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Múltiplos benefícios do uso de xilanase em fábricas kraft de hardwood

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MULTIPLE BENEFITS FROM THE USE OF XYLANASE IN A HARDWOOD KRAFT MILL AT NEXFOR FRASER PAPER IN THURSO QUEBEC

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SUMMARY

A xylanase treatment stage was implemented in the fiber line at Thurso, Quebec, in the high-density storage tower, before the first bleaching stage. A Total Kappa Factor (TKf) reduction of 10.9% was obtained as a result of xylanase treatment, while maintaining the final product properties. The xylanase treatment also allowed an increase in the feed kappa number of 0.8 units, a decrease in steam consumption of 0.21 GJ/adt and a boost in maximum bleach production of 10 adt/day. The results obtained in the mill matched and in some cases exceeded the experimental data.

RESUMO

Um estágio de tratamento com xilanase foi implementado na linha de produção de fibras em Thurso, Quebec, na torre de armazenagem de alta densidade, antes do primeiro estágio de branqueamento. Obteve-se uma redução do fator Kappa total (TKf) de 10,9% como resultado do tratamento com xilanase, enquanto se manteve as propriedades do produto final. O tratamento com xilanase também permitiu um aumento no número kappa de alimentação de 0,8 unidades, representando uma redução no consumo de vapor de 0,21 GJ/adt e um aumento na produção máxima de branqueamento de 10 adt/dia. Os resultados obtidos no moinho foram condizentes e, em alguns casos, excederam os dados experimentais.

KEY WORDS
Xylanase, enzymes, kraft mill, bleach plant, total Kappa factor, energy, production, Kappa number, strength properties.

PALVRAS CHAVE
Xilanase, enzimas, moinho de polpa Kraft, planta de branqueamento, fator Kappa total, energia, produção, número Kappa, propriedades de resistência

INTRODUCTION

First reported in 1986 [1], xylanase technology was introduced commercially in 1991. 20 mills in North America are now successfully using the technology on a continuous basis [2,3]. Xylanase treatment is a low capital technology aimed at improving the pulp bleachability by treating the brownstock with a xylanase enzyme prior to bleaching. The increased pulp bleachability corresponds to a diminution in chemical requirements for the same final bleached product. The mechanism by which partial xylan hydrolysis improves the pulp bleachability is still a subject of debate [4, 5].

The enzyme in use at Thurso is Biobrite ®, a *Trichoderma* xylanase engineered for thermophilicity [6]. The application started in June 2000 and continues as an ongoing operation. The present paper gives a detailed description of the validation process and the mill results of the xylanase implementation.

THURSO MILL

The Nexfor Fraser Paper mill at Thurso produces on average 680 adt/day of bleached hardwood kraft pulp. A blend of hardwood chips is pulped in eight batch digesters, washed through two lines totaling five counter-current washers, thickened on one vacuum drum and stored in a high density storage tower, before entering the bleach plant via a vacuum drum pre-washer. Prior to installing the xylanase application, the bleaching sequence was DEopDED, with a final brightness of 90.5% ISO.

The major objective of the xylanase stage installation at Thurso mill has been to reduce the bleaching cost with the least capital investment and environmental impact, while maintaining the physical properties of the final product, the production rate and the bleached pulp yield.

XYLANASE APPLICATION

Xylanase is added to the brownstock in the chute below the thickener (Fig.1). The xylanase treatment takes place in the high-density brownstock storage tower. Concentrated sulfuric acid is added along with xylanase, to bring the pH of the pulp slurry to an optimum range for the enzymatic treatment. The acid and enzyme dosage are controlled by the addition system which is provided by the supplier to eliminate the need for capital and provide other automated services.

