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Effects of Chrysotile Asbestos Additions to Cellulosic Paper

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The effects of incorporating a new, highly purified, grit-free chrysotile asbestos fiber in cellulose paper are discussed. Data are presented from both laboratory handsheet tests and paper mill trials on the effect of the fiber on both operational factors and on sheet properties. Effects discussed include retention of cellulose fines and fillers such as TiO_2, freeness, drying rate, pitch control, brightness and opacity, softness, strength, porosity, printability, show-through, and dye retention. Savings possibilities and other economic factors are also discussed. Operational feasibility was maintained while important gains in economics, pollution control, and product properties were obtained with a wide variety of furnished types.

THE three principle characteristics of a highly refined chrysotile asbestos product that apply to paper applications are:

1. The surface charge—cationic
2. Particle shape—fibrous
3. Surface characteristics
   (a) Organic adsorption
   (b) Chemical reactivity

These properties differ sufficiently from those of the more conventional paper additives to indicate a promising potential for use in the paper industry. In addition, refined asbestos is a material of low cost and is available in sufficient quantity to supply a consumer as large as the paper industry. Advances in processing techniques have insured a uniform product that can be supplied within quite rigid specifications. With respect to abrasiveness, radiometric determinations have shown that the purified asbestos is considerably less abrasive than ordinary fillers or bleached sulfite pulp. The properties imparted to paper by addition of purified chrysotile asbestos, as well as paper-machine behavior, were determined by experimental work both in the laboratory and in full scale mill trials. These results are discussed in this paper.

LABORATORY DATA

The laboratory results, as reported herein, were obtained in our own laboratories at Tuxedo, N. Y., and through the efforts of Professors L. C. Jenness and A. J. Chase of the University of Maine, who have acted as our consultants during this program. The tests were conducted principally in the laboratory Noble and Wood handsheet machine and, unless otherwise specified, used a bleached sulfite stock beaten to a Canadian Standard freeness of 300 ± 10 ml. Handsheets were made at the standard basis weight of 60 g/sq m and tested, wherever applicable, according to the TAPPI standard procedures.

Effects on Retention

The effects of incorporating a highly defibrillated chrysotile fiber in cellulose paper were found to be unique among inorganic additives. Because of its electropositive surface charge, the self retention of the asbestos fiber is very high when compared with clay or titanium dioxide pigment. As shown in Fig. 1, this improved retention is significant on a single pass retention system or in one where white water recirculation is employed. On the basis of single pass retention, the asbestos showed almost 80% retention compared with only 40% for either clay or titanium dioxide.

It can be postulated that any method of introducing a positively charged material into a paper furnish should tend to improve retention of all components. A summary of the relative surface charges of papermaking constituents (as calculated from laboratory measurements of individual mobilities) is shown in Table I.

Accordingly, the chrysotile asbestos should coflocculate with any and all of the furnish constituents. That this is so is shown when asbestos and TiO_2 pigment are agitated together to form what appears to be a fibrous titanium dioxide pigment. Titanium dioxide dispersed in water produces a milky liquor that tends to remain cloudy for long periods of time. When coflocculation is achieved, the water at the interstices of the flocs is clear. Thus, all of the TiO_2 is being held by the asbestos. Electron micrographs of the combined product (Fig. 2) show that the pigment is still in the dispersed state and is held by the asbestos. Most important is the fact that these flocs are formed without agglomeration of the pigment. This should allow maximum efficiency in obtaining its optical properties.

The advantages of asbestos over conventional flocculants, either inorganic or organic are twofold: (1) retention without agglomeration, and (2) floc stability. Experience has shown that no degradation of the floc occurs even after repeated agitation. Once formed, these flocs are stable even under prolonged high-shear agitation of a Waring blendor. Laboratory studies have shown asbestos to be compatible with all types of organic and polymeric flocculants. In a furnish of high filler content, particularly, the combination of asbestos and coagulant is especially effective. Usually the net effect is greater than can be achieved by either alone.

Table I

	ζ, mv	pH
Bleached sulfite cellulose	−14	6.4
	−9	5.0
Titanium dioxide (RA-50)	−19	10
	None	6
Talc	−15	6.6
Purified chrysotile asbestos	+38	6.6
	+45	5.0

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Data from laboratory tests run on handsheets to demonstrate the retention properties of chrysotile fiber are shown in Figs. 3 and 4. The control series for this evaluation were made with 4% clay. Where asbestos was employed, it was substituted on a pound-for-pound basis for clay, so that at equivalent retention the ash and opacity values would be comparable. The level of TiO_2 addition was then varied from no TiO_2 to 10% added based on the stock. It is apparent that the retention of the additives is greatly improved with as little as 2% asbestos. Clay retention is also greatly affected. Because these data are based on single pass retention, the values are quite low (Fig. 4). Since this is probably the most difficult retention condition, the effectiveness of the purified fiber is clearly demonstrated.

