ABSTRACT

Ginning is a prime subject of textile engineering and integral part of agricultural machinery engineering. The ginning process can significantly affect fiber length, uniformity, trash and the content of seed coat fragments. The problem in ginning of cotton in Pakistan is that while separating lint from seed; the ginning machines damage the cotton fiber as well as seed because of outdated local machinery. In this research paper work has been done on modification the design and development of gin-saw blade as to improve the spinning characteristics of lint cotton. Cotton fibers generally losses its inherent physical characteristics at cotton ginning stage due to imperfect saw-gin blade design. The tooth profile of gin-saw is main functional part of gin-stand, it largely influences the physically characteristics of cotton fiber. In this study, it was evaluated the performance and efficiency of the modified tooth profile of gin-saws effects inherent characteristics of the ginned cotton fibers. The designed and manufactured gin-saw types were subjected to comparative ginning testing on lab gin stands to study effects of different designs of gin-saws on ginning and lint quality. According to statistical evaluation the best result was obtained at the tooth angle of 24°.

Key Words: Cotton Ginning, Gin-Saw, Pakistan

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* PhD Thesis, Doktora Tezi
Introduction

Cotton ginning is a complex and professional job requiring full time attention to various aspect and stages of ginning. In ginning, the gin-saw blades play a key role in separating the lint from seed while keeping the fiber characteristics intact (Basra, 1999). It is the tooth profile of the gin-saw, which is highly functional and vital feature of the gin-saw with regard to effective ginning. Design of saw tooth has implication in the ginning performance and the lint quality; with its tooth angle (pitch angle) having the most significance. Improper tooth profile of gin-saw results in improper ginning hence, affects the ginning out turn (Doraiswamy, 1993). Ginning Out Turn (GOT) is the defined as the percentage of cotton fibers obtained from the whole seed cotton ball.

In most of cotton ginneries in Pakistan, locally manufactured gin-saws are used. Some major flaws are associated with tooth profile of these gin-saws.

The pitch and the shape of saw teeth are important in maintaining capacity and cotton quality. In order to preserve and retain inherent characteristics of cotton fiber, it is imperative to modify this processing stage to minimize the influence upon characteristics. To ensure good ginning, the teeth must pass through the ribs at the proper angle. The point of tooth should enter the rib slightly ahead of the throat (Figure 1.1). In case the throat passes through the ginning rib ahead of tooth point, fibers will be ginned half the way from their base on cotton seed.

Material and Method

Modified designs of gin-saws were sketched on the estimation that the point of the tooth should pass through the ginning rib slightly ahead of the throat of tooth. Another important consideration was that if the saws were improperly filed
or saw-rib relationship was not properly adjusted so that throat of tooth enters the rib ahead of point, the resulting cutting action will break fibers and may cause choking at the top of the ribs. As a principle of cotton ginning, the fibers must be ginned from their very base on seed cotton (Chaudhry, 2000).

The gin-saws used in Pakistani ginneries have straight back teeth as shown in Figure 1.2.

![Conventional Gin-Saw](image1)

**Figure 2. Conventional straight teeth gin-saw with the tooth angle of 29°**

**Modifications in Gin-Saw Design**

To formulate modification of the gin-saw blade, prototype gin-saw blades were designed with its tooth angle decreased from 29°. In order to modify the tooth profile, both back angle and pitch angle of tooth were also changed. Consequently, the depth of tooth was increased.

Referring to the Figure 1.3, pitch angle has been decreased from 29° to facilitate curving of back and throat and thus to allow point of tooth pass through the ginning rib slightly ahead of throat. By this way fibers are ginned from very base on cotton seed and no or minimum fibrous residues on seed surface are left.

![Modified Gin-Saw](image2)

**Figure 3. Modified gin-saw with curved teeth**

Concept design and drawings with added value of engineering features for manufacturing of prototype gin-saw blades were sketched. The detailed drawings with all the dimensions, specifications, gauge and appropriate material were provided to gin-saw manufacturer for its development as per generated ideas. A total of 9 different saws with tooth profiles ranging from 21° to 30° were designed. 20 Nos. of saw blades of each profile were ordered to be made for the prototype testing. They were compared with standard tooth profile of 29° with respective
tooth designs, in accordance with specified material of twenty one gauge SAE 1060 heat treated for better physical and mechanical features. The cotton used for testing was Niab-78 as it’s the most common variety in Southern Pakistan.

In order to modify tooth profile, the tooth angles had been changed. Consequently, depth of tooth also increased since the back of the tooth was roached. Also there was a 5% increase in the number of teeth per saw. In order to evaluate the performance and efficiency of the different tooth profiles of saw-gin, experiments on cotton ginning by gin-saws with current tooth (flattened back) profile and with modified (curved back) tooth profile were made respectively at Atomic Energy Agricultural Research centre, Tandojam, Sindh, Pakistan by lab-gin stand for testing.