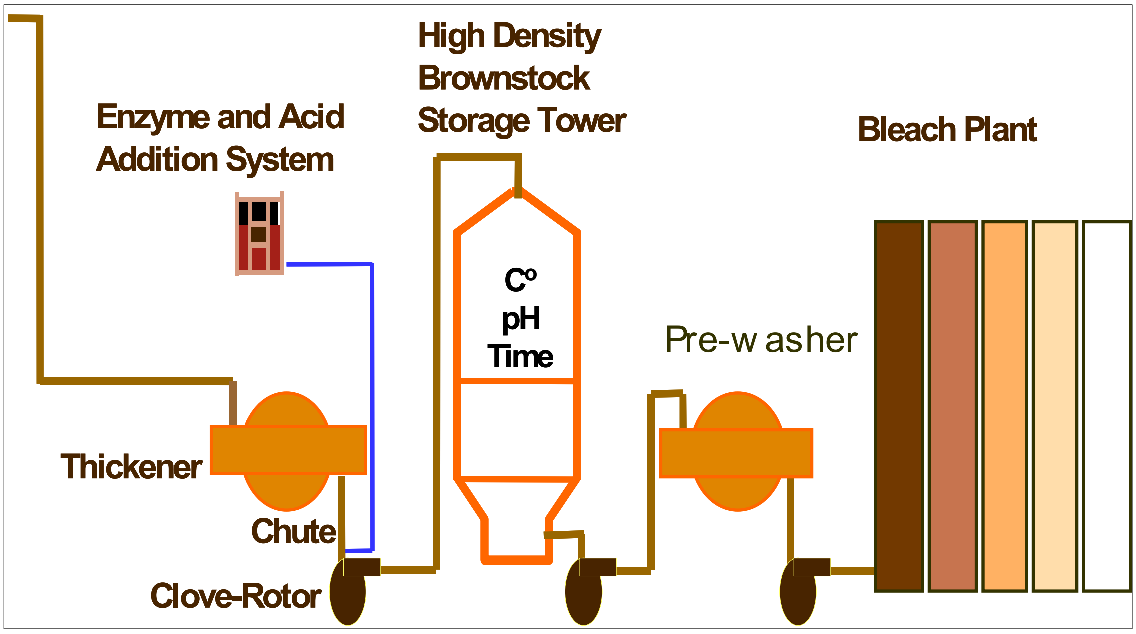

Figure 1. Schematics of xylanase application at Thurso mill

SUPLIER TECHNICAL PROCESS

The process audit conducted prior to the application startup provided specific information about the metallurgy of the process, mixing quality, pH and temperature control, and potential contact time between pulp and xylanase. It played an important role in the choice of location of the enzyme addition.

As the enzyme application at Thurso required addition of concentrated acid, it was crucial to ensure that this addition take place in a closed area, in order to contain any spray, to reduce the risk factors such as acid spills, and to ensure safe and easy access to equipment. Iogen provided the equipment required to safely control pH and key enzyme conditions.

Tracer tests performed with an inert chemical showed adequate retention time in the high-density storage tower for the xylanase treatment to take place, despite channeling. The channeling occurring at Thurso is due more to the squat geometry of the tower and less to the pH, temperature and pulp consistency, which are nominal for plug flow [7]. The temperature in the high-density tower was close to xylanase optimum.

LABORATORY ASSESSMENT

Specific information about bleach plant operating parameters such as kappa number, chemical charge, pH, temperature, and brightness was collected and used for simulating the mill's bleaching sequence in the experimental work. The mill data analysis, in combination with practical experience, was used to establish a trial plan and ultimately a new bleach plant strategy.

The optimum parameters for xylanase treatment, namely pH, temperature, and enzyme dosage, were determined in a preliminary laboratory study using a representative pulp sample from the mill.

A bleaching test, simulating the mill's sequence based on the results from mill data analysis, indicated an estimated reduction of Total Kappa factor (TKf) of 10% at a xylanase dosage of 100 ml/t (Fig. 2).

