Reduction in Pollution Load and Pulp Quality Improvement with Enzyme, Alkali-Oxygen Delignification Prior to Mill Pulp Bleaching

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Oxygen delignification renders pulp readily accessible to xylanase enzyme and increases the bleaching benefits of enzyme treatment. In this paper unbleached pulp was treated with different dosages of VLBL enzyme and reaction temperature was maintained at 40^0, $50^0$and 60^0c for 60 minutes to get higher pulp kappa reduction. Resultant pulps consume less in bleach chemicals to achieve desired brightness while pulp quality is observed to be superior to enzyme untreated bleached pulp.

In other set of experiment pulp of Kappa 19.0 was bleached under C-Ep-H-D, O-C-Ep-H-D, O-Enz-C-Ep-H-D and Enz-O-C-Ep-H-D bleaching sequences by incorporating enzyme stage before and after Alkali-Oxygen delignification. By application of Alkali-Oxygen delignification, pulp Kappa was reduced by 38.0 %, which has helped in considerable reduction of total bleach consumption under O-C-Ep-H-D sequence, compared to C-Ep-H-D sequence.

By addition of enzyme prior and after Alkali-Oxygen delignification stage the total chlorine consumption could be reduced by more than 50% under Enz-O-C-Ep-H-D and O-Enz-C-Ep-H-D sequence respectively compared to blank experiment.

Physical strength properties of the bleached pulp under Enz-O-C-Ep-H-D sequence were observed to be inferior both to O-C-Ep-H-D or O-Enz-c-Ep-H-D bleaching sequences. Physical strength properties of the bleached pulp in O-Enz-C-Ep-H-D sequence were better than other bleaching sequences.

The pollution load in terms of COD, dissolved solids and chloride content was found to be on higher side in Enz-O-C-Ep-H-D sequence compared to O-Enz-C-Ep-H-D sequence but lower than O-C-Ep-H-D and C-Ep-H-D bleaching sequences.

INTRODUCTION

Environmental concerns have necessitated measures to reach lower lignin content in pulp before bleaching with conventional chlorine compounds. A lower kappa number in the pulp means that the chlorinated organic matter will also be reduced in bleach plant effluents. In 1986 Viikari et al were the first to demonstrate that xylanase prebleaching facilitates the subsequent bleaching of kraft pulps[1]. The first mill trial of xylanase in North America were carried out at port Alberni in 1991 and ongoing usage in some mills started in early 1992. There after it was confirmed and further developed by extensive laboratory studies with hard wood and soft wood pulps[2-4]. Xylanase added bleaching has been tested on numerous chlorine based[4-9], and E.C.F[4,10-13] bleaching sequences. Over the last decade, the active and potential applications of enzymes in production of pulp and paper have steadily grown with several processes being used on a commercial scale.

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Enzyme treatment causes a physical loosening of the fibre due to partial depolymerisation of hemicellulose chains which facilitates extraction of residual lignin during bleaching[5,12].

Oxygen delignification renders pulp more accessible to xylanase enzymes and increases the bleaching benefit of enzyme treatment[15,16]. Roughly 40% of North American bleach plants use oxygen delignification system. While almost 100% of bleach plants in Scandinavia use oxygen delignification[16-18]. The use of oxygen delignification systems has steadily increased worldwide since 1st commercial installation in 1970[19].

Installation of oxygen delignification system do not typically justify the higher rates of return on capital employed demanded by the industry today[20] but the environmental benefits and lower operating costs of oxygen delignification as compared to alternate bleaching sequences are well acknowledged throughout the industry. Oxygen delignification system exhibits many environmental advantages including reduction in AOX, BOD, COD and effluent colour. As a result oxygen delignification plants in India are now being installed at a faster pace with due significance to environmental protection.

EXPERIMENTAL DETAILS

VLBL enzyme is a brown liquid which contains endo-1,4-bets-D-xylanase and is virtually free of cellulose activity. It is non toxic and readily biodegradable. Pulp enzyme VLBL is an alkaline and thermo stable xylanase product for the treatment of kraft pulp prior to bleaching which selectively removes xylan from the surface and pores of the fibres. This facilitates subsequent bleaching, reducing the level of bleaching chemicals required to reach the same degree of delignification or brightness target.

