wet end (Fourdrinier and press section), at the dryer section, at winding and at the converting operations (cutters, packaging machines, etc.). The added amounts of all this broke are rather high, ranging from 10 to 25% of the gross production of the mill, i.e. that measured at the paper-machine Jumbo roll. Therefore, it is easy to conclude that either the papermaking technology available is wasteful and relatively inefficient or the problem is in the people using that technology. On my part I choose both reasons: both the technology is ingenuous and wasteful and the mill personnel has already got so used to generate broke, that they do not even pay any attention to its generation. The worst of it all is that there are papermakers who like to have "dry broke" in their stock preparation. They say that the machine production stabilizes the stock drains better on the wire and the web gets more easily dry. This all can be easily explained as far as integrated pulp and paper mills are concerned, but cannot be justified by any means. The papermaker using pulp that has never been dried finds it more difficult to drain and to dry it. This is absolutely true. The never dried stock

swells to a greater extent when being refined, it is “fatter”, as it is referred to by papermakers. On the other hand, the reprocessed broke pulp, which was already dried, drains and dries more easily, because it has endured a process called “hysteresis”, which is a phenomenon characterized by a partially irreversible cellulose chain molecules “linking”, making the stock more difficult to rehydrate. This stock, when dried once or more times, becomes more “reluctant” to water absorption and to swelling, all this a result of this physic-chemical phenomenon called hysteresis. A tremendous nonsense on the part of the papermakers is to want for this reason to have more broke in their stock preparation. Broke occupies paper-machine capacity in the same proportion as it is added and dosed. When returning to reprocessing, it occupies the space of virgin stock, which might be producing equally virgin paper. As a result of it, broke means production loss of a saleable product for two good reasons:

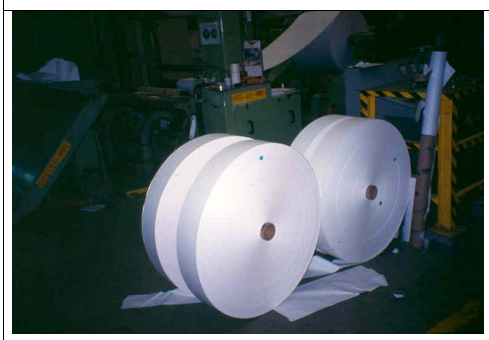
- Its quality is not suitable for sale and because of that it must be reprocessed;
- When it is reprocessed it occupies paper-machine production capacity, thus reducing its saleable net production.

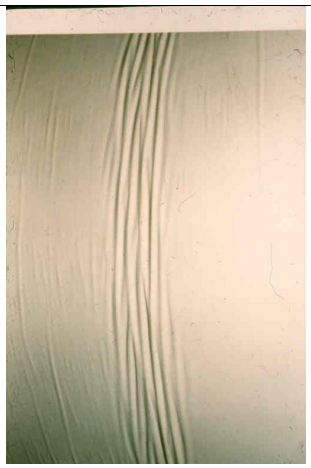
For the above reasons, very far from being positive for the runnability, as imagined by some people, broke is, on the contrary, very perverse to the papermaker. In case a papermaker of an integrated mill is facing drainage and drying problems with his web-forming machine, it is better to purchase a part of the required pulp on the market, as dry market pulp. He will pay a little more for it, but will guarantee a better result for the company. He should make his calculations of production and margins of contribution, in order to confirm this or some other option.

At a paper mill, broke is generated in several operations, such as:

- Trim on the wire (wet section);
- Web breaks in any paper-machine section;
- Slitter plus winder dry trims;
- Format remainder in roll slitting operations;
- Core shaft remainder (paper remaining on the roll after it has been unwound, due to the high rotational speed this paper roll gains at the end of its unwinding process);
- Rolls and reams of off-grade paper;
- Paper returned by customers;
- Cutting of “blankets” or “covers”, which are high amounts of paper sheets cut from the roll for some reason (continued web breaks, quality problems or defects, product or basis weight change, lab sampling, etc., etc.);
- Converting operations (cutters, packaging machines, etc.);
- Improper paper storage and handling;
- Etc, etc.

Have a look at some of these examples below:

| | |
|---|---|
|  | Wet trim on the wire |
|  | Trim and format remainders at winding (“cheeses” or “pizzas”) |
|  | Trim and format remainders at winding (“cheeses” or “pizzas”) |
|  | Roll remainder |

| | |
|---|---|
|  | Defective Jumbo rolls |
|  | Jumbo roll with moisture profile defect |
|  | Paper roll sacrificed for quality problems |
|  | Disqualified sheets of already cut paper. All added value has been lost. |

| | |
|---|---|
|  | Off-grade paper in sheets and rolls already cut at converting, awaiting to be reprocessed |
|  | Pulp sheets discarded by the lab after their analysis!!! |
|  | Little toilet paper rolls discarded for several reasons (bad sheet gluing at the roll end, defective core, format remainder, etc.) |
|  | Blankets or covers cut by the operator |

| | |
|---|---|
|  | Paper roll damaged during transportation and returned by the customer |
|  | Colored paper broke waiting for a new paper production of the same color, in order to be reprocessed |
|  | Dry and creped trims from a tissue paper-machine |

In general, at a normal paper mill, broke consumes from 10 to 20% of the applied resources (power, chemicals, water, personnel, effluent treatment, handling, etc.). I consider all this to be a sort of painful canker of our industry. This must be finished with; it must be aggressively attacked both by the paper mills and the machine manufacturers, who are technology generators. It is difficult to accept that a product manufactured in the very 21$^{st}$ century, with all advances existing in the most different technological areas, is still an object of so many wastes and so much rework. This only occurs because paper is an inexpensive product, easy to reprocess and to handle. In case it were something expensive and difficult to repair, I am sure that something would have already been done.

This painful process of losing ready paper does not end on the paper-machine; it extends throughout the value chain of the business segment. In continuation of the paper mill, the ready product, packed, in its best condition, is sold to customers such as printing houses, packaging box manufacturers or to paper end users (toilet paper, copy and graphic papers, computer papers, etc.). The losses and wastes continue happening; it seems to be an endless process of tormenting a wonderful product, made with renewable natural resources.

The paper broke generated at the printing houses is also rather significant, even though paper is the highest one among all of their costs. Paper broke corresponds to the most significant residue generated by the printing industry and to the most valuable as well. Paper represents on average 60% of the printing production cost, which is an enormity to be wasted so much. The average paper losses at a normal printing house ranges from 10 to 15%, but there are also extreme cases ranging from 3 to 30%. When paper is lost at a printing house, losses do not amount to paper only, they also include ink, electric power, working hours, handling, productive machine hours, etc., etc.

The main printing house paper broke components are as follows:

- Residues of improperly printed paper;
- Crumpled or soaked paper, or damaged by handling;
- Paper packaging;
- Broke and trims generated when cutting printing piece formats;
- Inky, greasy, oily paper and the like;
- Paper spoiled by handling;
- Paper spoiled at tests and trials;
- Paper preventively removed from the roll beginning, to guarantee good machine operation;
- Printed products returned by customers;
- Etc., etc.

The same problem occurs at converting mills, which purchase corrugated board or cardboard, converting them into packaging boxes. Due to the different kinds of losses, among which are those resulting from box cutting, losses in these operations may reach from 15 to 25% of the purchased paper. Once again, huge amounts of paper being rejected. And the worst of it all is that at those converters and printing houses there is not even the possibility of internal reuse, i.e. to direct the rejected material back to the pulper. The residue must be handled, pressed, stocked and sold at prices very far from the purchasing price of good paper, which was purchased as raw material for the production process.

Let’s have a look at some more examples:

| | |
|---|---|
|  | Printing house remainders |
|  | Paper residues generated at exercise book manufacturing (hole opening for the plastic spiral) |
|  | Printing piece trims |
|  | Cardboard box cut-outs |

| | |
|---|---|
|  | The boxes that generated the cut-outs represented on the photo right before. This photo shows also some discarded boxes, rejected because of quality problems. |

Among the great losses occurring, not only the physical ones (tons of products) are important. Something the technicians of all these broke generating industrial units must learn is to calculate the losses of economic nature, not to speak of those of environmental nature, resulting from the higher use of resources of Nature (fibers from trees, water, power, fuels, additional pollution, etc., etc.). Economically, broke and the paper residue depreciate value, they destroy value at the companies in the twinkling of an eye. If a paper leaves the product status (at the paper mill) or the raw material one (at the printing house) to assume a new broke or residue status, destruction of value is immediate and very great.

We will now give a very simple example of a printing house consuming 10 daily tons of offset type white papers in the form of rolls and reams. The printing company pays on average approximately US$ 1,800/ton of paper. Its daily paper raw material expenditure corresponds to US$ 18,000. However, in its printing, storage and handling operations it goes as far as to lose (generating broke and wasted paper) about 10% of this amount, which is converted into wastepaper residue. It means that this printing house rejects as residue one ton of paper per day, such residue being generated in the most different ways, as well as in varied formats and cleaning levels. This one ton of paper residue generated at the printing house every blessed day begins to require some working operations, such as: spoiled paper collection, separation by type (clean, dirty, etc.), pressing it in order to save space, storage, handling, transportation, hours worked even to find customers for the residue, etc. To spoil paper the printing house spends also many resources having costs: electric power, ink, handling, worked hours, water, machine maintenance, etc., etc.). Let's suppose, based on a deliberate underestimate, that this additional expenditure amounts to US$ 350 per ton of paper residue, this whole amount being spent in "silly" operations, which do not add any value, but on the contrary destroy some value of our printing house. As the paper broke is pressed to bales, the sales manager succeeds in selling this broke as second-class white broke (since it

is inky, oily, etc.) at a price of US$ 300/ton. Based on these data, it is now possible to calculate the daily value destruction of our printing house as a result of such a paper residue generation. Let's go through our simple financial mathematics:

<u>1 daily ton of paper residue</u>:

- Value of the paper purchased as raw material: - US$ 1,800
- Value of printing processing, handling, storage , etc.: - US$ 350
- Paper selling price as broke to a broke buyer: + US$ 300

Final negative balance of US$ 1,850 per day just with this wasted residue. In one month, this would correspond to nearly US$ 55,000. It would be interesting to the printing house owner to reduce losses by 2%, so as to lose just 8 instead of 10%, to have his net result increased by approximately US$ 11,000 per month. It is easy to understand that any new expenses with training of personnel, machinery maintenance, technological optimizations and even a new investment, might easily pay back for themselves.

Yet to complete a little more this negative paper broke role at our printing house: this amount of US$ 55,000 per month is just the tip of the iceberg. When generating broke, disqualifying the product and losing saleable production, the company generates less net sales. Instead of a good product from valuable raw material, it generated residue. Its overall and unit costs will increase, its margins of contribution and its profits will decrease. Which level of losses a company can afford? It is a good question; to be answered case by case.

