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LEADING EDGE OF CARDING TAKER-IN CLOTHING WITH VARIABLE ANGLE OF INCLINATION IN COTTON SPINNING

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ABSTRACT

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The card is regarded as the heart of the spinning mill because of its immense significance for quality of ultimate yarn. Quality of carding process is mainly determined by the parameters of card clothings. The angle of inclination of leading edge of the taker- in clothing is one of the most important parameters that determines effectiveness of various function. The review of relevant studies demonstrates that optimum values of this angle are different for different functions which are sometimes conflicting. For example, if theoretically combing or of fiber materials is performed with greater angle of inclination of teeth, then throwing of impurities and transfer of fibres from the taker-in to the cylinder take place better with less inclined teeth. In practice, the same teeth of the taker-in with a definite angle of inclination perform both types of functions. This article reveals and sorts out these conflicting aspects in the region of the taker-in and comes out with the suggestion of a new type of taker-in clothing with variable angle of inclination along its leading edge. Such profile of the taker- in must provides better interaction of fibre and the teeth thanks to simultaneous possession of higher penetrating capacity of teeth and fulfillment of conditions of stable equilibrium.

Key words: *card clothing, fiber fringe, friction cone, leading edge of clothing, stable equilibrium of fibre on tooth surface*

INTRODUCTION

In the processing sequence of spinning machinery blow room opens the fibre material to tufts or flocks. The task of carding is to open these flocks to individual fibres. In a carding machine, the taker-in is the first working organ to interact with fibre. The entangled mass of fibres entering the machine come under the action of revolving saw-toothed clothing of the taker-in. During the interaction the fibres forms a fringe or beard that lies on the front face of the feed plate. Lawrence CA describes that taker-in opens the fibre tufts effectively when one end of a tuft is momentarily held while the teeth of taker-in pull individual fibres and groups of fibre from the other end. The interaction of fibres with the teeth of clothing results in opening of the flocks that leads to individualization of about 50% of the fibers and elimination of most of the foreign impurities (80-90%) in the taker-in zone (Klein 1995). Individualization is essential to enable elimination of impurities and performance of subsequent drafting. The fibres are then transferred to the cylinder, the next organ of the machine. On the way to cylinder, the taker-in teeth pass over mote knife, under grid and some times carding segments when they chiefly throw the impurities under the taker-in and retain the fibres. Between the taker-in and the cylinder full transfer of fibres are essential so that stripped off taker-in teeth may come into action with fibres at the entrance (Lawrence 2003).

Thus we can see that taker-in teeth have to perform different special activities or functions at different points during each revolution eg (i) at first combing of the fibre fringe or opening of flocks along the feed plate, (ii) then throwing impurities and retention of fibres while passing over the mote knife and under- grid, and (iii) full transfer of fibres to the cylinder in further travel (Klein 1995).

Effectiveness of all these functions depends on various factors such as type of feed material and orientation of fibres in it, geometric profile of feed plate, position of knives and under-grid and parameters of taker-in clothing etc. Among these, the leading angle of inclination of taker-in teeth (β) is vitally important as effectiveness of all above functions largely depends on this angle (Fig. 1).

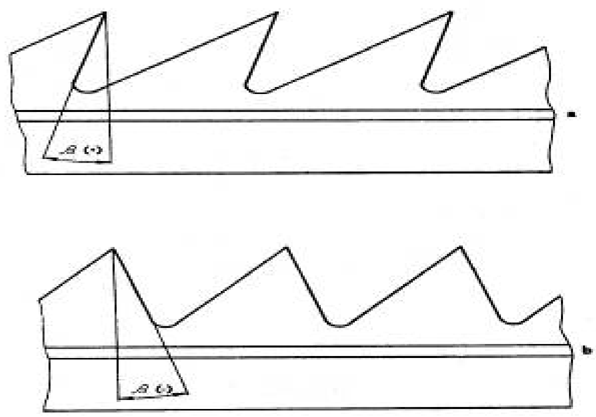

Fig. 1. Carding Taker in Clothing angle

The review of different relevant studies reveals that optimum value of this angle is different for different functions. Thus, theoretically if combing of fibre fringe or opening of fibre is performed better with positively inclined teeth of taker-in clothing, then a neutral or negative angle of the teeth is congenial to fibre transfer. However, in practice, the same teeth of the taker-in with a definite angle of inclination perform both the functions. This article examines these conflicting aspects in the region of taker-in in order to understand them better and comes out with a suggestion of optimum profile of the teeth of the taker-in clothing.