In the preliminary lab experiments VLBL enzyme dosages @ 0.3, 0.4 & 0.5 kg/ton of pulp were applied for 60 minutes at 40^oC, 50^oC and 60^oC. It was observed that 0.3-0.4 kg of VLBL enzyme/ ton of unbleached pulp for 60 minutes retention at 60^oC gave higher pulp kappa reduction compared to other

dosages. Thereafter the three enzymes treated pulps at 60°C and pulp of blank experiment were bleached under C/Ep/H/D sequence to achieve 87-88% P.V. brightness after which fibre classification and physical strength properties of the above bleached pulps were evaluated.

Mill pulp was also bleached under C/Ep/H/D/, O/CEP/H/D, O/Enz./C/EP/H/D and Enz /O/C/EP/H/D sequences to achieve 87-88% P.V. brightness. Effluent samples at each stage of bleaching were also analyzed for various parameters, while fibre classification of above bleached pulps were evaluated for physical strength properties.

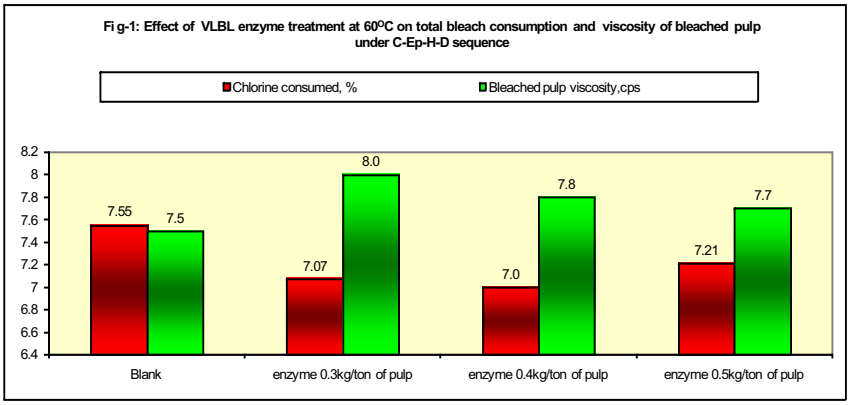
RESULTS AND DISCUSSIONS

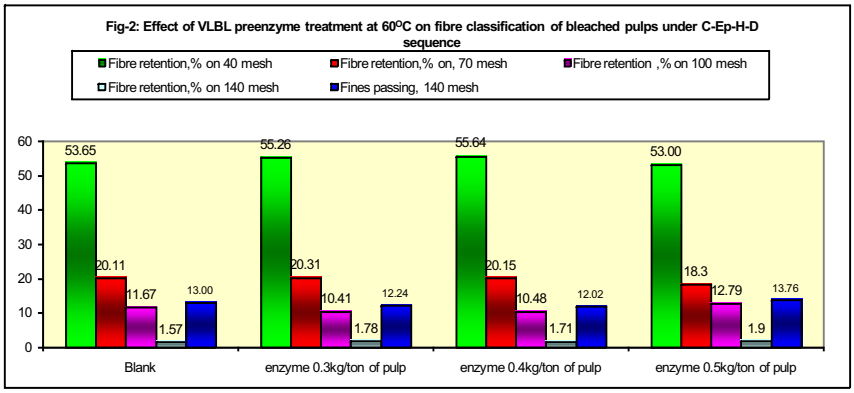
VLBL enzyme dosages @ 0.3, 0.4 & 0.5 Kg/ton of mill unbleached pulp was applied at reaction temperature of 40ºC, 50ºC and 60ºC. It was observed that higher unbleached pulp Kappa reduction (0.9-1.4) was obtained at 60ºC with different enzyme dosages compared to other temperatures. Subsequently all the VLBL enzyme treated unbleached pulps at 60ºC were bleached under C-Ep-H-D sequence for pulp brightness to 87-88% P.V. It was observed that total chlorine consumption was reduced and bleached pulp viscosity improved with enzyme dosages in the range of 0.3-0.4 Kg/Ton of pulp followed by C-Ep-H-D bleaching sequence. Total bleach consumption and viscosity of above bleached pulps are depicted in Fig.1.
Fibre classification results of enzyme treated bleached pulps show that fibre retention percentage on 40 mesh was higher with 0.3-0.4 Kg/ton enzyme dosages but reverse trend was observed with higher fines passing through 140 mesh. Increase in VLBL enzyme dosage to 0.5 Kg/ton of pulp reduced fibre retention percentage on 40 mesh and fines passing through 140 mesh was observed to be on higher side compared to lower dosage of VLBL enzyme. These findings are highlighted in Fig.2.