In another series of tests, run under similar conditions but with high levels of clay, the results were equally encouraging. The ash values for levels of clay additions ranging from 25 to 50% show that the retention of the filler is increased with increasing asbestos additions up to the 6% asbestos (Fig. 5). The effects of white water recirculation on the ash content of the sheet were also determined and are shown in Fig. 6. Whereas the average ash retention only reached about 47% with a one pass circuit, with recirculation the average retention was increased to 70%. There is also evidence that equilibrium was reached in the recirculation system at 3% asbestos whereas it required about 5% for the single pass system.

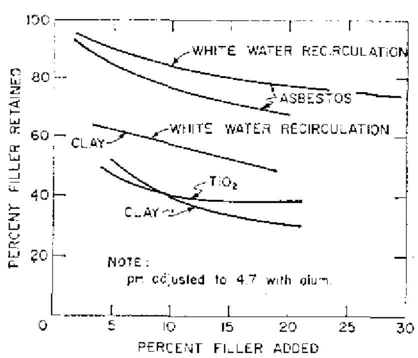

Fig. 1. Filler retention—comparative data

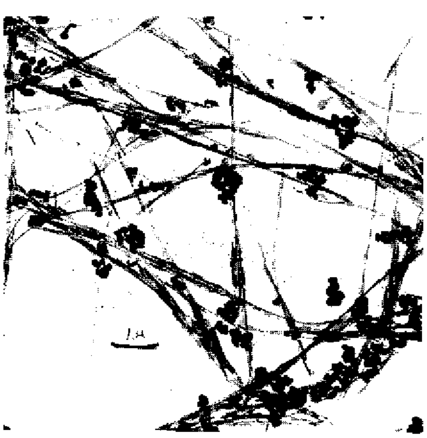

Fig. 2. Co-flocculation of purified chrysotile asbestos and TiO_2 (electron photomicrograph). Magnification = 5600×

Effects on Opacity

Inasmuch as chrysotile asbestos has an index of refraction of 1.52–1.55 that is similar to that of kaolin, it could be expected to have equivalent opacifying power. On the basis of the amount added, asbestos-filled sheets showed higher opacities; however, as is shown in Fig. 7, the opacities are essentially identical at corresponding filler weights in the sheet. In the series where asbestos was substituted for 2% clay in a titanium dioxide filled sheet, the resulting opacities associated with the asbestos were invariably higher. In Fig. 8, the average opacity increase is from 2 to 3 points. This is attributed to the increased retention of all components through the cationic charge of the chrysotile asbestos.

Effects on Tear and Tensile

The comparative tear values for the addition of either clay or asbestos are similar. For both minerals, small quantities are beneficial whereas larger quantities prove to be detrimental. Figure 9 shows that small quantities (<5%) of asbestos resulted in better tear factors.

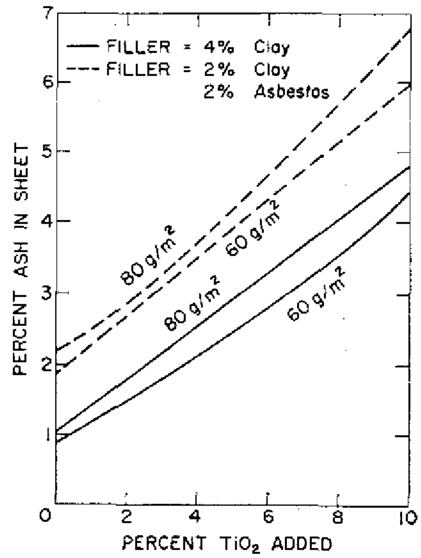

Fig. 3. Ash content versus per cent TiO_2 added—with and without asbestos

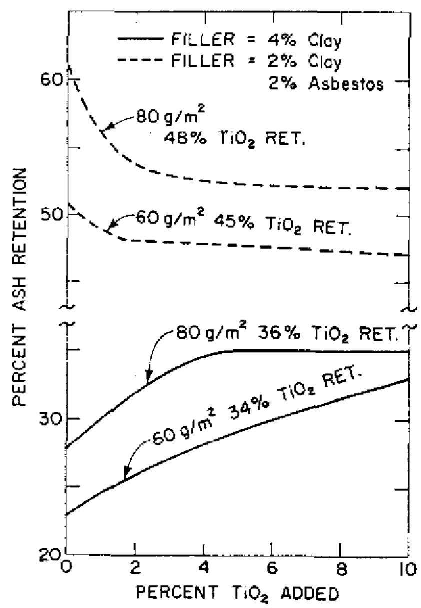

Fig. 4. Effect of basis weight and per cent TiO_2 additions on ash retention—with and without asbestos

