BACELL: A new Dissolving Pulp Mill with latest Technology

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INTRODUCTION:

The Origin of this pulp mill in Camaçari / Bahia is an old sisal pulp mill from the seventies, named Company Cellulose da Bahia. The mill was built in a time when the sisal price was at the very bottom. with a shortage of the raw material the mill had to be closed.
In 1990 is was taken over by KLABIN, one of the biggest pulp and paper producer in South America.
Together with LENZING AG from Austria, a joint project was developed, to rebuild this mill as a dissolving pulp mill with a capacity of 115000 tons per year.
LENZING is a world-wide leading rayon producer. In three locations in Austria, the United States and Indonesia at about 315 000 tons of rayon or 15% if the world market are manufactured. The Lenzing mill in Austria is fully integrated, but to ensure the supply of dissolving pulp for the two others this engagement in Brazil was made.

The cornerstones of the project were:

- Implementing the latest available technology by using as much of the existing equipment as possible and reasonable.
- Achieving very high quality standard to make a relatively small mill profitable.
- Using the wood resources of the area, in this case eucalyptus of COPENER ´s plantations.
- Providing a high level of environmental protection.

The project was developed together with Jaakko Poyry and definitively started in June 1994. On January 15 we could make the first cook; this was two months later than planned but still within an acceptable schedule.
On February 6 we succeeded to produce the first bale. While on March 5 the first dissolving pulp quality was achieved, on March 8 the first lot of prime grade dissolving pulp could be produced.

TECHNOLOGY

What are the latest technologies mentioned in the headline?

- In cooking: the VISBATCH - process which is a combination of the ENERBATCH - process plus a vapour phase prehydrolysis.
- In bleaching: the first TCF bleach plant for prehydrolysis kraft pulp
- In dewatering: the TETRAFORMER, a new development of a low energy wet end.

Dissolving pulps are special wood pulps used for chemical conversion into, for example rayon for textile and technical applications, cellophane, cellulose derivates such as cellulose acetate and nitrocellulose. The requirements for dissolving pulps are mainly high purity and a high content of uniform cellulose with a constant degree of polymerization, meaning a low content of hemicelluloses, lignin, ash and extractives. As it is mostly dissolved during the conversion, physical strength properties are only of marginal interest.

COOKING:(1)

The sulphite process predominates world wide in the production of dissolving pulp. Acid sulphite process is mainly used in single stage cooking because of its rapid hydrolysis of hemicellulose and beta-cellulose as well as its good delignification rate.
The first prehydrolysis kraft dissolving pulp mill started production in 1945, processing wood into cord fibres for tires. In 1992 the production of prehydrolysis kraft pulp was 1,1 million tons world wide, of which 40-45 percent was based on hardwood.
Sulphite technologies are restricted to certain wood species, mainly hardwoods. Prehydrolysis kraft can also use softwood and wood rich in resins.
In the case of BACELL, the choice of the prehydrolysis kraft process was given by the already existing recovery boiler.

Vapour phase prehydrolysis:

The major disadvantage of the prehydrolysis kraft process was the aqueous phase prehydrolysis, which requires high energy amounts and evaporation capacity. Scaling and clogging in tubes and valves is normally caused by resins and the reaction products of the hemicellulose and sugars.
A steam phase prehydrolysis, as it is already used in some mills in Brazil and Eastern Europe, should prevent these problems. IVA had optimised the procedure for steam heating of the chips, that is the injection and distribution of the steam in the digester, first in the VABIO pilot digester and then in the 165m3 digester of an Enerbatch pulp mill. By measuring the temperature at five different points in the centre of the big digester, during the steam treatment, a fast and uniform heating of the digester content by the applied steam distribution technology was confirmed.
This uniformity in combination with a neutralisation with hot black and white liquor and followed by a hot displacement leads to the same results as water prehydrolysis, avoiding its high energy consumption, high evaporation capacity and pollution.

Process Description (figure 1):

Prehydrolysis and cooking are accomplished periodically in three batch digesters, equipped with a steaming and a liquor circulation system. High pressure tanks for hot white liquor, neutralisation liquor, hot and warm black liquor are the base of the modern Enerbatch technology.

Chip filling:

Chip filling is accomplished by means of low pressure steam in a Svensson chip filling system, which assures a high chip packing in the digester.

Steam heating and prehydrolysis:
The digester is heated up to 160-170°C with medium pressure steam; hydrolysis of hemicellulose is achieved by organic acids, mainly acetic acid, that are formed during prehydrolysis and after about 40 minutes most of the pentosanes are hydrolysed and dissolved.

Neutralisation and alkali charging:
The digester is filled under pressure with caustic liquor, consisting of hot black and hot white liquor. This neutralises the organic acids formed during prehydrolysis and adds the alkali charge required for cooking. Part of the neutralisation liquor is displaced to the neutralisation liquor tank during the hot displacement.

Heating and cooking:

The digester is kept at cooking temperature until the desired degree of delignification is reached.

End of cooking and discharging:

Cooking is completed by displacing the hot cooking liquor with washing filtrate from the washing filters. Thus the pulp in the digester is cooled below 100°C and pumped into the blow tank.

Hot white liquor heating:

Hot white liquor is prepared from white liquor, continuously heated with neutralisation liquor from the previous cook and led into the hot white liquor tank.

Control and monitoring of the cook:

The measuring, control and monitoring of the cooking process is achieved by a distributed control system. This system is also designed to control the position, function and reliability of valves and measurements. Digesters are operated according to either the basic sequence programme or as a fully automated system for production planning and tank farm management. Pumps, valves and other devices are controlled automatically.
To achieve homogenous pulp quality an advanced control system was installed. This is based on measuring the residual alkali content of the cooking liquor and correction of the resulting H-factor.

BLEACHING:

From the very beginning of the project, there were no doubts, that a new pulp mill must have a TCF-bleaching sequence. On the one hand, to gain the advantages on the market, on the other hand to ensure that also the future environmental regulations will be fulfilled.
The only realistic alternative, using chlorine dioxide instead of ozone, causes more or less the same investment and operating costs.

Development:

LENZING has installed the first ozone bleach plant in 1992, according to the sequence EOP - Z - P.(2) Based on the excellent experience concerning pulp quality and operations, our aim was to transfer this technology to prehydrolysis kraft pulp.

The basic work was done in LENZING´s research department (3), in cooperation with KVAERNER Pulping and RIOCELL. The brown stock used in these trials came from the pilot plant of IVA as well as from RIOCELL mill.

Herbert Sixta presented these results on the 1994 Non Chlorine Bleaching Conference at Hilton Head Island.

Oxygen Delignification:

Facing the very low lignin content of high quality dissolving pulp, it is evident that the oxygen delignification stage has to be extremely efficient.

Drastic conditions like temperatures up to 115°C, alkali charges between 15 and 30 kg/bdt, retention times up to 120 minutes and oxygen pressure of 0,7 Mpa resulted in a delignification rate of maximum 73%, but a significant drop in viscosity was observed when the lignin removal rate was increased above 60%.

For this reason an alternative concept with a two stage delignification treatment was investigated.

As an optimum there was found to split the reaction into the first stage of 15 minutes with 50 to 80% of the total alkali charge and a second stage of 60 minutes. The benefit of an intermediate washing was not big enough to justify an additional installation. Figure 2 shows a comparison of the selectivity of one- and two-stage oxygen delignification, starting from a eucalyptus PHK-pulp with kappa number 9 and intrinsic viscosity 1200ml/g. The advantage in selectivity of the two stage concept appears at an extended delignification range of higher than 55%.