MATERIALS AND METHODS

Review of relevant studies on optimum values of angle of inclination of taker-in clothing for different functions

The angle of inclination of leading edge of taker-in tooth (β) is shown in the figures 1 and 2. This angle has been termed as carding angle (Klein 1995). This is the most important angle of the tooth; the aggressiveness of the clothing and the hold on the fibres are determined by this parameter. This angle may be positive (a fig.1), negative (b) or neutral. The angle is neutral if the leading edge of the tooth lies in the vertical (β = 0). Clothings with negative angles are used only in the taker-in in processing of some synthetic fibers. Since the fibres are held less strongly by this form of tooth, they are transferred more easily to the cylinder and the clothings are less inclined to choke. For the taker-in it ranges from $+5^0$ to -10^0 (-15^0). In practice, $+10^0$ is also frequently used. We can now look into how the effect of this angle at three different points of actions in the taker-in region of the card.

Combing of the fibre fringe or opening of flocks along front face of feed plate: Interaction from view point penetration of teeth of taker-in clothing into fibre fringe

Interaction at this point has been explained from the view point of penetration of teeth into fibre mass and the optimum value of the angle β was determined theoretically proceeding from this view point (Borzunov 1982).

The leading angle of the taker-in teeth providing their penetration into fibre fringe at the entrance point D is given by $\beta = \beta_1 + \beta_2$ (Fig. 2); where 0 is the centre of taker-in with radius R and z represents feed roller. As a result of interaction of a tooth and a fibre or a tuft of fibres at the point D the fibres are pressed with a force P directed along the fringe i.e. parallel to the front face of feed plate (Fig. 2). This force is resolved into two components: one component is Q along the leading face of the tooth that helps the tooth to penetrate into the fibre fringe and the other component N is the force normal to the leading face of the tooth. The force Q is opposed by the force of friction, F. Thus fibres will not be compressed by the tooth to the feed table but will move or slide along the leading edge of the tooth to the bottom if $Q \geq F$ (1).

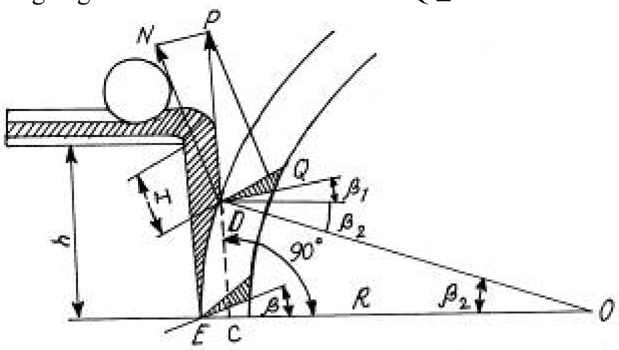

Fig. 2. Feed plate-Taker-in zone of carding machine

From Amontons' Law of Friction,

$F = \mu N$ and $Q = P \sin \beta$; $N = P \cos \beta$

where μ is coefficient of friction

Putting the values of Q, N and F in (1) we get,

$P \sin \beta_1 \geq \mu P \cos \beta_1$

or $\tan \beta_1 \geq \mu$; $\beta_1 \geq \arctan \mu = \epsilon$ where ϵ – angle of friction between fibre and metal of the tooth or $\beta_1 \geq \epsilon$ (2)

The optimum value of the angle β was determined from the view point of penetration of teeth into fibre fringe in the work.

Angle β_2 is calculated from the triangle DOE, angle OCD is a right angled triangle, therefore $\beta_2 = \arcsin b/_R$ (where, b is length of the front edge of the feed plate and R is radius of the taker-in).

As $\beta = \beta_1 + \beta_2$; $\beta \geq \epsilon + \arcsin b/_R$ (3)

In the figure b = 25 mm, R=117 mm, x –the distance between top of working edge of feed plate and the point of entrance of tooth into the fringe which is very small (0-2mm). Taking μ=.2 ($\epsilon=12^0$) and x=0 the value of β is found out to be 25^0.

