Optimizing the frequency of oscillating beater in double roller gin

S B Jadhava & K M Paralikar
Central Institute for Research on Cotton Technology, Matunga, Mumbai, 400 019, India

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Variable speed double roller gin has been used to optimize the frequency of oscillating beater, considering three levels of oscillating frequency, namely 750, 1000 and 1250 cpm and conventional frequency of 1000 cpm. The factors considered for optimum rates include lint turn out, fibre quality and ginning rate. Overall, the fibre quality remains unaffected for all types of cottons, whereas the lint out-turn and ginning rate are found to be highest at 1250cpm frequency for long and extra long staple cottons. The conventional frequency is found to be better for short staple cottons. The short fibre content, seed coat nep and nep in the lint are comparatively less at higher frequency.

Keywords: Cotton, Double roller gin, Fibre parameters, Lint out-turn, Short fibre content, Seed coat nep

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1 Introduction

The double roller (DR) gin continues to enjoy the dominating role in the Indian ginning industry due to its gentle handling of fibres. It is easy to operate with low maintenance cost. However, its slow ginning rate especially for long and extra long staple cottons has made it expensive and affects in increasing the short fibre content and seed coats in the lint.

There are mainly four factors that determine quality and quantity of fibres and lint out-turn, namely (i) moisture content in seed cotton. (ii) geometry between the ginning roller, stationary and oscillating knife (iii) rate at which the seed cotton is being fed, and (iv) speed of the roller. It has been observed that the higher roller speeds have given higher lint productivity in DR gins with conventional oscillating frequency of beater (1000 cpm) but increased the short fibre contents and seed coat neps. Short fibre content is an important measure of fibre quality that is of relevance to textile manufacture. Zero short fibre content is an ideal situation but not realizable in cotton. There are three basic sources of short fibres, namely (i) genetical, (ii) ginning process and (iii) vigorous cleaning.

Cotton naturally contains some percentage of short fibres known as fuzz. The fuzz fibres are short, remain on the seed itself and account for up to 1.5-4.0% in some species. During ginning, some fibres are broken due to pulling and hammering and hence the percentage rises sometimes up to 12%. Vigorous cleaning before and after ginning also causes increase in the short fibres in the lint. Thus, it is clear that the major contribution to SFC (Short Fibre Contents) is the ginning process itself. Gentler ginning, of course, will break fewer fibres, but no other ginning than the roller ginning is known to be a gentler process. The widely practiced saw ginning is known to result in more fibre breaks, giving rise to higher percentage of SFC than the roller ginning. Gillum and Armijo found that the ginning rate was significantly different due to treatment giving higher seed coat fragments (SCF) and SFC in ginned lint. The present study is aimed at observing the effect of different oscillation frequencies of beater on productivity and quality of lint.

2 Materials and Methods

A variable speed double roller gin designed and developed at Central Institute for Research on Cotton Technology, Mumbai was used for the experiment. The gear system of the gin was redesigned; the gear was de-linked and fitted in the gear box of the gin stand. This helped to run the beater and roller independently. One could choose any speed for the beater as well as for the roller by simply using a step pulley and appropriate V-belt combination.

The cotton varieties having wide variations in the staple length and other fibre parameters were chosen for the study. The cottons were DCH-32, Surabhi,
Initially, four beater speeds were chosen for the experiment, but the oscillation frequency of beater beyond 1300 cpm caused high vibration during ginning, so the experimental trial was restricted to three beater speeds, namely 750, 1000 and 1250 cpm. This was done by changing the diameter of pulley using appropriate V-belt. The trials were performed for 100 and 130 rpm roller speeds. The reason for choice of two roller speed was their ability to give higher lint turn out at higher speed for long and extra long staple cottons. The lot size was kept at 15 kg of seed cotton in each ginning trial. Three tests were performed for each lot and average readings are given in the various charts. The seed cotton lots used in ginning trials were mixtures from the three pickings collected from UAS, Dharwad; GAU, Surat; and CICR, Nagpur. The seed cotton was purposely not processed through pre-cleaner to avoid any breakage of fibre and multiplication of impurities, but was carefully opened and cleaned manually before ginning. The moisture level was maintained at 8% in the seed cotton.