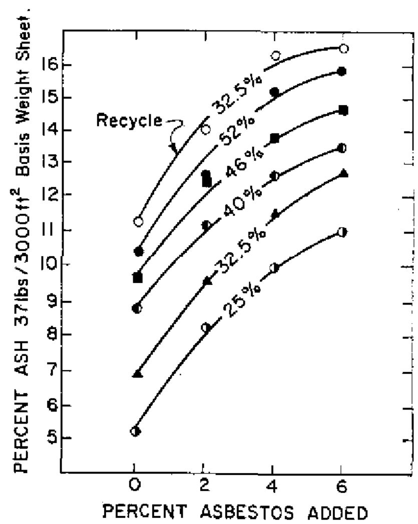

Fig. 5. Effects of asbestos additions on ash content in highly filled handsheets

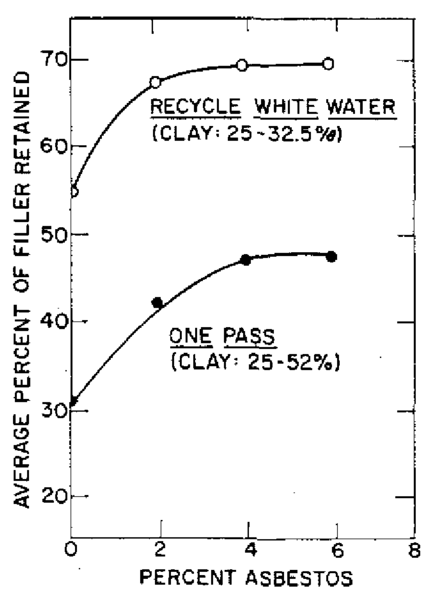

Fig. 6. Average filler retention versus asbesost additions

Above 5% asbestos additions the tear factor decreases below that for clay-filled paper. This effect is probably due to the geometry of the fiber as well as to its smaller particle size. Asbestos is more efficient at disrupting the hydrogen bonding of the cellulose fiber than are nonfibrous minerals. An even better example of the geometry effect can be seen in Fig. 10, where the tensile values are shown for corresponding filler content of the sheet. Once 3% filler in the sheet is exceeded, the effect on tensile strength is influenced considerably more by the asbestos than by either clay or TiO_2.

Effects on Softness

While the strength of the sheet is reduced by asbestos content, a corresponding softening effect is also achieved. This relationship is shown in Fig. 11. In a lightweight tissue sheet a 9% asbestos content resulted in doubling the softness values obtained on a Clark softness-stiffness tester. Various furnishes were investigated and all types appeared to respond in a manner similar to the lightweight sulfite furnish.

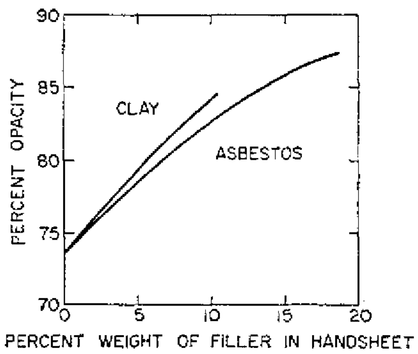

Fig. 7. Handsheet opacity versus filler content

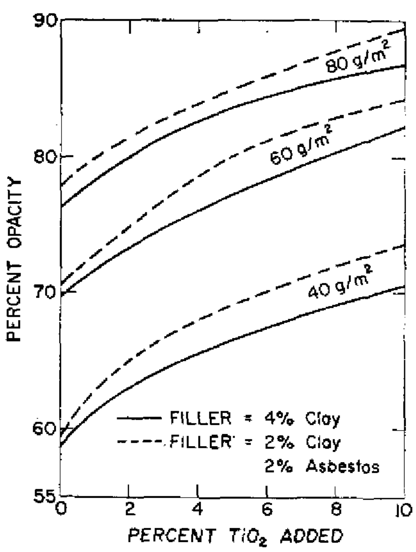

Fig. 8. Opacity gain versus per cent TiO_2 added—with and without asbestos

Effects on Pulp Freeness

As might be expected from the use of a small sized, fibrous filler, the freeness of the furnish is affected. The degree to which the asbestos slows up the furnish drainage appears to be dependent on the original freeness of the stock. For example, the data in Fig. 12 show that the lower the freeness of the stock the less it is affected by asbestos. At the low levels of asbestos addition normally used in paper this has not been a problem in the mill.