Removal of transition metals:

It is well established that trace levels of transition metals have a profound negative impact on ozone and peroxide bleaching. The presence of transition metals, particularly Co, Fe, Mn and Cu ions, results in both, excessive ozone and hydrogen peroxide consumption by self-decay and in degradation of carbohydrates, apparently caused by free radical reactions. To use ozone and hydrogen peroxide effectively during the subsequent bleaging stages, transition metals must be removed or at least deactivated. Not only the bleaching process itself but also the product dissolving pulp requires a very low content of transition metals.

A major part of our eucalyptus is growing on the typical red, iron containing soil, you will find in Bahia. So the wood chips have a relatively high content on iron too and the risk to contaminate the process and the pulp is immanent.
For this reason it was decided to implement a separate and, at least at the beginning, open washing stage between oxygen and ozone delignification, operated with sulphuric acid at a pH around 3.
The ozone stage was also designed as a ZQ-stage, where the ozone reaction is followed by a chelation with EDTA.

Final bleaching:

The final bleaching of the BACELL mill corresponds to the concept, realised in LENZING (2).
The ozone bleaching is carried out as a Medium Consistency stage with two MC-mixers, which should provide an ozone yield of higher than 90%.
Ozone is very effective in reducing the kappa number to very low levels, which is an important issue for dissolving pulps. The course of brightness and kappa number proved to be symmetrically, as figure 3 demonstrates.

For the production of ozone a MEGOS-System of SCHMIDDING was installed, the required oxygen is produced by a PSA-plant of VAIS. The off gas of the ozone bleaching is used for the delignification and white liquor oxidation.

The ozone stage is followed by an alkaline peroxide stage. The purpose of this final bleaching stage is to adjusted the brightness target. The reaction conditions of this peroxide stage are rather moderate because of the high incoming brightness and the activation potential of the preceding ozone stage. For that reason the viscosity loss can be kept very low.
The cause of the total TCF-bleaching sequence in terms of viscosity-brightness relationship is illustrated in figure 4.

DRYING MACHINE:

BELOIT has modernised the drying machine, using big parts of the existing drying section. The wet end of the machine was completely rebuilt. The TETRAFORMER is a new development, combining the sheet formation properties of a Fourdrinier machine with the low energy consumption of a double wire press. After some trials on the Bolton pilot plant of BELOIT, this prototype was installed at BACELL for the first time (figure 5).

START UP

COOKING

As already mentioned above, the first cook was made on January 15, 1996. To our big surprise we reached very soon a kappa number of 5, but with a much too low consistency of 500 ml/g. Nevertheless the circulation of the digester was working until the end of the cook and during the cold displacement no problems appeared and the pulp was good to handle in washing and bleaching, but not on the drying machine. Anyway, to my knowledge, this should be one of the lowest kappa numbers ever received from an industrial scale kraft digester (figure 6).

To improve the runnability of the pulp on the drying machine, a higher kappa number was set for the following cooks. At the moment we are adjusting the system for a kappa number around 10.

The biggest question mark, the vapour phase prehydrolysis, proved very soon to work correctly and was good to handle. The desired range for S_{18} between 3 and 4% could be achieved with some exceptions, as figure 7 demonstrates.

One of the cornerstones in the technology of the VISBATCH-Process in the displacement from the top to the bottom, which distinguishes it from their competitors. Figure 8, a copy of the DCS-screen, shows a very good functioning of the cold displacement, causing an excellent energy balance, lower than the expected values and a low amount of carry over to the washing plant.

As there were still some difficulties in the recovery area, we could not supply the cooking plant with sufficient white liquor of good quality all the time. Especially the sulfidity was sometimes rather low due to frequent synthetic white liquor preparation . This made is partly difficult to reach the desired viscosity to kappa number relation. But single results shows, that the plant has the potential to achieved optimum quality (figure 9).

BLEACHING:

Oxygen delignification:

Oxygen delignification has been proved to be very efficient. The Kappa number (average values from March 2 until March 15) can be reduced from 9,5 to 2,8 before and 2,6 after acid wash. This corresponds to a kappa number reduction of more than 72% at an average viscosity drop of 30%. These results are in good agreement to the laboratory outcomes. The performance of oxygen delignification can be controlled by temperature and caustic charge with accuracy. The results so far are summarised in figures 10 and 11.

Ozone bleaching:

In the ozone stage we had and still have some technical and operational problems, like for example stabilising the consistency at a higher level and the ozone flow, so that a statistical evaluation is difficult. But anyway we could see the viscosity degradation due to ozone treatment is rather moderate and takes place in a controllable way. The viscosity drop was determined to be 115ml/g. At the same time the brightness by 12% in average. Figure 12 shows the brightness values after the O-, Z- and P- stage. Important is the good bleachability of ozone bleached pulp in the following P-stage for producing high brightness dissolving pulp.

Peroxide bleaching:

Peroxide bleaching turned out to be very sensitive to water quality. The recycling of white water to P-stage had a drastic negative effect on pulp viscosity. As soon as we turned to fresh water the selectivity of P-bleaching improved. The corresponding results are shown in figure 13.
The addition of EDTA during the phase of white water recycling could not stabilise pulp viscosity. Therefore we decided to add $MgSO_4$ at an amount of 0,5 kg/bdt just before the addition of hydrogen peroxide. The effect was very significant. The residual hydrogen peroxide concentration increased rapidly from values <0,1 g/l up to 0,5 - 1 g/l and as a consequence the viscosity went up to the expected values. So we know that we have to localise and eliminate the source of heavy metals, probably iron in the white water system, but in the meantime we have the possibility to produce prime grade dissolving pulp.

DRYING MACHINE:

Between the first cook and the first bale there was a three weeks period, more or less caused by difficulties on the drying machine. This low kappa, low viscosity dissolving pulp from the first cooks, without any mechanical strength properties, was a too tough nut to crack. It proved to be impossible to adjust this new machine with that pulp, especially after having it recycled several times. But with the addition of 15% bleached long fibre paper grade we were able to start the machine and to find the right parameter.
After some minor modifications, the TETRAFORMER and the drying machine is now operating with dissolving pulp and is a good solution for low energy operation.
Dissolving pulp with low hemicellulose content allows to reach easily up to 55% dryness after the second press before the drying section.

FINAL PRODUCT QUALITY:

During the last days we have reached a very promising quality level (figure 14). Our big concern, the high iron content seems to be less harmful than expected and first reactivity measurements in Lenzing showed excellent results.