In the ginning process, the oscillating beater guides the seed cotton towards the exposed roller surface. Here the fibres are gripped in the grooves of the roller and dragged forward towards the ginning point. When dragged, the seeds reach the ginning point, i.e. exactly at the edge of the fixed knife. The oscillating beater strikes the cotton seed at that point separating it from the lint. The experiment was repeated with two roller speeds (130 and 100 rpm) by merely shifting 'V' belt for the appropriate size pulley. Kapas ginned/h, lint out-turn/h and ginning percentage were observed. The important lint properties measured were 2.5 % span length, micronaire and uniformity ratio using High Volume Instrument (HVI), and short fibre content, maturity ratio, neps and seed coat neps in the lint using the Advanced Fibre Information System (AFIS). The observations recorded for ginning productivity are given in Fig. 1 for 100 and 130 rpm of roller speed corresponding to different beater frequencies.

The fibre parameters measured with HVI instrument are graphically represented in Fig. 2 while short fibre content, neps and seed coat neps measured by AFIS in Fig. 3 for both the roller speeds.

![Fig. 1—Ginning productivity at different beater speeds for (a) 100 rpm and (b) 130 rpm roller speeds](image-url)
Fig. 2—Quality parameters studied with HVI at different beater frequencies with roller speeds of (a) 100 rpm and (b) 130 rpm

Fig. 3—Short fibre content, neps and seed coat neps at different beater frequencies with roller speeds of (a) 100 rpm and (b) 130 rpm
3 Results and Discussion

Figure 1 shows that the roller speed of 100rpm with high beater frequency of 1250 cpm has given the higher lint out-turn over the standard frequency of 1000cpm for long staple cottons like DCH.32 and H.6, while it is at par for the cottons like Surabhi and G-Cot hy-10. However, the standard speeds for roller and beater have given better results for the short staple cottons like G-Cot-23, MECH-23 and Jaydhar. The combinations of higher roller speed of 130 rpm and beater frequency of 1250 cpm have given still better results than the earlier one for almost all the cottons than the conventional speeds as well as for the lowest beater frequency of 750 cpm.

The function of the rollers in the roller ginning is to pick up the fibres adhered to the exposed surface of the roller and drag them in such a way that the seed could be brought exactly to the ginning point. If the beater is not allowed to oscillate, whatever the speed of the roller, very few fibres are going to be removed from the seed. The fibres so gripped form a bed, being trapped between the fixed knife and the roller without being ginned. The fibres are neither broken nor detached from the seed by the rotating roller. It means that only oscillating beater is responsible for either detaching or removing the fibres, giving higher lint out-turn or mechanical damage to the fibre, if any. The beater also performs other important functions to shuffle the seeds vigorously and drain out from the jolly.

Almost all the DR gins in India, the reciprocating knife (beater) oscillate with the frequency of 900-1000 cpm. What happens when the changes are affected on the beater frequency and the relationships between beater frequency, time period, time available for the roller to pick fibres per cycle, the beater and roller movement are discussed hereafter.

It is well known that in DR gins the beater oscillates with a frequency of 900-1000 oscillations per minute. The time available per cycle for roller for picking up the fibres is only half of the time period and is found to be

\[ T = \frac{60}{1000} \times 1/2 = 0.03 \text{ s} \]

The effect of different oscillation rates of the beater on the removal of fibres and the breakage, if any, is discussed below:

For example, if the frequencies are 750,1000 and 1250 cps, the time periods \( T \) will be 0.04, 0.03 and 0.024s respectively and correspondingly the total distance \( D \) the roller moves during this time \( (T) \) will be

\[ D = \frac{T \times \pi \times r}{60} \]

where \( n \) is the roller speed in rpm; and \( r \), the radius of roller. For 100rpm roller speed, 0.03 s time period and 82mm radius, the total distance \( (D) \) will be

\[ D = \frac{0.03 \times 100 \times 2 \times 3.142 \times 82}{60} = 25.8 \text{mm} \]

Similarly for \( n=130 \), the \( D \) will be 33.5mm.

