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Development of a mathematical model for weft yarn tension of an elastomeric weft insertion of rapier

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Abstract:

The weft brake, a noxious event in weaving could often result in high tension peak values with a high risk of yarn breakage. Yarn tension is of paramount importance especially in the case of elastomeric weft yarn insertion as it can be stretched and recovered. Further, at any point of weft insertion, the elastomeric yarn tension of the weft shall not exceed its elastic limit to ensure complete recovery and avoid unexpected breakages. The greater acceptability of stretch fabrics is due to their exceptional qualities like higher extensibility, high degree of recovery, and extensive care. Core-spun yarns having elastane filament at the core and wrapped cotton fibers or polyesters are commonly used in the weaving process. To impart stretch ability to the yarns, elastic fibers like lycra /spandex are incorporated in them. In literature, there is a fundamental lack of a complete mathematical model related to weft yarn insertion processes. A mathematical model was developed to bridge the long-standing technological gap in related to elastomeric weft insertion on a rapier loom. Tension devices along the entire yarn path across the tension head were used in the derivation of a mathematical model for static tension variation at the weft insertion on a rapier loom. The dynamic tension added to the static tension was also modeled for elastomeric weft insertion. The model was validated with practical results within 10% accuracy level. However, during the experimentation, rapier Loom was run at a constant speed of 250 picks/min and the variation of dynamic tension with loom speed is yet open for .

Keywords — **elastomeric yarn, stretch ability, rapier loom, weft tension, mathematical model.**

I. INTRODUCTION

Fabrication techniques of cloth can be mainly divided into three methods namely Weaving, Knitting, and Non-woven. Knitted fabrics become one of the most popular types of fabric because of their inherent stretchability. However, weaving stands as the oldest and still the very widely used technique of fabric manufacturing in the world. With the advent of technology in weaving, stretchable fabrics can be produced using weaving with the usage of elastomeric weft yarns. Stretchable denim fabrics are one of the most popular stretchable woven fabrics in use.

In the fabrication of woven fabrics, crosswise yarn known as weft, and lengthwise yarn known as warp are interlaced at right angles.

Based on the weft insertion method the weaving machines are classified as shuttle loom sand shuttle-less looms such as projectile, rapier, air-jet, and water jet. What type of weaving machine should be used for a particular type of fabric production is determined by various factors such as the construction of the fabric, composition, count, and density of warp and weft yarns, type of product, product range, product quality, etc.

Due to the most versatile nature of rapier looms, rapier looms are inevitably an option for high-quality, technical, and stretchable fabric manufacturing. Rapier looms are capable of inserting very coarse to fine counts without any significant change in the loom setup, producing adjustable fabric widths within the loom's specification limit and ability to weft colour selection capability (8 to 16 colours). Further, the weft yarn is constantly controlled throughout the weft insertion process of the rapier loom. Rapier looms are further subdivided into many types such as single rapier, double rapier, flexible rapier, and rigid rapier. Further, according to the method of weft transfer, rapier scan be tip and loop transfer and negative/positive weft transfer, according to the weft insertion mechanism used. The weft yarn is picked up by the left-hand rapier and transferred to the right-hand rapier to bring the weft to the rightmost end while the right rapier achieves zero velocity at the end. So left rapier is subjected to high accelerations in the first half of the trajectory and similar deceleration in the right half of the trajectory. Subsequently, the weft yarn is cut at the left edge of the fabric and the cycle is repeated more than 600 times per min in a medium-speed commercial rapier loom

Weft brakes are highly probable at the left side of the loom during the acceleration phase of the weft yarn insertion process. The weft brake, a noxious event in weaving (needs direct human intervention to restart the process) could often result in high tension peak values with a high risk of yarn breakage [3].

