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Determination of optimal dose in adding cationic starch to paper quality 150 gsm with interpolation

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Abstract
Cationic starch was an additional chemical in making paper that served as an adhesive material between fiber and fiber, as well as fiber with filler. In making 150 gsm using cationic starch with dose (11-12) Kg/Ton. The research consist of three stages : preparation stage, test phase, and data processing stage. Analytical methods and research specifications refer to the Technical Association of the Pulp and Paper Industry (TAPPI). The result was obtained for a crack resistance test of 300 kPa using a 6 kg / ton cationic starch dose, a tensile strength test of 7.5 kgf / 15mm using a cationic starch dose of 5 kg / ton, 2,5 mm spatial test using a cationic starch dose of 10 kg / ton, folding resistance test with 15 fold using 10 Kg/Ton cationic starch dose, tear resistance test 105 gf using cationic starch 5 Kg/Ton and strength bond test between 250 J/m2 fiber using cationic starch dose 6 Kg/ Ton. It was concluded that the optimal dose of cationic starch addition was used to make 150 gsm paper that was 10 Kg/Ton.

Keywords: Starch, Paper, Cationic, TAPPI, Dose

Introduction
Starch was a polysaccharide naturally obtained from renewable plants [1]. Starch played an important role in the food processing industry and was widely used in industries such as paper, glue, textiles, candy, glucose, dextrose, fructose syrup, and others. The main source of starch in Indonesia was rice, besides found some other sources of starch that were corn, potato, tapioca, sago, wheat, and others.

Paper industry required modified starch type (starch modified). The modifications in question were changes in molecular structure from which can be done chemically, physically, or enzimatis. The modified starch used in the paper industry was the cationic starch (cationic starch) function as an adhesive agent between fiber and fiber with other chemicals [2].

According to a large Indonesian dictionary paper was a sheet item made from ordinary pulp slurry or wrapped for wrapping. The materials used in paper making were fiber, filler, and auxiliary chemicals such as cationic starch, alkyl ketene dimer (AKD) and peretensi materials (anionic and cationic). In paper making requires a cationic starch to increase paper strength. In papermaking 150 gsm using cationic starch with dose (11-12) kg / ton. No studies had concluded that the dose of starch used was an optimal dose, therefore it was necessary to do a testing to determine the optimal dosage for the production cost to be low but the paper quality was maintained well according to the standard [3].

The research consists of three stages: preparation stage, test phase, and data processing stage. The preparation stage was done by making 150 gsm paper sheet with variation of cationic starch dose (0, 5, 10, 15) kg / ton. The testing stage was carried out by potential zeta testing, crack resistance test, tensile strength test, resistance test, tear resistance test, folding resistance test and fiber strength bond test. Phase data processing performed calculations to determine the optimal dose of starch positively charged. All analytical methods and research specifications refer to the Technical Association of the Pulp and Paper Industry (TAPPI).

This study aims to determine the optimal dose of the addition of cationic starch on paper quality of 150 gsm. The result then compared with the standard refers to the international standards of TAPPI paper.

Material and Methods

Material

The materials used in this study consist of test materials and chemical reagent. The test material used was pulp slurry containing LBKP and broke. The chemical used were fillers, cationic starch of various dosage variations, Alkyl Ketene Dimer (AKD), and peretensi materials (anionic and cationic).

Methods

Crack Resistance Test

The test was performed based on TAPPI T 404 om-03 standard method. The sample was placed exactly on the pressurized clamp, the sample must be perfectly pinched and the surface should be flat, the start button was pressed so that the appliance will work and put pressure on the paper until the paper was cracked. Note the pressure value residing on the tool display. The test was done triplo.

Tensile Resistance and Sprawl Resistance Test

The test was performed on the based of TAPPI T 494 om-06. Sheets of paper cut in size 10 cm x 1.5 cm with cutting tools. The cut sheets were inserted into the tensile tester tool, the start button was pressed, note the result of attractiveness and spacing. The test was done triplo.

Folding Resistance Test

The test was performed based on TAPPI T 511 om-96 standard test method. Sheets of paper cut in size 10 cm x 1,5 cm with cutting tools. The cut sheets were inserted into the folding tester tool by loading 1,5 kg on the tool, then the start button was pressed, and recorded results obtained. The test was done triplo.