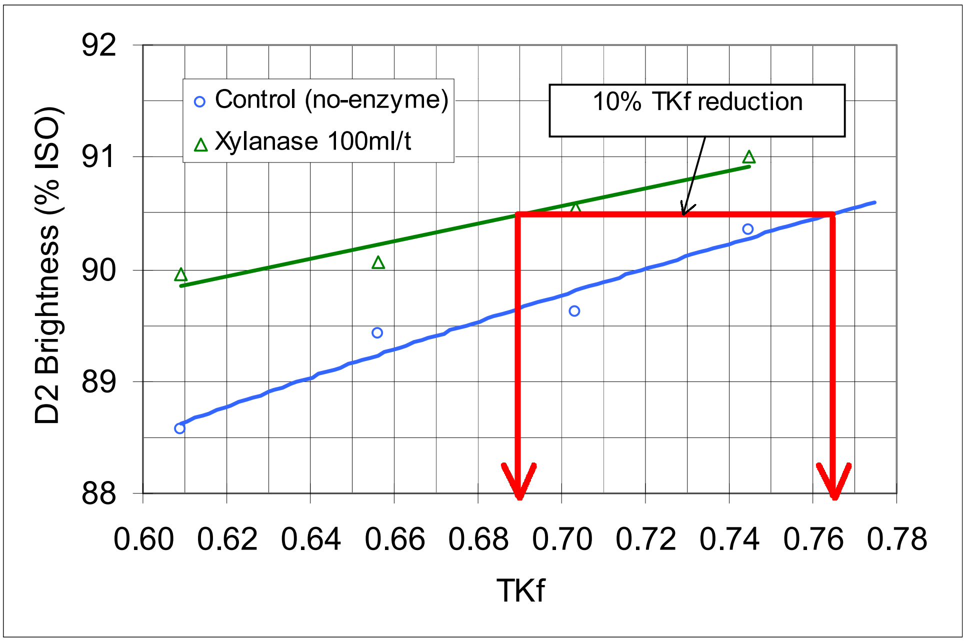

Figure 2. Total kappa factor reduction for Thurso pulp at 90.5 % ISO brightness

MILL RESULTS

The xylanase treatment stage began operation in June 2000. Four months later, a significant corrosion of the standpipe was observed at the acid addition point, due to direct contact of the 316 stainless steel and concentrated acid caused by fluctuations of the pulp level in the standpipe. The 316 stainless steel formulated for use in alkaline conditions had to be replaced. From October 1st 2000 until November 11th 2000, the xylanase treatment was interrupted pending the replacement of the corroded standpipe with a 904L stainless steel pipe. At the same time, the clove rotor casing was upgraded to 317stainless steel in order to minimize the risk of corrosion in the acidic environment. Continuous xylanase stage operation was restarted on November 12th 2000 (Fig.3).

The analysis of the results will refer to Baseline 1 as the time period preceding xylanase stage implementation (from March 30th, 2000 until June 6th, 2000), and Baseline 2 as the interval between October 1st and November 11, 2000, when the enzyme stage was temporarily interrupted. Xylanase 1 and Xylanase 2 refer to the first and the second xylanase treatment period, respectively (Fig. 3).

In order to maximize benefits from xylanase treatment, the bleaching strategy was changed with enzyme implementation: the chemical charge was decreased at the front end of the bleaching sequence and increased at the back end (Table I). This enzyme bleaching strategy was kept during Baseline 2 operation.

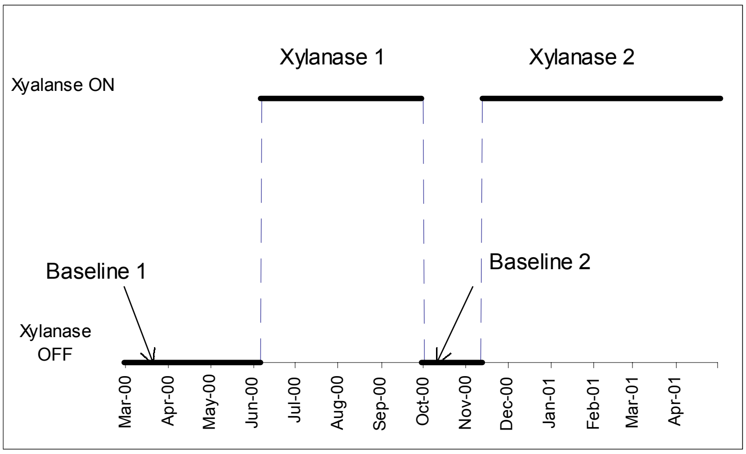

Figure 3. Time periods used for analysis of mill results.