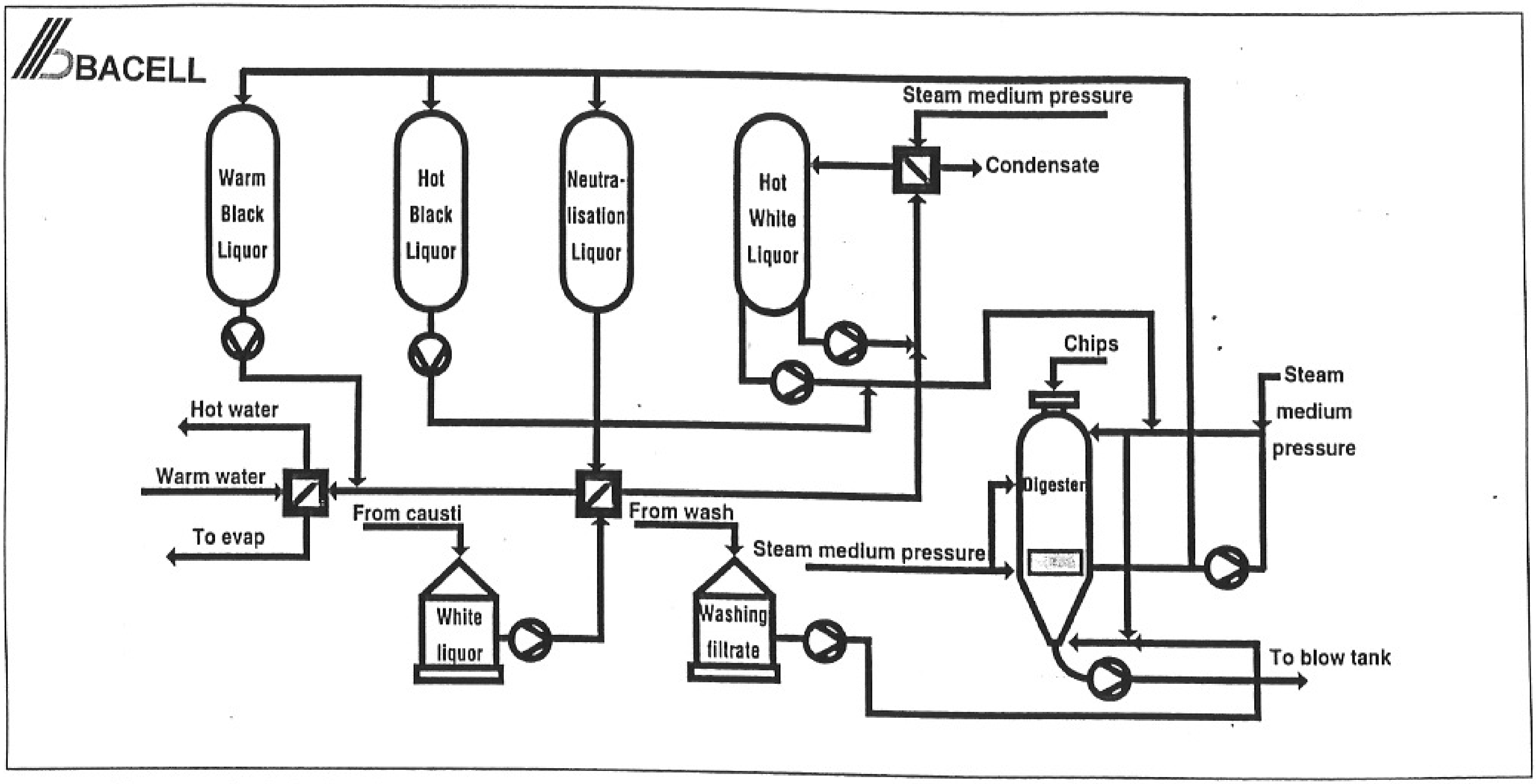

Figure 1. Steam prehydrolysis — kraft displacement cooking process.

Figure 2: Comparison of the selectivity of one- and two-stage oxygen delignification. Eucalyptus-PHK, kappa number 9, intrinsic viscosity 1200 ml/g.

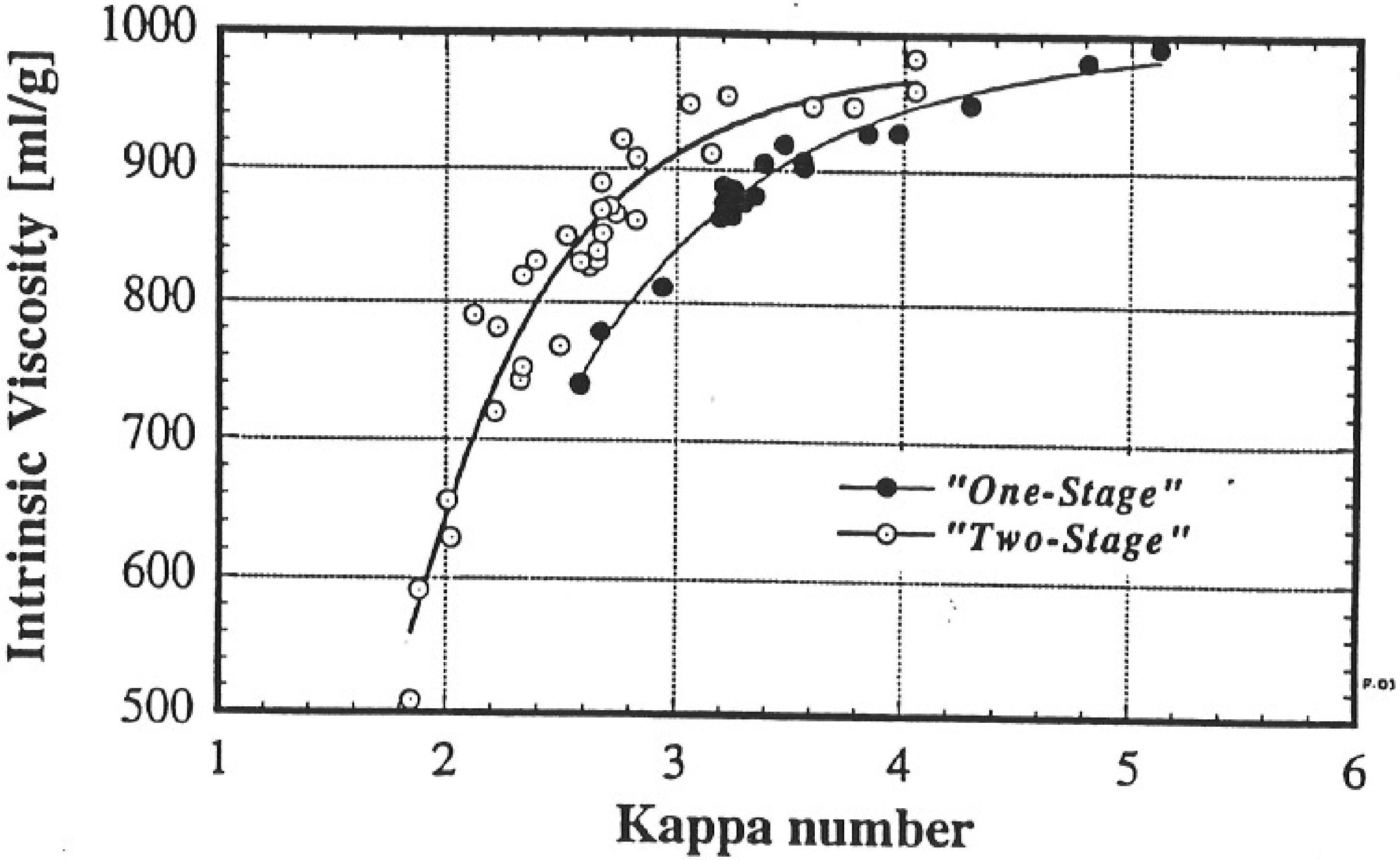

Figure 3 : Course of kappa number and brightness versus ozone consumption.