With the speed of the loom, yarn tension is significantly influenced, especially the weft yarn tension on fabric formation, and it in turn affected impact fully on the properties of the fabric. Hence the study on the weft yarn tension on a rapier loom is of paramount importance especially in the case of elastomeric weft yarn insertion as it can be stretched and recovered. Further, at any point of weft insertion, the elastomeric yarn tension of the weft shall not exceed its elastic limit to ensure complete recovery and avoid unexpected breakages. Wearing comfort plays a crucial role in the mass-scale acceptance of a particular fabric as a suitable apparel fabric for a specific application. The achievement of this kind of comfort is determined by the mechanical properties of fabric in particular stretch properties. Stretch is regarded as an essential property of textiles as it decides the comfort of the wearer. The greater acceptability of stretch fabrics is due to their exceptional qualities like higher extensibility, high degree of recovery, and simple care.

To impart stretchability to the yarns, elastic fibers like lycra /spandex are incorporated in them. Core-spun yarn shaving elastane filament at the core and wrapped cotton fibers or polyesters are commonly used in the weaving process. There are four main methods to cover an elastane yarn. Single covered yarns, a core yarn is wrapped by a second yarn. Double-covered yarns, two separate yarns are wrapped around the core yarn. Those two layers are twisted in opposite directions, which prevents the untwisting of the inelastic yarns. Air-covered yarns, the outer yarn is intermingled around the core. Core yarn, an inelastic fiber material is spun around the elastane yarn [1]

At present, stretchable fabric is used in most apparel products such as denim, skirts, trousers, etc. as a modern style as well as a trend with ever-increasing volume. The production of stretchable woven fabric is achieved by using an elastomeric yarn as the weft in the production process, which affects the production process, the final product price, and applicable properties. To produce sucha stretchable woven fabric weft should be elastic yarn and the warp should be a standard set of yarns. When the elastomeric yarn is used as a weft it will stretch when it comes out from the package and during the weft insertion. The tension of weft may vary under such conditions. Such variations affect the production process, product properties, and subsequently quality of the fabric. In literature, there is a fundamental lack of a complete mathematical model related to the weft yarn insertion processes. Despite few partial models and related results of weft insertion that could be found in the literature being noteworthy, adequate analysis and modelling have not been still carried out with elastomeric yarn insertion on a rapier loom. So, the authors of this paper attempt to analyse and model the weft yarn tension of an elastomeric weft yarn insertion on a rapier loom.

II. LITERATURE REVIEW

A historical milestone in weaving was marked by John Kay with the invention of the fly shuttle and which doubles the speed of weaving. The rigid rapier was invented in 1870 and perfected by O. Hallensleben in 1899. R. Dewas introduced the novel idea of grasping the weft at its tip by the giver rapier and then transferring it to the taker in the middle of the shed. In the 1960s rapier weaving became commercialized. Since then, many significant inventions have been done to achieve high-speed weft insertion.

The tension of weft yarns during woven fabric production is very important for proper interlacement with warp yarns for the formation of the fabric. If the weft tension is suddenly changed, there may be a slight change in the structure of the fabric, but the change becomes much more prominent when the fabric is no longer subjected to its limiting action. The wefts that had more stress than the others would be more stretched when they entered the fabric in a relaxed form. Therefore, the fabric becomes narrower than the rest of the fabric [5]

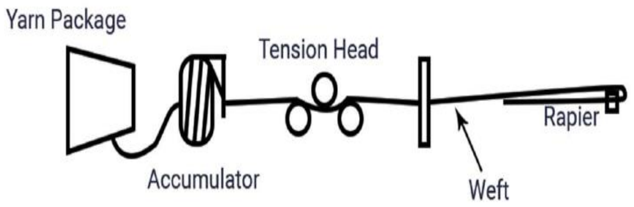

Fig.1: Rapier weft insertion system

Figure 1 shows the basic path of the weft from the supply package to the rapier head. The weft yarn from the stationary package, generally a cross-wound cone passes through a weft accumulator (or weft feeder), a suitable tensioning system, a weft monitoring system, the yarn presenter, and finally to the weft insertion element. The tensioning system passes many ages (details are given in the next paragraph) and evolved to its optimally controlled form using microprocessors.