As part of the optimization process, hydrogen peroxide was intentionally removed from the extraction stage on October 23, 2000. Xylanase compensated for the brightness loss due to peroxide elimination in the extraction stage (Table I).

Table I. Changes in bleaching strategy for maximization of benefits from xylanase

		% from Total Active Chlorine (TaCl)			
Stage	Chemical	Baseline 1	Xylanase 1	Baseline 2	Xylanase 2
D	ClO2	45.7	44.6	44.4	44.7
Eop	O2	21.4	23.3	22.9	24
	H2O2	3.8	2.6	4.8	0
D	ClO2	16.9	16	15.2	17
E		0	0	0	0
D	ClO2	12.2	13.3	12.7	14.3
Total		100	100	100	100

Xylanase treatment allowed the mill to increase the feed kappa number by 0.8 units, as a result of increased pulp bleachability (Fig. 4). This was not economical before xylanase implementation, due to limitations in the bleach plant's throughput capacity associated with the increase in feed kappa number.

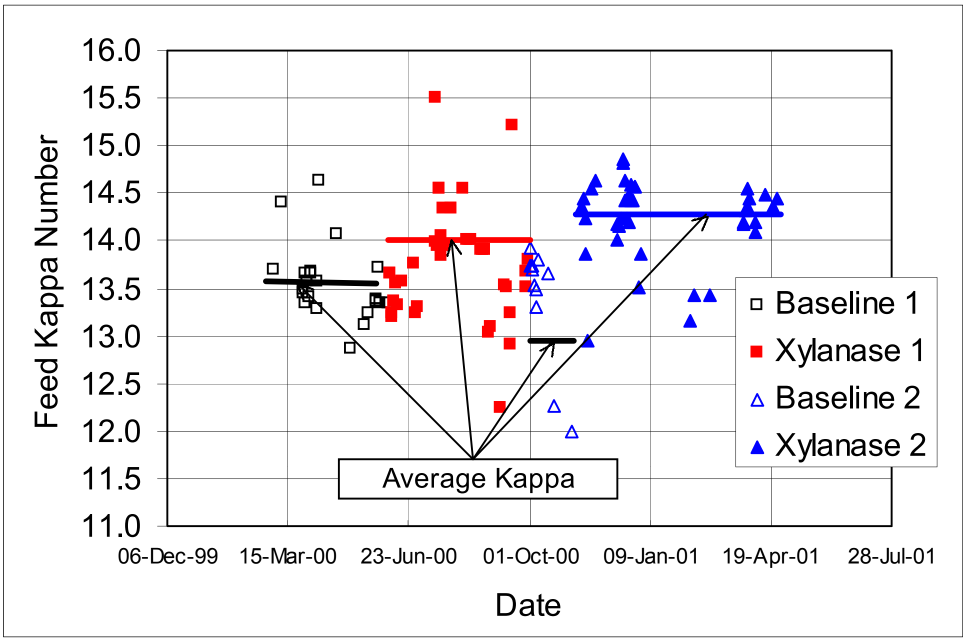

Figure 4. Feed kappa number increase with xylanase treatment over one year period

Total active chlorine was decreased during Xylanase 1 and Xylanase 2 operation as a result of increased pulp bleachability due to xylanase treatment (Fig. 5.a. and 5.b.). The differences between TaCl for Baseline 1 and for Baseline 2 were not significant, indicating that, in the absence of enzyme, the required chemical charges were about the same for both baselines, regardless of bleaching strategy.

