Preparation and Application of the New HYP

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ABSTRACT

The HYP (high yield pulp) has been widely used in paper's production because the paper made by the HYP features higher bulk and lower cost. But the tensile strength of the paper has lower tensile strength compared with that obtained by chemical pulp. In order to make the paper made from HYP to achieve the higher bulk, along with comparable or higher tensile strength, the effect of the fines on the properties of paper was discussed, and the aspen APMP refined with PFI was researched. It was demonstrated that the property of paper is affected markedly by the amount of the fines of HYP, and its effect on tensile strength is much larger than that on the bulk. In comparison with the paper made from the coarse fibers, with the fines returning back the screened coarse fibers from 0% to 100%, the bulk decreased from 3.31cm^3/g to 2.64cm^3/g and the tensile strength increased from 10.41N·m/g to 23.95N·m/g. A new HYP made by mixing the HYPs with different freeness can achieve a high bulk along with constant tensile strength. Compared with the HYP with 366 CSF (Canadian Standard Freeness) made in the mill process, the new HYP made by mixing the HYPs with 583 CSF and 54 CSF shows an increase in the bulk of paper obtained from 2.64 to 3.08 cm^3/g.

Keywords: high yield pulp, bulk, tensile strength, freeness

Introduction

In recent years, the high yield pulp (HYP) has been widely used in paper's production because of its advantages showing on the course of production and application. However, the paper made by the HYP features higher bulk and lower tensile strength compared with that obtained by chemical pulp. Therefore, the search of the best balance between the bulk and the tensile strength has become very important [1]. In order to achieve the high bulk, along with comparable or higher tensile strength, much effort has been devoted and many achievements have been made. Tembec Co. produced High Bulk (HB) and High Tensile (HT) HYP by adjusting the dosage of alkali used during the pretreatment process [2]. However, such HB and HT were achieved just by using HB or HT HYP, separately. It is difficult to improve the bulk with the comparable tensile strength or tensile strength with the comparable bulk. Recently, the researchers found [3], under the comparable bulk, high tensile strength can be obtained by mixing different wood species at certain ratio on the pulping process, This technique has been used to produce high tensile strength paper with comparable bulk. But this method still has some drawbacks, in particular, it can not achieve high bulk of paper with the desired tensile strength. More recently, based on the theory that the paper strength is mainly provided by fine fiber [4~7], we found that the high bulk can be obtained by mixing the HYPs with different freeness, and the tensile strength remains constant [8].

In this work, we prepared a series of new HYPs by mixing the HYPs with different freeness, the effect of the fine fiber on the properties of paper was investigated, too.

Material and Methods

Material

Aspen APMP 1 # and aspen APMP 2 # were taken from the Henan pulp mill. The pulps had been refined by two stage sequence refiner. The pulp quality was given in Table 1.

Table 1 the quality of two kinds of aspen APMP

	APMP 1#	APMP 2#
Freeness ml	583	366
Brightness %ISO	78.3	80.6
Bulk(/cm^3/g)	3.23	2.64
Tensile index(N·m/g)	14.27	23.95
+28 mesh (%)	17.7	8.2
-28 mesh +48 mesh (%)	29.4	26.3
-48 mesh +100 mesh (%)	21.5	21.1
-100 mesh +200 mesh (%)	23.6	20.7
-200 mesh (%)	7.8	23.7
Weight of Bundle ((≥0.15 mm %)	0.182	0.095

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Preparation of new HYP

The aspen APMP 1# was refined with PFI to certain Freeness as appended HYP, and then mixed with unrefined APMP 1#(as backbone HYP). The ratio of both was adjusted to render the freeness of the final new HYP comparable with the aspen APMP 2# in order to have identical drainability. The results were displayed in Table 2.

Preparation of handsheet

With the recycling of white-water (about 1.5L), the handsheets with a basis weight of 100g/m^2 were prepared according to Tappi Standard.

ResultS and Discussion

Influence of recycling times of white-water on the bulk and tensile strength

The handsheets were prepared by using the APMP 2# with recycled white-water. The effect of the recycling times of white-water on the properties of the handsheets was shown in Fig 1.