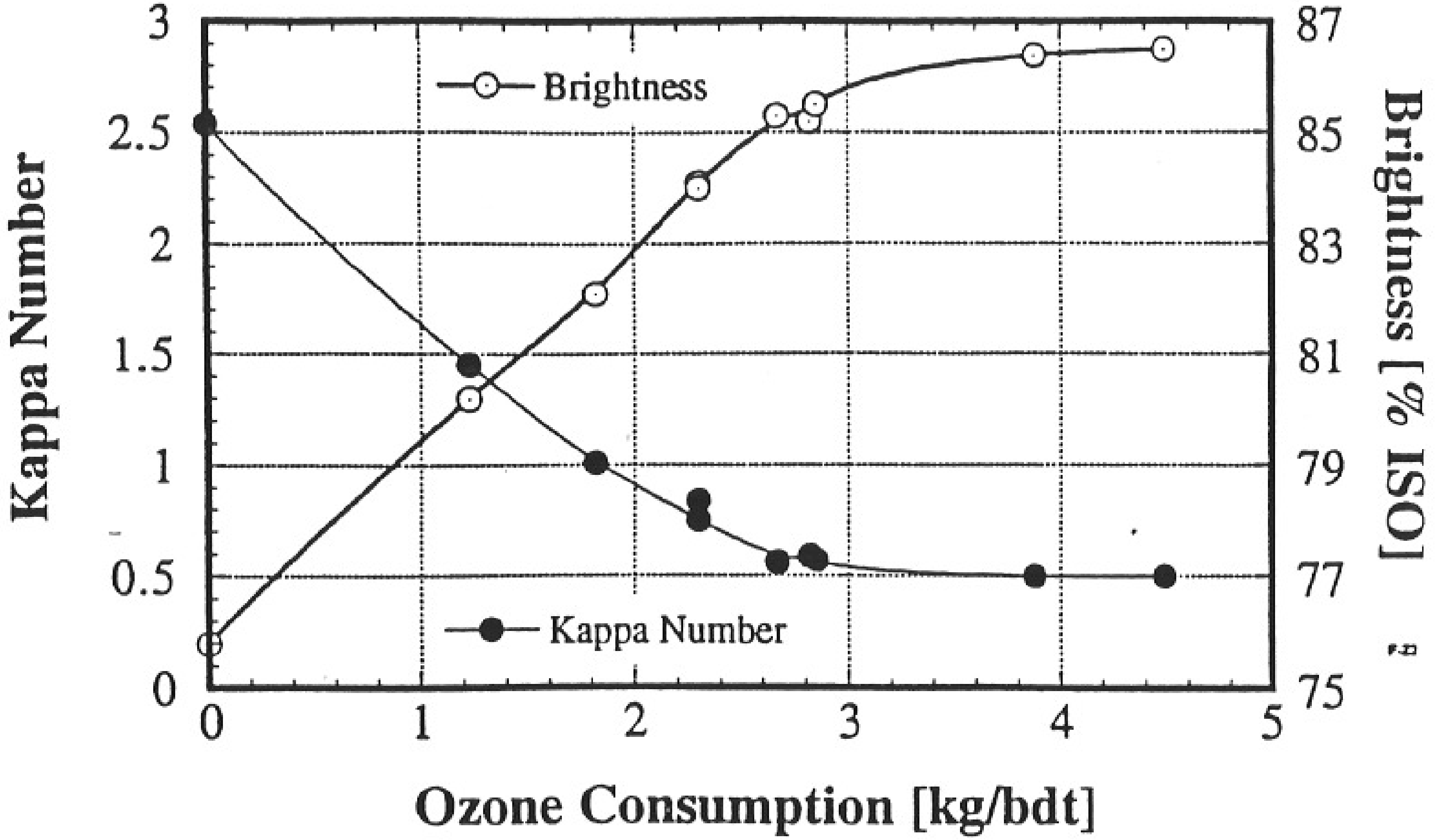

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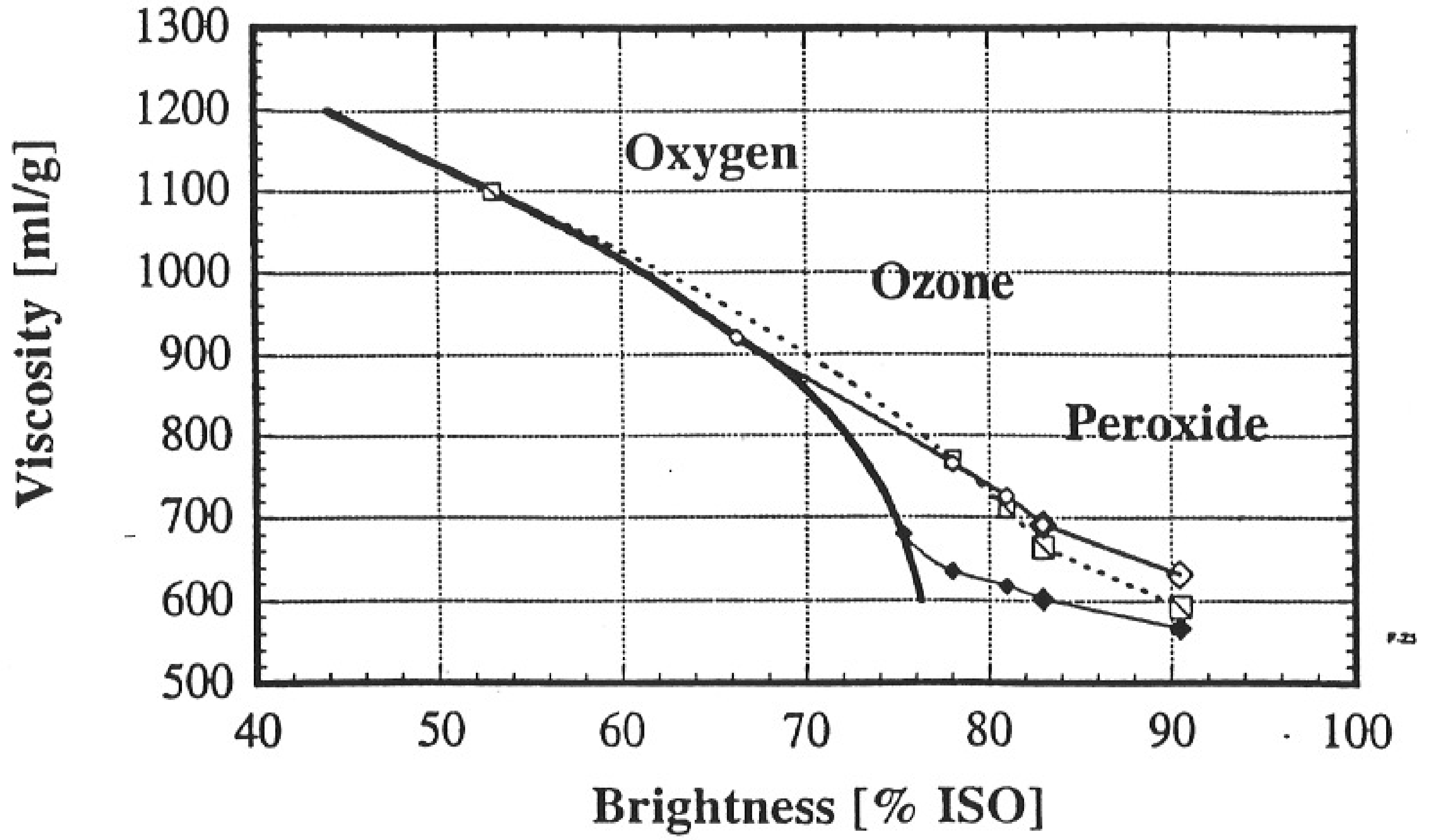
Figure 4 : Course of viscosity and brightness during OZP-bleaching. Effect of different degrees of delignification after oxygen bleaching on overall selectivity.