Effects on Porosity

With the incorporation of the highly refined asbestos the sheet porosity invariably has a tendency to decrease with increasing asbestos content as shown in Fig. 13. The initial high increase in porosity values obtained by the addition of between zero and 2% asbestos is attributed to the retention of fines. This effect normally accompanies the addition of chrysotile asbestos.

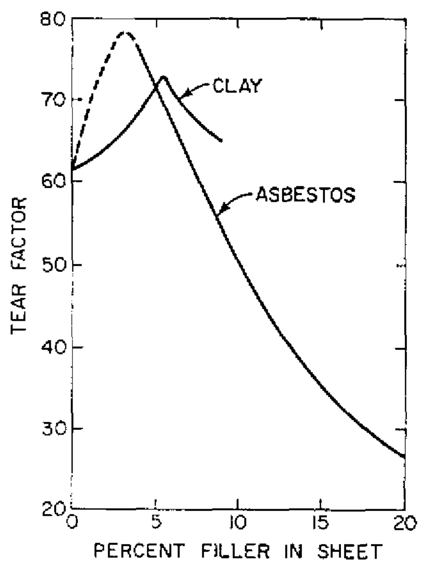

Fig. 9. Tear factor versus filler content

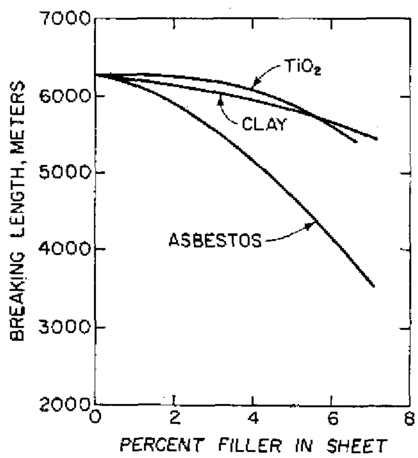

Fig. 10. Handsheet tensile strength versus filler content

Effects on Printability

Normally, any time the porosity of the sheet is reduced and the formation of the sheet is improved, the printability is subsequently benefited. Printing evaluations by the Research Institute for the American Newspaper Publishers' Association of samples obtained from the various mill trials verified these conclusions. Where sheets containing asbestos were compared to the control runs on the same grade, improvements in the following properties were noted:

1. Smoothness
2. Opacity
3. Ink transfer
4. Printability

In most cases, improvements were noted for both the felt and wire sides. Usually the more significant improvements were observed on the wire side thus demonstrating an improvement in two-sidedness.

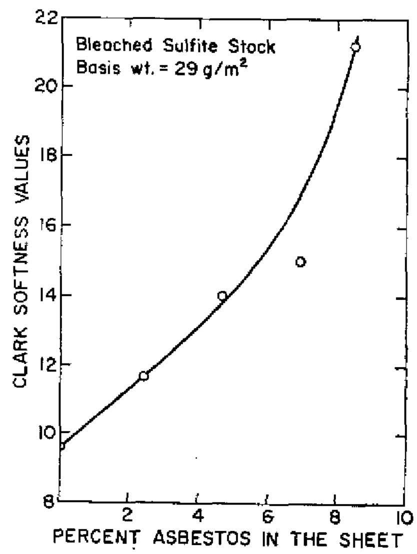

Fig. 11. Handsheet softness versus asbestos content

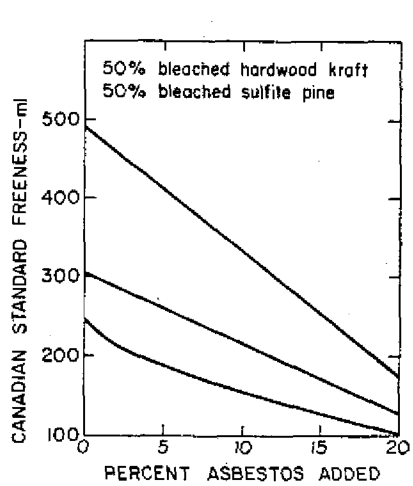

Fig. 12. Furnish freeness versus asbestos content

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Effects of Stock Type

Some data have been obtained on furnishes employing stocks other than a bleached sulfite stock. For the most part the data obtained were consistent with the results reported so far. The most notable exception was in a typical newsprint furnish of 80% groundwood—20% bleached sulfite. Under these conditions, as much as 6% asbestos in the sheet caused no appreciable reduction in the tensile strength. This probably can be attributed in part, to the inherent weakness of the sheet and, in part, to the retention of the groundwood fines which contribute to the sheet strength.