I would like to stress the following in our example: the company purchased paper, its main raw material, was paid at US$ 1,800 per ton. In a fugacious space of time, this paper may become residue and the same ton may be sold at US$ 300. I wonder whether there is at our printing house anything destroying more value than that. Then, why does one not attack this problem straight, with creativity and determination? Why should one get along with this residue, thinking that it does not exist just because the spoiled paper does not accumulate, as far it is sold at once as broke?

The same kind of understanding applies to a mill converting board to boxes, or even to a paper mill generating high amounts of reprocessed broke. Economic examples of the latter case will be seen just a few pages ahead. Do you agree now with what I have been always referring to as "broke perversity"? Then wait a little more, this perversity is even much more perverse than that.



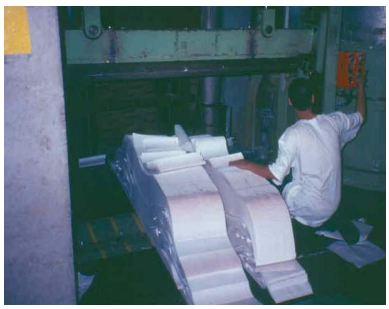
Good paper converted to wastepaper at a printing house

It is more than evident that broke and paper residue cause value destruction at our industry, throughout the whole value chain. For this reason, the index of generated broke and the value destroyed by it should be some of the most important indicators of our mills. As far as the paper mill is concerned, there is also the problem that broke is immediately disintegrated, returning to the process. Thus, managers and shareholders lose sight of it. It is as though broke were an "invisible loss": we know that it exists, but have no clear sight of it. It is also common that we have at our mills no precise idea of all kinds of broke, no broke type segregation and quantification. Should we have it, the search for solutions would be facilitated. It should be also remembered that each kind of broke has different value destruction cost. One ton of off-grade paper on the ream-packing machine destroys more value than an equivalent ton of off-grade paper generated at Jumbo roll rewinding. Both are perverse value destroyers, but the packing machine off-grade paper is even more perverse, since it consumes a higher amount of work, power, raw materials, packaging, intermediate inventories, etc., etc. A good technician can easily calculate this all. Thus, indicators of daily value destruction by the different broke types should be created. I am sure that such indicators would stir mill owners and managers much faster to action, so as to attack the problem with determination, aiming to minimize it. Therefore, let's keep our eyes widely open; the time to change our attitude and action at our mills has definitively struck. It should be also remembered that every paper scrap has a very low economical value, even the one returning to the process to become paper again.

There is another problem at our paper mills, another one my goodness. A part of the broke has not even the chance of turning into paper again, it does not deserve to be reprocessed, because it is too much dirty or stained with lubricating oils and greases. Then, instead of being reprocessed it is sold at symbolic prices or burned in the biomass boiler. However incredible it may appear, this type of broke is very common. At many mills the paper-machine basement is very stained with oil. When web breaks occur, the paper dropping there gets dirty, becoming unsuitable to be reprocessed. Well, if the web gets dirty every time there is a break at the dry end of the machine, the state of cleanliness of these basements can be easily imagined… Or else the state of mechanical maintenance of the machines,

with continuous lubricating oil and grease losses. One problem more to be faced by our managers. They avoid spending in maintenance, but at the end of the month they sell some tons of contaminated and dirty paper at derisory prices. Another example of value destruction just in front of our very eyes. On average, for mills with not very modern machines and presenting some deterioration, this corresponds to approximately 0.2 to 0.5% of the production. It is incredible, is it not? I wonder whether the managers are fully acquainted with these figures. Nobody throws 0.2 to 0.5% simply in the garbage can, is it not so? Then why accept to lose such an amount of oily and greasy paper? For a medium-sized mill producing 5,000 monthly tons, this oily paper loss may correspond at least to 10 to 25 monthly tons. I wonder whether the investments to prevent these machine basement contaminations would not be paid with this wasted value. What would it amount to solve the lubricating and oil loss problems of our machines? Moreover, how much is lost with these oils and greases, which are also expensive and are also being systematically lost? Wait for the end of this chapter to find some examples of economical valuation of losses, which will enable you to easily calculate some cases of your real life.

Due to the intense broke generation at a paper mill, all of them have a broke system. Its purpose is to recover fibers and minerals as much as possible, doing this so as not to cause any problems to the new paper manufacturing, as well as to minimize the losses resulting from this work. The function of this broke system is to disintegrate the broke, to stock it, to readapt it to a new use and to mix it with the virgin stock. Thus, the broke has a new opportunity to be transformed into a paper sheet. Even so, as broke generation is high, a part of this reprocessed broke will at last come back again as re-broke. One more loss to add up. There is definitively an inefficiency loop in this technological way of making paper. It is lower on the best and most modern paper-machines, but it still exists and is always present in our operating day-to-day life. For this reason we cannot remain insensitive to this problem.




Wasted paper preparation and disintegration system

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## BROKE SOURCES AND CAUSES

As already seen, broke means wastes, losses, sources of rework and misuse of natural resources. They occur in all areas where the paper web is being processed in order to become a saleable quality product. It also occurs even when the sheets are already finished, ready, packed and in their best possible quality to be delivered to the customers. For this reason, broke is not only a responsibility of the production area, but of the sales and internal and external logistics areas as well. Because of that I stress that it is necessary to know very well the causes and the generated quantities of each type of broke, in order to search for solutions at the point where each problem occurs. After all broke goes to the pulper and therefrom to the re-slushed broke chest, we will only know the overall quantity, without discerning individual causes and reasons. Considering this, I intend to evaluate in this section case by case the main wasted paper generating causes at our mills. Besides identifying the generating points, it is also important to quantify them. In case there are no measures and figures, an internal indicator may be even established, like a volume (piles and rolls) measured by means of a measuring tape, a volume of buckets full of broke, etc. What really matters is to have a quantification system, as otherwise the magnitude of the problem will not be known.

Broke is no paper mill exclusiveness. The market pulp mills also generate broke, although in lower amounts. The sheet formation of a higher basis weight web, the lower machine speeds, the unitized bales always of the same size cause the broke percentage at those mills to decrease much, but anyway broke does occur there as well.

Following are the broke types generated for reprocessing at the market pulp mills:

- Wet end trims (the narrower it is, the less broke is generated);
- Dry end trims (the narrower it is, the less broke is generated);
- Web breaks (wet end and dry end);
- Off-graded pulps;
- Bales ruined by handling;
- Bales returned by customers;
- Dirty covers;
- Format remainders from cutting pulp sheet covers;
- Etc., etc.

Also here, broke is an illness, but it is of small morbidity, without any serious consequences for the health of the mill, since the broke and repulping proportion is very low. Nevertheless, also here broke means losses, which can be studied and minimized. Let's have a look at some examples, in order to solve the problem at its origin:

- Operating, engineering and maintenance improvements to reduce web break number and duration;
- Pulp handling and storage improvement;
- Faster product classification;
- Development of specific customers for selling off-grade products, for instance; low viscosity, higher moisture or higher dirt level , etc.;
- Study of a new cover sheet size, in order to avoid format remainder to be repulped when manufacturing covers.

Good practice, production organization, a clean machine, good process and operation management, good maintenance and very good planning help reduce broke generation considerably.

Broke in the form of sheets and bales damaged by market pulp transportation

Broke generation is considerably higher at paper mills. According to the paper grade and the technological mill age such a generation may reach up to or even over 30% of the gross paper-machine production. For this reason, I consider calculating broke based on the gross production at paper-machine outlet (Jumbo roll) to be an unsuitable procedure. The mill can

produce 1,000 daily tons of gross production, but is able to make only 700 tons of saleable product. Its inefficiency in terms of broke generation based on gross production is calculated as 30%, but if it is calculated on the saleable production basis this value raises to 42.8%. Saleable production is the one that generates the earnings to the mill, not the gross machine production, which is something just of internal nature, to see how much the machine has run (runnability measure). Observe that in the above example the mill produced 300 daily tons of paper that have returned to the machine as broke. When entering again to the machine, those 300 daily tons have occupied machine production space for the rework. Then, the machine has lost 30% capacity, since it has used 30% of it to make a paper that had already been made previously. Then, there are losses on both sides: on the outlet (as broke) and on the inlet (as paper-machine capacity loss). This is very serious for someone having a business intended to yield positive economical results. Earnings and margins of profit decrease, while costs increase.

To reduce broke it is necessary to measure it, i.e. to quantify its generation, no matter how difficult it is. Besides, it is necessary to identify the causes of its origin, which we will call "root causes". Sometimes we believe some causes to be simple, we do some make-ups, but the problem basically remains. For this reason the real understanding of our process should be searched with determination. Some causes are relatively easy to identify, as they are associated with web breaks, both at forming and drying machine (wet and dry ends). In other cases, they are associated with the paper quality produced. In case of off-grades, the operators in general have records of disqualified paper quantities. However, in case of breaks, the operators do not weigh the wasted paper, sending it directly to the pulper. Notwithstanding, it is possible to easily calculate this generation by multiplying the theoretical machine production by the time the break kept generating broke due to the web break. Simple and necessary. Thus, we will be able to know not only the break time, but also the broke quantity generated. And to value it in economic terms.

Another serious cause of broke generation is the variability of the process, which causes product quality fluctuations. Part of this variability is natural and is due to the variation of raw materials itself, of their preparation, of the machine operating conditions and the operators' attention. Another very significant part is variability introduced by the operators and the managers. The amount of broke generated by this root cause – management – is very high. Some of its derivations are listed below:

- Frequent changes of products, basis weight, paper grade, paper color, etc., etc.;
- Frequent roll format changes to meet customers' requirements regarding formats not compatible with our machine widths;
- Lack of planning between sales area and production area;

- Lack of planning between production operating area and maintenance area;
- Etc., etc.

A better planning between areas is fundamental for these great broke sources. If production and sales get in tune with each other, the variability of the process will decrease very much and thus broke generation will be also reduced. For this reason, broke generation should be highlighted with regard to the amount of saleable product at each paper run. One way of improving this mismanagement is to calculate the value of each ton of generated broke, to identify its cause and to place this additional cost ("cost of the loss") exactly in the area causing the loss. If the cost is always paid by the larger area (production), without discriminating the reasons and without making the causers responsible, it becomes very difficult to solve the broke generation problem because of inappropriate management. When a regular procedure of making responsible those causing the loss will be adopted, a greater internal discipline will be gradually imposed. It may last a little until they learn to work in this way, there will be some complaints, but things will accommodate soon and the mill will change in terms of quality level. It is more or less as demanding full machine cleanliness. The personnel meets with some difficulties, it may even occur that some production is lost in the beginning, but at last everything accommodates quickly. And thus, the results will surpass the initial losses. The human being easily adapts to changes; it is one of the most versatile animals among those created by Nature.