Results
All the gin-saw types were subjected to comparative ginning testing on lab gin stands to study effects of different designs of gin-saws on ginning and lint quality. The data was collected with variables such as fiber length, uniformity ratio, presseley strength and micronaire value and assessed on SPSS v17. Experimental testing results of ginned fibers are given in Table 1.1.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Ginning by local saw design 29°</th>
<th>Ginning by modified saw 24°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gin-out turn (GOT) %</td>
<td>34.16</td>
<td>35.82</td>
</tr>
<tr>
<td>Fiber length (inch)</td>
<td></td>
<td></td>
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<tr>
<td>2.5% SL</td>
<td>1.09</td>
<td>1.11</td>
</tr>
<tr>
<td>50% SL</td>
<td>0.51</td>
<td>0.53</td>
</tr>
</tbody>
</table>

All values were taken as mean after 10 replications ± SD.

A one way analysis of variance was done between groups to assess the impact of angle of saw tooth on GOT (Table 1.2).

Data was divided into 10 groups according to the angle of the teeth on the saws:

- Group 1: $\mu_1 = 21°$
- Group 2: $\mu_2 = 22°$
- Group 3: $\mu_3 = 23°$
- Group 4: $\mu_4 = 24°$
- Group 5: $\mu_5 = 25°$
- Group 6: $\mu_6 = 26°$
- Group 7: $\mu_7 = 27°$
- Group 8: $\mu_8 = 28°$
- Group 9: $\mu_9 = 29°$
- Group 10: $\mu_{10} = 30°$

Two hypotheses were made at 95% of confidence level:

- Null hypothesis $H_a: \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7 = \mu_8 = \mu_9 = \mu_{10}$
- Alternate hypothesis $H_a: \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5 \neq \mu_6 \neq \mu_7 \neq \mu_8 \neq \mu_9 \neq \mu_{10}$

CR (Critical Region)

if

- $F > F_a$
- $F > 2.47$

Then $H_0$ would be neglected; hence alternate might be true.
There was a statistically significant difference at the $p < 0.05$ level, implying the tooth angle had an effect on GOT values, resulting in different gin-out turns as the tooth angle varied from 21 to 29 degrees.

<table>
<thead>
<tr>
<th>Table 2. ANOVA with Degree of Freedom (df) for Naib-78</th>
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</thead>
<tbody>
<tr>
<td>Sum of Squares</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Between Groups</td>
</tr>
<tr>
<td>$21^\circ$-$30^\circ$</td>
</tr>
<tr>
<td>Within Groups</td>
</tr>
<tr>
<td>$21^\circ$-$30^\circ$</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Tukey HSD test for post-Hoc comparison indicated that the mean score for $24^\circ$ was $(M=0.358, \ SD = 0.06)$, significantly different from all other groups. After 10 replications of readings, the best result for GOT were obtained at $24^\circ$ when compared with $29^\circ$ local saw shown in Figure 1.4.

Discussion

There was a significant difference between the values of measured variables such as GOT%, fiber length and short fiber content when different tooth angles were used for ginning. As three major yarn characteristics count for quality yarn, namely yarn strength, yarn appearance and spinning end breakage rate. High strength, better performance and optimum end breakage while spinning may be important to yarn through processing high quality cotton. High quality cotton
must possess good spinning characteristics namely; high length uniformity, high fiber strength and low short fiber content.

The ginning out turn (GOT, %) by modified saw was a significantly higher than that by current saw used in the industry. The fact that fiber length was increased using the modified saw lead to higher 2.5% SL and 50% SL; hence higher uniformity ratio (U.R %). By the virtue of higher span length, these fibers have higher presseley strength (lb/in²) and lower short fiber content due to higher length uniformity as compared to testing results of fibers ginned by locally used saw.

Higher fiber strength and presseley strength adds to strength of yarn. Higher length uniformity (U.R %) results in reduced yarn unevenness (U %); whereas lower short fiber content adds to reduced yarn unevenness (U %), reduced yarn hairiness (H), reduced spinning end breakage rate and ultimately higher yarn appearance grade.

The current tooth design of Pakistan Gin Saw is not favorable for the fibers to be ginned. Little modification in the tooth profile by imparting a curve on its back throat may be taken to prevent loss of GOT% (or ginning yield %) and fiber characteristics. Cotton ginning by modified saw is practically possible and can be imparted in the Ginning Industry on commercial level.

The suggested Gin Saw can be manufactured commercially in Pakistan with no premium in price on long term basis.

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Literature