DISCUSSION

MR. C. G. LANDES[1] (*presented in written form*).—The paper summarizes very neatly the role of interfiber bonding in the making of paper. The importance of wet strength resins is pointed out as well as the need for more efficient bonding agents with better flexibility and durability properties.

An important factor not stressed in the paper is the recent development of many specific new types of wet and dry strength resins or polymers. The chemical diversity of these synthetic and natural polymers presents a challenge to those investigating the fundamental mechanisms involved in binding fibers together. It is also noteworthy that there is a growing need for fiber binding agents that will give improved dry strength but which will not impart sufficient wet strength to interfere with easy reuse of the fiber for papermaking.

MR. L. E. KELLEY[2] (*presented in written form*).—This paper presents intriguing questions for basic research and implies interesting areas into which the paper industry may progress.

The problem of improving the properties of paper in terms of high tensile strength with high tear resistance and high folding endurance has been before the papermaker for some time. The authors show emphatically that papermakers' fibers, pine kraft for example, are excellent raw materials with which to work. The strength is there in the fiber; it is the fiber-to-fiber bond that needs improvement. The fact that amine-formaldehyde resins can fortify or modify the natural bonds to make them water resistant indicates a state of knowledge that can be expanded. The question is, why cannot these bonds be modified to alter or improve other properties? Can extensibility, flexibility, nonrigidity be engineered into the bonds to produce a stretch quality which would in turn give improved tear resistance and folding endurance?

This objective has been achieved in part by replacing the cellulosic (hemicellulose) bond with synthetic polymers saturated from emulsion or dispersion into a web or sheet of loosely bound fibers. Paper products derived from treatments of this type are well known. Shoe innersoles, imitation leather, tape backing, book covers, etc. have been produced commercially for some time. However, the ratio of synthetic bonding agent to fiber is high, particularly if viewed in the light of the relatively small amount of amine-formaldehyde wet strength resin required to effect large improvements in water resistance of the natural bond.

The authors ask that the chemistry and mechanics of interfiber bonding be reviewed, that a fresh approach be taken, that the wood pulp fibers be recognized as an inherently excellent raw material. Utilize this strength; improve the bond;

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study it as a problem in adhesion, or in plasticization. Give the bond the strength of the fiber. In the course of improving bond strength, test methods for assessing internal bond strength (particularly on lightweight papers) may need to be developed.

The demand is with us to produce lightweight papers with high tensile and tear strength and internal bond strength in order to meet such requirements as high-speed printing and to lower shipping costs. Furthermore, the demand for paper is steadily increasing and the supply of low-cost wood or natural fibers is limited. The ultimate potential strength of the fiber must be utilized if we are to face the supply and demand problem in the next few years.

Another aspect in fiber bonding, as pointed out in the paper, is the interest shown by papermakers in synthetic fibers. Use of these fibers with efficient bonding agents can bring the papermaker into broad new fields. Already the terms "synthetic fiber papers" and "nonwoven fabrics" are being confused if not used interchangeably. The papermaker has equipment at his disposal with hourly production measured in tons. His product could approach the properties of woven fabrics. A key to this prospect is the fiber-to-fiber bond.

CHAIRMAN F. F. NEWKIRK.[3]—In all of the work which you have done on internal bonding, have you made any attempt to correlate internal bonding characteristics with dimensional stability factors?

MR. K. W. BRITT (*author*).—We have not concentrated upon this matter of dimensional stability. I would say that whereas the bond is undoubtedly important in this factor, perhaps an equal or greater importance resides in the character of the fiber itself. Of course, this paper is focused primarily on the bond, rather than upon fiber. I would say that any work on dimensional stability would have to combine the two.

MR. FREDERICK C. SCHMUTZ.[4]—Any industry can borrow from another industry. The wool people have been very much concerned with fiber bonding, so they could card wool to a very thin denier. They have met that problem, in some cases, by treating the surface of the wool with certain materials, as for example, fine silicas, and have increased the interfiber strength or interfiber bonding. Has any of that approach been taken in the paper industry?

MR. BRITT.—So far as I know, it has not. I do not know very much about the wool situation, but I would say that the factor you are dealing with there is primarily interfiber friction, rather than bonding. Did you mention silicas as modifying interfiber friction?

MR. SCHMUTZ.—Yes.

MR. BRITT.—I can see that in the case of wool, such a material as that would change the interfiber friction and have a pronounced effect.

I believe that the thinking in the paper industry is that friction has very little to do with strength. I know that twenty or thirty years ago, there was quite a debate as to the importance of friction or the mechanical entanglement as against bonding or chemical relationship. I believe the thinking today in the paper industry is that it is almost entirely a chemical or intermolecular relationship. Whether some of the experience in wool could be applied to paper, I could not say, but I do see quite a distinction.

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