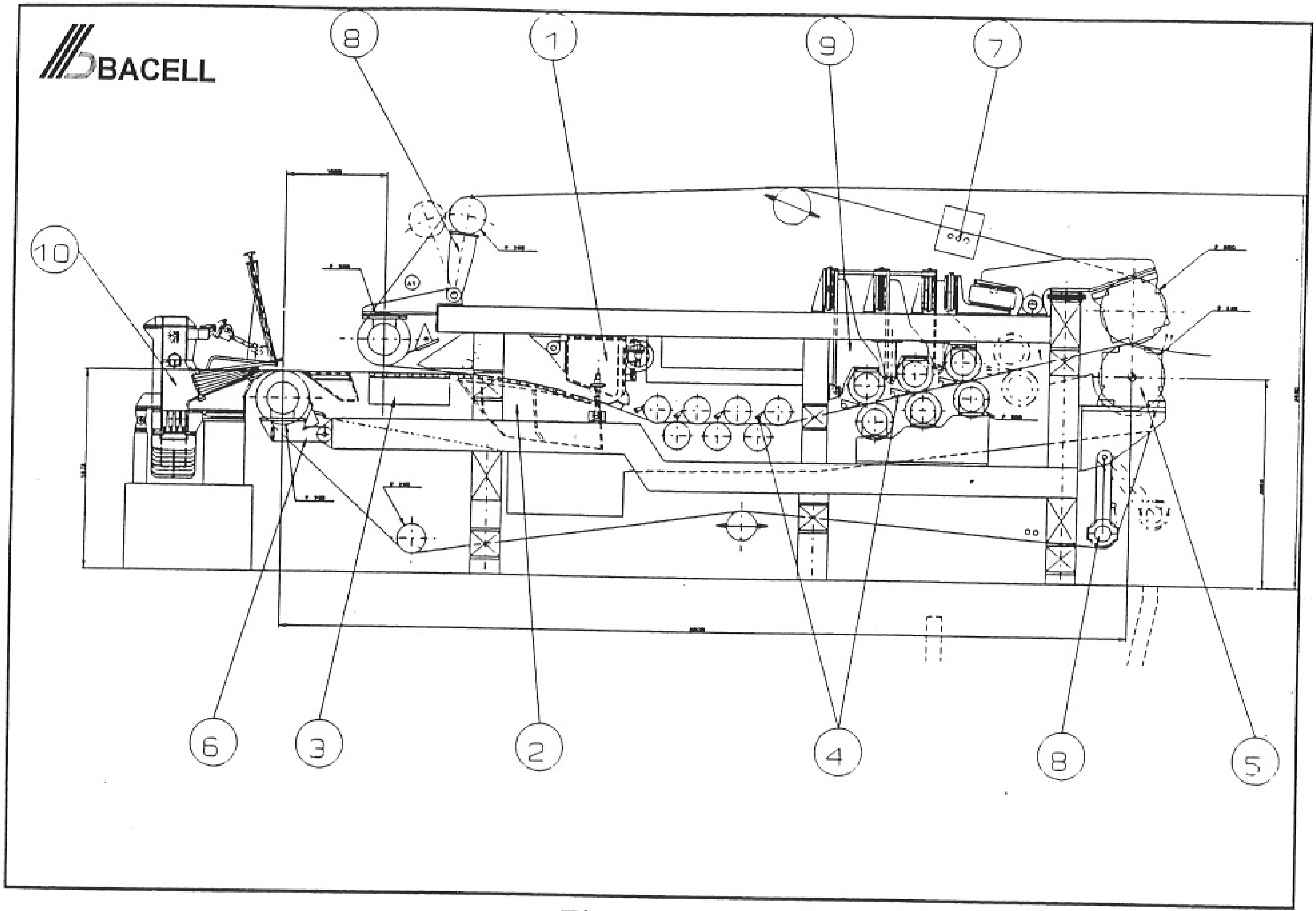


Figure 5

Figure 6

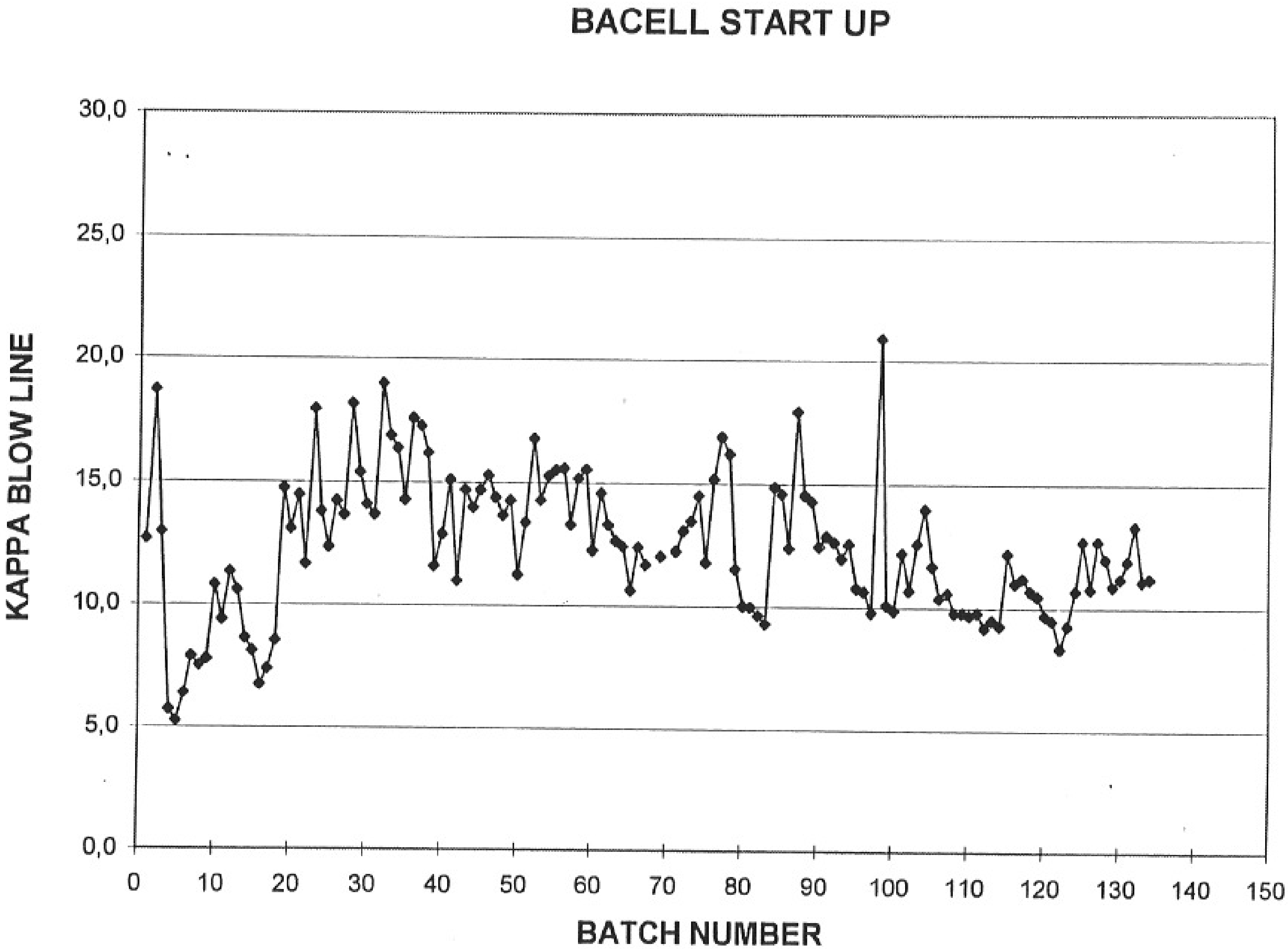

BACELL START UP
KAPPA BLOW LINE
30,0
25,0
20,0
15,0
10,0
5,0
0,0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
BATCH NUMBER