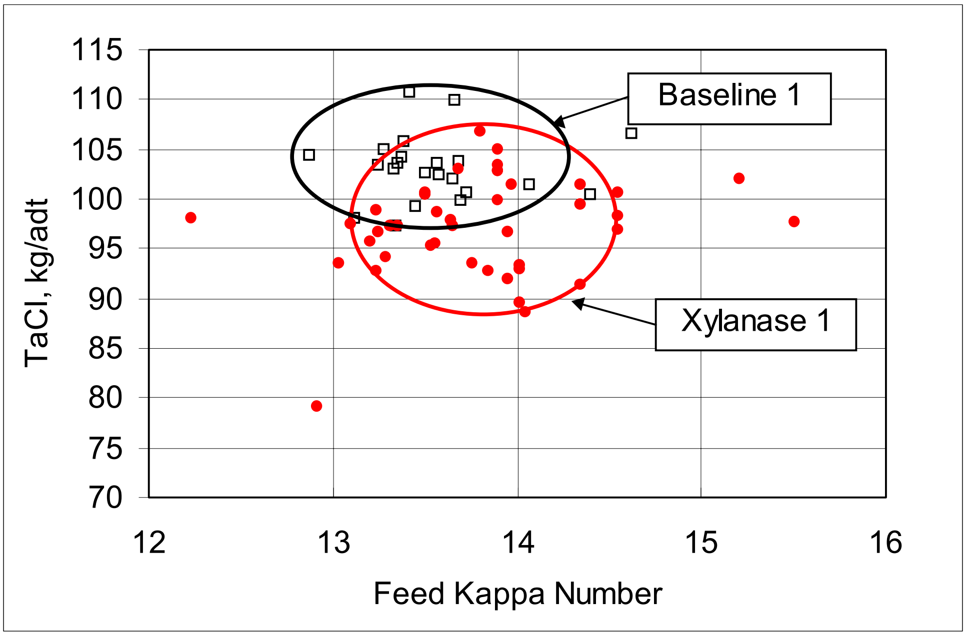

Figure 5.a. Total active chlorine versus feed kappa number: evaluation of first Xylanase period.

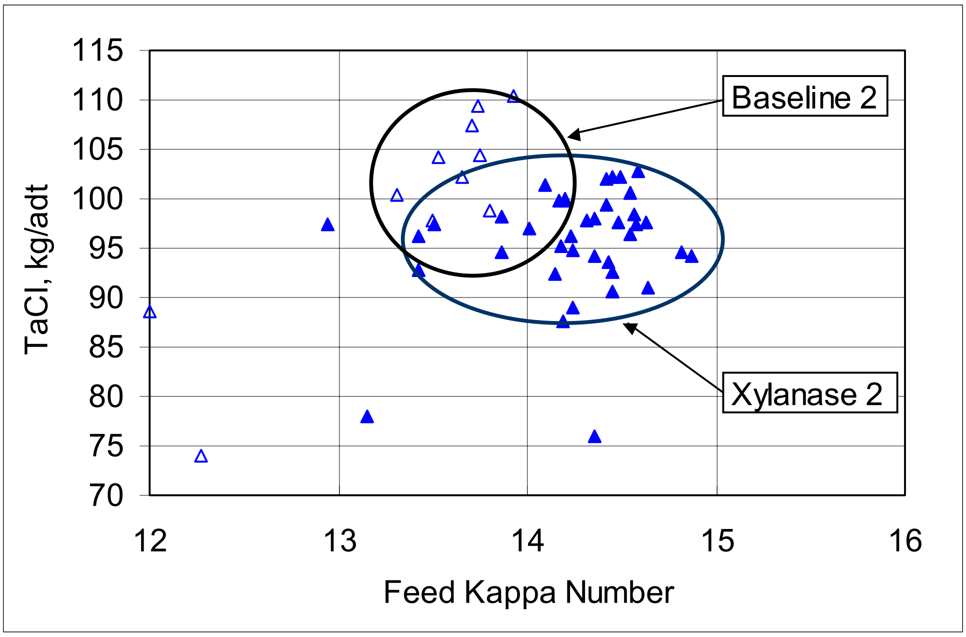

Figure 5.b. Total active chlorine versus feed kappa number: evaluation of the second Xylanase period.