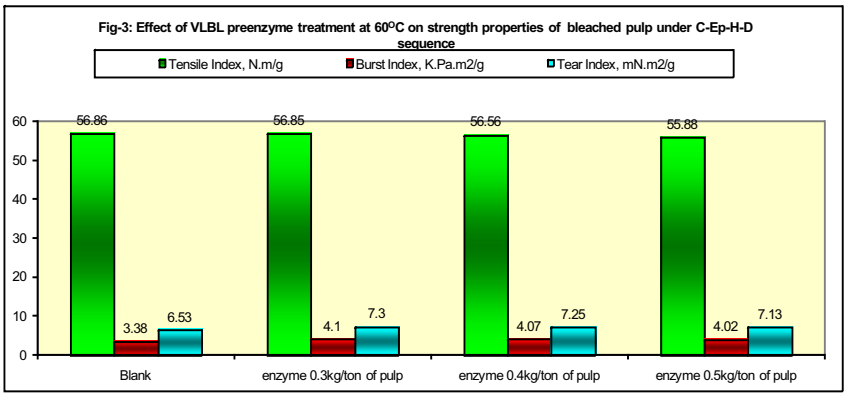
Enzyme treated and untreated bleached pulps were evaluated for physical strength properties which show that Burst index, Tear index & double folds are higher at lower enzyme dosages compared to blank experiment and the findings are highlighted in Fig.3 .

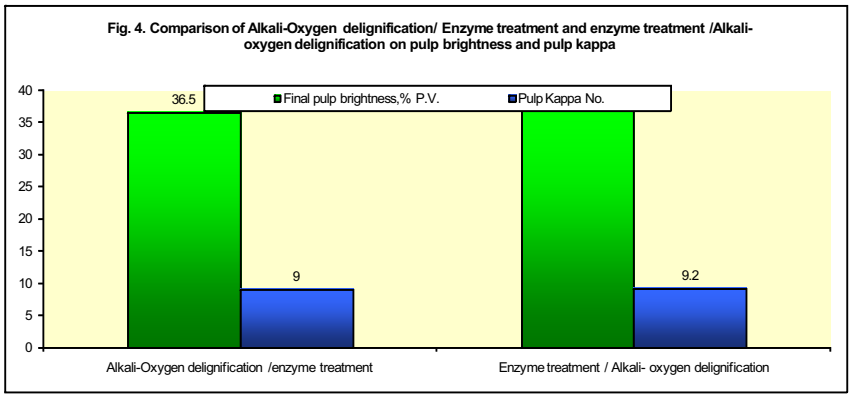
In order to reduce chlorine consumption alkali-oxygen was applied to unbleached pulp (Pulp kappa 19.2) followed by enzyme treatment (@ 0.3 Kg/ton of pulp stage), which resulted in pulp kappa reduction by 53.1% and pulp brightness improvement by 52.0%.

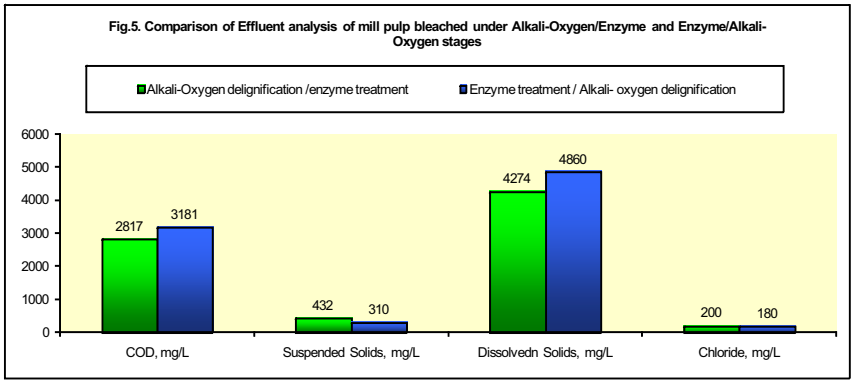
In another experiment VLBL enzyme (0.3 Kg/ ton of unbleached pulp) was applied in the first stage followed by alkali/oxygen delignification stage. This resulted in pulp brightness improvement by 54.6% and pulp kappa reduction of 52.1%. Comparison of