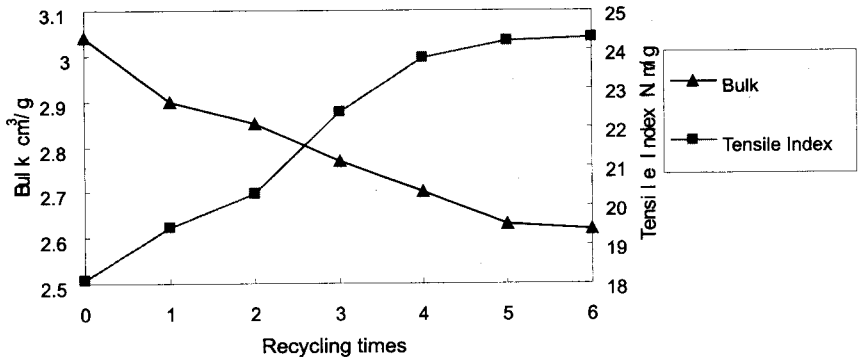

Fig 1 Effect of recycling times of white-water on properties of handsheet

As shown in Fig 1, with the increase of the recycling times of white-water, the bulk and tensile strength of handsheets increase. It was demonstrated that the fines have influences on both the bulk and the tensile strength of handsheets. When the white-water was recycled five times, the properties of handsheets were leveled off. It indicates that the fines of APMP 2# are present in dynamic equilibrium. In comparison with those prepared with unrecycled white-water(0-level), the handsheets made with the 5 times recycled white-water show a decrease about 13% in the bulk and an increase about 35% in the tensile index.

Effect of PFI refinement on properties of the handsheets

Table 2 Preparation of new HYP

New HYP	Freeness ml	Freeness of backbone HYP ml	Freeness of appended HYP ml	Proportion of the appended pulp
Pulp A	370	583	255	55
Pulp B	364	583	186	38
Pulp C	361	583	105	25
Pulp D	370	583	68	17
Pulp E	367	583	54	12

The aspen APMP 1# was refined with PFI at 10%(w/w) consistence and a 0.2 mm refining interval. The handsheets prepared by using refined aspen APMP 1# was compared with those by aspen APMP 2# (Fig 2).

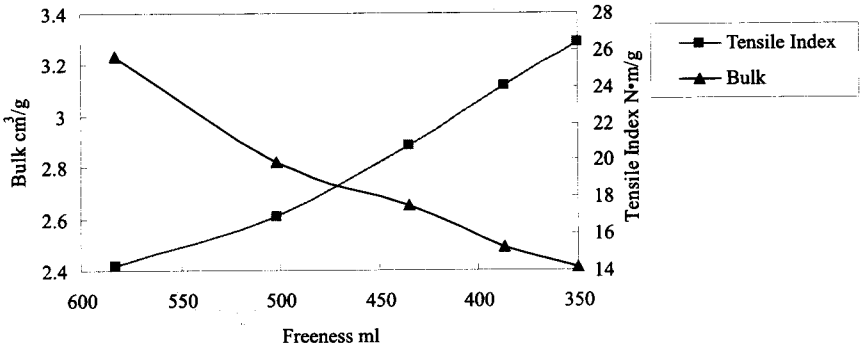

Fig 2 Effect of PFI refinement on properties of the handsheets

Note: The bulk of handsheets made from target pulp (APMP 2#) is 2.64cm^3/g, and the tensile index is 23.95N·m/g.

When the bulk of handsheets made from refined HYP is close to that made from APMP 2#(about 2.64cm^3/g), its tensile index is reduced (20.81 *vs* 23.95 N.m/g); when its tensile index reaches the value obtained by APMP 2#, its bulk is decreased (2.49 *vs* 2.64 cm^3/g). It indicates that it can not obtain the higher bulk and tensile at the same time by using PFI. It is mainly caused by the reason. The fiber was cut off continuously in the refining process. It can fill the gap of fibers when the refined pulp is used to prepare the handsheets.

Effect of fines on properties of the handsheets

The coarse and fines were prepared by screening APMP 2 # by 200-mesh sieves. In order to investigate the effect of fines on the bulk and tensile strength of handsheets, the fines obtained were added back to the coarse ones at a certain ratio and the corresponding handsheets were prepared. The physical properties of the handsheets were shown in Fig 3.

From Fig 3, it was shown that, with the increasing amount of the fines, the bulk reduces and the tensile strength increases. It is worth to note that, with the increasing of returning fines from 0% to 100%, the bulk decreased from 3.31cm^3/g to 2.64cm^3/g and the tensile strength increased from 10.41N·m/g to 23.95N·m/g. The variation rate of the tensile strength is substantially bigger than that of the bulk. In comparison with those made from the coarse fibers (the amount of the fines added is 0%), the handsheets made from APMP 2# (the fines were completely added back) exhibit an increase about 130% in the tensile index and a decrease about 20% in the bulk.