Broke is generated at all paper mills. We have already seen many of its causes, typically technical and management-related ones. There exist also those connected with improper procedures, as well as with operators' qualification. There are also causes related to the operating conditions, as ergonomic situations unfavorable to the operators. It is really amazing that there are still paper mills in this our large papermaking world where the paper web hole detector is a worker lying under the web passing over him in an open part of the machine. He has an alarm to sound whenever he notes a hole that may disqualify the paper roll. It is very difficult to ask the workers for commitment in situations where the work is done under such conditions.

Another thing I often observe is the operators' lack of affection and love for the paper. They forget that the paper is the result of their work, it is their masterpiece of workmanship. The paper should be respected as our own work of art. However, one sees the personnel using paper sheets to protect themselves from the rain, as a carpet to clean their shoes; or else using short paper rolls to serve as stair or chair to carry out some maintenance, etc., etc. I consider this lack of affection and respect for the paper (and for the pulp in sheets as well) as something our managers should solve and demand more at the companies. The paper product valuations, the cleanliness, the organization of areas, are basic things in any productive

process. Unfortunately there is still much to be done in these respects at many paper mills, in practically all countries where paper is manufactured.

Many companies use to calculate the broke cost within their "non-quality costs". When calculating these values, making them public to the managers, the operating efficiency improves and the relationships between areas become more professional and less informal. The skillfulness to negotiate is developed, as well as a better understanding of the business the papermaker is inserted in. The areas possessing higher broke generating potentials due to the management are: production, sales, maintenance, quality control, logistics/storage. A suitable relationship and joint effort concentration, so as to observe the whole and not the feud may have a strong impact on broke reduction by the mill.

All mills want and need to increase their operating efficiency, not only the efficiency of their machines. When speaking of better efficiency we refer to the whole, rather than only to the paper-machine. We may have machines operating with high operating efficiency with regard to time, availability, capacity utilization and quality. However, the products made by the paper-machines are directed to converting, which may generate a huge amount of broke. Also at storage, at handling and during transportation, good products may be rejected, because they are damaged by bad operation. As a result of it, our paper-machines show excellent machine efficiency, while the company as a whole is going on badly.

The paper-machine operator in general is used to keep his machine producing and operating at its design capacity, above it, or else at the so-called sustained production capacity. He also knows that many web break and broke generation possibilities may be minimized if he reduces the machine speed. Nevertheless, if he lowers the speed too much there will be in fact no more web breaks, but the machine efficiency will also become too low (low capacity utilization). For this reason, the machine managers must be well acquainted with economic values and results, not only with technical values and production costs. They must optimize relations between paper-machine operating efficiency, broke quantity and time lost with breaks and production losses (not only those due to web breaks, but also those caused by broke return). I would like to insist once more that the broke return to the machine is much more perverse than many of our papermaker friends suspect, as it means a loss of saleable production of the mill. It is curious that this has not been included among the indicators developed to measure the paper-machine operating efficiency. It is already time to begin to deduct this inefficiency from the efficiency calculations.

The broke generated at our paper mills is in general rather clean, it has a well-known quality, it is a young, fresh, recently produced paper. It is

also rather similar to the paper we are used to produce, as after all it is generated from it. For these reasons, the papermaker does not get mixed up to use such a broke. He has only troubles when the paper is of a very different type; as for instance colored paper broke or made with unbleached fibers. These special broke types do not accept mixtures with many other paper grades; they must keep waiting for their turn to be repulped again. If for instance a red colored paper broke is not repulped during the red paper run, it should remain in the warehouse, waiting for the new red paper run. This causes financial costs connected with storage and increases the need of working capital for the company. All the money already spent for producing this broke will remain stopped until it turns into saleable paper. It may last some days or some months. In a country where the rate of interest is still high, this financial broke storage cost is also high. I suggest this to be also calculated and to be included in a spreadsheet regarding the so-called "invisible costs".



Broke types that the moment of turning again into paper is difficult to determine for (problematic broke)

The generated broke at recycled paper mills often ends up mixed with broke purchased on the occasion of stock preparation. The papermaker, as already seen, prefers his own broke, because it has a better quality than the purchased broke. For this reason, even instinctively he tends to want more own broke and less purchased broke. It is very naive of him, but this does happen! Wanting to generate more own broke in order to facilitate the

machine runnability is definitively a nonsense. The mill produces paper, not broke. Someone must urgently open this operator's eyes to this fact.

Paper broke is a sum of wastes: material, labor, financial storage costs, rework, reprocessing, defect recovery, etc., etc. It means an inefficiency of process, of production, of technology and of management. Broke demands immediate action and consistent plans of attack and search for solutions. The quality and environment programs always try to privilege the broke rates as goals to improve in their continuous improvement plans. It was already said that the best way to start this is by understanding how much and why broke is generated. Then, a good papermaker begins to try to understand his broke generation as much as possible. He begins to talk to the broke, to ask why it was generated, what is the reason for its appearance in the process? To clarify the matter even more, he tries to make mass balances, as well on the paper-machine as in the winding and converting operations and also includes the paper returns from the commercial area. A simple mass balance on an Excel spreadsheet will give us good ideas of where resources are being wasted. A mass balance is concerned with material inlets and outlets in each area. The inlets are in the form of inputs, raw materials and power, while the outlets are in the form of products, solid wastes and pollution. When doing this, step by step, and having everything recorded on a spreadsheet, any papermaker, in any place all over the world, will be able to manage better his broke. He will be also able to have a better vision of his process and of the results of his decisions. It is not at all difficult to work by means of mass balances, of quantifications, of process analysis and by searching for creative solutions for the problems. This has been a victorious procedure even at small mills, without much instrumentation, automation and sophistication. It is enough to have good will and determination, in addition to a suitable training and knowledge. The knowledge required is the normal one for any papermaking technician.

Let's now review what may be included in the broke addition, in order to facilitate its separation. We will not consider the Fourdrinier white water to be waste. White water is a recycled item, an internal loop, having also its inefficiency, but this is another thing. White water is something inherent in the paper manufacturing process, in the way it is made at present. White water may be only considered to be waste if one begins to throw it away, thus wasting fibers and minerals. However, this would be rather the case of fiber losses, which was already seen in the beginning of this chapter. Retention of fibers over the wire is one of the possible ways to evaluate "white water inefficiencies".

- **Wet broke**

Wet broke sources are:

- The trim cut on either side of the web on the Fourdrinier, if this trim drops into a wet broke pulper and does not go out with white water. The wider this trim, the higher will be the amount of it. This figure is significant. If a 10 m wide machine rejects 5 cm width on either side, it will be rejecting 1% of the web area.
- Web breaks at wet end, more usually after the couch roll or in the wet press section. It is the paper that continues to be formed at the breaks and is directly sent to the pulper located at the wet end of the machine.

- **Dry broke**

Dry broke sources are:

- Paper web break at the dry end (dryers, machine end section);
- Dry trims;
- Paper out-of-specification because of moisture profile defects (curl, streaks, wrinkles, creases, etc.);
- Paper out-of-specification for other defects (fold, folded sheet, badly piled paper, rolls with many splices, holes, dirty paper, paper contaminated with plastic, etc., etc.);
- Paper returned by the converting area because of defects such as: irregular edges, irregular rolls, eccentric core, misaligned pile, out-of-format paper, badly packed paper , etc.;
- Damaged, hit, holed, soaked paper, or mistreated by handling (associated with storage, transportation and handling problems);
- Paper disqualified for intrinsic properties (brightness, dirt, tear, opacity, bulk, porosity, fiber direction, two-sideness, wire marking, internal sizing, delamination, etc., etc.);
- Core shaft or roll end remainders;
- “Blankets” or “covers”;

- “Cheeses”, “pizzas” rolls discarded for improper format, even having excellent intrinsic properties;

- Returns by customers;

- Paper preventively off-graded at run changes (transition paper): basis weight, paper grades , etc. (this preventively disqualified paper may leave in the form of blankets or else it may be directed to the dry pulper at machine end, until the new paper run has stabilized on the quality specifications required);

- Broke generated in the converting operations; cutter trims, blankets preventively removed by the operators, paper with defects, crumpled paper, folded paper, the most different defects, according to the paper grade and the converting type in question.

Broke is often a question of attitude

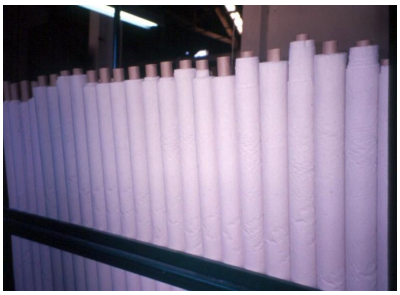
The whole added broke reaches extremely high amounts at our mills. A standard benchmark type mill producing printing paper has 2 to 5% of broke generation between paper-machine and slitter + winder, plus 2 to 5% between slitter + winder and the finished product, sent either to converting or to customers purchasing rolls. At conversion (“cut size” – format cutting into reams, office paper, A4, etc.) the broke generation rate ranges from 2 to 5%. Without considering the other types of broke, just adding the broke types generated by the operation of our process itself under optimum conditions, it can be seen that this overall broke can range at this model mill of ours from 6 to 15%.


Dry trim type broke

With regard to tissue paper, its manufacturing in Brazil is considerably based on using wastepaper and paper recycling (secondary fibers, deinked or not). Also used is much wastepaper purchased from printing houses, which are also great paper residue generating units, as already seen. Paper recycling also generates much paper residues and many fiber losses, in case one does not pay due attention to these manufacturing process "illnesses". Besides, the machinery of many recycling based tissue paper companies is relatively old; a part of it already tired due to the long life of efforts. Thus, if one does not pay the due attention, much broke may be generated and many fibers may be lost as well.
At such a mill, the following broke generation figures can be considered to be normal:

- Broke generated on the paper-machine: 2 to 5%
- Broke generated at the slitter + winder: 3 to 5%
- Broke generated at "log" production and selection: 2 to 4%
- Broke generated at the reels and little roll slitting: 3 to 6%
- Broke generated at finishing (defective rolls, packaging problems, etc.): 2 to 6%
- Trims, "log" sawdust , etc.: 2 to 3%

"Logs" are cored paper rolls (about 2.5 m long), containing the sheet exactly as long as it is desired on the toilet paper roll (30 or 40 m). The "log" slitting operation into little roll shapes generates paper dust, an additional broke, not in the form of sheets, but of dust, which later turns into fiber sweeping. Vacuum devices are frequently installed to collect dust and to send it back to the paper manufacturing.



"Logs" and toilet paper rolls

The sum of all these broke types generated and previously reported for toilet paper manufacturing is also rather perverse. From 15 to 30% of the production takes at last the form of broke.