Other Applications

Probably the largest single application for asbestos, in addition to those already described, is as a pitch controlling agent. Laboratory studies have been conducted on a wide variety of pulps, but because of the diversity of pitch problems, no universal data are obtainable. In the majority of the cases, however, asbestos has proved to be more effective than other commercially available products. The total reduction in pitch is generally only slightly lower than competitive products but the amount of asbestos necessary to reach this level is usually significantly less.

Considerable laboratory effort has also gone into the retention of beater-additive latices. Since most of the commercially available latices are anionic, they have proved to be compatible with the cationic chrysotile. It has been found advantageous to blend the asbestos with the cellulose first in order to put the asbestos on the cellulose in a dispersed state. Thus, when the latex is added, it is deposited uniformly throughout the furnish and minimizes the tendency to form the latex agglomerates which are undesirable in the finished sheet. The overall asbestos retention is almost universally improved and the resulting physical properties have been found to be enhanced (particularly wet tensile and fold) to a higher degree than can be attributed to the improved latex retention.

Studies in dye retention have shown that 2% asbestos addition will generally improve the retention and greatly reduce the two-sidedness. This is particularly true with acid and pigment dyes. It has also been possible to predye the asbestos which in turn can be added directly to the furnish and results in a close control of color and shade.

A rather unique application was also discovered in the field of conductive paper. Its function in this area is to improve the sheet formation and to provide a more uniform distribution of the conductive media through coflocculation. Again, the asbestos addition levels required for this application are found to be in the 2–3% range.

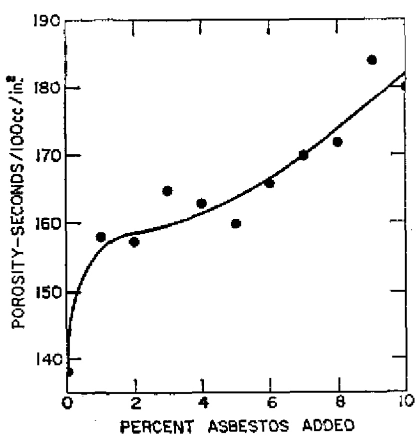

Fig. 13. Handsheet porosity versus asbestos content. Stock, bleached sulfite. Test, Gurley Densometer

MILL TRIAL DATA

Since the beginning of this program, something in excess of 200 mill trials have been conducted. In the majority of these trials the purified asbestos has performed as predicted from the laboratory studies. In addition, on machines where mineral additions are commonplace, no serious problems have developed due to the addition of asbestos. These trials have been conducted on a wide variety of paper grades as well as in paperboard. A review of some of these trials demonstrates the versatility and advantages obtained with the chrysotile fiber.

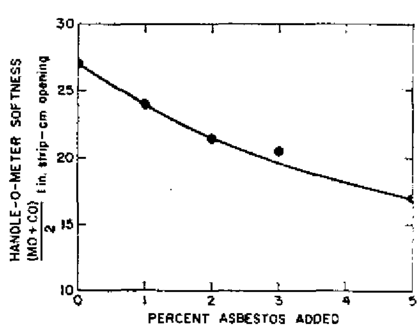

Fig. 14. Towel softness versus asbestos content. Freeness, 600 ml CS

Table II

Condition	Clay, %	Asbestos, %	TiO_2, %	Glue, %	Opacity
1 (control)	4	...	8.25	0.25	89.5
2	1	3	7.0	0.25	92.5
3	1	3	6.0	0.25	91
4	1	3	6.0	...	91

Table III

Condition	Paper analysis			
	Opacity	TiO_2, %	Ash, %	TiO_2 retention, %
Pre-trial	82.5	1.64	12.0	65.5
2% asbestos added	83.5	2.20	13.9	88
Post-trial	82.0	1.75	12.2	70

Retention

In a machine trial on a 40 lb opaque printing paper, 3% asbestos substituted for 3% clay resulted in a reduction of the TiO_2 requirement from 165 to 120 lb/ton and eliminated the glue previously used as a retention aid. This was accomplished without departing from the specifications of the sheet and without machine problems. A summary of these results is shown in Table II.