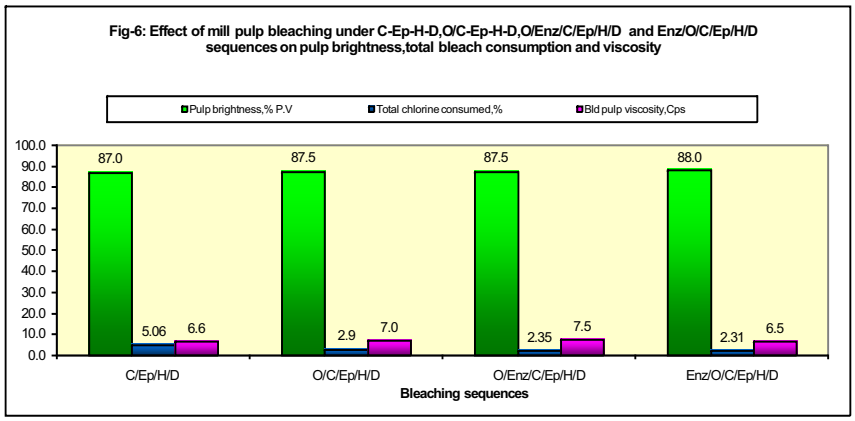


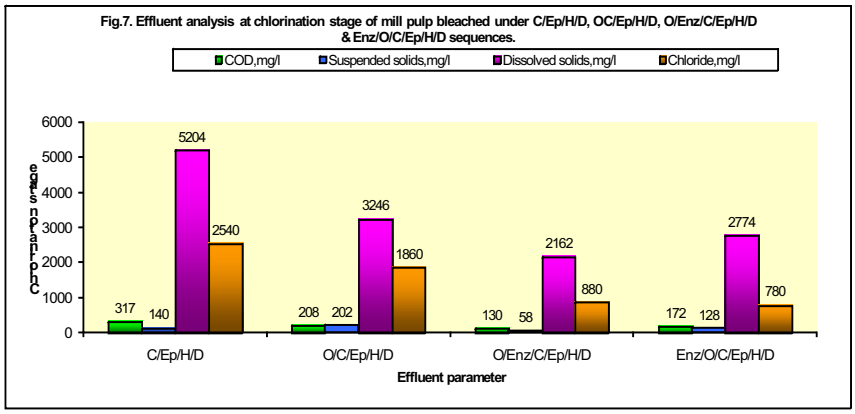


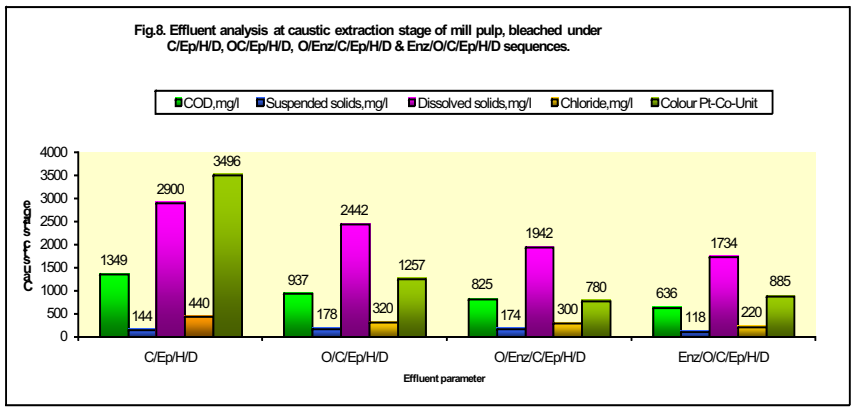












pulp brightness and pulp kappa reduction in alkali/oxygen delignification followed by VLBL enzyme treatment and VLBL enzyme treatment followed by alkali/oxygen stage is depicted in Fig.4.

Total pollution load in the form of COD, suspended solids, dissolved solids and chloride in alkali/oxygen stage followed by enzyme treatment is compared with VLBL enzyme stage followed by alkali/oxygen treatment in fig.5. COD and dissolved solids in enzyme treatment / alkali-oxygen bleaching were higher than alkalioxygen /enzyme treatment stage.

Mill unbleached pulp (Kappa 19.2) as well as Alkalioxygen / enzyme and enzyme/ alkalioxygen treated pulps were also was bleached under C-Ep-H-D bleaching sequences to achieve the target brightness 87-88% P.V. Total chlorine consumption under O/C/Ep/H/D, O/Enz/C/Ep/H/D and Enz/O/C/Ep/H/D bleaching sequences was observed to be lower by 47.2%, 53.55% and 54.35% respectively compared to blank experiment (C/Ep/H/D sequence).

