The Manufacture of Fancy Laces by Machine

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(*Continued from August issue, page* 709)

II Movement Equation for the Thread Tension Weight Eyelet

Figure 11 gives the schematic arrangement of a yarn carrier and its running course with relation to the center of the braiding machine (braiding point). From the figure it will be seen that "r" is the radius of the carrier circle and "R" is the radius of the horngear circle, that is, "R" is the distance from the center of each carrier circle (the running plate) to the center of the machine (below the braiding point).

The following deductions are worked out under the presumption that the carrier works continuously without intermediate stops as is the case with plain braiders and on two or three thread lace machines. In such cases the carrier moves with uniform speed around the center of its running plate. During this movement its distance from the center of the braiding machine changes; the distance may be expressed by the formula $= (R + \xi)$, where ξ represents the projection of "r" on "R."

We find the relations of movement similar to the crank movement. The approximation above mentioned, therefore, is only permissible if the relation r:R = λ (the so-called "crankshaft formula" of the cranking movement) is very small. This is generally the case on lace machines. Thus, if "z" is the number of carrier plates on a machine, "R" is the radius of

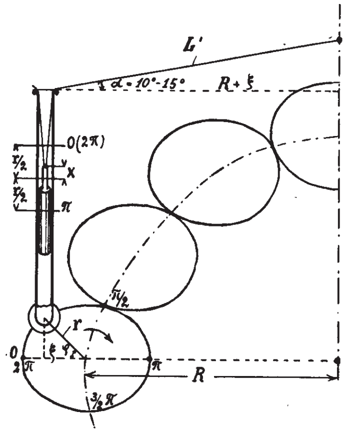

Figure 11

the horngear circle, and "r" is the radius of the carrier circle, we have

$$2R\pi = 2rz \text{ or } \frac{r}{R} = \frac{\pi}{z} = \lambda$$

A medium sized lace machine, for instance, one of 68 carrier plates, will give the following result:

$$\lambda = \frac{\pi}{68} = \frac{1}{21.6+}$$

Even a small lace machine with only 44 carrier plates will show

$$\lambda = \frac{\pi}{44} = \frac{1}{14+}$$

Therefore it appears that an approximation ($R + \xi$) is quite permissible.

The value of ξ changes in dependency from the temporary position of the carrier according to the law of simple harmonic motion and would appear as:

$$\xi = r \times \cos\gamma \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The distance of the upper carrier eyelet b from the braiding point is

$$L' = \frac{(R + \xi)}{\cos\alpha},$$

where α represents the so-called braiding angle.

Since the value of α on lace machines generally varies between 12° and 15°, cos α has the value of 0.978 to 0.966. With considerable approximation therefore we may set upon $L' = R + \xi$, or expressed differently: the value ξ is equal to the change in length of the thread, which must be leveled down by the thread tension device.

Since the thread tension device is suspended in a loop of the thread, the travel "x" of the thread eyelet needs to be only half of the size of the thread length to be leveled.

Accordingly the travel of the thread tension device would be

$$x = \frac{r}{2}\cos\gamma$$

or expressed differently in relation to the time factor

$$x = \tfrac{1}{2}\, r \times \cos\omega t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

During the turning of the carrier the up- and downward movement of the thread tension device also acts approximately according to the law of Simple Harmonic Motion.

The *speed,* as the first deduction from the travel in relation to time, would be therefore:

$$v = \frac{dx}{dt} = -\frac{r}{2}\,\omega \sin\omega t \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The *acceleration* is the second deduction from the travel in relation to time and is found to be

$$b = \frac{d^2x}{dt^2} = -\frac{r}{2}\,\omega^2 \cos\omega t \quad . \quad . \quad . \quad . \quad (4)$$

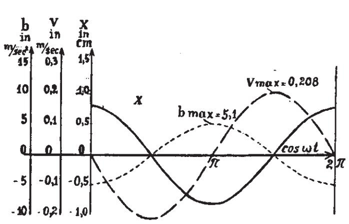

Figure 12

In Figure 12 the time curves of travel, speed, and acceleration for the thread tension eyelet of a certain one thread lace carrier machine are shown. It is the same machine that was used in practical experiments for checking the results and which will be discussed more fully later on. This machine was built according to drawings 6 to 8 (Aug. issue, p. 707), possessed 44 carriers and the same number of turning plates, a pitch diameter of 32 mm. ("r" accordingly = 16 mm.), and was constructed for a normal turning speed of the horngears of n = 240 revolutions per minute. Therefore the carrier speed was thus:

$$v_k = \frac{2r\pi n}{60} = 0.403 \text{ m/sec},$$

$$\omega = \frac{v_k}{r} = 25.2^{\text{Rod.}}/\text{sec},$$

$$\omega^2 = 635^{\text{Rod.}}/\text{sec}^2.$$

The actual travel of the thread tension eyelet according to equation (2) is

$$x = \tfrac{1}{2} r \cos \omega t$$

At the moment t = 0 the factor "x" has reached its maximum value: $\frac{1}{2}$ r = + 0.008 m. The thread tension eyelet accordingly is in its upper final position.