For time period \( T = 0.024 \), the distance travelled by the roller \( (D) \) will be 20.6 mm and 27.0mm for 100 rpm and 130 rpm roller speeds respectively.

The increased area will result higher ability of the exposed roller surface to catch more fibres and drag to the fullest length along with the seeds towards ginning point. This is the reason why the higher speeds of the roller give higher lint out-turn for longer length cottons. Iyer et al.,8 as well as Iyenger,9 while measuring the energy required for detaching the fibres from the seed, observed wide variation among the different varieties of cottons, and related it to the strength of attachment of the fibre to the seed. This was in the range of 1076 j/kg for Suvin cotton to 2800j/kg for MCU.5.

As already mentioned, the speed of the roller has minor role for detaching the fibre. The cottons which are having low strength of attachment of fibres to seed, like DCH-32, was getting detached from the seeds up to certain extend, but for other cottons, it only picks and grips the fibres between roller and fixed knife and fetch them towards the ginning point. Then, only alternative left for detachment of the fibre is the oscillating beater. Here, the oscillation frequency plays a major role by imparting a force on the point edge of the fibre and seed while separating from each other.

It can also be stated that when the fibres over the seed are pulled by the rollers at their fullest length during the available time period, fetching the seeds at point- edge of fixed bar, then oscillating beater separates the seed from fibres at appropriate frequency neither damaging the seed-coat nor the length of fibre. This is reflected in most of the cottons having exposed roller surface equal to the span length of the cotton fibre, giving less short fibre contents and seed coat neps.

4 Conclusions

Variable speed double roller gin has the flexibility to permit different roller and beater speeds with
independent drive system. It is observed that while only running the roller, few fibres with low strength of attachment to seed are getting detached from the seeds, like DCH-32, but it is not true for the cottons of *hirsutum* and *arboretum* species. In these cases, unless beater hammers the seed there is no ginning at all. In this experiment, three beater speeds (750, 1000, and 1250 cpm) are coupled with two roller speeds (100 rpm and 130 rpm) to observe the effect of beater frequencies on the lint productivity and quality.

4.1 The beating action of the oscillating knives of the beater acts at appropriate time helping to increase the lint out-turn and reducing seed coat neps and short fibre content in the lint.

4.2 The beaters guide the seed cotton towards the exposed roller surface, hammer the seeds at edge of fixed knife and drain out the seeds through grid bars during oscillation.

4.3 Lowest beater frequency of 750 cpm gives lower lint productivity for both the roller speeds of 100 and 130 rpm as compared to the standard setting of 100 rpm roller speed and 1000 cpm beater frequency. This may be due to the lower kinetic energy of beater which is responsible for hitting the seeds at the ginning edges for their removal. There is no damaging effect on fibre quality.

4.4 The oscillation frequency of 1250 cpm of beater gives highest lint out-turn for most of the cottons under study for roller speed of 130 rpm but the results are outstanding for the longest staple cottons such as DCH-32, H-6 and Surabhi.

4.5 It is worth to notice that the kinetic energy of beater at highest frequency certainly will be more than the standard beater frequency, thus removing more number of fibres with greater impact. While oscillating with higher frequency, it shuffles the seeds vigorously to drain out soon from the grids of jolly.

4.6 There is no adverse effect on fibre quality especially on fibre length and strength.

4.7 The short fibres content, seed coat neps and neps in the lint are comparatively lower when ginned with higher beater frequency.

4.8 The combination of beater frequency of 1250 cpm with roller speed of 130 rpm is suitable for longer and extra long staple cottons.

4.9 The combination of 1000 cpm beater frequency and 100 rpm of roller speed is better for short and medium staple cottons for qualitative and quantitative measures.

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