Considering the results obtained in Fig 2 and Fig 3, an assumption can be put forward, that is, the high bulk with constant tensile strength can be achieved by tuning the amount of the

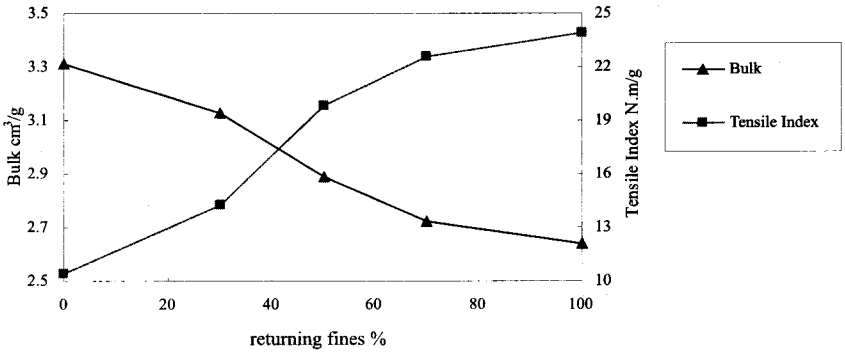

Fig 3 Effect of fines on properties of the handsheets

Note: the amount of returning fines 0% means the pulp is all coarse fibers. The amount of returning fines 100% means the pulp is APMP 2#.

fines of APMP. But how to do this? From the Laivins' research[9] and the results of Fig 3, the strength of paper is ensured by a certain amount of fines. So it must be to ensure that there are enough fines in the pulp. When the fines are obtained from the surface of the fiber, the coarseness of fiber and the thickness of the cell wall are decreased. This can lead to increase the flexibility and the compressibility of the fiber, and decrease the bulk of paper. So a high freeness and a low freeness HYP can be used to make up of a new HYP. The former can be used to set up a backbone structure of paper and ensure the bulk, the latter can be used to ensure the H-bond.

Properties of handsheets made by the New HYP

The properties of handsheets made by the new HYP are given in Table 3.

It was shown that, from Table 3, the bulk of handsheets made by the new HYP increases with the decrease of freeness of the refined pulp. The handsheets made by Pulp C (105 CSF) exhibit a bulk comparable to that obtained by APMP 2#, and the further decrease the freeness of appended HYP gives rise to an increase in the bulk. When the freeness of appended HYP is reduced to 54 CSF (Pulp E), the bulk is increased by 16.7 % compared with that obtained by APMP 2# (2.64 *vs.* 3.08 cm^3/g). Although along with the freeness of appended HYP slow down, the tensile index of paper decreased slightly. When the freeness is reduced to 54 CSF (Pulp E), the tensile index is decreased from 23.95 N·m/g to 22.07 N·m/g. For the HYP, the bulk is more important than the strength. So the increased bulk obtained from the new HYP is worth.

As shown in Table 1, when APMP 1# is refined from 583CSF to 366CSF on the mill process, the content of fines is increased from 7.8% to 23.7%. The fines are obtained mainly by surfacial spalling of the fiber, which also leads to the decreases in the coarseness of fiber and in the bulk of the paper obtained. In addition, surfacial spalling also gives rise to a decrease in the thickness of the cell wall [10], thereby leading to an increase in the compressibility of the fiber and a further decrease in the bulk of paper. Addition of the fines into the coarse fiber has not effect on the stiffness of the latter, which favors the improvement of the bulk of paper[11]. The presence of the latter ensured the strength of paper, which can be demonstrated by the little variation on the tensile index in Table 3. But for the internal bond strength, the reason why it is enhanced is unclear.

When the new HYP with the same freeness as the target pulp is prepared, the lower freeness of the appended pulp, it can obtain the less dosage of the appended pulp and the higher the bulk of paper. At the same time, when the appended pulp as filler is used to fill the backbone structure of the coarse fiber, the smaller the fiber, the more likely the filling. Therefore, the presence of the fines in the appended pulp favors the improvement of the bulk of paper with the constant tensile strength. The result of this work shows that, in order to achieve a high bulk, the freeness of the appended pulp should be less than 100 CSF.

Table 3 the properties of the handsheets made from new HYP

Pulp	Basis weight /g/m²	Bulk cm³/g	Tensile index N·m/g	Internal bond strength J/m²	Remark
APMP 2#	100.7	2.64	23.95	153.84	Target
Pulp A	99.2	2.47	23.89	175.42	
Pulp B	101.6	2.56	23.55	170.53	
Pulp C	100.3	2.65	23.04	168.15	
Pulp D	99.0	2.92	23.63	168.03	
Pulp E	98.6	3.08	22.07	164.78	

Conclusions

The property of paper is affected markedly by the amount of the fines of HYP, and its effect on tensile strength is much larger than that on the bulk. In comparison with the paper made from the coarse fibers, with the fines returning back the screened coarse fibers from 0% to 100%, the bulk decreased from 3.31cm^3/g to 2.64cm^3/g and the tensile strength increased from 10.41N·m/g to 23.95N·m/g.

It was demonstrated that the new HYP made by mixing the HYPs with different freeness can successfully adjust the bulk of paper. Compared with the HYP with 366 CSF made in the mill process, the new HYP made by mixing the HYPs with 583 CSF and 54 CSF shows an increase in the bulk of paper obtained from 2.64 to 3.08 cm^3/g.

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