In case of μ = .36 (ϵ=20^0), β = 32^0.

So it follows from penetration point of view that the angle β should be not less than 25^0 and the larger the value of β the greater is the penetration of the teeth into the fibre fringe by opposing the frictional force. As a result, better interaction between fibres and clothing is likely to take place.

However, this proposition does not conform to practical experience, where almost the contrary is true. In practice, β is around 5^0-10^0 for short and medium staple cotton and even it is equal to zero or negative for longer cottons and synthetic fibres. It may be mentioned here that such values are comparatively more conducive to transfer of fibres from the taker-in to the cylinder.

Holding frbres on taker-in clothing and throwing impurities while passing over mote knife and under-grid

The taker-in teeth on the way to the cylinder, should hold the fibres on the surface but throw the foreign impurities. Reference 1 finds the conditions of holding the fibre on the surface of tooth and throwing of the impurities with reference to figure-3 as described below.

Individualized fibres, tuffs or flocks of fibres and foreign particles held or retained on the (open) surface of a tooth of the taker-in are subjected to the following forces:

F- centrifugal force, W-force of wind pressure, N-Reaction of the tooth, T-frictional force, G- mass of foreign particle.

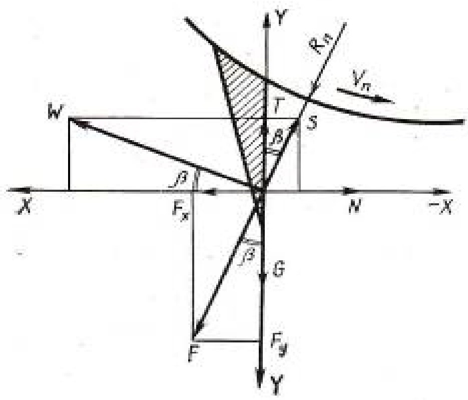

Fig. 3. Forces acting on fibre, held by taker-in tooth

The force G is very small compared to F and therefore may be ignored. All the forces are considered to be applied at the point of contact between the fibre and the tooth. The point of application of all the forces is taken as the origin of coordinates. The Y- axis is placed along the working (leading) edge of the tooth and X-axis is placed perpendicular to it.

The projection of all the forces on the co-ordinate axes may be written as follows:

$$X = F\sin\beta + W\cos\beta - N = 0 \qquad (4)$$

$$Y = F\cos\beta - W\sin\beta - T = 0 \qquad (5)$$

The fibre will be held on the tooth of the taker-in if

$$W\sin\beta + T > F\cos\beta \qquad (6)$$

Putting the value of frictional force, T = μN (μ = coefficient of friction between fibre and metallic surface of the tooth) and value of N from the equation (4) to the equation (6), we get

$$W\sin\beta + F\sin\beta + W\cos\beta > F\cos\beta$$

As, $\mu = \tan\varphi$, then $\beta = \arctan F(W-\varphi)$ (7)

Here φ = angle of friction.

With the angles of β, as calculated by equation (7) the fibre will be held on the tooth even if the fibre is not in contact with other fibres. The results of the calculated values of β at the open surface of the taken-in with W_{max} and at the working areas with W are given in the Table 1.

Table 1. Calculated values of β at the open surface of the taken-in with W_{max} and at the working areas with W

Taker-in rpm,min^{-1}	F cN (10^3)	W, cN (10^{-3})	W_{max}, cN (10^{-3})	(degree)	(degree)
800	0.425	0.4	1.97	Not Less than 27^0	Not Less than -8
1400	1.28	1.18	5.65	Not Less than 27^0	Not Less than -8

The calculated values of β show that, the teeth, while passing over mote kinfe and the under-grid (set around 0.5mm apart), will retain the fibre if the angle β is no less than 27^0. On open surface of taker-in the fibres will be held if β max is not less than -8^0. If we take two clothings-one with $\beta = 30^0$ and another with $\beta = 15^0$ – the fibre will be retained on the open surface of the clothing,and in case of passing over mote knife etc, they will be thrown off the clothing more easily from the surface of the clothing with $\beta = 15^0$ than that with $\beta = 30^0$.

