The Action of the Beater

INTRODUCTORY

It is a matter of common knowledge among those connected with the art of papermaking that the beating process exercises a very marked influence on the character of the finished sheet of paper. If the stuff has not been properly treated in the beater, the utmost skill in handling it on the paper machine may be unavailing, and with such stuff it will frequently be impossible to produce the required quality of finished sheet. In fact it has become almost proverbial to say in connection with many classes of papers that the sheet "is made in the beater."

Notwithstanding the recognised importance of the beating operation, however, the existing state of knowledge of the principles which it involves is distinctly unsettled. This is pretty clearly evidenced alone by the numerous articles on beating appearing in the technical press which give the impression that the subject is practically inexhaustible.

Some maintain that the most economical beating is obtained by employing thick furnishes, others recommend rapid circulation, while a third school advocates that the beating time should be kept as short as possible.\(^1\) While some claim that with the modern

\(^1\) Wochenblatt fuer Papierfabrikation, 1915, p. 171\(f\) (hereinafter referred to as W.f.P.).
THE ACTION OF THE BEATER

large beaters it is impossible to achieve the same beating effect as with the old-fashioned small beater,\(^1\) and adduce numerous examples to support their case, others again will contest this view and assert that it is merely necessary to adapt the new beaters to the mill conditions of operation.\(^2\)

One of the chief reasons for the inaccurate arguments so frequently encountered is the extraordinarily large number of factors involved in the beating process. One or other of these may so easily be overlooked or forgotten, and the prospects of agreement between two controversialists thus reduced to zero. No biased and subjective method of examination is likely to lead to a clear understanding of the action of the beater: on the contrary, any reliable theory of the beating operation must be largely based on detailed investigation of all the factors concerned and on the properly co-ordinated numerical results of experimental observations.

Makers of beaters are also far from unanimous as to the principles on which the dimensions of beaters should be determined. Different firms frequently recommend very different dimensions for beaters of the same dry capacity. It will be shown later that the cutting length per second is a most important factor in determining the output of a beater, yet an examination of various makers' lists shows this figure to vary from about 7,300 to 25,000 ft. per second for a 3-cwt. beater, for the same peripheral speed of beater roll. Some makers increase the value of the cutting length per second in approximately the same proportion as the furnish of the beater increases. Others, for example, only increase the cutting length per second in the ratio of 1:1.4 when the dry capacity of the beater is increased from 3 cwt. to 12 cwt. Usually

\(^1\) W.f.P., 1915, pp. 1355 and 1494. 
INTRODUCTORY

the weight of the roll is not stated, although the relation of this to the number, size, and spacing of the bars is of considerable importance.

It is scarcely surprising that under these conditions papermakers are sometimes sorely disappointed when changing over from one size of beater to another; and not infrequently refuse to depart from a type and size with which they are already familiar. Builders of beaters lack definite data on which to base the relative dimensions of beating tackle—roll and bedplate. If a firm of engine builders is asked to build a steam engine to develop a certain horse power at a given speed and under a given steam pressure, they will have the main dimensions of the engine ready to hand, for these are calculated according to certain definite and proved methods, and the dimensions adopted by different firms will tally very closely with one another. Buying a beater of a given capacity is a different matter. It would appear that makers are under the necessity of dimensioning beating tackle on a somewhat insecurely founded method of estimation.

Turning from papermakers and machine builders to professors one finds a similar absence of agreement on the points in question. If, for example, it were required to design a beater to produce stuff of the same character as an existing beater, but to give double the output, the literature on beating would be found to provide an odd assortment of directions.

The first attempt to lay down definite rules for beater calculations was made by Ferdinand Jagenberg,1 of

1 Jagenberg comes from an old papermaking family, and after completing an educational course of studies, himself became a papermaker, turning later to the manufacture of beater rolls and bedplates. The book referred to is a result of his latter activities. It has met with widespread success, and has formed the basis for the writings of the majority of subsequent workers.
THE ACTION OF THE BEATER

Remscheid (a former papermaker). In his little book, "Das Hollaendergeschirr in Briefen an einen Papiermacher," Jagenberg in 1887 attempted to describe the principles on which the beating effect of a beater can be determined.