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Figure 7

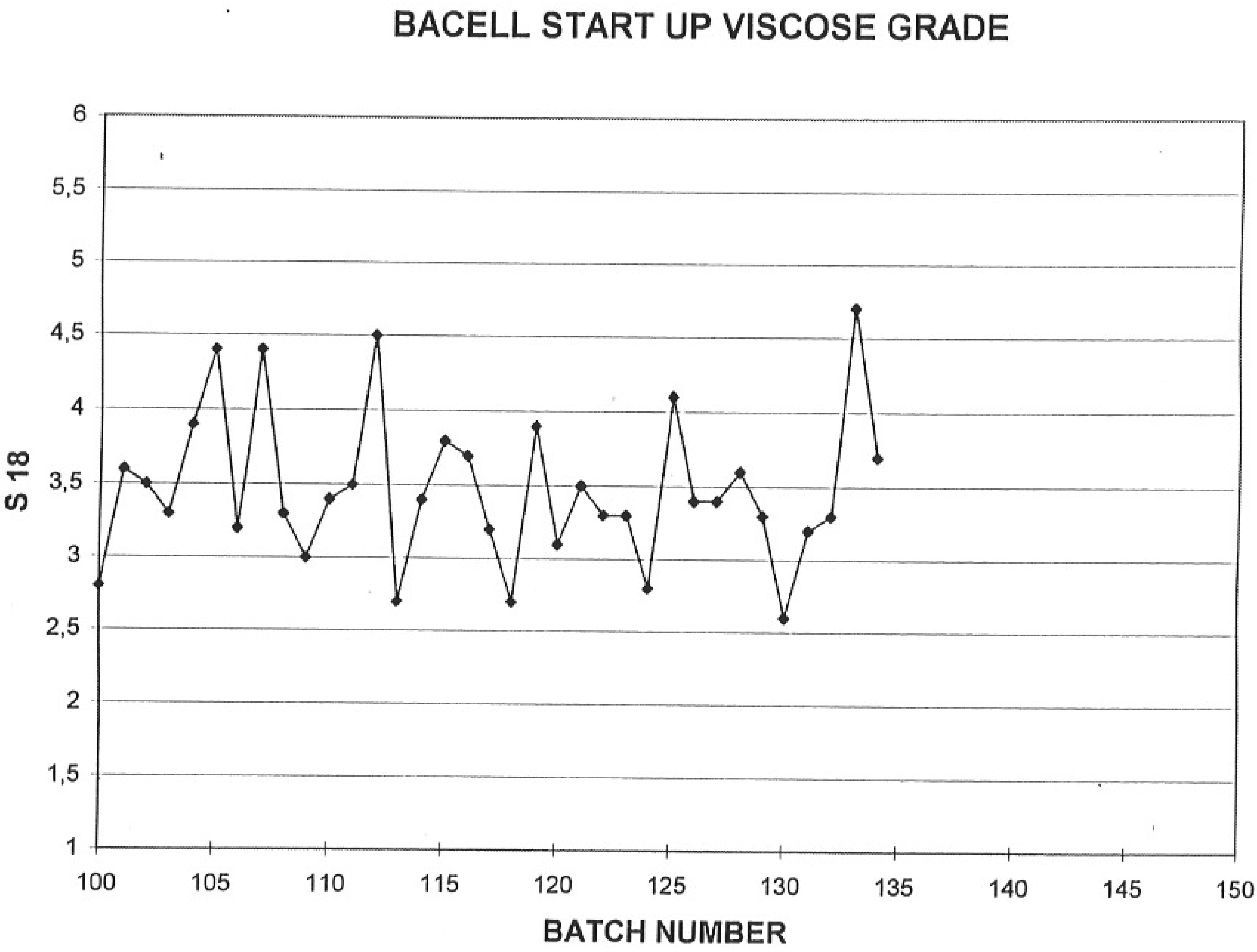

Figure 8

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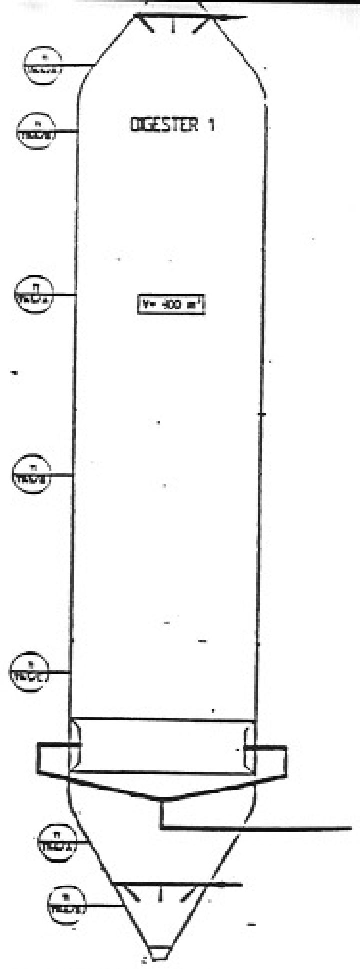

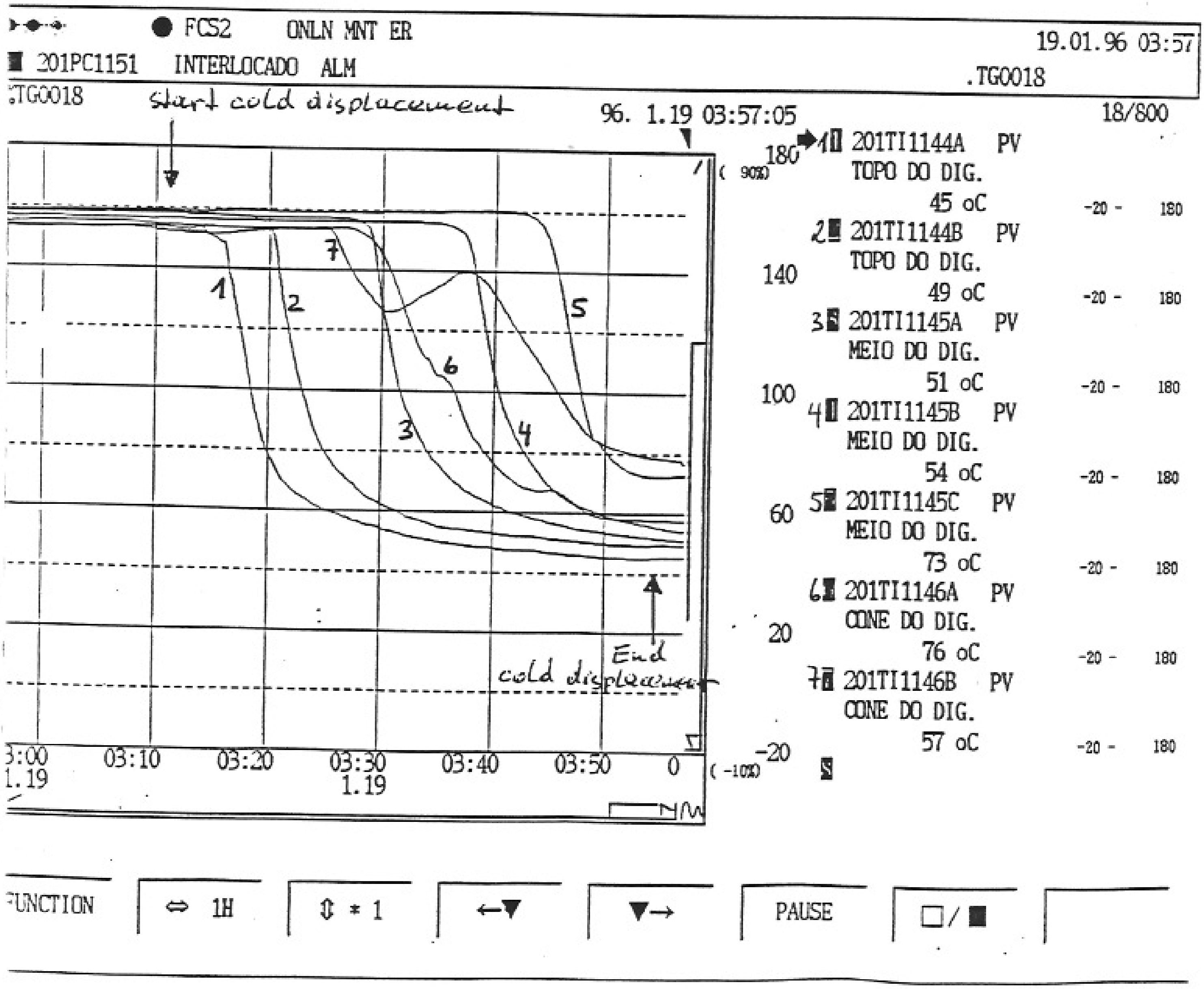

Figure : 9

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BACELL S.A. VISBATCH COOKING PLANT