Condition for throwing impurities

To determine the angle of inclination β that will let the throwing of particles of impurities, let us consider a particle (of leaf) in form of a plate having dimensions of 0.1x1x1 mm and density of 1.5 g/cm^3. Then the weight of the particle will be $0.15.10^{-3}$ cN. and an area (perpendicular to the flow) equal to 0.32 mm^2. The centrifugal force acting on the particle at 800 rpm of the taken-in is given by $F=1.5x10^{-3}$ $x9.8^2/(9.8x0.117)= 12.5.\ 10^{-3}$cN.

The force of wind pressure, W, on 1mm^2 of the particle is given by

$W= (1.5x0.32x9.8^2x\ 0.123.10^{-6})/2 = 2.9x10^3$ cN

The angle β can be calculated by the equation (7) and as per calculation this angle should not be less then 57^0. The taker-in clothing with β from 15^0 to -15^0 are far less than 57^0. So the trash particle, losing contact with fibre material, will be thrown out of taker-in surface.

Transfer of fibres from Taker-in to Cylinder

For transfer of fibres, the taker-in and the cylinder clothings should be in doffing disposition(Fig. 4). The force P may be resolved into two two components: the normal component N presses the fibre against the tooth and the stripping component Q tends to push the fibre off the tooth. It is obvious that less inclined angle is preferable for fibre transfer. Besides, the transfer of fibre is governed by the ratio of speeds of taker-in and cylinder. According to various investigations, this ratio should be slightly more than 2.

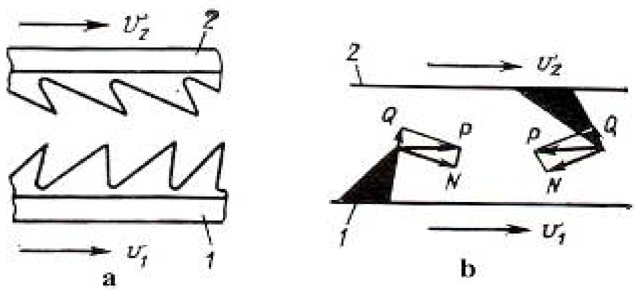

Fig. 4. Doffing disposition of taker-in and cylinder clothings

Interaction from viewpoint of stable equilibrium of fibre on the surface of metallic clothing

The interaction between fibre and taker-in teeth has better been explained in the dissertation (Chowdhury 1987) by a novel application of the theory of stable equilibrium of a yarn on the surface of a winding package in winding process as described in the work of Svetnic FF.

According to this theory high quality package of yarn can be obtained if the following two conditions are fulfilled during winding: i) Condition of form of yarn on the package and ii) Condition of tension of between the feed side and the uptake side ends of the yarn.

The first condition may be expressed as

$$\tan \alpha \le \tan \theta \le \tan \epsilon = \mu \quad (8)$$

Where ϵ = angle of friction, μ - coefficient of friction, α – angle of inclination of the winding surface to the axis of rotation of the package, θ – angle of geodesic deviation, AB- a portion of yarn (or fibre) on the winding surface (or clothing tooth), subtended by the angle dΨ ; (Fig. 5).

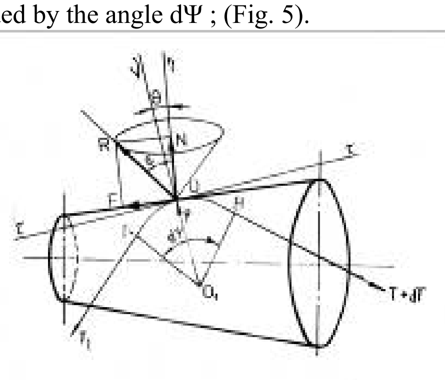

Fig. 5. Forces acting on elementary fibre/yarn

By applying the above mentioned theory to the case of the interaction between a tooth and a fibre (or a tuft of fibres) as in the zone of feed plate and taker-in the condition of form may be written as follows:

$$\tan \epsilon \leq \tan \theta \leq \tan \epsilon \qquad (9)$$

In (9), ϵ is the angle of friction between metal of tooth and fibre.

