Optimum Consumption Levels of China Clay and GCC in Mixed NSSC/OCC Fluting Paper

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Due to the strength loss, filler application is not frequent in fluting boards. However, the shortage of lignocellulosic resources and lower price of mineral fillers provide motivation to find a proper balance between filler consumption and mechanical properties of fluting paper. Hence, the current study aims to elucidate the optimum consumption of these additives without considerable decrease in mechanical properties of fluting boards. GCC and china clay were added to the mixed furnish of NSSC and OCC in 5, 10, and 15% addition levels and at constant level of CPAM. The handsheets were then made and some mechanical properties including tensile, tear, and burst indices as well as CMT and air resistance were determined. Results indicated that a 5% addition level of fillers did not significantly affect the strength properties and also GCC was superior to clay for this furnish.

Keywords: NSSC , OCC , China clay, GCC, Strength properties, Fluting paper

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INTRODUCTION

Corrugated board is one the fast-growing products of paper industry with an increasing consumption rate in recent years. More than 90% of packaged goods such as food, clothing, paper products, and high-weight commodities, *etc*., are shipped in corrugated containers. Corrugated boards include two components *i.e*. top and back liners and corrugating medium. Corrugated containers provide higher strength properties compared to their weight thanks to the corrugating medium. In the case considered, this grade of paperboard is usually composed of 65% Neutral Sulfite Semi Chemical Pulp (NSSC) and 35% Old Corrugated Container (OCC) or sometimes 100% OCC. The corrugating medium provides the stiffness desired for container boards.

Fibers as the raw material comprise a substantial cost in paper and paperboard manufacturing, and therefore papermakers are continuously looking for optimizing fiber consumption strategies. Fillers have long been used in papermaking. Regular mineral fillers are, in general, lower in price than typical papermaking fibers; thus, replacing fiber by mineral fillers usually provides better papermaking economics. *Recent* decades have seen step changes in filler application practices, accentuating the special properties of fillers for quality improvements of paper products. Considerations in filler selection and consumption include the effect of the filler on paper quality, raw material costs,

machine productivity, and chemical consumption (Chauhan *et al*. 2012). Loading of fillers in the paper matrix contribute to the adverse effect to paper strength by directly interfering in the interfiber bonding (Al-Mehbad 2004; Subramanian *et al.* 2007; Ashish *et al.* 2012).

For a certain type of filler, the shape and size play important roles relative to the extent of interference with strength attributes. Generally speaking, a lower particle size leads to lower paper strength properties. Besides, plane-like and rounded fillers generally exasperate the properties more than irregular ones. Since these materials can cause adverse effects on other papermaking properties, papermakers should utilize them cautiously and be aware of their intrinsic properties and the mechanisms affecting their efficiency.

Important properties of corrugating papers include their strength against crushing and compression. In this current research, the corrugating medium produced in *Mazandaran Wood and Paper Industries Company* (MWPI) was investigated.

Due to increasing demand in the Iranian market for this specific product, a fiber line with the annual capacity of 85000 tons with the basis weight ranging from 113 to 128 g/m^2 has been set up. The required pulp is supplied by a NSSC pulping unit with 300 tons daily capacity which uses 8 different hardwood species of the Iranian northern forests. Unfortunately, the forest owned by this factory is not able to supply more than 30% of its required raw material. Therefore, OCC pulp has been used as an alternative to virgin pulp with a ratio of 80:20%.

Considering the shortage of hardwoods as the raw material, replacing fillers such as clay and carbonate calcium with the fibers will save the consumption of wood as well as will reduce the manufacturing costs due to the lower prices of fillers. However, the interactions of fillers with this new furnish needs to be studied. The objective of the current study was to optimize fillers application in corrugating medium made of the OCC and NSSC pulp without scarifying the strength properties.