The *speed* of the thread tension eyelet during the travel is directed away from the starting point 0 — π, consequently the motion is negative, and according to equation (3) for

$$\omega t = \frac{\pi}{2} \text{ and } \frac{3}{2}\pi \text{ shows the value:}$$

$$v^{max} = \mp \tfrac{1}{2} r\omega = \mp 0.202 \text{ m/sec}$$

as the maximum value.

The *acceleration* of the thread tension eyelet reached its maximum, as shown by equation (4), at π and 2π. Thus the maximum acceleration is: $\pm r \times \omega^2 = \pm 5.1$ m/sec², and the negative sign indicates the retardation.

From these equations it is evident that the thread tension eyelet possesses the speed "0" in its highest and in its lowest position, or at the points farthest from and nearest to the braiding point and that at these two positions the acceleration is at its maximum.

III. The Influence of Acceleration on Thread Tension

(a) Carriers with Tension Weight

Figure 13 shows a travel-time, and acceleration diagram in which the force of the tension weight G = Mg is drawn in as a horizontal line. The tension weight is accepted as having a mass of 10 g/m sec², or a corresponding gravity effect of Mg = 10 × 9.81 = 98.1 grams, this figure representing about 6 lots (100 grams) and is approximately the average thread tension used in the trade. Since the weight is suspended from a loop of the thread, only half of the above value should be considered for the thread friction.

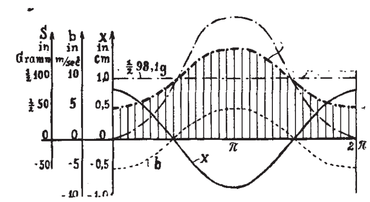

Figure 13

The force of gravity Q of the tension weight is composed of the actual weight and the acceleration; expressed in formula

$$Q = Mg - Mb,$$

thus if we substitute in this equation the value of "b" from equation (4) we have

$$Q = Mg - M \tfrac{1}{2} r\omega^2 \cos \omega t \quad . \; . \; . \; . \quad (5)$$

In the present case the maximum acceleration is $\pm \frac{1}{2} r\, \omega^2 = \pm 5.1$ m/sec², and the tension weight (98.1 grams) will be increased or decreased by the acceleration Mb = ± 10 × 5.1 = ± 51 grams. Because of acceleration the thread tension is changed from 0.5 to 1.5 of its average (ideal) tension line at each turning of the horngear.

If the acceleration $\frac{1}{2} r\omega^2$ were increased by making the speed of the machine such that the number of horngear revolutions per minute would be equal to the acceleration of the earth, 9.81 m/sec², the action of the weight would be absolutely eliminated temporarily. This would happen if the carrier were at the maximum distance from the center of its course, at which moment there is no tension exerted upon the thread. Theoretically this case represents the maximum speed that a machine of this type is capable of attaining. Since the acceleration increases with ω^2, the critical point is reached very soon and in the present case would be when n = 335, compared to a normal speed of 240 revolutions per minute.

At the same time the maximum tension increases when the carrier is at the point nearest to the machine center. In this case the tension doubles the average tension value. This fact has been indicated in Figure 13 by a long dash-dotted line.

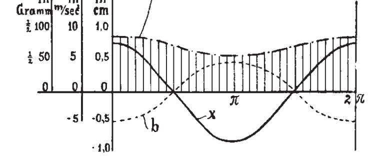

Figure 14

(b) Carrier with Tension Spring

Figure 14 shows the travel-acceleration diagram in relation to the thread tension curve, and the 6 lot (100 grams) spring is taken as an example. The required figures and their values are taken from Figure 10 (Aug. issue, p. 709) under the assumption that the thread eyelet is moving in the neighborhood of its upper working capacity, or just before a thread is released. At this time the spring tension is at a maximum. The weight of the springhead, which passes up and down with each tension variation, is 1 gram and, therefore, its mass, or force of gravity, $M = \frac{1}{9.81}$ g/m sec². The acceleration appears in its maximum stage as

$$Mb_{max} = \frac{1}{9.81} \times 5.1 = -0.52 \text{ gram}$$

Here also, as under III (a) in the case of the tension weight, the loss or increase in tension caused by the acceleration is approximately ± ½ of the weight. Since the weight of the springhead is very small (1 gram) the change only amounts to ± ½ gram, and this value compared with the average spring tension (75 grams) appears to be so insignificant that we feel justified in neglecting this factor. Its small value made it impossible to show it in the diagram.

Though the influence of acceleration is considerable for the carrier with tension weight, as fully discussed under III (a), we find that the spring tension carrier is hardly influenced by acceleration. At any rate, it is remarkable that the acceleration curve and the spring tension curve both follow the cosine curve, but with contrary signs. By adequate loading of the thread eyelet at the tension spring, for instance, with an additional weight, the difference in tension caused by the changes in the spring length could be entirely eliminated. This procedure, however, possesses only theoretical and no practical significance, as the thread tension is influenced far more by *friction,* which will be shown in the following chapters.

(To be continued)