An active filling tensioner is one of the sophistications in the tensioning system used in high speed rapier weaving. Each pre-winder is equipped with a programmable TEC filling tensioner and by controlling tension, makes it possible to weave weak yarns at even higher speeds. Electronic filling tensioners and programmable filling tensioners are two new inventions to control weft yarn tension. An electronic filling tensioner electronically control the brake using very long yet extremely light lamellas together with damping elements and it is installed between pre winder and the fixed main nozzle but slows down the weft at the end of insertion. To overcome the disadvantages of an electronic filling tensioner, a programmable filling tensioner was invented and it is controlled by a microprocessor to ensure optimum weft yarn tension throughout the whole insertion process. Reducing the basic tension is an important advantage when piecing up weak yarn while adding tension is an advantage in the transfer of the yarns and avoids the formation of loops. [4]. The nature of the variation of weft tension and velocity during picking in a double rapier loom with tip transfer in the weft insertion cycle could be found in Figure 2.

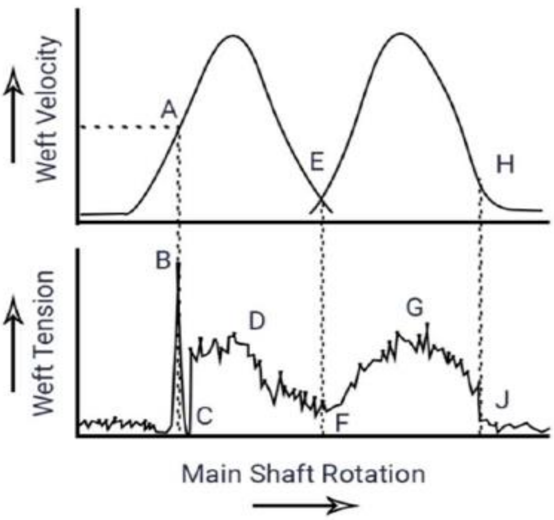

Figure .2: Weft tension profile during weft insertion [6]

In the case of the rapier picking system, the convenient place for interposing the tension measuring unit is between the weft presence monitor and the weft presenter [6]. For the convenience of correlating the nature of weft velocity with that of weft tension, the weft velocity diagram is also exhibited in Fig. 2.

In Fig. 2, it is observed that at the commencement of picking, the donor (or giver) rapier picks up the weft at A and a high-tension peak B occurs which incidentally is the highest during the entire course of insertion of a pick. This follows a sudden fall to a very low value at C because of the overrunning of the yarn from the weft accumulator (or weft package if the accumulator is not used) due to acceleration jolt. With increasing rapier speed, the tension increases, D, and then decreases as the rapier slows down for transfer of the weft. At the instant of transfer from the donor to the receiver (or taker) rapier at E at the center of the warp shed, the weft tension falls appreciably at F. Following the transfer, as the receiver rapier starts receding, the weft tension again first rises, G, and then falls by the nature of the movement of the receiver rapier. Finally, when the weft is released by the receiver rapier at H after weft insertion, the weft tension decreases and remains nearly constant at J until the next weft insertion takes place. It should be noted here that there is no weft tension peak following the transfer, like that observed during the picking of the weft by the donor rapier (B).

The dynamic tension of the weft is determined by the static tension of the yarn and the frictional tension added due to the yarn count and rapier velocity of the yarn. The dynamic tension of the yarn is given by

$T_{dynamic} = V^2T(1 + e^{\mu\alpha}) + T_{static}$- --- (1)

Where T is the tensile stress (tenacity) of the yarn,μ is the coefficient of friction of the yarn, α is the contact angle of the yarn with the yarn guide and V is the velocity of the rapier [7].

The yarn path meanders through many guiding posts and the tension is added by yarn guides as well as tension devices. The output tension of the yarn is determined by Amon ton's Law and depends on the angle of the wrap in addition to the coefficient of friction between the yarn and the curved surface. So, it can be considered a multiplicative tensioning system. Fig. 3 illustrates the tension guide,

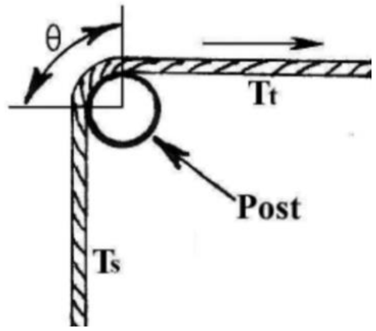

Figure. 3: Multiplicative tensioning system

The tension of the yarn at the tensioned end T_t can be expressed as

$T_t = T_s e^{\mu\theta}$ -------(2)

Where T_s is the tension of the yarn on the secondary side, μ is the coefficient of friction between the guiding post and the weft yarn, θ is the angle of lapping on the guide post and e is the base of the Napierian logarithm [8].