EXPERIMENTAL

The mixture of OCC and NSSC pulp (the 80:20 ratio) was sampled from the level box of MWPI. The chemicals, including GCC, clay, and cationic polyacrylamide were supplied by MWPI. The initial freeness of the pulp was measured according to TAPPI T227 Om-04. Beating using a laboratory Hollander beater was carried out to reach to the target freeness of 300± 20 mL CSF according to TAPPI T200 sp-01. Handsheets were made according to TAPPI T205 sp-02, and the ash content of furnish and handsheets were measured according to TAPPI T211 om-02. In order to measure the strength and physical properties, the handsheets were prepared according to TAPPI T220 SP-06. Tensile, burst, tear, air resistance, and caliper were determined according to T403 om-02, T414 om-04, T460 om-02, and T411 om-05, respectively.

Concora Medium Test (CMT) was determined according to TAPPI T809 om-99. SPSS 16 software was used for statistical analysis of the data (ANOVA). Also, the results were statistically analyzed using Duncan multi-range test. Means were compared and grouped using Duncan's multiple range test at α=0.05.

RESULTS AND DISCUSSION

Air Resistance of Handsheets

The ability of paper to pass air from one side of the sheet to another side under the pressure difference is called *air permeability*, and this is related to the structural characteristics of paper including the number, size, shape, and distribution of pores as well as its formation. Practically the measured value is not the air permeability but is the resistance of paper against air (Scott and Abbott 1995). As Fig. 1 shows, loading of fillers reduced the porosity of paper and consequently increased the air resistance of handsheets in comparison with the control sample. Also, air resistance in sheets containing GCC was shown to be greater than in sheets containing clay, which is assumed to be due to the higher particle size and bulk of the clay.The highest air resistance of the sheets was observed in 15% GCC addition level while not only increasing the addition level of clay over 5% had no increasing effect on the air resistance of the sheets but also decreased the air resistance. Proper distribution of fillers improves the air resistance in paper (Hubbe 2004), and 5% clay addition seems to properly fill the pores, but there is a probable undesired aggregation of fillers at higher addition levels that deteriorates the suitable covering of pores. In the presence of cationic polyacrylamide, fines and fillers effectively fill the pores in the fiber network and bond with fibers, which results in increased air resistance (Hamzeh and Rostampour Haftkhani 2008).