Farther the broke is generated from the machine headbox, more expensive it is because economic value addition. To reject a ready toilet paper roll because the packaging design is not centralized, or because the glue sticking the sheet did not glue the roll throughout its width, should be considered to be an environmental outrage. More water, power, work, chemicals and much more than that will be spent just for typical make-up reasons. To reject a ready toilet paper roll means to reject paper, core, packaging, aromatizing compound, glue and much more than that, which was added to it.



Broke types generated at tissue paper manufacturing

We have seen up to now that there exist several broke types at paper mills and that their generation has numerous causes. They are so many that a certain organization is required to face them. Moreover, many of them are interrelated like a matrix network. For this very reason one has to look very attentively for the root causes, those feeding the remaining ones. Usual tools for quality and process control management are very useful: fishbone, Pareto graph, cause tree, control graphs, etc. In case you are not yet using these tools for continuous improvement, start by studying and by choosing some of them in order to be used by your operators. They are very simple to use and extremely useful.

The paper defects may be considered as one of the main reasons for having more broke at a mill. Defective papers become invariably broke, or else they are sold as a second-class article at a lower price. In some situations they may also become raw material for some secondary process at the mill (for instance, as packaging, at core manufacturing, etc.).

Defects can have generic and technical causes. There are many mill operation and mill machine conditions that are reflected in the production of worse quality paper. Thus, the off-grade paper rate may increase. We will show you some of these technical conditions, in order to call your attention to the points where some of the root causes are situated, which we are mentioning as the greatest broke generation causers.

- **Most common causes of paper defects, originating at the paper-machine wet end**

- Abrupt consistency variations;
- Insufficient slushing of the pulp purchased in sheets;

- Badly prepared stock (excessive refining, wrong ingredient dosages, etc.)
- Dirt in the stock (a serious cause of breaks);
- Generalized dirt in the paper-machine circuits (pitch, stickies, decayed and putrid stock, slime, etc.);
- Machine feeding fluctuations;
- Wire speed variations;
- Wire holes;
- Changes of products being manufactured;
- Temperature variations;
- Deficient headbox, irregular wire supply;
- Dirty, spoiled, compacted felts and wires;
- Piping plugging;
- Irregular pressure in the press nips;
- Irregular drainage on the wire;
- Foam and air bubbles in the stock;
- Irregular web caliper, both in longitudinal and cross profile;
- Irregular moisture in both profile types;
- Excess or lack of retention;
- Flow variations (badly controlled pumps and valves);
- Too much turbulence on the wire and on the forming table;
- Two-sideness due to unsuitable wire or felt design;
- Excessive fiber orientation;
- Improper maintenance: unlevelling, wear, oil and grease leakage, equipment positioning, wire tension, adjustments, misalignments , etc.;
- Power shortage;
- Precarious controls;
- Etc., etc.

- **Most common causes of paper defects, originating at the paper-machine dry end**

- Vibrations, misalignments, adjustments, positionings;
- Unsuitable web tension;
- Irregular drying on both cross and longitudinal profiles;
- Cylinders that do not drain the water condensate;
- Bad steam distribution to the dryers;
- Unsuitable web temperature variations (over-drying, lack of drying);
- Worn rolls, irregular surfaces;
- Dirt on the dryers (pitch, glue specks, pigments, etc.);

- Clothing: worn, plugged , etc.;
- Air pockets between sheets and cylinders;
- Badly made splices;
- Irregular cutting and edges;
- Marking caused by the calender stack;
- Badly positioned core;
- Energy shortage (electricity and/or steam);
- Precarious controls;
- Etc., etc.

Most of these causes have a domino effect, they potentialize the paper defects, they combine with other causes and increase the suffering of all operators and managers, producing web breaks, lack of quality specifications, production losses.

It is common for web breaks on paper-machines to happen at points where the paper web (or the roll) needs to show conformity (strength, integrity, uniformity, cleanliness, tension, etc.). They occur more frequently at the following points:

- Fourdrinier outlet;
- Wet press section;
- Dryer section inlet;
- Size press;
- Dryer section outlet;
- Winding;
- Rewinding;
- Calendering.

At converting, as the rolls are slit into formats and packed, the commonest breaks occur for the following reasons:

- Dirt in the sheet;
- Dirt of the equipment;
- Lack of planning between the different sections;
- Unsuitable tensions;
- Change of products;
- Equipment failures (slitter cutting, wear, misalignments, vibrations, etc.);
- Operating failures;
- Lack of care on handling;
- Etc., etc.

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## THE BROKE PERVERSITY

All generated broke is associated with losses, even if it is reprocessed and becomes paper again. It is not at all advantageous to do this reprocessing operation. If reusing broke did not exist it is very likely that other solutions to generate less broke would have been already found.

The broke perversity expresses itself, as already seen, in two major ways:

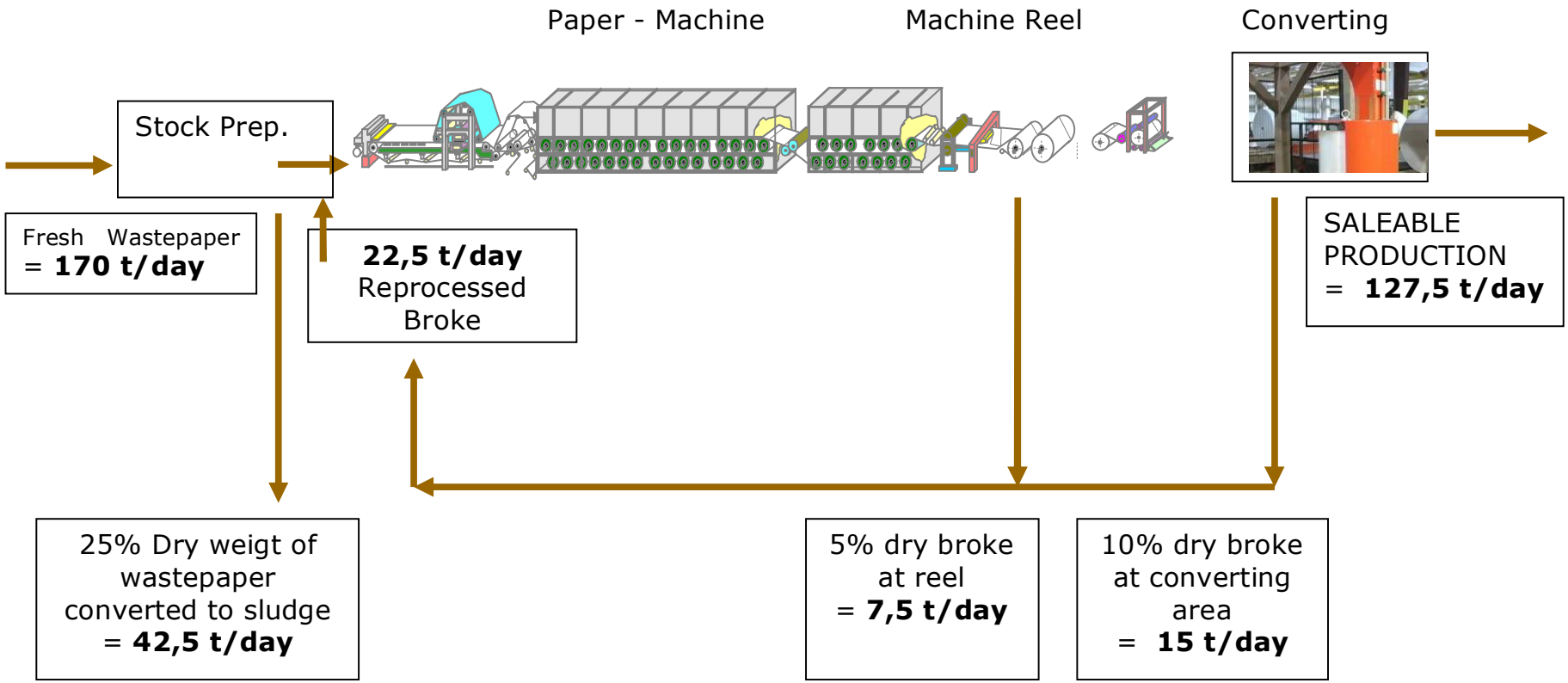
- By transforming products that might be good and saleable into broke to reprocess, consequently consuming resources;
- By the capacity lost by the paper-machines, which when reprocessing the broke are failing to produce further amounts of virgin saleable product.

Broke lowers perversely our results, both of technical (efficiency and productivity) and economical (costs, margins and profits) nature. Economically, there is a high cost involved in managing, controlling and reprocessing all this. An economical loss also results from the fact that the article which was produced and became broke could not be sold, involving still more costs. Therefore, costs are higher, sales are lower, results are worse. A triple penalty for the company.

Just for a graphic and numerical view of this perversity, let's consider the example of a recycled paper based toilet paper mill. Our hypothetical company has a machine capable of processing 150 dry t/day of ready fibrous stock. This is the sustainable feeding capacity of its paper-machine. These 150 t/day comprise both the stock produced from wastepaper purchased from third parties and the broke from its own process. When it generates less own broke the mill is able to purchase more wastepaper and its production of saleable products increases. On the contrary, when the mill generates much broke, it occupies much machine capacity by reprocessing that broke, it purchases less wastepaper from third parties and produces less saleable paper.