Disc tensioning devices are an integral part of the tensioning system. Here yarn is sandwiched between two-disc tensioners and the yarn is simply dragged between the surface in a straight path along its length. Strain or tension will be imposed on the yarn if it is pressed between the surfaces of two solid materials, as shown in Fig. 4, and the yarn tension T_t of the output side (tensioned side) is given by

$T_t = 2\mu 1N + T_s$ --------(3)

Where $\mu 1$ is the friction between the yarns and the discs while N is the normal force exerted on the discs. So, this can be considered as an additive tensioning system.

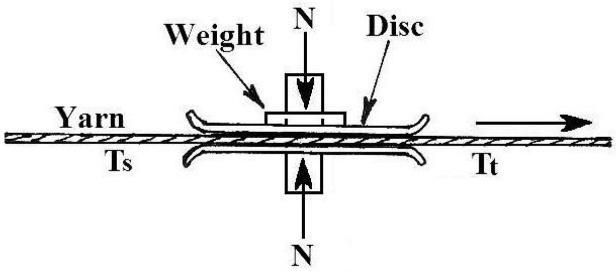

Figure.4: disc tensioning device

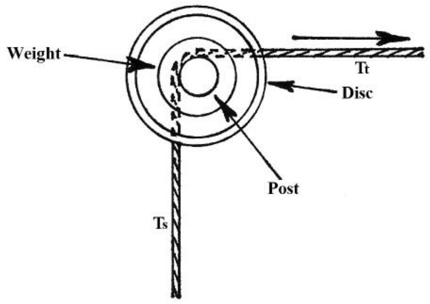

Figure.5: The tension system for the yarn passes around a post and between a pair of discs [6]

It is very often observed that the yarn passes around a post and between a pair of discs placed over the post, as shown in Fig. 5. Dead weight or spring is usually attached to one of the discs to give the desired tension of the yarn. In this combined system of tensioning, the yarn is subjected to additive tensioning as it passes between the pair of discs as well as multiplicative tensioning as it passes around the post. So, output tension on the tensioned side can be expressed as

$$T_t = T_s + 2\mu N + T_s e^{\mu\theta}$$

$$T_t = T_s\left(1 + e^{\mu\theta}\right) + 2\mu N \quad \text{----(4)}$$

Though tensioning devices such as disc tensioners, gate tape tensioners, and combined tensioners for the yarn passes around a post and between a pair of discs were mathematically modeled, the complete tension derivation along the entire yarn path of the weft is still lacking according to the best of the knowledge of the authors. Further, a mathematical model for the weft yarn tension of an elastomeric yarn has gotten little attention from researchers. The authors attempt to address this niche through this article.

III. MATHEMATICAL MODEL DEVELOPMENT

Mathematical modelling is the process to describe a real-world problem as an iconic model in mathematical terms. Usually, mathematical modelling is expressed as a mathematical equation and these equations help to understand the real-world problem and to discover new features of the problem. Further, mathematical models help engineers to design control systems systematically, analyze their stability and robustness, and also as a means for technology in the future [2]

Developing a mathematical model for weft elastomeric yarn tension on the rapier loom and helping to predict the stretchable fabric properties quantitatively and thereby avoid the trial-and-error method practiced by the industry in producing stretchable fabrics. However, determining the loom parameters, especially the weft tension according to the mechanical properties of elastomeric yarn to achieve a predetermined set of stretchable fabric properties is beyond the scope of this paper

In respect of the elongation of the weft yarn when the yarn is subjected to tension it first stretches out before being tensioned [9]. Therefore, the weft yarns with higher elongation property experience lower insertion tension, Figure 6.