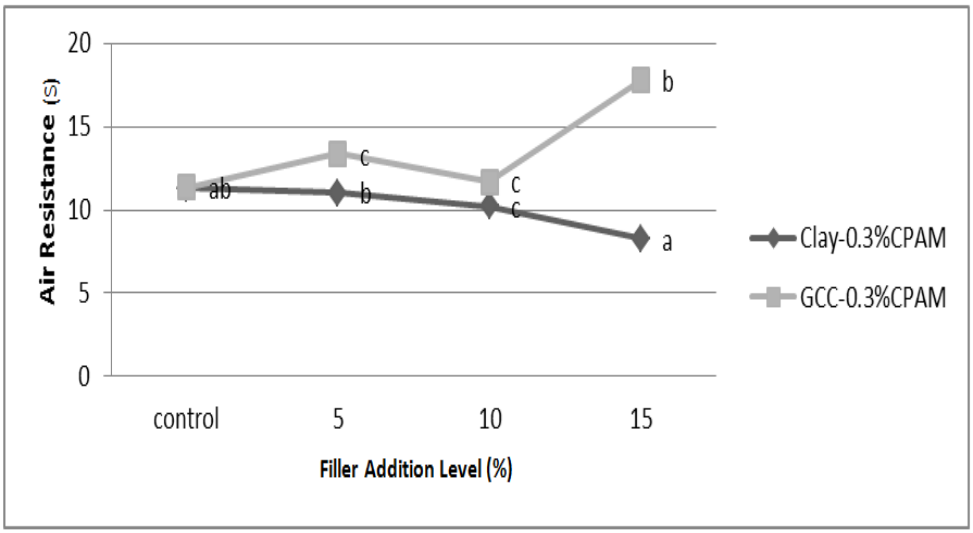

Fig. 1. Air resistance of handsheets containing clay and GCC

Tensile Index

Tensile and burst are closely interrelated. The tensile strength depends on the intrinsic strengths of fibers and their bonding. The most important factor is the amount and quality of inter-fiber bonding. A decrease in bonding results in a tensile strength loss. The effect of different addition levels of clay and GCC in the presence of polyacrylamide on the tensile strength of the handsheets was studied (Fig. 2). The results indicated that tensile index was adversely affected by the filler addition, which is due to the interference of fillers with the fiber-fiber bonding (Scott 1995).

Tensile strength in sheets containing GCC was superior to sheets containing clay, which was due to higher particle size of clay and the formation of bigger aggregates. The bigger aggregates interfere the bonding among fibers, therefore, reducing tensile strength.

Increasing the addition of fillers in the absence of retention aids, filtration in the dominant mechanism in the handsheets formation, and the loss in strength and handsheets defects are intensified while addition of 0.3% CPAM results in better bonding through the colloidal forces among fines, fillers and fibers Miyanishi (1998).

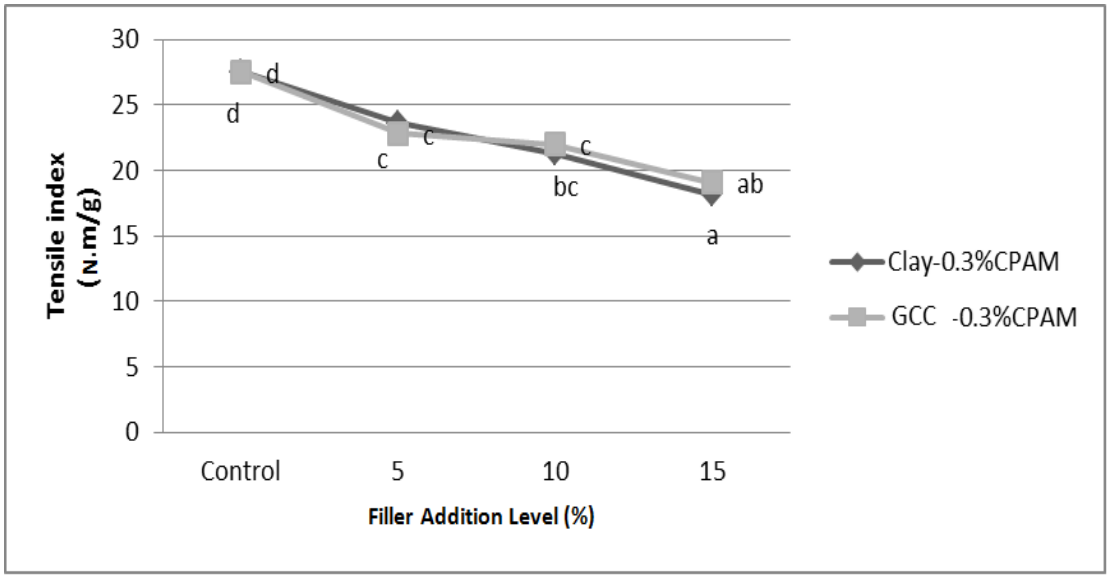

Fig. 2. Tensile index of handsheets containing clay and GCC

Burst Index

Burst index is an important property that depends on fiber length, fiber strength, and the bonding among fibers. The effect of clay and GCC addition in the presence of CPAM on burst index was studied.

The difference among treatments was significant at the 0.5% confidence level. Figure 3 shows the effect of fillers addition level on burst index in the presence of CPAM. The results indicated that there was no significant difference between the effect of clay and GCC on burst index. However, increasing the addition level of both fillers reduced burst index due to loss in bonding among fibers.