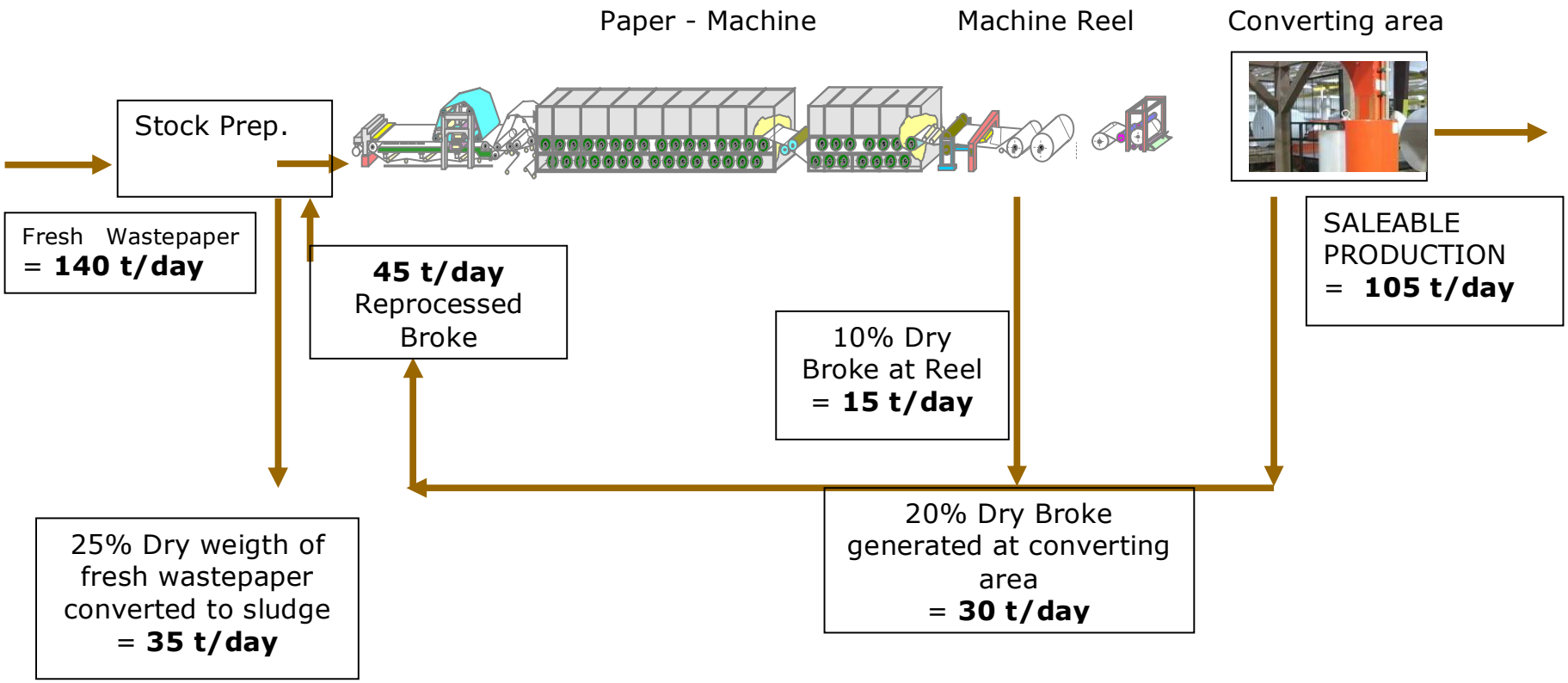
Let's consider two situations for this company, taking as examples two extreme cases of total broke generation for operations like that: 15% and 30%. We will consider these 15 and 30% of the paper-machine gross production. We are considering here just the dry broke generated at the dry end of the machine. The wet broke would further worsen both situations.

**Case 1**: 15% of dry broke generated in the dryer section and converting area




Paper-machine being fed with 150 t/day of dry stock and considering that no stock losses occurred between headbox and paper roll outlet, due to internal white water recirculation.
Broke being reprocessed at the rate of 22.5 t/day.

**Case 2**: 30% of dry broke generated in the dryer section and converting area




Paper-machine being fed with 150 t/day of dry stock and considering that no stock losses occurred between headbox and paper roll outlet, due to internal white water recirculation.
Broke being reprocessed at the rate of 45 t/day.

Some naive people may even think that the broke return give some relief to the stock preparation area, "it is better for the environment, as less sludge is generated", etc. This is definitively a unilateral vision. However, it is sufficient to consider the saleable production output in both cases to see the leak resulting from broke increase. In our hypothetical case 2 the saleable production is significantly lower for the same paper-machine gross production. It is the saleable product, not the paper-machine gross production, that settles the company's accounts. The paper-machine production at the reel was kept the same. I can state without any hesitation that gross production is an indicator used just for the internal paper-machine runnability control. All our accounts and indicators need to and must be referred to the production of saleable products.

Then let's recalculate the broke generation based on the saleable production, not on the paper-machine gross production:

The results of it will be as follows:

Case 1: (22.5/127.5) x 100 = 17.6%
Case 2: (45/105) x 100 = 42.9%

The situation has become even more dramatic, do you not agree? It will get even worse when we begin to do an economical valuation in addition to these technical values. We will see this in the following item.

An interesting thing is to consider these two cases from another perspective, that of the improvements we may obtain if we reduce broke incidence. For instance, if a mill is in situation 2 and it manages to shift to situation 1, have a look at what it will obtain with the same mill facilities. Maybe it will have to make some investments, but they will be small when considering what may be gained by means of them.

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## ECONOMICALLY VALUING THE BROKE GENERATION

The following should be clear for all of us from the very beginning of this valuation: when it is generated, broke yields a first loss, which is its own generation, instead of good paper, ready for sale. This has a cost, which we will show you what it amounts to. The other loss represented by broke is the reduction it causes in the production to follow from our paper-machine, because its return acts as a brake for machine production. Our production capacity decreases when broke is reprocessed. For this reason there is a double loss, as I have repeatedly mentioned. And it is for this reason that

broke must be negatively valued in economical terms twice: as the production loss it causes after being generated ("production slow-down") and as residue when it was generated, consuming resources and losing value due to the fact that the paper that should have become a good product has turned into broke instead of it.

Then, to understand well the real value of broke, let's divide our calculations into two parts:

- The first one will be called **cost of non-production** (or of the non-generated earnings due to the saleable production loss, as a consequence of using the machinery capacity for the broke);

- The second one will be called **value destruction by broke as a residue**, where the loss of value of the broke that should have come out as good paper will be valued; plus the losses due to handling, storage, etc. of that residue.

- **"Cost of non-production" or "stopped hour cost" or "cost of the non-productive hour"**

It is very simple to calculate the "stopped hour cost" at a paper mill. It is sufficient to know exactly three figures: the net unit price, the product average unit variable cost and the saleable production that failed to be produced during one hour.

When manufactured, any product is composed of two basic costs, to be paid by each product unit:

- Fixed unit costs: unit costs of all tasks, services, rentals, etc. to be paid by the company, regardless of being producing or not. In other words, even with stopped machine the company incurs these costs.
- Variable unit costs: direct manufacturing costs, those paid when making products for sale. They consist in inputs, raw materials, power; everything used for that manufacturing. If the mill does not produce, these costs do not exist. The companies must know how to do this cost separation very well, in order to be able to understand how it all works and thus to optimize their results.

When our mill is stopped for any reason, the variable costs do not exist: since one does not produce, one does not spend either. However, the fixed costs go on occurring. On the other hand, the production that failed to be produced during that shutdown failed to be sold as well (since it has not been produced) and did not yield a net income.

The difference between net sales price and the variable unit cost is the difference in income that failed to get in the company, per each product unit that was not produced. It was cash that did not enter in the company's accounts. This difference is called margin of contribution, that is:

**Margin of Contribution** (MC) = NUP - VUC

where: NUT = net unit price
VUC = variable unit costs

By way of example, let's imagine a printing & writing paper mill having a gross sales price of US$ 1,850.00/ton. After deducting taxes, freights, insurance, etc., the resulting value will be the net sales price at our mill gates. Let's estimate that this all corresponds to 30% of the gross sales price.

NUP = 0.7 x US$1,850.00 = US$1,295.00/ton

Let's now suppose that our mill has in its records a variable unit cost of US$ 800.00/ton for manufacturing the product in question. Then, the margin of contribution per ton of produced and saleable product will be:

MC = US$ 1,295.00 – US$ 800.00 = **US$ 495.00/ton**

If the hourly production of this mill is 40 ton/h of this product, in the form of saleable product, ready to be sent to the customers, our net result per stopped hour will be reduced by:

Lost Net Results = MC x (Production lost per hour)

= US$ 495.00/ton x 40 ton/h = **US$ 19,800.00/hour**

This value may be also called "the cost of the lost production per hour", hourly non-production cost, hourly production economic loss, etc.

This is striking, is it not? When the machine has some web breaks during the day and for this reason it does not produce during 30 minutes, it is failing to yield at least US$ 9,900.00 for this very simple example of ours. Then, how would be your case, dear reader? Does this calculation exist at your mill? If it exists, it is very important for everybody to know about this loss, in order to stir faster at stops and web breaks.

Almost all paper-machines have production losses due to stops and web breaks equivalent to 20 to 60 minutes per day. In such cases the loss is

even a little higher, because the machines go on running idle, spending electric power for no production whatever.

This same calculation methodology may be used to calculate the cost of production loss due to broke recirculation, which means occupying space on our machines, just for having again a "stroll" through the manufacturing system. Recirculating broke is a great economic loss, you are to see this soon.

Let's imagine that this exemplifying printing and writing paper mill of ours, producing 40 ton/h of saleable product, is rather efficient in its operations. Let's admit that it fails to produce 50 t/day due to broke return (approximately 5% of generated and reprocessed broke).

The net result loss due to that broke return, reducing its saleable production, will be:

50 x US$ 475.00 = **US$ 24,750.00/day**

Since managing paper mills without broke generation consists in a technology that has not yet been discovered; we may calculate our losses with regard to a goal to be reached. We may suppose, for instance, that the exemplifying mill of ours had a goal of 3.5% of broke at the most, but is generating 5%. It is worse, as it is generating 1.5% more broke, which corresponds to 15 t/day plus than the goal.

Its loss of net results due to non-achievement of the goal would amount to:

15 t/day x US$ 495.00/ton = **US$ 7,425.00/day**.

By annualizing this loss due to failure to use the full machine capacity because of the broke, it results: US$ 7,425.00/day x 345 days/year = **US$ 2.5 millions/year**

It should be remembered that although the figure is rather high, this is just a part of the total loss. Now we will value the broke as residue.

- **Value destruction by the broke as residue (loss of status of the paper which when produced becomes broke, plus handling of that broke)**

It must become clear that this is a cost to be added to the previous one.

In the previous item we have just measured the part corresponding to the loss of machine production due to the fact that broke return uses the

machine net capacity in proportion to its return. The higher the broke, the lower the saleable production, the higher the production loss.

But there is the other economical loss, which is due to the broke itself. When it is generated and returns to the process broke changes "status". If it came out as a good product, it would be sold at the price of a saleable product. By returning to the process, it acquires a value of raw material, if at all! Everything added and aggregated for its manufacturing gets lost. The margin of contribution that it would generate as a good product also vanishes off the face of the earth.

Let our printing paper be that of the example we are considering. Its net sales price was US$ 1,295.00/ton. Valuing the broke coming back as recycled fiber and as mineral filler to the process, it is possible to estimate that it is worth US$ 650.00/ton of off-grade paper, based on the current prices of cellulosic pulp and mineral fillers and on the composition of this paper.

**Loss of "status" value** = US$ 1,295.00 – US$ 650.00
= **US$ 645.00/ton of broke**

As the broke is being valued just as raw material, everything added at its first conversion into paper is built-in in this value destruction, which we are presenting as the difference between net sales price and value of return of this broke to the process as raw material. There are also the additional costs to pulp, to handle, and to stock the broke. In addition, there are financial costs regarding higher stock of materials, etc. Let's suppose all this to cost **US$ 50.00/ton of broke.**

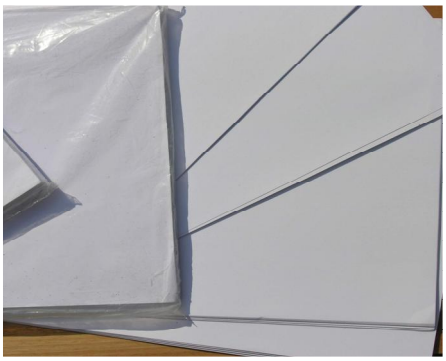
Therefore, the value destruction of each ton of broke as residue returning to the process becomes: US$ 645.00 + US$ 50.00 = **US$ 695.00/ton**.