An interesting angle for the analysis of the xylanase benefits is the detailed impact of xylanase on chemical requirements in bleaching stages (Table II). Although the peroxide was removed from the first extraction stage during the Xylanase 2 period, xylanase treatment overcame the decrease in active chlorine and the mill could still see positive bleaching economics.

Table II. Detailed impact of xylanase on chemical requirements

Total Kappa Factor Changes, %			
Stage	Xylanase 1	Xylanase 2	Xylanase Overall
D	-3.9	-6.3	-5.0
Eop	-1.5	-7.2	-4.0
D	-2.2	-1.2	-1.7
E	0.0	0.0	0.0
D	0.2	-1.1	-0.2
Total	-7.5	-15.8	-10.9

A comparison between baselines and xylanase treated data revealed an overall constancy in average final brightness at 90.5 % (Fig. 6). During Xylanase 2 operation, the average brightness remained approximately 90.5 %, despite peroxide elimination.

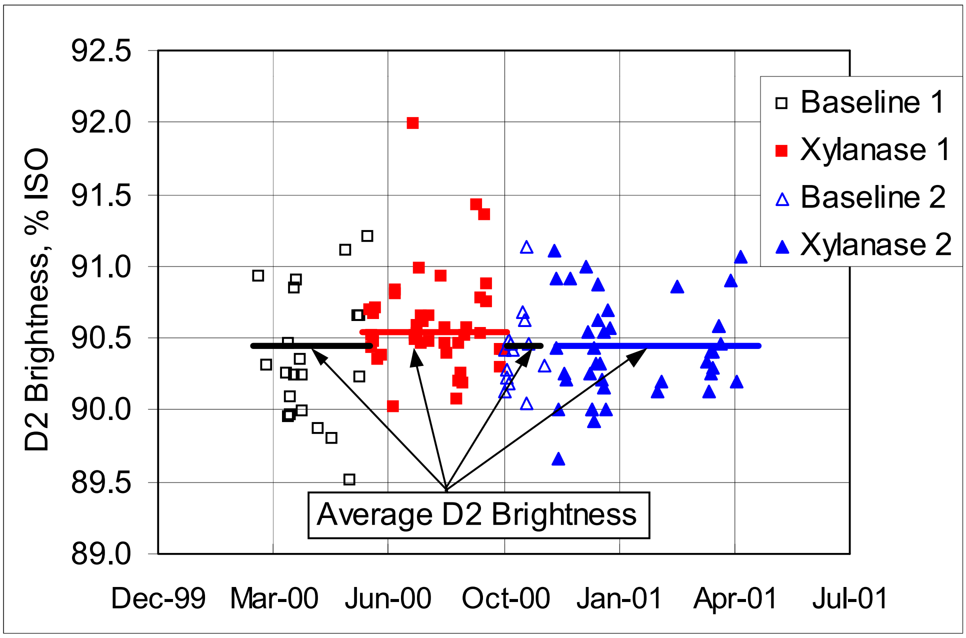

Figure 6. Brightness with xylanase treatment over one year period.