In the absence of retention aids, the retention of fillers in paper is controlled by mechanical entanglement without bonding, but in the presence of CPAM the surface charge of fillers becomes positive and therefore they are attracted to fines and fillers and the bonding; consequently, burst strength is improved (Hamzeh and Rostampour Haftkhani 2008).

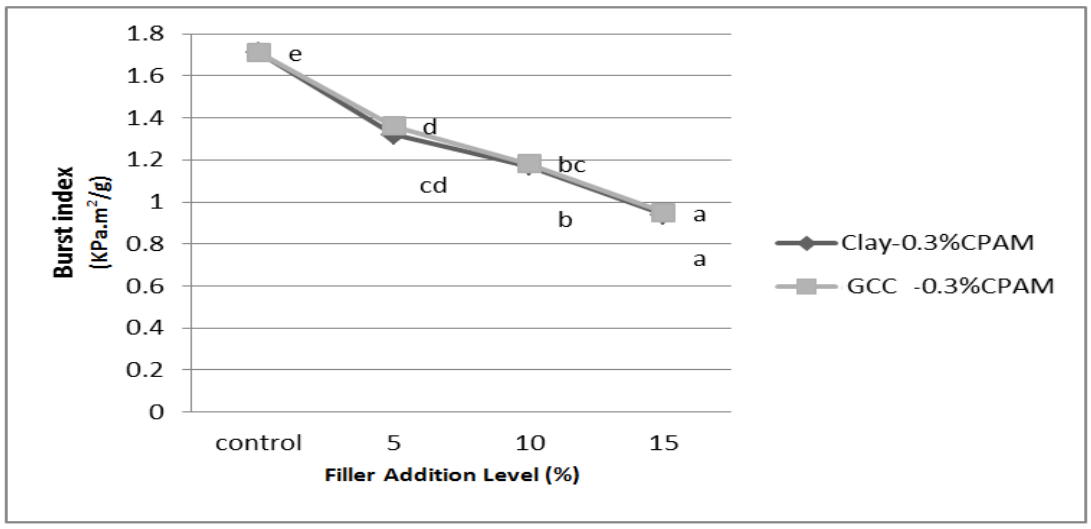

Fig. 3. Burst index of handsheets containing clay and GCC

Tear Index

The effect of fillers addition on tear index in the presence of CPAM was studied. The difference between treatments was significant at the 0.5% confidence level. The results showed that tear index decreased with addition of both fillers (Fig. 4). No significant difference was observed between the effect of clay and GCC addition on tear index, though, GCC has narrower particle size compared to clay. Tear index depends to a great extent to on the fiber length of the pulp. Because the addition of fillers does not change fiber length, no great difference in tear index was noted between these two fillers.