We have not sold the ton of paper for US$ 1,295.00, we will spend plus US$ 50.00 as new money and will recover US$ 650.00 (just raw material), as the value lost with the loss of "status" cannot be recovered. From the total value that might be sold, which was US$ 1,295.00, we used to advantage US$ 650.00 and spent further US$ 50.00 to use it again.

As white and clean broke, the broke might be worth a gross price of US$ 650.00 on the wastepaper market, at the most. It seems that the white wastepaper market knows our weak points and wisely establishes a price compatible with what our white and clean broke is worth. The only advantage we have by not selling it as white wastepaper and reusing it instead of it is the tributary aspect. If the broke were sold it would have to be taxed, while if it is consumed inside the mill as internal residue it is not subject to any tax.

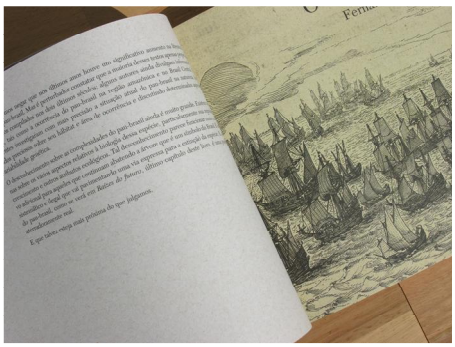
Anyway, at whichever sales price the broke is sold below the net sales price of the original product, we will make a loss. We might lose less, and this is the managers' function, as long as a way of making paper without generating broke is not discovered.

One creative way of making a profit with broke would be to use it as paper raw material (without pulping) at new product developments, as paper cut to format for stationery papers to students. The price of this paper per weight, as it is sold in small quantities, is at last better than that of the mother product. There are well-known situations on the market for that, but this market is not very big.



Off-grade paper cut to A4 or office size and packed to be sold to students

Another way would be to use the generated broke as raw material for manufacturing some creatively designed paper having a higher market value, for some sophisticated paper grade. The use of coated off-grade paper to produce noble printing paper, of excellent quality, by mixing this broke with recycled paper of post-consumption at stock preparation, is well known. The creativeness of our mills to find solutions for the broke of this paper difficult to be pulped is fantastic. However, such uses correspond to not very big markets, where there is not so much elasticity to absorb large amounts of transformed broke material.



Fine printing paper containing coated off-grade paper (broke)

## Case studies of broke valuation

Let's come back to our example of a printing and writing paper mill, with products cut to format for copiers and computers. This mill has a machine capable of receiving under sustainable conditions an equivalent dry stock supply of 1,130 t/day. Its fiber and mineral losses due to contaminated water loss amounts to 20 t/day at the paper-machine wet end. The net sales price of this paper is US$ 1,295.00/dry ton. To simplify this introductory demonstrative study, I chose not to complicate things with the usual differences between oven dry, air-dried, dried as such, etc., tons. For our case let everything be oven-dry or absolutely dry basis. If you wish to reproduce this for your situation, pay attention to this fact.

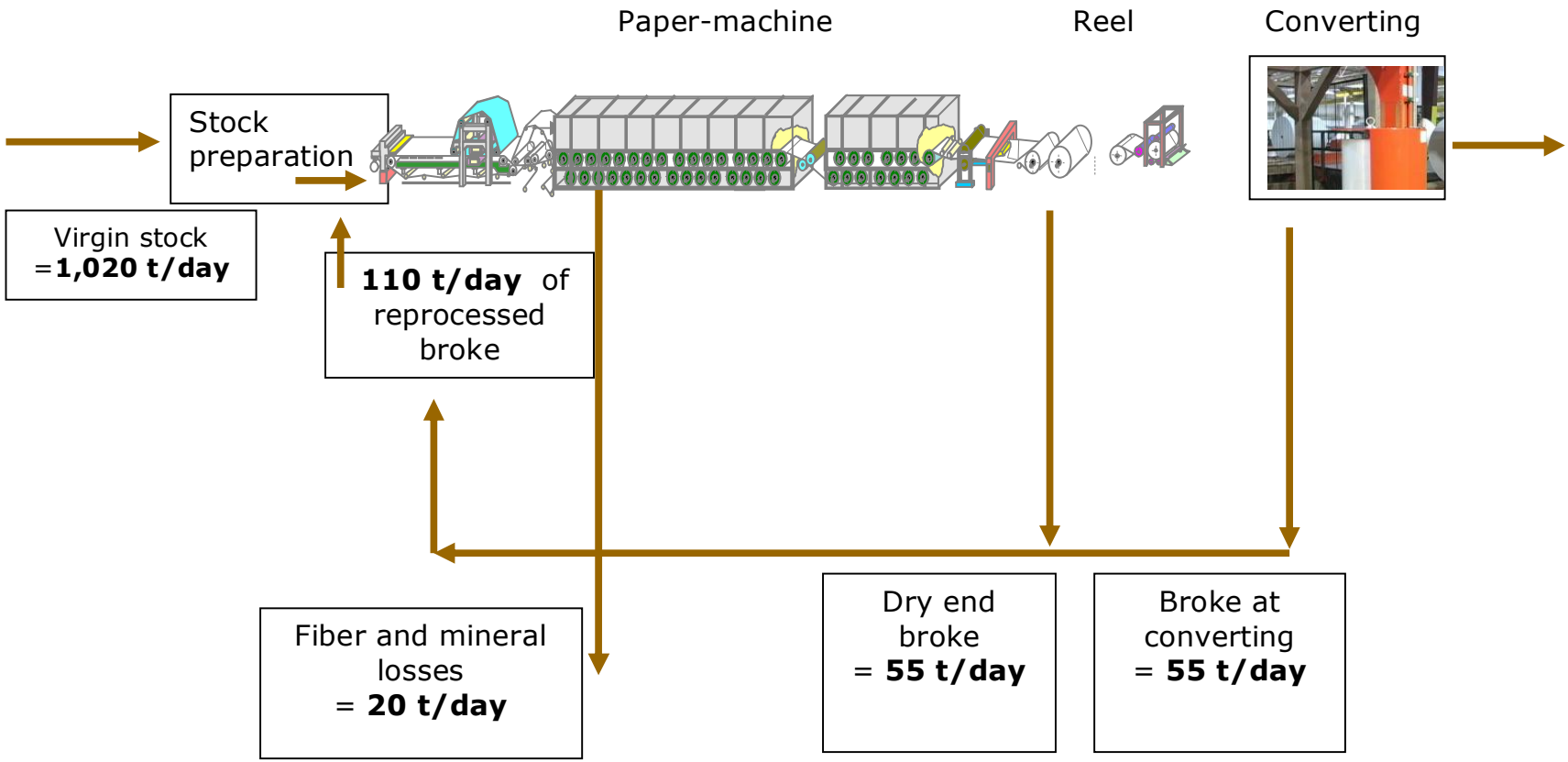
Let's consider two situations for comparison purposes:

Case 3: normal equilibrium situation. The saleable daily production was 1,000 tons in this case. The broke generation at paper-machine dry end was 55 t/day, as well as at converting.

Case 4: uncontrolled situation in the converting area, with increase in broke generation to 84 t/day, while broke generation at paper-machine dry end remains constant at 55 t/day.

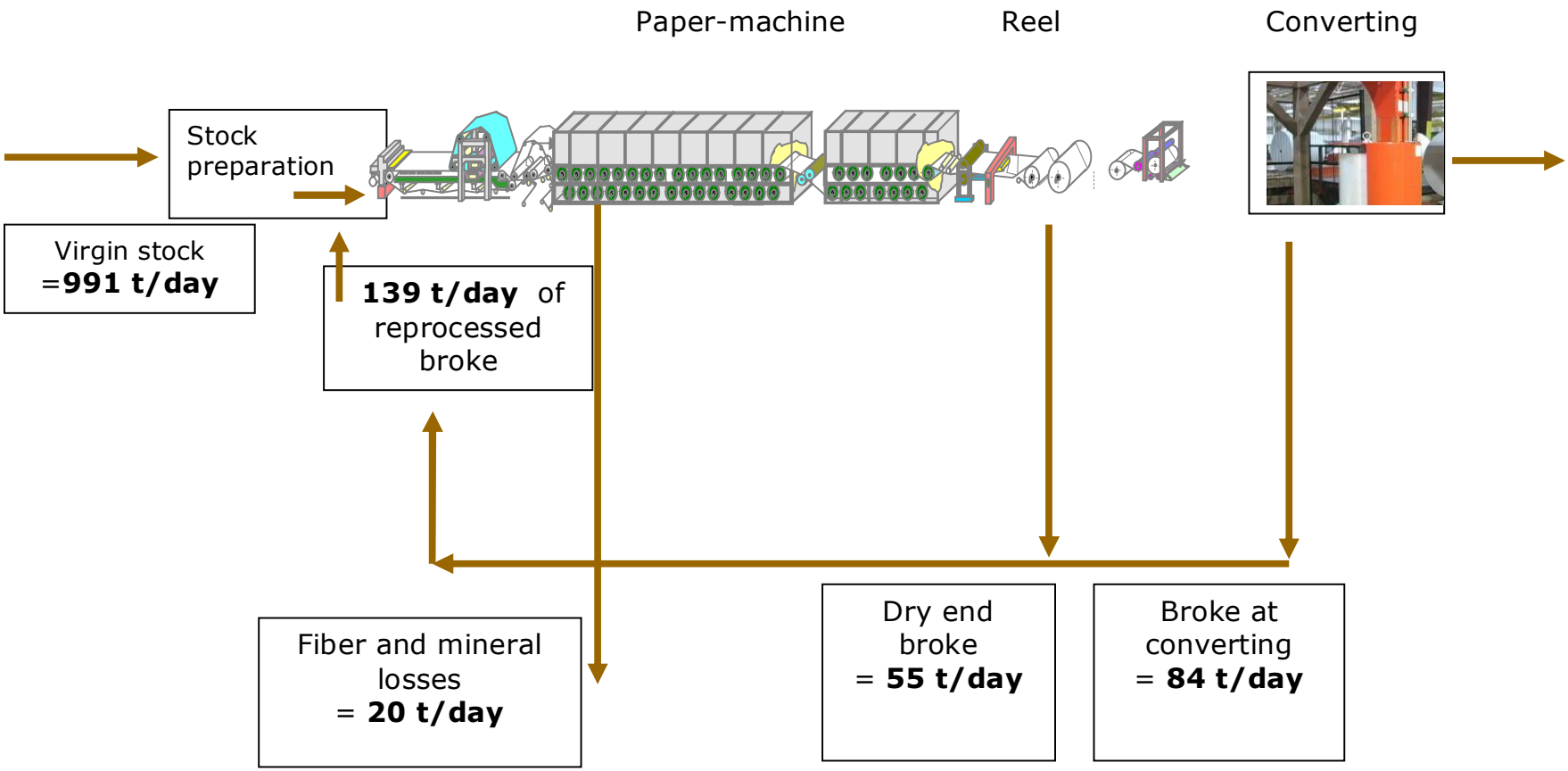
In both cases, the mill returns the whole generated broke to its stock preparation, consuming it in its own production. However, the paper-machine cannot change its cruise speed, as it is at its limit. Then the amount of dry stock being fed into the paper-machine headbox will be the same, i.e. 1,130 t/day. On this machine there occur daily fiber and mineral losses of 20 tons, as we have already defined, since the system is not completely closed.