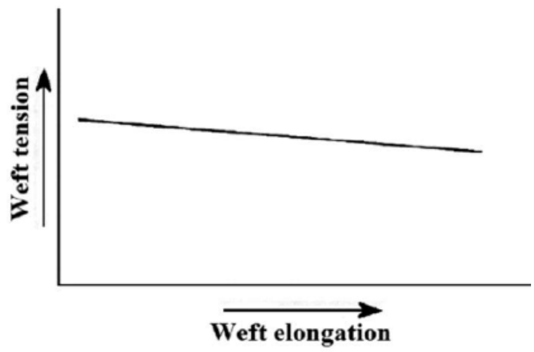

Figure.6: Effect of weft yarn elongation on weft tension

Despite the above scenario, in an elastomeric yarn, the static tension is increased due to its elongation according to Hook's law within the elastic region and the tension increment experienced by the yarn guide posts, disc tensioners, etc. Therefore, the complete yarn due to the tension head shall be under consideration. Figure 7 shows the complete yarn path across the tension head of the rapier loom of Tsudakoma make and R200 in the model.

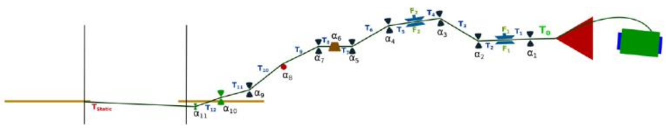

Figure.7: Complete yarn path across the tension head

The weft yarn is taken off from the weft yarn package and take-off tension is determined by the balloon formed at the take-off point. The take-off tension T_0 can be expressed as

$$T_0 = mv^2\{2 + k(H/r)^2 sin^2\beta\} \text{ ----(5)}$$

Where m is the mass per unit length of the weft yarn, v is the linear velocity of taking off, H is the balloon height, r is the winding off the radius of the weft, k is a coefficient which depends on unwinding condition mainly on the drag of the weft yarn on the package and β is the coil angle [7].

The yarn passes through 11 guide posts and two-disc tensioning devices as depicted in Fig. 7. The tension of yarn at different segments in the tension head is given in Fig. 7 as T_1, T_2, etc. The final static tension T_{12} can be expressed as

$$T_{static} = T_{12} = ((T_0 e^{\mu\alpha_1} + 2\mu F_1)e^{\mu(\alpha_2+\alpha_3)} + 2\mu F_2)e^{\mu(\alpha_4+\alpha_5+\alpha_6+\alpha_7+\alpha_8+\alpha_9+\alpha_{10}+\alpha_{11})} \text{ -----(6)}$$

Where T_0 is the weft yarn tension at the accumulator, μ is the coefficient of friction between the yarn guides and the weft yarn, α_i is the contact angle of yarn with the ith yarn guide and F_i is the normal force acting on the thread tensioning device i.

However, in elastomeric yarn weft insertion, the take-off tension due to formation of balloon as quantitatively given by equation (5) is not significant and the tension due to elongation is dominant as the elastomeric yarn is stretched before it is tensioned due to the formation of balloon. Hence the weft yarn tension at the accumulator can be derived from the definition of Elastic modulus E [10].

$$E = \frac{F/_A}{\Delta l/_l} \text{ - - - - - - -(7)}$$

Where E is the elastic modulus, $F/_A$ is the stress on yarn and $\Delta l/_l$ is the strain on the weft yarn. When the force F is replaced by the yarn tension T_0 equation (7) can be used for the tension of an elastomeric weft yarn as given by

$$T_0 = AE(\Delta l/_l) \text{ -----(8)}$$

By substitution of T_0 from equation (8) in equation (6), the static tension can be expressed as

$$T_{static} = ((AE(\Delta l/_l)e^{\mu\alpha_1} + 2\mu F_1)e^{\mu(\alpha_2+\alpha_3)} + 2\mu F_2)e^{\mu(\alpha_4+\alpha_5+\alpha_6+\alpha_7+\alpha_8+\alpha_9+\alpha_{10}+\alpha_{11})} \text{ -----(9)}$$