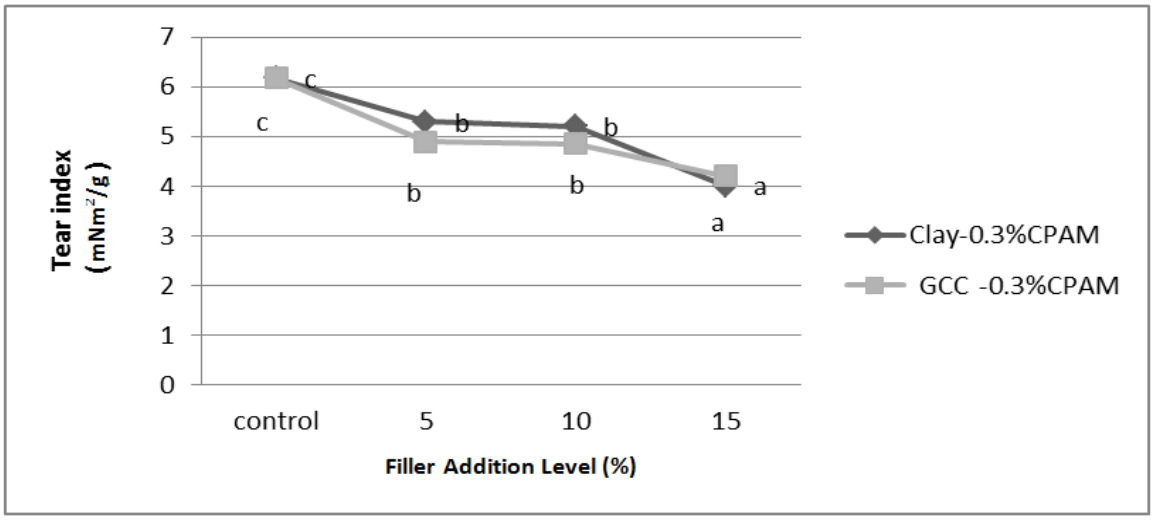

Fig. 4. Tear index of handsheets containing clay and GCC

Concora Medium Test (CMT)

The CMT-strength is considered to be one of the most important quality properties of paperboards (Markström 2005). This strength property is dependent on refining, adhesives type, chemical additives, and the fibers (Scott 1995).

Figure 5 shows the relation between fillers addition in presence of CPAM on CMT. The results showed that CMT was not greatly influenced by filler addition, though the effect of clay and GCC on this property was not identical. GCC increased CMT in 5% addition level, while no significant change was observed in higher addition of this filler. On the other hand, clay addition had no significant effect on CMT until the 15% addition level, which decreased CMT drastically. The difference in the influence of these two fillers was attributed to the difference in the particle size of clay and GCC.

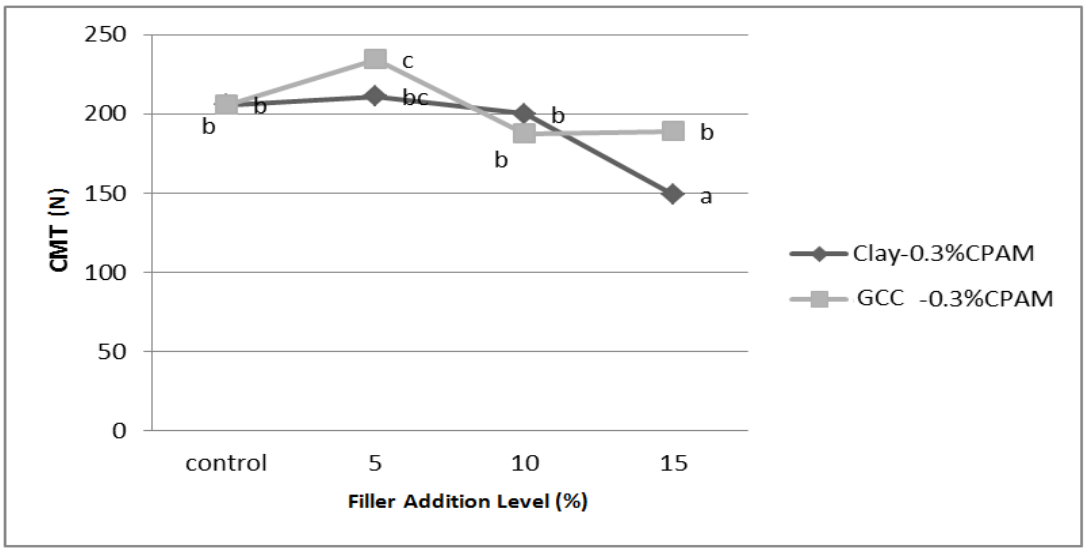

Fig. 5. CMT of handsheets containing clay and GCC

CONCLUSIONS

1- Tear strength in NSSC handsheets is not dependent on the type of filler and is less sensitive to the filler addition levels except at higher levels (15%).

2- Considering the technical and economic aspects, GCC with 5% addition level is recommended for MWPI.

3- Clay and GCC exhibit different performance in development of air resistance and strength properties of NSSC handsheets. GCC had less detrimental effect compared to clay which was assumed to be the difference in particle size of these two fillers.

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