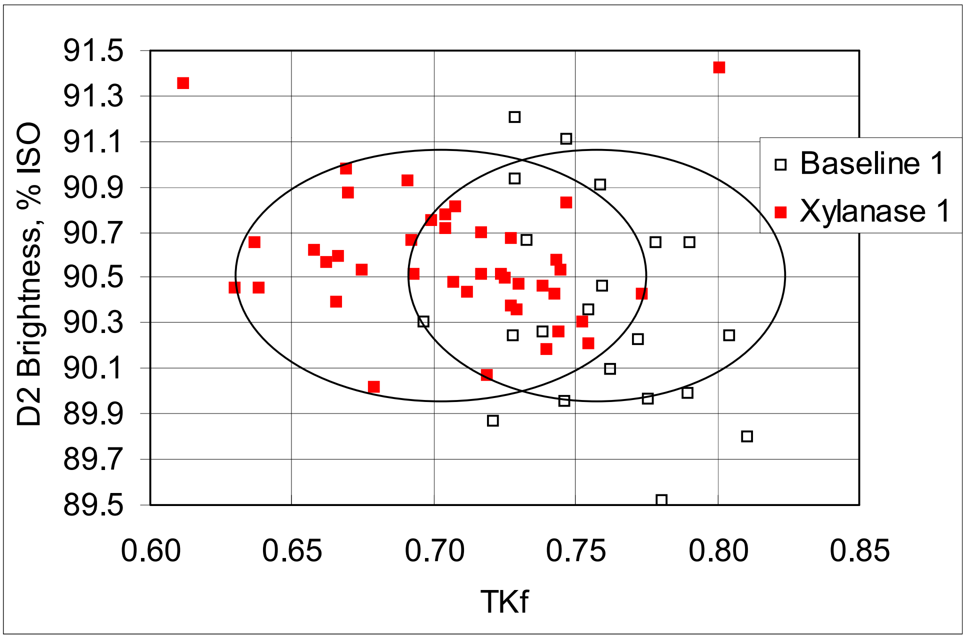

Figure 7.a. Total kappa factor reduction: evaluation of the first Xylanase period.

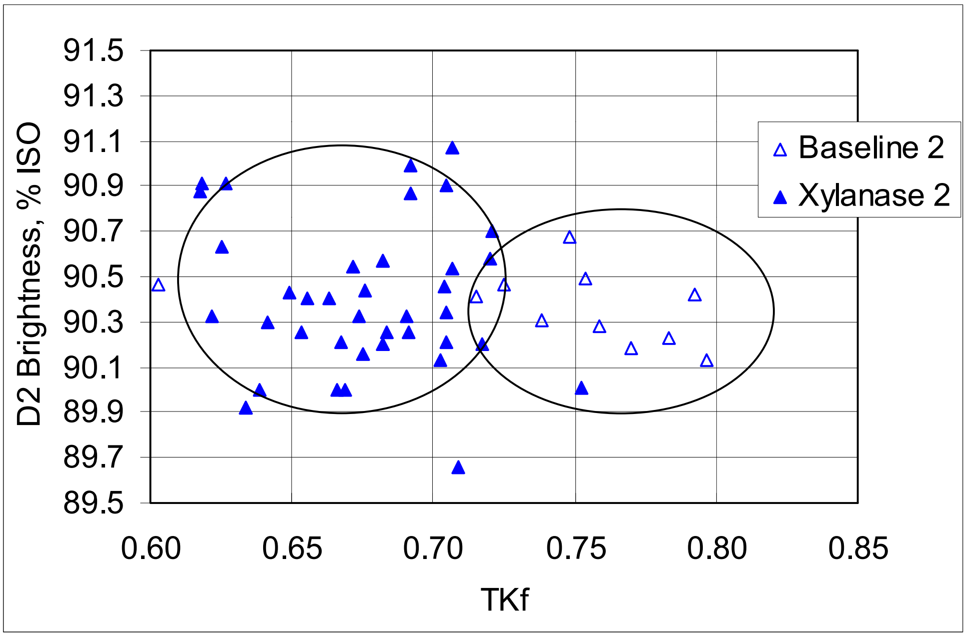

Figure 7.b. Total kappa factor reduction: evaluation of the second Xyalanase period.

The TKf reductions achieved with xylanase were of the order of 8% for the first Xylanase period and 16% for the second Xylanase operation (Fig. 7.a. and 7.b.). Overall, TKf was reduced by 10.9%. The reductions in TKf coupled with the increase in feed kappa number and final brightness allowed important economic savings to the mill.