Viscosity of bleached pulp in O-C-Ep-H-D and O-Enz-C-Ep-H-D bleaching sequences were found to be higher than Enz-O-C-Ep-H-D and plain C-Ep-H-D bleaching sequences. Effect on total bleach consumption, pulp brightness and pulp viscosity in various bleaching sequences are highlighted in Fig.6.

As already explained mill pulp was bleached under various bleaching sequences and the effluent parameters at each stage of bleaching were also analyzed separately. It was observed that COD, dissolved solids and chloride content in chlorination stage was higher in C-Ep-H-D sequence followed by O-C-Ep-H D, Enz-O-C-Ep-H-D and Enz-O-C-Ep-H-D sequences. These parameters are depicted in Fig.7.

In the alkali extraction stage COD, dissolved solids, chloride, suspended solids and colour of effluent were on higher side in C-Ep-H-D sequence followed by O-C-Ep-H-D, Enz-O-C-Ep-H-D and O-Enz-C-Ep-H-D sequences. Various effluent parameters are compared and projected in Fig.8.

Effluent characteristics viz, COD, dissolved solids, chloride and suspended solids of calcium hypo chlorite stage were on higher side in C-Ep-H-D sequence followed by O-C-Ep-H-D, Enz-O-C-Ep-H-D, and O-Enz-C-Ep-H-D bleaching sequences. The parameters of various bleaching sequences are compared in Fig.9.

In Chlorine dioxide stage COD, suspended solids and dissolved solids were on higher side in C-Ep-H-D sequence followed by Enz-O-C-Ep-H-D, O-C-Ep-H-D and O-Enz-C-Ep-H-D sequences and the parameters are compared in Fig.10.

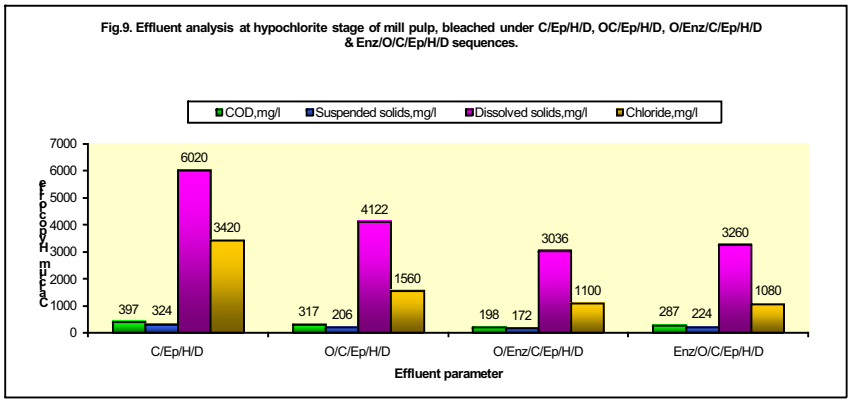


Fig.9. Effluent analysis at hypochlorite stage of mill pulp, bleached under C/Ep/H/D, OC/Ep/H/D, O/Enz/C/Ep/H/D & Enz/O/C/Ep/H/D sequences.

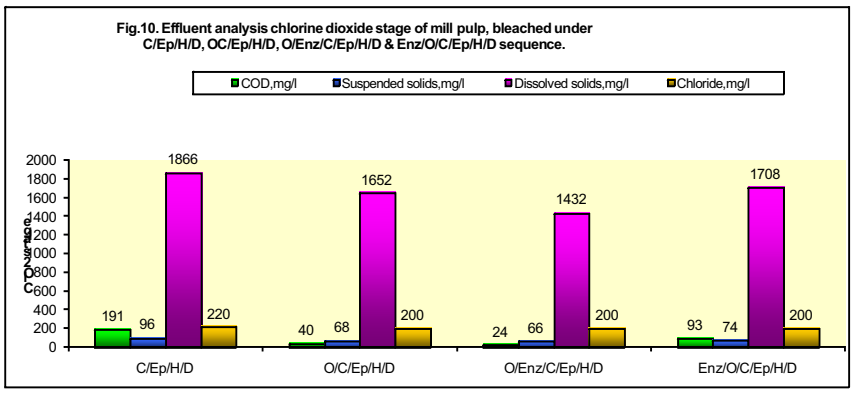


Fig.10. Effluent analysis chlorine dioxide stage of mill pulp, bleached under C/Ep/H/D, OC/Ep/H/D, O/Enz/C/Ep/H/D & Enz/O/C/Ep/H/D sequence.

