Blending Delay Time of Multimixers

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An analysis of the blending delay time (BDT) of the multimixer shows that BDT is not constant for the initial period of time. After starting from a particular value, which depends upon the number of compartments of the mixer, it increases with the number of layers being delivered by the mixer on the conveyor belt and then gets stabilized after a certain number of layers. Other factors remaining constant, BDT increases with increase in the number of compartments.

Keywords: Blending delay time, Multimixer

1 Introduction
The sequence in spinning is quite long. There have been constant efforts by research and development organizations to cut short the sequence. This has been largely achieved today, at the expense of a reduced number of doublings in spinning. As a result, there is an increasing demand for maintaining a constant mix over a longer period of time. As this is not possible with the existing standard blending equipment, automixers have been developed. The multimixer is one such machine. There is no direct method to assess the intimacy of a blend when fibres of the same type are mixed, e.g. 3 or 4 types of cotton, to produce a given mix. An indirect method to express this is to calculate the blending delay time (BDT), a relatively new term. BDT is defined as the time that elapses between the bales or section of bales within a laydown during the feeding operation or the separation in time between the first and last portion of cotton at any one process within a specified time interval. This delay time is an important factor for optimum blending efficiency. To achieve better blending, BDT should be as prolonged as possible. The weight equivalent of BDT, which takes into account the production rate of the machine, is an alternative term to denote blending delay. In the present paper, an analysis of BDT of a multimixer has been carried out.

2 Description of Multimixer
A detailed description of a multimixer is given by Shrigley and Szaloki. It is basically a huge box, consisting of a number of compartments—6, 8, 10 or 14. Each compartment is filled with cotton in a particular fashion and the material that rests at the bottom of the various compartments when delivered on to a conveyor belt gets mixed up. As the material that is being mixed up was fed to the various compartments at different times, a large blending delay is achieved and, as a result, blending improves.

3 Mode of Feeding
The feeder situated at the top of the mixer is capable of moving from one end to the other of the mixer and then back to the starting point. There are two methods of feeding and thus filling the compartments—a continuous and a discontinuous one. In the latter case, all the compartments are completely filled before the delivery is started. When the compartment is empty the delivery is stopped and the compartments are filled again. In the continuous method, which is more common, the first compartment is filled to 1/nth of its height (where n is the number of compartments). The second one is filled to 2/nth of its height and so forth till the last compartment which is filled to its full height when the delivery is started. The feeder then goes back to the first compartment and the second feeding cycle starts. Now onwards, in all the feeding cycles the compartments are filled from bottom to top, one after another. By the time the first layer, whose thickness is 1/nth of the height of the compartment, comes out from all the compartments, the first compartment in the second cycle of feeding is filled to the top and all the compartments which were filled in the first cycle are emptied down by 1/nth of their height. The process is shown in Fig. 1 for a multimixer with 6 compartments. The feeder then moves to the second compartment and starts filling it up in a similar fashion and the process continues with the series of layers, having 1/nth of the height of the compartments, coming out one after another.

4 Analysis
The entire multimixer can be imagined as consisting of a large number of small boxes (Fig. 2) whose
As BDT is the time interval between the first and the last portion of the cotton, which is getting mixed, the parameter in the case of a multimixer can be determined by finding out the difference in the time of filling of the earliest and the latest box, in a particular layer, e.g. $B_{11}$ and $B_{41}$ for the first layer and $B_{12}$ and $B_{11}$ (fed in the 2nd cycle of feeding) for the second layer.

4.1 Time of Filling

The time required for a box to be filled to its full height has been considered as its time of filling. The time of filling of a particular box depends upon the feeding cycle and the location of the box in the matrix considered.

4.1.1 First Cycle of Feeding

The nature of feeding in the first cycle is such that only one box is filled up in the first column, two boxes are filled up in the second, three boxes in the third column and so on till the last column in which all the boxes are filled up. So the boxes which are filled up in various columns can be written as

<table>
<thead>
<tr>
<th>Column No. (i)</th>
<th>Box (Bi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$B_{11}$</td>
</tr>
<tr>
<td>2</td>
<td>$B_{21}$</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>n</td>
<td>$B_{n1}$</td>
</tr>
</tbody>
</table>

Now the time of filling up any box ($B_{ij}$) in this cycle will be

$$x + 2x + 3x + ... + (i-1)x + xj$$

$$= x \{1 + 2 + 3 + ... + (i-1)\} + xj$$

$$= x \frac{i(i-1)}{2} + j$$

where $x$ is the time taken to fill a single box.

The time of filling up the last box ($B_{nn}$) is given by

$$x + 2x + 3x + ... + nx$$

$$= x \{1 + 2 + 3 + ... + n\}$$

$$= x \frac{n(n+1)}{2}$$

which is equal to the time taken to fill up all the boxes in the first feeding cycle.

4.1.2 Second Cycle of Feeding

The nature of feeding in the second cycle is different from that in the first but remains the same for subsequent cycles. It should be noted that as soon as this cycle starts, the delivery of the material from the multimixer also starts. The time of filling up any box

$$x + 2x + 3x + ... + nx$$

$$= x \{1 + 2 + 3 + ... + n\}$$

$$= x \frac{n(n+1)}{2}$$

which is equal to the time taken to fill up all the boxes in the first feeding cycle.
CHATTOPADHYAY and SALHOTRA: BLENDING DELAY TIME OF MULTIMIXERS

(B_{ij}) in the present cycle will be the sum total of the times taken to fill up all the boxes of the (i - 1) number of compartments and j boxes in the ith compartment. This can be given by

\[ x \{ (i-1) n + j \} \]  \hspace{1cm} \ldots (3)

The time of filling up the last box B_{nn} in the present cycle is equal to \( n n x \), i.e. \( n^2 x \), which is equal to the total time taken to fill up all the boxes in the second cycle of feeding.