**Case 3**: Broke generation of 110 daily tons, the whole of it to be internally reprocessed




**SALEABLE PRODUCTION for this case 3 = 1,000 t/day**

**Case 4**: Increase in broke generation to 139 t/day due to troubles at converting section




**SALEABLE PRODUCTION for this case 4 = 971 t/day**

As in case 4 the amount of broke was increased, the need of virgin stock decreased, since the machine has no capacity to increase its speed and to compensate this increase in return of broke to reprocess.

Considering the broke increase at converting, it can be seen that in the beginning (case 3) the amount of broke of 55 t/day corresponded to 5.5% of the saleable production. Having increased to 84 t/day in case 4, this proportion became 8.6%, since the amount of broke increased and the saleable production decreased. However, total broke for the broke system increased from 110 t/day to 139 t/day. This corresponds to an increase of 26.4% for this broke pulping and treatment system. It is for this reason that a small percentage increase in broke generation based on paper production, as in our case, often suffocates and overloads at last the whole broke system. It is now completely overloaded and it becomes a new bottleneck at the mill. One more perversity of our broke. On the other hand, many managers, instead of trying to invest in solving the cause of broke generation, ask for resources to enlarge the broke system. Once more, the candor of some managers, among many others, that we may find in our daily life.

Let's now try to calculate the mill loss in terms of economical value when passing from situation 3 to situation 4. This will be done step by step, requiring several estimates and assumptions. But this is just an example to show you how a balance of this valuation should be done.

Our evaluation basis will be one day of production.
Case 3: 1,000 t/day of saleable products
Case 4: 971 t/day of saleable products
Case 4 versus case 3 (which caused the increase by 29 t/day of broke)

| | **Case 3** | **Case 4** | **Difference** |
|---|---|---|---|
| Daily production of saleable products (t/day) | 1,000 | 971 | - 29 |
| Virgin stock fed to machine (t/day) | 1,020 | 991 | - 29 |
| Broke generated at paper-machine dry end (t/day) | 55 | 55 | 0 |
| Broke generated at converting section (t/day) | 55 | 84 | + 29 |
| Total broke to reprocess (t/day) | 110 | 139 | + 29 |
| Total net sales value (net sales price equal to US$ 1,295.00 /t) | 1,295,000 | 1,257,445 | - 37,555 |

| | | | |
|---|---|---|---|
| Margin of unit contribution (as production decreases, MC slightly decreases due to the increase in the variable unit costs) – (US$/t) | 495 | 490 | - 5 |
| Overall daily margin of contribution (US$/day) | 495,000 | 475,790 | - 19,210 |
| Unit value of "broke status" loss (US$/t of broke) | 645 | 645 | 0 |
| Unit cost of broke pulping, handling and storage (US$/t of broke) | 50 | 50 | 0 |
| Value destruction per broke unit (US$/t of broke) | 695 | 695 | 0 |
| Virgin stock consumption (t/day) | 1,020 | 991 | - 29 |
| Virgin stock unit cost (US$/t) | 650 | 650 | |
| Purchased virgin stock expenditure (US$/day) | 663,000 | 644,140 | - 18,850 |
| Value destruction with the additional 29 tons of broke (29 t/d x US$ 695.00/t) | | | - 20,155 |
| Overall value of the daily loss due to the increase by 29 t/day of broke (US$/day) | (- 19,210) + (- 20,155) – (-18,850) | | **- 20,515 US$/day** |

This cost increase, this value destruction and this economic result loss correspond to a net loss of about US$ 20.00/ton of saleable product, a rather significant figure. All produced units will be carrying this economical inefficiency value. It is for this reason that the corrective measures have a quick payback. It is no use trying to hide this fact; often what seems to be cheap at last becomes expensive. When trying to eventually save some small change in the converting area (in the above example), or in material, or in maintenance, or in personnel training, at last the whole mill is impaired. The impact is not little, but significant. Production was lost, wastes increased, costs increased, incomes decreased, profits reduced. There was also a loss in quality. In short, the perversity of broke showing all its claws, without mentioning the factors of personnel's lack of motivation, the greater working difficulties, the operational stress, etc.

An additional fact to be highlighted: as a result of saleable production decrease by about 3%, all fixed unit costs should also increase additionally at least in the same proportion, because the overall unit fixed costs should not

be altered as a function of this increase in broke generation, but the saleable production did decrease by approximately 3%. As the fixed unit cost is obtained by dividing the overall fixed cost value by the saleable production, by decreasing the denominator the division result value increases; i.e. higher unit and overall costs in addition to the other perversities.

I believe that I have tried to put enough emphasis on this issue, as the target I am aiming at is to open the mind of all those papermakers who do not yet see this broke generation problem clearly. My friends, I hope you have felt the importance of this matter. The potential gains are always significant. Sometimes, courage is needed to face the required changes. But it is worth while, do you not agree? I thank you very much for your patience to read attentively these comments of mine.

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## PAPER BROKE MANAGEMENT

One of my strongest and most sincere suggestions to the papermakers is that they dedicate themselves to quantify and to value their broke and wastes. The papermaker often becomes too obsessed with looking at his machinery, with its speeds, its breaks and the qualities of the products being manufactured. He knows that the rhythms of production are very important and that breaks represent production losses. He also knows that the mill managers are very attentive and take a dim view of a machine that does not operate well. All this is very important, we do agree upon.

The machines are constantly monitored to be efficient with regard to:

- Production speed or rhythm (use of machine capacity);
- Availability (quick and effective maintenance, readiness to produce);
- Utilization of the available time (efficient use of the machine with regard to the time it was available);
- Quality (quantity of accepted and saleable product with regard to the total production, which is connected with the generated broke).

Breaks, shutdowns, speed drops, changes of rhythms, etc., have much impact on these indicators. For this reason, total attention should be paid to them. However, even if the machine is processing 30% of broke, it may be presenting good runnability and good Jumbo roll quality. I wonder whether the papermaker should be happy therewith. Where would so much broke be coming to the machine from? From converting? From customers' return? From paper spoiled at transportation? Therefore, do not be misled by

machine efficiency, because this is just one indicator, one should be also looking attentively all around.

Broke represents costs, misuse of resources, loss of opportunities, rework, additional pollution and unfailing losses. For this reason, broke should be focused as much as paper-machine efficiency by managers.

Besides broke reduction, we may try to develop other uses for the off-grade paper, provided that they result in economical gain and reduce the operational disturbances. Internal searches are suggested, as already mentioned previously, or even partnerships with third parties. In terms of internal opportunities, one can think for instance of a small slitter + winder and a small cutter to process the "cheeses" (good quality paper but rejected because they were out of format). As far as partnerships are concerned, they might for instance involve small converters, who would buy out-of-format rolls in order to slit them and to convert them into paper products for the market (tissue paper napkins, little paper pads, envelopes, notebooks, drawing paper, etc., etc.). With creativity and wisdom, our companies would be helping create other kinds of paper business around them, cooperating with their greater social insertion. This is already successfully happening in the forest area, where the forest companies share the responsibility to generate wealth from wood with Society. Paper might become the new opportunity for this purpose; I believe it very much!

Let's imagine another situation, our case 5. For this purpose, let's come back to that printing and writing paper company of ours, that of case 3, which produced 1,000 t/day of saleable products and generated 110 t/day of broke. A part of this broke is considerably usable, it consists in such formats that are unsuitable for the customers. Other out-of-specification are papers off-graded by tear, tensile, bulk, etc., which would however allow using these qualities without any problems if they were reconverted by someone for some other purpose. I have always preached this, i.e. to develop other business with paper in our communities. The first solution is certainly to reduce broke, but why not use that part of it which is inevitable to make the local economy around the mill more dynamic?

Let's suppose that our above mill succeeds in finding a use for half the broke generated in its daily operation. It would mean that it would sell 55 t/day of broke and would reprocess further 55 t/day. Its saleable production would become 1,000 daily tons of the mother paper, plus 55 tons of a product that it would have to develop a creative name for. That paper might be destined for partners of the community, to be converted into products used by Society. The saleable production would become 1,055 t/day. The virgin stock requirements would increase in this proportion. The virgin stock demand would become 1,075 t/day. The price of broke now transformed into a product (or raw material for some converter) should remunerate this new

stock and help improve the overall net economic results of the mill. This is a basic condition. We should not look for uses unless they yield positive results. It should be considered that 55 t/day surely means some small converting mills being fed with that paper.

Using the same sequence of the previous table, we might remain with case 3 as the basic case, compared to case 5 (sale of 55 t/day of broke to converting partners). Let's admit net sales price of US$ 875.00/t for the new saleable product originating from broke.

Case 5 versus case 3, based on one day of production:

| | **Case 3** | **Case 5** | **Difference** |
|---|---|---|---|
| Daily production of saleable products (t/day) | 1,000 | 1,055 | + 55 |
| Virgin stock fed (t/day) | 1,020 | 1,075 | +55 |
| Broke generated at machine dry end (t/day) | 55 | 25 | - 25 |
| Broke generated at converting (t/day) | 55 | 25 | - 25 |
| Total broke to reprocess (t/day) | 110 | 55 | - 55 |
| Net mother product sales value (net sales price equal to US$ 1,295.00/t) | 1,295,000 | 1,295,000 | 0 |
| Net sales value of the secondary product originating from broke (net price equal to US$ 875.00/t) | 0 | 48,125 | + 48,125 |
| Overall sales value per day (US$/day) | 1,295,000 | 1,343,125 | + 48,125 |
| Margin of mother product unit contribution (US$/t) | 495 | 495 | 0 |
| Margin of contribution of the new product (US$/t) | | 50 | |
| Margin of overall daily contribution (US$/day) | 495,000 | 497,750 | + 2,750 |
| Value destruction by broke (US$/t of broke) | 695 | 695 | |

| | | | |
|---|---|---|---|
| Gain with reduction in value destruction with the lower broke rate of case 5 (55 t/d x US$ 695.00/t) | | 38,225 | + 38,225 |
| Virgin stock consumption (t/day) | 1,020 | 1,075 | + 55 |
| Virgin stock unit cost (US$/t) | 650 | 650 | |
| Purchased virgin stock expenditures (US$/day) | 663,000 | 698,750 | + 35,750 |
| Overall daily gain value due to the new way of broke marketing (US$ / day) | (+ 2,750) + (38,225) – (35,750) | | **- 5,225 US$/day** |

The result is positive and rather interesting. The greatest advantages are not only those concerning higher economic results and higher efficiency, but also mainly those of social and community-related nature. We need to be prepared to develop business with paper in the mill region and not to be afraid of new competition that these new business branches might cause. Let's think about a plus rather than a minus world.