Later Professor E. Kirchner, of Chemnitz, devoted himself to the subject, and was followed by Strobach, manager of the Olleschau paper mill.

In his book, "Der Hollaender," and afterwards in the Wochenblatt fuer Papierfabrikation, Professor Haussner, of Bruenn, publishes some theoretical discussions on the action of the beater. In 1907 Professor Pfarr. of Darmstadt, produced a study of the beater in which he attempted to evolve an expression for the beating output. Finally Clayton Beadle and Henry Stevens have carried out very extensive experiments in connection with the economy of beating, in addition to micro-measurements conducted with a view to ascertaining the effect on the fibre.

Of these investigators, Jagenberg concludes that the main factors which determine beating output are the beating pressure and the number of cuts per second. Kirchner is of opinion that the cutting effect of the bars depends on the cutting length per second, on the beating pressure and on the number of points of intersection between the flybars and bedplate bars.

1 Various articles in the W.f.P. and in Kirchner’s treatise, “Das Papier. IV., Ganzstoffe.”
2 W.f.P., 1904, “Hollaendertheorie.”
3 Stuttgart, 1902.
5 W.f.P., 1907, “Hollaender und deren Kraftverbrauch.”
8 “Das Papier. IV., Ganzstoffe,” p. 43.
Haussner, on the other hand, holds that no takes place between the flybars and the bedplate bars, and that the beating action depends entirely on crushing and tearing between the surfaces of the bars.  

Stroebach regards the cutting effect of the beater as being proportional to the cutting length per second, and the crushing effect as proportional to the product of three factors, viz., the area of the bar surfaces in mutual contact, the roll pressure, and the speed of the flybars. Kirchner, however, confines himself to stating that these three magnitudes, in conjunction with the number of intersections per second between the flybars and bedplate bars, materially affect the tearing action of the beating tackle.

Pfarr supports the view that the beating output is affected by the speed of circulation of the stuff round the trough, but is undecided as to how much importance should be attached to the cutting length per second, nor does he express any definite opinion as to the importance of the product "flybar speed" multiplied by "area of contacting surfaces."

Beadle and Stevens maintain that no cutting takes place if the flybars and bedplate bars are parallel, but only if they form an angle with one another. These authorities also assert that the speed of circulation of the stuff has no effect on the beating output. They consider that, at any rate as far as commoner classes
THE ACTION OF THE BEATER

of papers are concerned, the chief function of the beating tackle is to tease out the fibres.

Thus there is abundant divergence as to the identity of the factors which determine beating output—a divergence which discloses the obscurity surrounding the subject. The majority of writers do, however, agree that this obscurity is largely due to lack of serviceable experimental data.

There are still far too few and too incomplete reports available on beating tests to afford in themselves the basis for a satisfactory explanation of the beating operation.

The object of the present treatise is to throw more light on the conditions which govern the output of whole stuff from the beater. The theoretical methods of investigation adopted are based on observations obtained under mill conditions and on the results of experiment. Incidentally, the various opinions which have just been referred to are subjected to critical examination.

The experiments on which the work has been built up were all carried out with whole stuff. The theory which is developed applies primarily to well-beaten strong sheets prepared from chemical wood pulp and rag half-stuffs. It should, moreover, be remarked that no claim is made for the correctness of the present theory except in conditions under which the beater is really employed to disintegrate the stuff thoroughly, i.e., as a beater and not simply as a mixer.

Taken as a whole, the present work may be regarded as new, both with regard to its results and to the methods of treatment employed. In dealing with parts of the subject which have been treated so thoroughly by previous workers as to require no further comment,
the necessary reference alone is given.\textsuperscript{1} The only portions of this volume which are based to any considerable extent on earlier work, are the section dealing with the effect of beating on the stuff and to a lesser extent the section on the mechanics of the beating tackle.

\textsuperscript{1} Thus, for example, with respect to the variation in the area of contacting bar surfaces during a revolution of the beater roll, and also with respect to the conditions under which the stuff leaves the roll.