If the starting time is considered to be the time when the first box in the first column at the first cycle of feeding started getting filled up, then the time of filling up any box \( (B_{ij}) \) in the second cycle of feeding becomes

\[ x \frac{n(n+1)}{2} + x \{ (i-1)n + j \} \]  \hspace{1cm} \ldots (4)

4.1.3 Third Cycle of Feeding

Since the nature of feeding the boxes from second cycle onwards does not change, the time of filling up any box \( (B_{ij}) \) in this cycle

\[ = \text{time taken to fill up all the boxes in the first cycle} \]
\[ + \text{time taken to fill up all the boxes in the second cycle} \]
\[ + \text{time of filling up the box } B_{ij} \]

\[ = x \frac{n(n+1)}{2} + n^2 x + x \{ (i-1)n + j \} \]  \hspace{1cm} \ldots (5)

4.1.4 Fourth Cycle of Feeding

In this case, before the commencement of the fourth cycle, the first, second and third cycles of feeding of all the boxes are to be completed. The time taken to fill up all the boxes in any cycle (other than first) remains constant since every time all the \( n^2 \) number of boxes have to be filled up. So the time of filling up any box \( (B_{ij}) \) in the present cycle becomes

\[ x \frac{n(n+1)}{2} + 2n^2 x + x \{ (i-1)n + j \} \]  \hspace{1cm} \ldots (6)

4.1.5 Nth Cycle of Feeding

Following the same logic as mentioned earlier, the time of filling up any box \( (B_{ij}) \)

\[ = x \frac{n(n+1)}{2} + (N-2)n^2 x + x \{ (i-1)n + j \} \]  \hspace{1cm} \ldots (7)

for \( N \geq 2 \)

where \( N \) is the cycle of feeding.

4.2 Determination of the Earliest and Latest Filled Box in a Layer

A particular layer consists of material from \( n \) boxes which get mixed up afterwards. All these \( n \) boxes contain material deposited at different times. In order to calculate BDT one has to know the time of deposition of the material in the earliest and the latest filled box or time of filling up of earliest and latest box in a layer. This can be found out easily either from Eq (1) or Eq. (7), from the location of the boxes (earliest and latest) in which these materials were initially dropped and the cycle of feeding.

4.2.1 Earliest Box

As far as the values of \( i \) are concerned one can observe the following pattern in the values of \( i \) as a function of layer number.

<table>
<thead>
<tr>
<th>Layer No. (l)</th>
<th>Value of ( j )</th>
<th>Cycle of feeding (( N ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>( n )</td>
<td>( n )</td>
<td>( n )</td>
</tr>
<tr>
<td>( n+1 )</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>( n+2 )</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>( 2n )</td>
<td>( n )</td>
<td>2</td>
</tr>
<tr>
<td>( 2n+1 )</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

So, for the generalized formula, \( i \) can be written as

\[ i = \{ 1 - (N-1)n \} \] for any value of \( l \)  \hspace{1cm} \ldots (8)

The values of \( j \) becomes

\[ j = 1 \text{ for } l < n \]
\[ j = n \text{ for } l > n \]  \hspace{1cm} \ldots (9)

4.2.2 Latest Box

Here the following pattern may be observed from second layer onwards.

<table>
<thead>
<tr>
<th>Layer No. (l)</th>
<th>Value of ( i )</th>
<th>Cycle of feeding (( N ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( n )</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>( n+1 )</td>
<td>( n )</td>
<td>( n )</td>
</tr>
<tr>
<td>( n+2 )</td>
<td>1</td>
<td>( 2 )</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>( 2n )</td>
<td>( n )</td>
<td>( 2 )</td>
</tr>
<tr>
<td>( 2n+1 )</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

75
Similarly for the latest box, the relationship will be
\[ N = 2 + \frac{2}{n} \]  
(13)

If the value of \( N \) lies between two whole numbers, then the value of the lowest number has to be considered as the feeding cycle.

\section*{Discussion}

In Fig. 3 BDT has been shown as a function of layer number for multimixer of different sizes. It shows that BDT does not have only one value as mentioned by Shrigley. The value mentioned seems to be applicable to the first layer only. BDT initially increases with the number of layers but gets stabilized after a certain number of layers. The layer number at which BDT stabilizes is different for different multimixers. It is dependent on the number of compartments of the mixer. It is seen that the layers at which BDT stabilizes are 5th, 7th and 9th for multimixer having 6, 8 and 10 compartments respectively. In other words, the number of layer at which BDT stabilizes is given by: No. of compartments \(-1\), i.e. \((n-1)\).

The stabilized BDT is then given by the square of the above term \((n-1)\) multiplied by the time to fill up a single small box \((x)\), i.e. \((n-1)^2x\). As an example the stabilized values of BDT for a multimixer having 6, 8 and 10 compartments will be \((6-1)^2x\), \((8-1)^2x\), \((10-1)^2x\) or 25x, 49x and 81x respectively. BDT of the mixer with 10 compartments is the highest, followed by the one having 8 and 6. It is therefore seen that other things remaining constant, a multimixer with a greater number of compartments will result in better blending.

\section*{References}

3 Szaloki Z S, Opening, cleaning & picking (Institute of Textile Technology, Charlottesville, Virginia) 1976, 62.