I admit that the proposal involves some points to be evaluated. One of them is that our goal should be to eliminate broke, not to depend thereupon for something. However, when migrating to case 5, we have several technological and sustainability-related points favorable for the mill, smaller residue-related environmental problems and a higher participation in the community activities and daily life. Technically our mill will become more efficient, there will be no broke pressure overloading the stock preparation system and consuming reprocessing resources any longer. There will be some investments to make for handling and storing our new product. Some handling costs will have to be replaced with other ones, which is a point to be checked. The mill will be cleaner and better organized, since the tender treatment of the broke will change its standard.

An interesting point is that there is a possibility for increasing the company's net result by US$ 5,225.00 per day, which would result in approximately 1.8 million dollars per year. At the same time, we will be reducing the fixed unit costs, as the production increased by 55 t/day and this new product will be paying a part of the overall fixed cost. The production will go on paying for some inefficiency aspects, but now a bit less (lower pulping costs, less reprocessing, lower power expenses, less rework, etc.).

Another solution some companies adopt is to sell broke as an unfit product at a lower price, corresponding to that of an "out-of-standard product". Many manufacturers do not like this practice, since they believe

that doing such they will be competing with their own main product. What really matters, when adopting such an approach, is to find the right market and the fair price for both supplier and customer. If we manage to reduce broke return, we will be able to gain saleable production, as already mentioned.

Another danger that terrifies the manufacturers is that the broke market may grow too much, so that only broke customers will appear. If the market would begin to put pressure for broke production, just imagine what would happen. It would be the very marketing-related "downgrading". In such a case, should this happen, it would be better to evaluate the whole portfolio of prices, products, specifications and markets we are acting on.

Another recommendation to the paper manufacturers is that they should also try to control the stock quality originated from the broke. The latter is very little observed at the mills. In most cases, the only measurements it is subjected to are flow and consistency determinations. I recommend a change of attitude in this respect. It would be very good to control the quality of that stock more accurately. After all, it goes to the paper machine headbox in proportions that are not at all small. I suggest evaluating at least the following items: freeness, pH, water retention value, fines content, level of contamination (dirt ands organic trash). Remember that if you do know nothing about it, all influences (both positive and negative) that broke stock will exert on paper manufacturing will not be visible.

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## SOME REPORTS ON CASES OF REAL LIFE, SHOWING FIBER AND BROKE ECO-EFFICIENCY OPPORTUNITIES

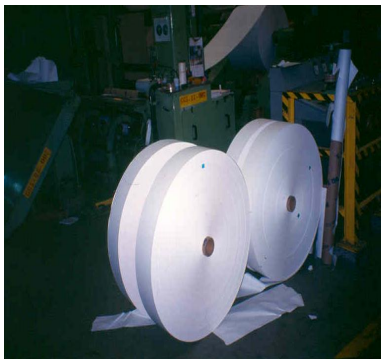
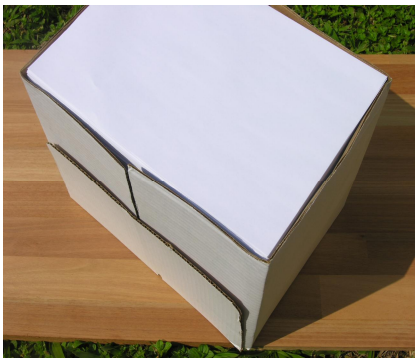
In this section I intend to show in a simple manner some situations that happened to me in real life, showing that there are always opportunities to practice eco-efficiency. Just to remind, to be eco-efficient is to produce more with less natural resources, wasting less and bringing sustainable and conscious consumption into practice.

I will present 10 cases, showing some photos and making concomitantly some comments. I hope that you will appreciate them and be amused by.

| Example of eco-efficiency number 01 | | |
|---|---|---|
| The case of the trims that became a product | | |
|  |  | The rewinding operation trims began to be pressed and sold as a new product. The company gained 2% of saleable production. High creativity and excellent technical and economical results. |

| Example of eco-efficiency number 02 | | |
|---|---|---|
| The case of fibrous sample recovery by the lab | | |
|  |  | The lab can adopt the method of separating all fiber samples and returning them to the process. Small gains, but a great example of commitment to fiber and broke recovery. |

| Example of eco-efficiency number 03 | | |
|---|---|---|
| The case of the wastepaper stations at mills using broke | | |
|  |  | At paper recycling mills every used paper must be directed to a wastepaper collecting station, in order to be forwarded directly to the pulper. The garbage is no place for raw materials. Develop ways to internally collect this wastepaper. |

| Example of eco-efficiency number 04 | | |
|---|---|---|
| The case of the little out-of-format rolls that gained a format for copies. | | |
|  |  | "Cheeses" and "pizzas" may be given a new opportunity to be cut into formats and sold on the local market to small digital printers or to students. |

| Example of eco-efficiency number 05 | | |
|---|---|---|
| The case of the big tissue paper community bag | | |
|  |  | "Short in width" tissue paper broke rolls may be given new uses when they are sold at cost price to the community, as paper "scrap".  |

| Example of eco-efficiency number 06 | | |
|---|---|---|
| The case of the coffee paper filter design | | |
|  |  | The coffee filter paper design represents a loss of area of about 30% (circle to square ratio). It is a complex wet strength paper broke. It is something that challenges us to change the coffeepot shape, in order to reduce broke at this production. We look forward to see how the future filters and coffeepots will be! |

| Example of eco-efficiency number 07 | | |
|---|---|---|
| The case of paper losses due to bad roll handling | | |
|  |  | Any paper roll handling damage requires a thick sheet blanket removal to cure the damaged roll. As this blanket is being removed from the largest roll diameter section, half a centimeter of a blanket may represent from 0.5 to 1% of the roll volume. Indicators and lots of care are needed. |

| Example of eco-efficiency number 08 | | |
|---|---|---|
| The case of the new opportunity for towel tissue paper rolls that were off-graded by size (width) | | |
|  |  | One more utility for small out-of-format towel tissue paper rolls, to be used in less demanding sectors (schools, bus stations, prisons, etc.). |

| Example of eco-efficiency number 09 | |
|---|---|
| The fiber loss mystery | |
|  <br>  | This is an unusual situation, showing that our managers must visit the areas and talk to the operators. Once, at one of our many paper mills, I saw a channel full of fibrous suspension running directly to the effluent. I went ahead, to see where it came from and discovered a pulper being drained to the channel. I asked the operator why that operation was being carried out. He answered me that he was charged with the task to repulping a whole broke stock till the end of the day. However, the paper-machine was out of operation and the broke tower was filled up to the top. For this reason he was draining the broke to the effluent, in order to be able to repulp more. Do you agree that this means lack of training and awareness of the operators? And the responsibility for it falls undoubtedly upon the managers.<br>Candor, innocence, lack of training, etc., etc. |

| Example of eco-efficiency number 10 | | |
|---|---|---|
| The case of paper roll or pulp sampling | | |
|  |  | This example is very similar to that regarding roll damages, where one tries to remove paper blankets to cure the damages. The quality control personnel like to take too much paper from the roll before taking their sample. All this paper returns as broke, a thing difficult to understand and to accept. |

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## FINAL REMARKS

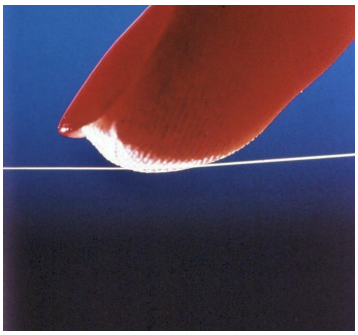
In the present chapter we addressed two of the most relevant paper-manufacturing subjects related to eco-efficiency. Fighting against fiber losses and broke generation is becoming a goal of the continuous improvement and environmental improvement programs of almost all our pulp and paper mills. They begin to bet more on recovery and prevention. The importance of such an attitude is vital to improve our technologies. The evaluation of our sectorial competitiveness has shown numerous opportunities with regard to these particulars. In spite of many recent gains at several companies, some of them due to installation of more modern machinery, there are still many units requiring much attention and much action.

The best suggestion for these fiber loss and broke generation related problems is prevention, the solution of the problem where it is started. The second best solution is internal recycling (ex. reusing lost fibers and broke in products of higher aggregate value inside the mill itself). The other alternative would be external recycling or selling these materials at prices remunerating them. To sell as residue, as garbage, is one of the worst alternatives. We need to develop new and creative utilization for them.

However, the worst of all ideas is to throw these valuable materials away. Among the internal use models, one interesting possibility for the mill consists in having available product lines able to absorb one or another residue among those difficult to eliminate at the source. For example: fibers lost by the tissue paper-machine may be sent to a cardboard paper-machine, in order to prevent the tissue system from being overloaded with fines. Instead of occupying space again on the tissue machine, those fibers will become fibrous raw material for cardboard manufacturing.

Another target to be met is to develop new valuable products from paper manufacturing broke. First of all it should be tried to reduce generation, which is the goal itself. The second goal is to avoid having to reprocess the broke, by developing uses and markets for these broke types. It is very little eco-efficient to pulp and to repeat the manufacturing process all over and over again, and so forth. Many mills are "commodity-oriented"; they think it more practical to pulp everything and to make again the same product as always. I can understand such a philosophy, but in this case, if they want it to work in this way, they should work as hard as possible to reduce broke generation. Savings and advantages have already been extensively discussed in the present chapter of our **"Eucalyptus Online Book"**. I sincerely wish to all of you good luck in the search for solutions for these forms of inefficiency of our pulp and paper processes.

*"The line separating the plus world from the minus world is very tenuous. All of us want a better world, without so many wastes, I1, sure about this.*
*I hope that this chapter has contributed to a better understanding of this point in a world so plenty of challenges and opportunities as the pulp and paper one".*



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