Tear Resistance Test

The test was performed based on standard TAPPI T 414 om-04 test with L & W tearing tester and cutting tool. The sample was cut with a special tear-resistant cutting tool. Do the initial tear by using the knife handle down until it stopped where the initial tear was 20 mm long. The start button was pressed so that the pendulum swings and tears the paper. The tear should be symmetrical (in the middle position) and then the pendulum was returned in stop position. Noted the tear resistance values that appear on the display with the gramforce unit (gf). The test was done triplo.

Test of bond strength between fibers

Test was conducted based on TAPPI T 569 om-14 standard. Each sheet of paper with a variation of the addition of a cationic starch was cut by a cutting tool, a special adhesive bonding test previously bonded to the tool, the sheet attached to the adhesive and re-coated with the adhesive, sealed with a bonding tester cover so that it will automatically exert pressure for adhesive with paper to stick, each part of the segment cut off, then read by pressing the start button. The result obtained was then recorded. The test was done triplo.

Data Processing Stage

The optimal dose determination of cationic starch was calculated by interpolation using the linear equation formula equation.

Formula:

$$\frac{y - y_1}{y_2 - y_1} = \frac{x - x_1}{x_2 - x_1}$$

Information

y = company standard
y1 = smallest value near standard
y2 = largest value near standard
x1 = the smallest positively charged dose of starch approaching the standard
x2 = the largest cationic starch dose that approaches the standard
x = optimal cationic starch dose

Results and Discussion

Based on the result of this research, the results of paper strength (crack resistance, tensile resistance, split resistance, fold resistance, tear resistance, bond strength) for addition of starch of various dosages ranging from 0 kg / ton, 5 kg / ton, 10 kg / ton, and 15 kg / ton. The results obtained were averaged and compared with international standards of TAPPI paper strength.

Table 1: Paper Strength Test Result

Parameter	Unit	Minimum Standard	The Addition of Cationic starch (kg/ton)			
			0	5	10	15
Bursting strength	kPa	300	275	295,5	317,9	321,1
Tensile strength	kgf/15 mm	7,5	6,9	7,5	7,9	8,3
Elongation	mm	2,5	2,04	2,27	2,50	2,66
Folding strength	-	15	10	11	15	18
Tearing strength	gf	105	103,4	105	110,9	118,6
Ply bonding	J/m^2	250	212,3	238,7	286,6	329,5

Crack Resistance Test

Crack resistance was the strength of the sheets of paper against the penetrating power it received until the paper was cracked, or the maximum strength that can be applied to a piece of paper until the paper was cracked or burst in kilogramforce per square centimeter (kgf / cm2) [4]. The following was a result of the crack resistance test made in FIG. 1.

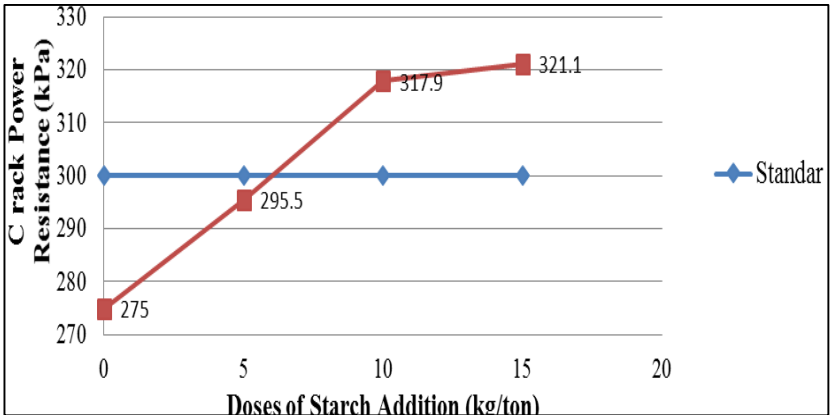

Fig 1: Graph of Crackability Test Result

In Figure 1, it was seen that the higher the dose of cationic starch the higher the resulting crack resistance, and for the paper which not use the cationic starch has the lowest crack resistance compared to the paper using cationic starch with a dose of 5 kg / ton, 10 kg / ton and 15 kg / ton. This was due to the presence of cationic starch as binder chemicals can help improve the durability of sheets of paper when pressured until cracks occured. Crack resistance was influenced by the use of fillers, long fiber compositions and short fibers and the use of cationic starch [5].