The dynamic weft tension of an elastomeric weft yarn can be expressed as

$$T_{dynamic} = vT\sqrt{E}10^{-2} + T_{static} \text{ ------------(10)}$$

Where E is the elastic modulus of the yarn in cN/Tex, v is the velocity of the elastomeric weft yarn in m/s, T is the tensile stress(tenacity)of the weft measured in cN/Tex

Equation (10) was used to estimate the dynamic tension while equation (9) was used to determine the static tension of elastomeric weft yarn tension on a rapier loom. The actual measurements were taken to with different yarn counts to validate the model and the details could be found under the sections of methodology and results.

IV. METHODOLOGY

A. *Material and Machine*

To produce a stretchable fabric, presence of elastomeric yarn is vital. Elastomeric yarn of different counts/materials are use as the weft of the rapier loom, while the warp is kept as constant with 30Tex cotton yarn. Three yarn packages with three different yarn counts which are used in the industry were selected as the weft yarn for model validation. The specifications of three weft yarns used are given in Table 1

TABLE 1
SPECIFICATIONS OF WEFT ELASTOMERIC YARN

Core Yarn	Wrapped yarn	Yarn count	Breaking tensile strength	Breaking elongation (%)
Spandex	Polyester	220 DTex	6.85 N	165%
Spandex (35%)	Polyester (65%)	340 DTex	6.89 N	254%
Spandex (40%)	Polyester (60%)	340 DTex	6.5 N	307%

Tsudakoma rapier loom is selected to carry out trials with different elastomeric yarn to validate the mathematical model developed and the specification of the loom is provided below for information.

Make: Tsudakoma
Model: R 200
Fabric width:140cm
Speed:250 rpm

To measure the weft tension three - pulley tension measuring device was deployed and the specification of the tension meter could be stated as follows,

Make:Zivy
Model: EL-TEN-M
Range:1-400cN
Minimum measurable value: 1cN

B Testing Conditions and Method

In carrying out the experiments, the loom was run at a constant speed of 250 picks/minute. This speed is adequate to create a reasonably distinct value in dynamic elastomeric weft yarn tension on the rapier loom and to avoid unforeseen tension variation (keep the assumptions made valid) due to the variation of loom speed.

The weft is elastomeric yarn package should be at same path of weft accumulator to avoid the possible weft breakages during insertion and also to eliminate the additional tension is created on weft insertion which was not considered in modeling. A stand was designed for that purpose and the weft packages were installed there. After careful assurance of the proper yarn path few test trials were carried out.

After calibration a stand was used to place the tension meter so that it can be used to measure the weft yarn tension of the elastomeric yarn inserted as the weft to the rapier loom. According to literature, the tension device should be placed as much as closer to the weft insertion device. Therefore, the tension device was placed between final yarn guide and filling detector

C. Results and discussion

Elastomeric yarns made out of spandex core and polyester wrap, have an extreme elasticity. Thus, yarn can be elongated with any force below its breaking load. Since the rapier weft insertion system has several elements in the tension head, the elastomeric weft yarn may extend unexpectedly at certain places. If the elastomeric yarn stretches, it means there is additional tension on the weft. For example, if the yarn package is set up at an angle to the accumulator, a tension between the two elements will act on the yarn. Which should be eliminated because it is uncontrollable. Therefore, yarn package should be at the same height and the same path to the accumulator.

In weft insertion, the elastomeric yarn is pulled by the rapiers to withdraw the necessary length. If yarn would not be able to easily withdraw from the accumulator, as it is elastomeric, yarn may stretch proportional to the applied force from the rapiers. When the yarn is at the selvage several forces would act on the yarn and due to those forces tension is generated. Frictional forces from yarn guides, the weight act on yarn in leaf tensioning device, tension due to ballooning, pulling force by rapier etc. would act on the yarn. If the yarn is inelastic, extension due to those forces can be neglected. Because those forces are not enough to extend the yarn in acceptable level. But with elastomeric yarn this phenomenon happens differently. A small force would be able to stretch the yarn due to its elasticity. Therefore, it should be considered when designing the yarn path.