In this case, θ may be called as carding angle because it is the angle between the direction of fiber fringe and direction perpendicular to leading edge of the tooth(<PDN in Fig. 2). From (9) it follows that interactions between fibres and metallic teeth of taker-in i.e plucking out of fibres by a tooth, combing of fibres and holding of the fibres by a tooth are expected to take place if at the point of contact on a tooth, the fibre lies within the cone of friction. Not fulfilling of this condition towards the feed table means impossibility of seizure of fibre and its combing by the tooth, and that toward the bottom of the tooth means gathering of fibre to that direction.

The second condition for stable equilibrium of yarn in winding package is given by the following formula:

$$T_1 \leq T_2\, e^{\int_0^{\psi} \cos\theta \sqrt{(\mu^2 - \tan^2\theta)}\, d\psi} \qquad (10)$$

Where T_1, and T_2 are tensions at the uptake side and feed side ends of yarn respectively, Ψ angle of contact of the yarn with the winding surface (Fig. 5, 6 and 7).

The second condition may be stated as follows:

The yarn in contact with a winding surface remains stationery at a point on it (does not move parallel to its own axis) until the tension at the leading end exceeds the maximum possible value.

In case of interaction between a tooth and a fibre or a tuft of fibres in taker-in zone we can infer that the fibre in contact with a tooth remains stationery at a point on the tooth surface of the taker-in (does not move along the tooth) until the tension at any one end exceeds the maximum value.

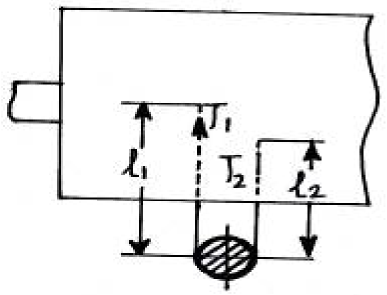

Fig. 6. Relative positions of fibre,tooth and feed roller

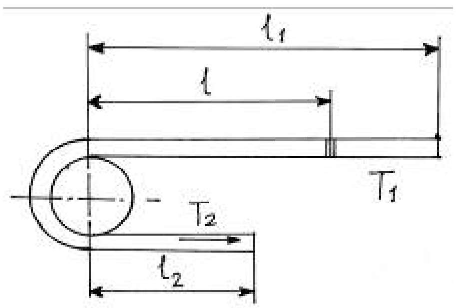

Fig. 7. Relative position of fibre and tooth

Fig. (6 and 7) represents the position of a fibre on the surface of a tooth moving at a velocity, with ends 1 and 2 of the fibre remaining at distances ℓ_1 and ℓ_2 in the fringe or under the clamp of feed roller and feed plate. It has been shown (Chowdhury 1987) that the tensions T_1 and T_2, at the two ends of the fibre, and the distance of the ends from the tooth (i.e. l_1 and l_2) are related as follows:

$$T_1 / T_2 = l_1 / l_2 \leq e^{\int_0^{\psi} \cos\theta \sqrt{(\mu^2 - \tan^2\theta)}\, d\psi} \quad ....(11)$$

Assuming μ =0.36, the relations T_1/T_2 i. e. ℓ_1/ℓ_2 were calculated for different values of θ and it was found that in case of $\theta = 0$, $\ell_1/\ell_2 \leq 2.566$ and for $\theta = 19.8^0$; $\ell_1/\ell_2 = 1$.

Obviously under identical conditions with the value $\theta = 0$ slipping out of fibres from the surface of the tooth will be minimum. Under such condition the fibre acquire most stable position on the surface of the tooth and thereby most favorable condition is created for straightening, combing and individualization of fibres and consequently isolation of foreign matters.

So $\theta = 0$ is the optimum condition for effective interaction between fibres and clothing teeth along the fringe in the taker-in region.

For effective interaction between fibres and taker-in teeth, the fibres should lie within the friction cone at the points of contact. Ideal condition to this end could be obtained if carding angle, $\theta = 0$ along the arc of interaction in the taker-in region. Since θ is changeable on the arc of interaction and its value depends on the angle of inclination of taker-in clothing (β), the most favourable conditions is likely to be obtained if the value of θ is equal to zero degree at the middle of the arc of interaction. In that case change in θ is distributed to the both sides of the friction cone that better fulfils conditions of form and tension.