Technical data

3 digestors of $300m^3$ each

		design	achieved
Daily production from digestors	bdmt/d	306	268 (*)
Steam Consumption	kg/bdmt pulp	880	780
Cooking cycle	min	317	333
Kappa from digester	no	10	9,5
Viscosity	dm3/kg	1200	1239
Alpha Cellulose	%	96	96
Alkali input	Y.A.A.as NaOH	23	22,5

(*) Due to limitation in recovery = 329 bont/d - based on present cooking-cycle

Figure 10:Course of kappa number before and after OO-delignification.

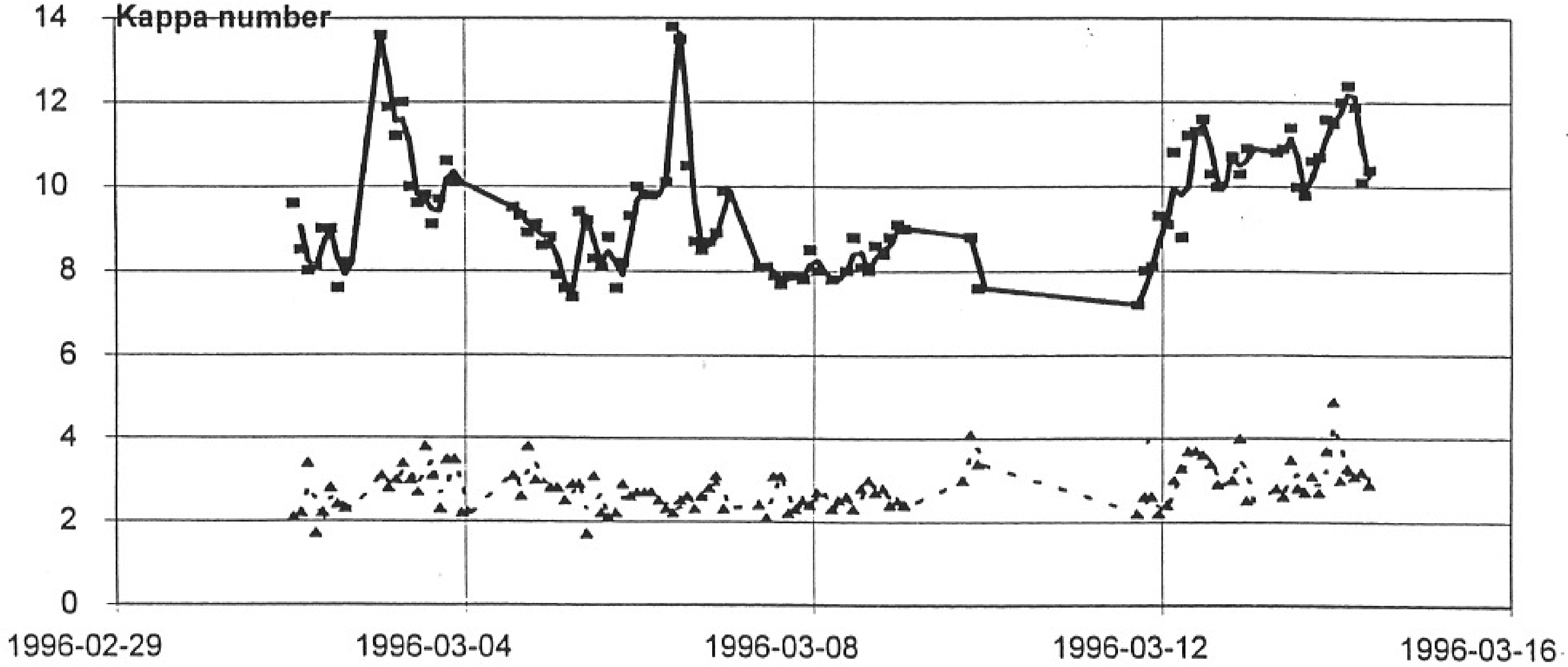

Figure 11: Course of viscosity before and after OO-delignification.

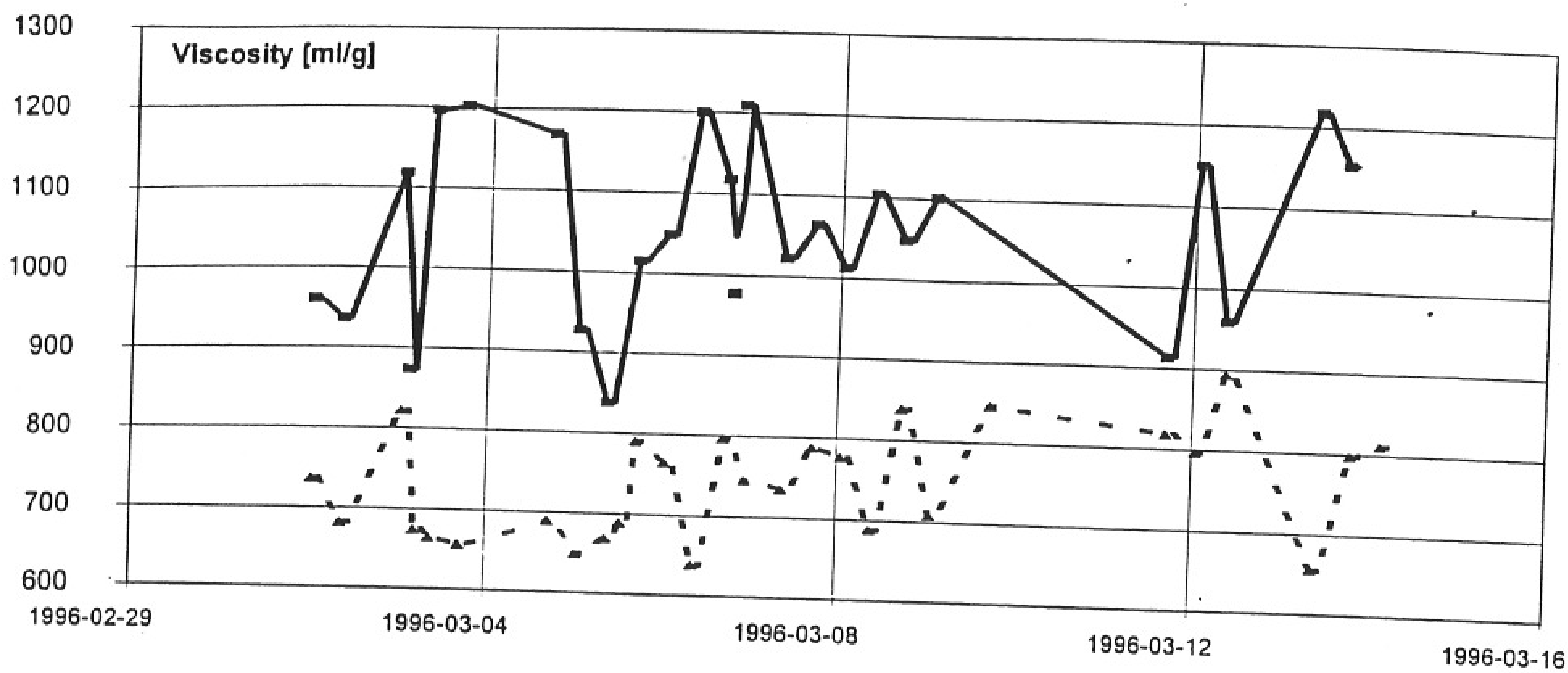

Figure12 :Course of brightness before (A-stage), after ozone (ZQ) and after P-bleaching.