In another trial, on a 37 lb bond paper, 2% asbestos was used for a corresponding amount of clay. Titanium dioxide amounting to 2.5% of the furnish was also going into this sheet for opacity. A summary of these results appears in Table III.

These data show an improvement in TiO_2 retention from about 68 to 88% with a 2% asbestos addition.

In addition, the saveall effluent was monitored during both the control and trial periods. The average solids content during the pretrial and posttrial period was 2.3 lb/1000 gal. During the trial the solids content was reduced to 1.5 lb/1000 gal. Due to the improved efficiency resulting from the asbestos, a 35% reduction in solids loss was realized.

It is not unusual to expect saveall efficiencies improvement during these trials. In one trial, particular attention was paid to the saveall unit since it had been operating under a heavy load with a low efficiency. In this instance both the influent and effluent were monitored. A summary of these data is given in Table IV.

Softness

A natural application for the highly refined chrysotile fiber is in the tissue and towel grades. This mineral is unique as an inorganic softening agent. Numerous mill trials have demonstrated its ability to impart both softness and a velvety handfeel to both tissue and

Table IV

Condition	Saveall, lb solids/1000 gal		
	Influent	Effluent	Saveall efficiency, %
Pre-trial	17.9	4.36	
During trial (2% asbestos), hr			
1.0	14.3	1.15	
2.0	13.2	0.90	
3.0	11.0	0.71	
Post-trial	21.4	6.00	
Average			
Without asbestos	19.64	5.18	74
With asbestos	12.83	0.92	93
Reduction in solids resulting from the use of asbestos, %	35	82	

Table V

Condition	Handle-O-Meter values	
	MD	CD
Control	15[a]	22.5[a]
Trial	9[b]	11.5[b]

[a] Average of 6 reels. [b] Average of 8 reels.

towels. A typical relationship between asbestos content and Handle-O-Meter values on a 40 lb towel is shown in Fig. 14. The levels illustrated, up to 5% asbestos, are typical of the levels used for this purpose. For this grade a 5% asbestos addition reduced the Handle-O-Meter values from a control of 27 to 17.

In a machine trial on a 13.25 lb tissue, 4% asbestos was added to improve softness and handfeel. The furnish consisted of 25% pine, 60% hardwood, and 15% broke. The effects on Handle-O-Meter values are shown in Table V.

Not only was a significant improvement in softness realized but the level of difference between machine direction and cross-machine direction was reduced by nearly 50%. This is probably due to the improved sheet formation. In addition to these improvements the improved drying rate of the asbestos-filled tissue resulted in a lower steam requirement to the Yankee drier.

By virtue of the inherent physical properties of chrysotile asbestos a wide variety of applications to the tissue and towel grades have been explored. Its largest single application at this time is as a tool to achieve quality in a wide variety of furnish components. In mills where the use of coarser and harsher cellulose stocks (or even wastepaper) is limited, the incorporation of asbestos has permitted a higher percentage of these cheaper and coarser pulps without a loss in quality and at a significantly reduced furnish cost. For still another mill, where the drying chain controlled the machine speed, as much as 30-50 fpm increase in machine speed was achieved with a 2% asbestos addition, a situation considerably more economical than the standard furnish at the slower rates.

Pitch Control

The most universal application to date is in pitch control. In mills where this use has been investigated it has been found to be more effective than other commercially available products. Where asbestos is currently being used it has replaced talc, at the ratio of 2 lb of asbestos/3 lb of the competitive product.

CONCLUSION

These studies have shown purified chrysotile asbestos to be unique as an inorganic additive to cellulose paper. Unlike other paper components this material is cationically-charged and, as such, performs as a retention aid to all constituents in the furnish. Its uniformity, small particle size, and fibrous geometry contribute to the softness of the sheet and improve two-sided effects. The high surface area and its adsorption of organics aid in dye adsorption and printability. Its performance on the paper machine has been most satisfactory and, as a rule, has caused no problem in the subsequent processing of the paper. Where care has been used to employ a sufficient quantity of asbestos to be effective, yet not so much that the strength of the paper is degraded beyond reasonable limits, the results have been quite successful.

Because of this versatility we believe that purified chrysotile asbestos will continue to grow in its present application to the paper industry and that new areas will develop where the unique properties of this material will be advantageous.

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