Another benefit from xylanase stage was the decrease in energy consumption. With the use of enzymes, the temperature in the first bleaching stage was decreased from a typical 50°C to 45°C, as a result of the improved reaction kinetics in that stage. This represented about 0.21 GJ/adt.

As a direct benefit from xylanase stage, the maximum bleaching capacity was increased by approximately 10 adt/day by lowering the chemical charge required to attain the target final brightness.

Xylanase treatment had no measurable/significant impact on final product strength properties in mill testing (Table III).

Table III. Xylanase impact on bleached pulp properties

Bleached Property	Changes due to Xylanase, %
Burst	+0.1
Tear	-1.6
Tensile	-0.6
Freeness	+3.2

Xylanase had no measurable impact on effluent biological oxygen demand or aliphatic organic compounds (data not showed).

CONCORDANCE BETWEEN LABORATORY AND MILL RESULTS

Mill results matched and exceeded laboratory results. Mill average brightness versus average TKf results for Xylanase treated pulp fell on the laboratory control curve, showing that the methods used in Iogen experimental work can predict the mill results (Fig. 8). The final brightness of the mill control was slightly lower than that obtained in the laboratory at same TKf charge, most likely due to differences in washing efficiencies or in kappa number range.

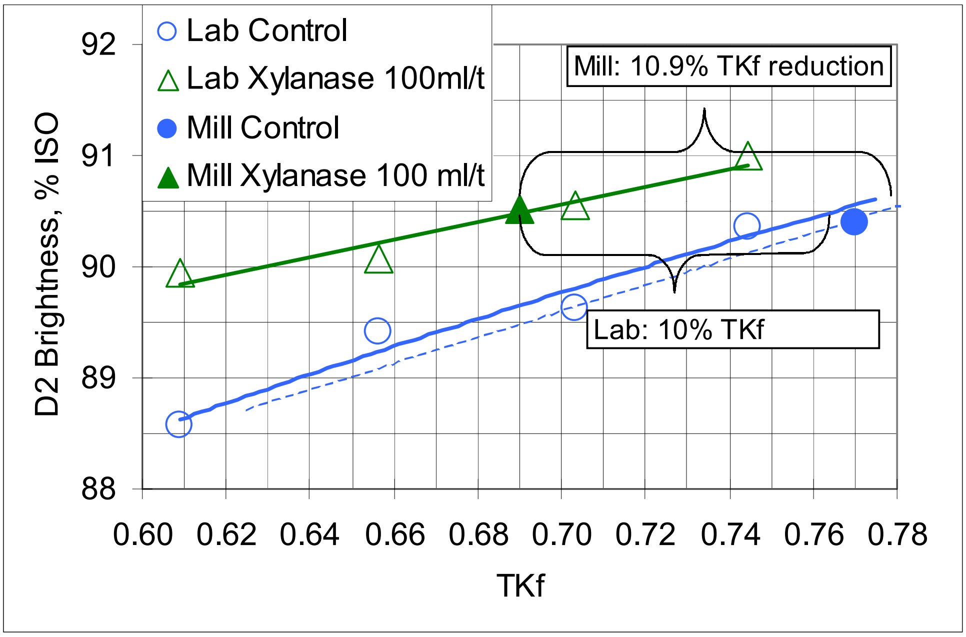

Figure 8. Comparison between laboratory prediction and mill results.

Multiple reproducibility of the laboratory work in mill process has been confirmed in both softwood and hardwood mills with three, four or five stage bleach plants.

CONCLUSIONS

Successful xylanase implementation and operation at Thurso Quebec resulted in several benefits to the mill. These included a 10.9% reduction in total kappa factor, coupled with an 0.8 units increase in feed kappa number, a boost of 10 adt/day in the maximum bleaching production and a steam consumption diminution of 0.21GJ/adt. Xylanase stage implementation did not have any significant impact on bleached pulp strength properties or mill effluent quality. The results obtained in the mill matched and in some cases exceeded the experimental data.

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