Based on TAPPI standard for the crack resistance test was 300 kpa, whereas the result obtained to reach the standard value was between the dose 5 kg / ton with 295,5 kpa and 10 kg / ton with 317 kpa. To find the right dose to obtain the value of 300 kpa was by calculating with interpolation and obtained the addition of starch positively charged at 6.05 kg / ton

Test of Tensile Strength

Tensile strength was the maximum resistance per unit of test strip width for sheets of paper against tensile forces acting on both ends of the test path until broken, expressed in units of force per unit of test width measured under standard condition [6]. Here was the result of testing the tensile strength created in Fig. 2.

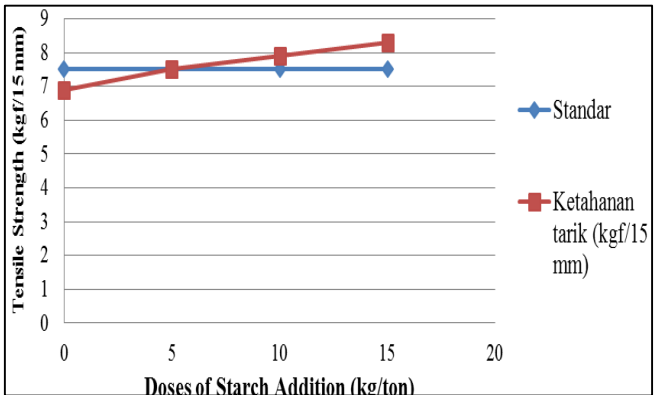

Fig 2: Graph of the result of tensile strength

Based on Figure 2, the addition of cationic starch using a dose of 5 kg / ton was the optimal dose as it achieved tensile strength according to the TAPPI standard of 7.5 kgf / 15 mm 105 gf. The higher the dose of cationic starch used in the paper making process its tensile appetite will increase, this was due to the bonding between fibers reinforced by the presence of cationic starch including binding of all paper chemicals [7].

Elongation Resistance Test

Here are the results of the elongation resistant test made in the graph.

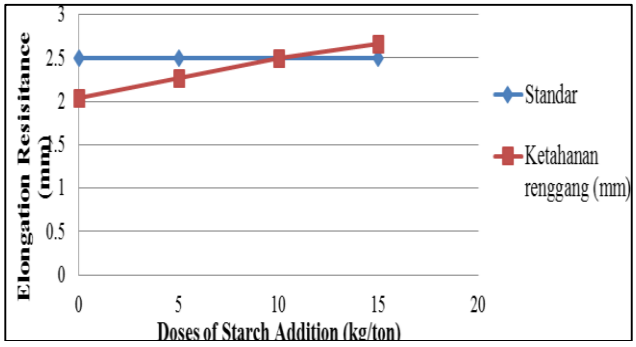

Fig 3: Graph of the Result of Elongation Resistant Test

Based on Figure 3, the addition of cationic starch using a dose of 10 kg / ton was the optimal dose as it achieved a elongation resistant according to the TAPPI standard of 2.5 mm. In Figure 3 it was seen that the paper strain value tends to increase with increasing dose of cationic starch. This was because the function of starch was positively charged as fiber binder with fiber and fiber with filler material so that the elongation resistant increases [8].

Folding Resistance Test

The folding resistance was defined as the number of folds required to break the paper as it was folded backward and then towards the front on the same track [9]. The following was the result of the folding resistance test made in FIG. 4.

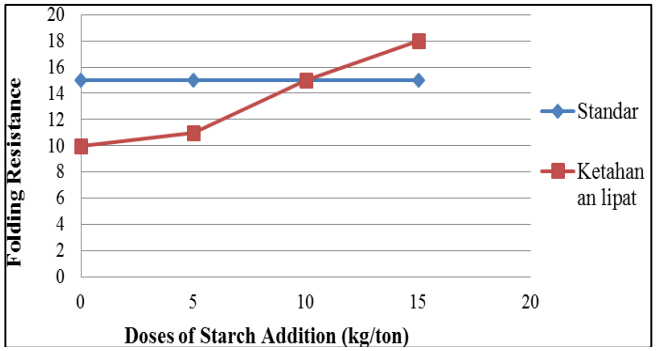

Fig 4: Graph of Folding Resistance Test Result

Fig 4: showed a significant increasing in the resistance of folding along with the increasing in the dose of cationic starch. Based on Figure 4, the addition of cationic starch using

a dose of 10 kg / ton was the optimal dose because it achieved a folding resistance in accordance with the TAPPI standard of 15 times.