The optimum angle of inclination of the leading face of taker-in clothing β with a typical feed plate was calculated and found around 5^0 which conforms more closely to the practical values in cotton carding. Practical result with such angle of taker-in also showed better quality of sliver and resultant yarn. If may be noted here that contrary to the theory of penetration of teeth into fibre mass (preferring more inclined teeth, greater β, for better interaction), the theory of stable equilibrium of fibre on tooth surface is in favor of teeth of smaller β.

RESULTS AND DISCUSSION

From the above review concerning the optimum angle of leading face of taker-in teeth providing condition congenial to different functions may be summarized as follows:

From penetration viewpoint (i) the angle of inclination of leading face β should be positive and not less than 25^0 and the larger the value of β the greater is the penetration of the teeth into the fibre fringe by opposing the frictional force. As a result better interaction between fibres and clothing is likely to take place. However, this proposition does not conform to practical field, where almost the contrary is true. In practice, β is around 5^0-10^0 for short staple cotton and even zero or negative for longer cottons and synthetic fibres (Lawrence 2003).

On the other hand, from the viewpoint of stable equilibrium of fibre on the surface of metallic tooth (ii), the fibre should lie within the friction cone at the point of contract with the tooth and the leading angle of taker-in clothing, β should be neutral or nearly so. Such value of β con forms more closely to the practical values in cotton spinning.

Results of the calculations regarding holding of fibre and throwing of impurities (iii) show that in order to retain the fibre on the tooth (while passing over mote knife and under-grid) the angle β should not be less than 27^0. In case of throwing the impurities, the angle β should not be less than 57^0 as per the calculation (Fig. 8).

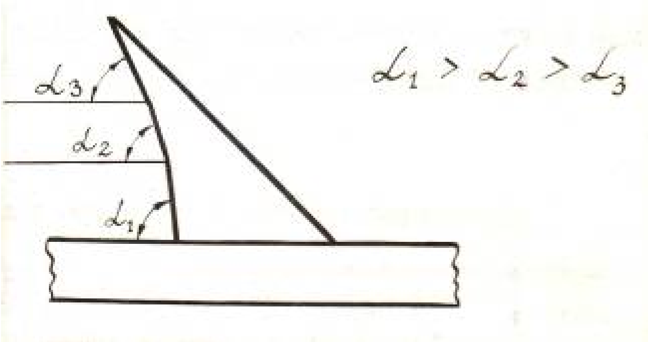

Fig. 8. Taker-in clothing with variable angle of inclination

CONCLUSION

As the increase in the value of β improves the interaction between fibres and tooth according to viewpoint of perpetration and on the contrary, the value of β around 0 is congenial to better interaction between fibre and teeth, and to better transfer of fibre and throwing of impurities, it is expedient that the leading face of the tooth possesses variable angle. This proposed clothing may possess β around 75^0 at the tip of the tooth; around 85^0 in the middle and 90^0 or more at the base. Such shape or profile of the front edge of taker-in teeth must provide better interaction of fibre and the teeth thanks to simultaneous possession of higher penetrating capacity and fulfillment of condition of stable equilibrium of fibre on the tooth. Impediment of fibre transfer owing to greater inclination of the angle at the tip can be eliminated by applying a second taker-in with holes on it and a suction system (as applied in the carding machine LD,USA, with 16000 holes, each of 1.6 mm diameter). It may be mentioned here that prompt transfer of fibres from clothing to clothing is a prerequisite for higher production of the card.

REFERENCES

Borzunov IG (1982) Spinning of Cotton and Synthetic Fibres, Moscow, Page 162-166.

Chowdhury MI (1987) Dependence of deterioration of fibre, and quality of sliver and yarn on parameters of taker-in of carding machine, PhD thesis, Tashkent Institute of Textile and Light Industries, Library, P159 Tashkent, Former USSR.

Klein W (1995) Manual of Textile Technology, Volume -2, The Textile Institute, UK.

Lawrence CA (2003) Fundamentals of Spun Yarn Technology, P.170-171, CRC press LLC.

Svetnic FF (1984) Design of winding mechanisms of yarn, Moscow, p.5-12.