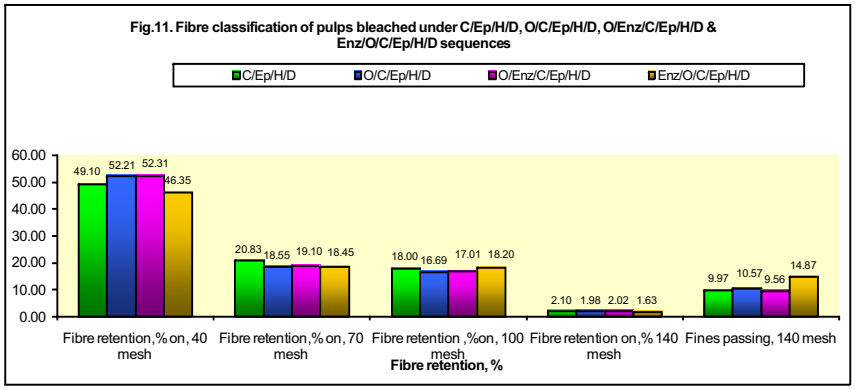


Fig.11. Fibre classification of pulps bleached under C/Ep/H/D, O/C/Ep/H/D, O/Enz/C/Ep/H/D & Enz/O/C/Ep/H/D sequences

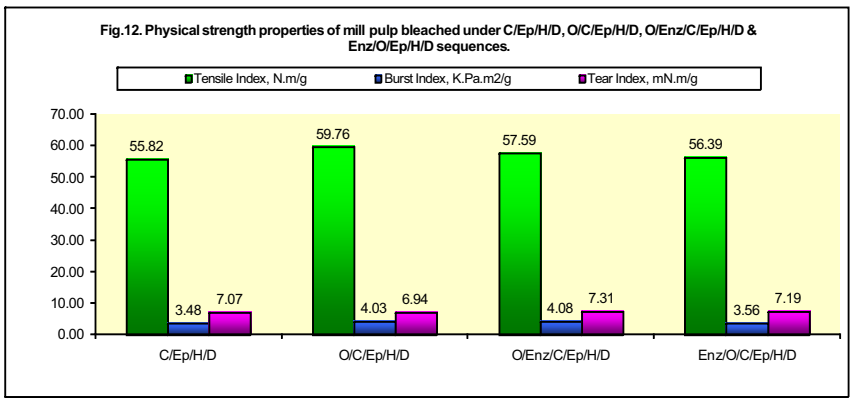


Fig.12. Physical strength properties of mill pulp bleached under C/Ep/H/D, O/C/Ep/H/D, O/Enz/C/Ep/H/D & Enz/O/Ep/H/D sequences.

It is observed from fibre classification results that the fibre retention percentage on 40 mesh was higher in O-Cp-H-D and O-Enz-C-Ep-H-D sequences compared to C-Ep-H-D and Enz-O-C-Ep-H-D bleaching sequences. Reverse trend was observed with fines passing through 140 mesh. Fibre retention percentage on different mesh and fines passing through 140 mesh are highlighted in Fig.11.

Bleached pulps produced under various bleaching sequences were beaten to 30 ^{O}S.R. in a P.F.I mill and tested for physical strength properties. It was observed that Tensile index, Burst index and Double fold of O-C-Ep-H-D and O-Enz-C-Ep-H-D bleaching sequences were higher than C-Ep-H-D and Enz-O-C-Ep-H-D bleaching sequences. Physical strength properties of various bleaching sequences are compared in Fig.12.

CONCLUSION

VlBL enzyme @ 0.3-0.4 kg/ton of pulp at 60^{O}C reaction temperature and 60 minutes retention time works better for higher unbleached pulp kappa reduction. As explained earlier unbleached pulp of Kappa 19.2 after bleaching under various bleaching sequences like C-Ep-H-D, O-C-Ep-H-D, O-Enz-C-Ep-H-D, and Enz-O-C-Ep-H-D is compared for various parameters. It is observed that total bleach consumption and pollution load was lowest under O-Enz-C-Ep-H-D bleaching sequence compared to other bleaching sequences but reverse trend was observed with physical strength properties. However laboratory findings of enzyme application along with alkali-oxygen delignification require corroborative studies at full scale plant level to asses the actual impact.

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