Folding resistance was influenced by the use of positively charged long and starch fibers. The higher the dose the use of long fibers the higher the resistance of folding, as well as the use of starch, the higher the dose of cationic starch used in paper making, the higher the strength of the sheet of paper when folded many times.

Tear Resistance Test

Tear Resistance was a force in grams (gf) needed to tear the paper at standard conditions [9]. The tool used in this test was tearing tester Elmendrof method, ie test sample sheets that have undergone initial tearing then torn using pendulum at a certain distance. Mean tear force was effort divided by total distance, indicated by pendulum scale or digital display. The following was a result of the tear resistance test made in FIG. 5.

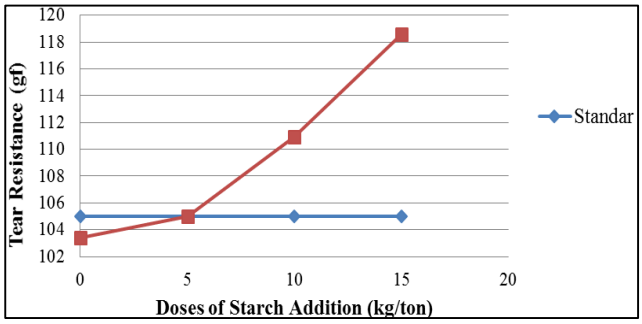

Fig 5: Graph of Tear Resistance Test Result

In Figure 5 showed that the tear resistance value of paper using cationic starch (dose 5 kg / ton, 10 kg / ton, and 15 kg / ton) was higher than on paper which did not use cationic starch (dose 0 kg / ton). Based on Figure 5, the addition of cationic starch using a dose of 5 kg / ton was the optimal dose as it achieved tear resistance according to the TAPPI standard of 105 gf. Increased tear resistance due to starch-adhesive power was positively charged to fibers and chemicals that can improve tear resistance at the time of tearing.

Test of Bond Strength Between Fibers

The interlayer strength test demonstrated the strength of the paper given a layer such as an adhesive, then loaded like a pendulum to separate the adhesive against the sheet of paper [10].The following was a result of the strengthening test of the fiber bond strength made in Fig. 6.

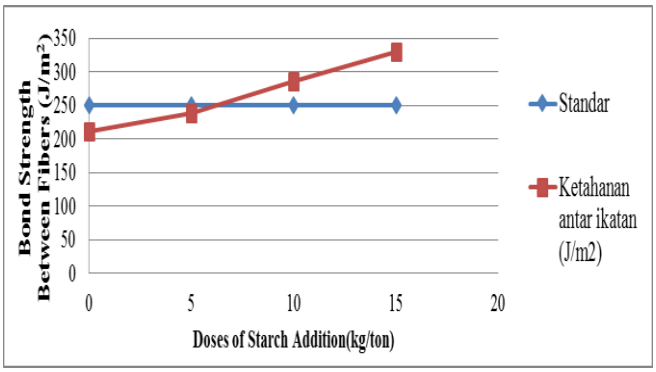

Fig 6: Graph of test bond strength between fibers result

Based on Figure 6, to comply the TAPPI standard for strength bonding test between 250 J / m2 fibers were between 5 kg / ton dose with 238,7 J / m2 and 10 kg / ton dose with 286,6 J / m2. To find the right dose to get the value of 250 J / m2 using interpolation to obtain the addition of starch positively charged at 6.18 kg / ton.

The internal bond strength of fiber was one of the important parameter in strength testing of paper. The thing that most affects the fiber's internal bond was the use of cationic starch. Fiber that had a negative charge required a starch that was positively charged to be able to bond between one fiber to another. An increasingly strong bond made it difficult to separate the fibers from one fiber to the other when pulled, torn, or folded. Therefore, the role of cationic starch was very important in improving paper strength.

Conclusion

Based on the result of research conducted the higher cationic starch enhancer used, the higher the strength of the paper produced. Based on the research, the results obtained for 300kPa crack resistance test using 6 kg / ton of cationic starch dose, tensile strength of 7.5 kgf / 15 mm using 5kg / ton cationic starch, 2.5mm split resistance test using charged starch dose positive 10 kg / ton, folding resistance test using 15 folds of 10 kg / ton positive starch dose, 105 gf tear resistance test using cationic starching dose 5 kg / ton, and strength bond test between 250 J/m2 fiber using 6 kg positively charged dose / ton. Based on the results it was concluded that the optimal dose of starch addition was used to make 150 gsm paper, which was 10 kg / ton.

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