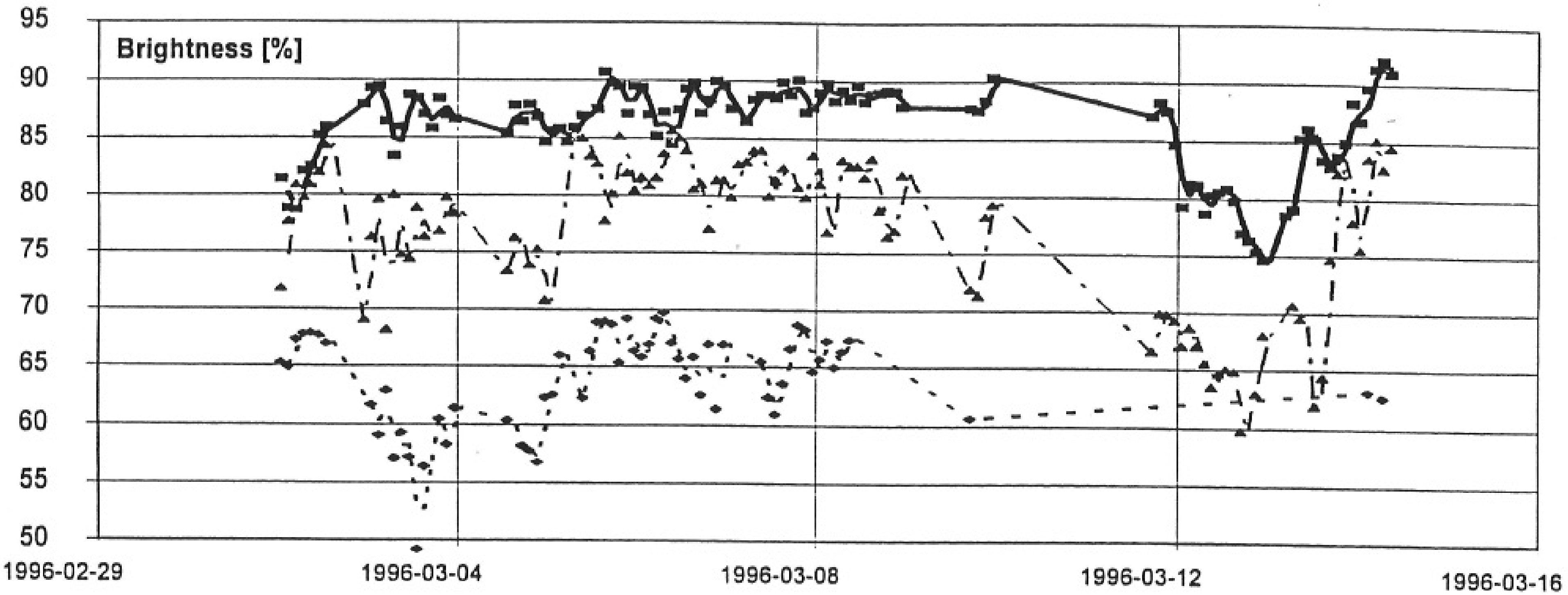

Figure13 :Course of viscosity before and after P-bleaching.

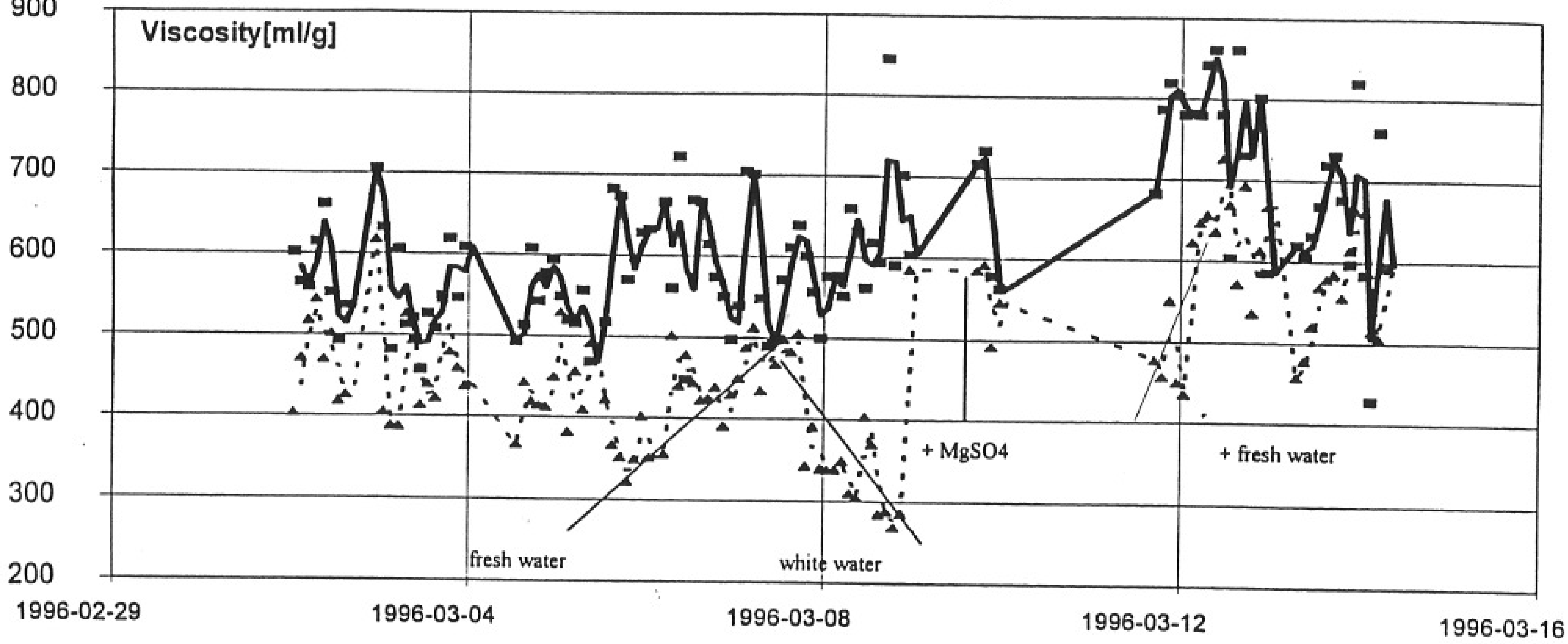

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Figure 14

PULP CHARACTERISTICS AFTER P STAGE WASHING
14/03/96 - PERIOD 03:00 TO 10:00 h

VISCOSITY	BRIGTHNESS	S18 *	KAPPA
(cm^3/g)	(% ISO)	(%)	NUMBER
535	91,3	3,6	0,5

PRODUCT CHARACTERISTICS

LOT	B. WEIGHT	DIRT	VISCOSITY	BRIGTHNES S	S18 *	ASH
NUMBER	(g/m^2)	(mm^2/ m^2)	(cm^3/g)	(% ISO)	(%)	(%)
6031801	666	0,33	537	89,4	3,9	0,12
6031802	667	0,27	528	88,8	3,4	0,08

*S18 = NaOH 18% solubility - Characterizes the low molecular weight polysaccharides soluble in alkali