The tension variation of an elastomeric yarn throughout the weft insertion cycle was studied. The weft tension variation (tension profile) for elastomeric yarn could be depicted in Fig. 8

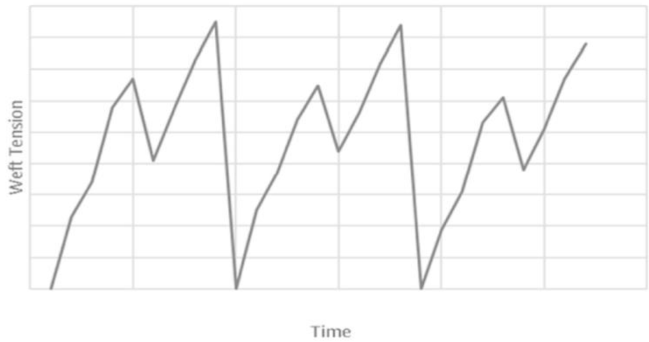

Fig.8: Tension profile of elastomeric weft insertion on a rapier loom

The weft tension is varied throughout the weft insertion cycle. The tension increases when the insert rapier starts to move, and the tension will further increase with taker rapier movement from middle of the shed to the selvage. When the taker rapier arrives the selvage, elastomeric yarn has its maximum tension. This inelastic yarn scenario is quite different from the elastomeric yarn and its tension profile can be descried in the following way. As the taker rapier reaches the selvage, the elastomeric yarn reaches its maximum tension. There is a slight tension reduction when transferring the weft from the insert rapier to the taker rapier, but it is not as much as inelastic yarn.

The tension meter was set near to the filling detector and the average meter reading was taken to measure the dynamic tension during a few weft insertions. Rapier paused at its initial position to get the average tension meter reading for static tension. From each yarn type, 20 experimental trials have been carried out covering three elastomeric yarns. According to the observation it shows that the dynamic tension is always higher than the static tension and a significant variation could be noted among readings. Further unlike in static tension, dynamic tension increases as the speeding up the rapier loom. The average dynamic tension, its coefficient of variation, average static tension and its coefficient of variation were calculated and tabulated in Table 2.

TABLE 2
AVERAGE STATIC AND DYNAMIC TENSION FOR DIFFERENT ELASTOMERIC YARNS

Elastomeric yarn count	**Average dynamic tension (cN)**	**CV of dynamic tension**	**Average static tension (cN)**	**CV of static tension**
220 DTex	23.75	0.3427	9.0	0.4626
340 DTexSpandex (40%)	27.25	0.3687	18.5	0.4984
340 DTexSpandex (35%)	25.5	0.4819	17.5	0.5310

In order to calculate the tenacity of the yarn, the breaking strength is required to be obtained. In addition, elastic coefficient of the of each yarn also to be determined in order to calculate the dynamic tension theoretically based on the model developed. Using a tensile strength tester, breaking strength, elongation and elastic coefficient of each elastomeric yarn is practically obtained with a sample size of 50. The average values of these yarn parameters are given in Table 3

TABLE 3
BREAKING STRENGTH, BREAKING ELONGATION AND ELASTIC COEFFICIENT FOR DIFFERENT ELASTOMERIC YARNS

Elastomeric yarn count	Tenacity cN/Tex	Breaking elongation (%)	Elastic Modulus (cN/Tex) @ 40%
220DTex	23	165%	2.6
340 DTex (Spandex 40%)	15	254%	6.7
340DTex (Spandex 35%)	19	307%	4.9

From the above data, tenacity is get reduced as the yarn count is increased. Further with the increment of yarn count of an elastomeric yarn and increasing polyester composition of same count, maximum elongation is got increased. Both phenomena are in accordance with the better tensile properties of the yarn as the Tex count is increased of an elastomeric yarn. The coefficient of variation for all readings were found to be less than 0.1 showing that lesser variation between readings.

Using equation (9) and equation (10) static and dynamic tensions were calculated and given in Table 4 with experimental values with comparison purposes.

TABLE 4
THEORETICAL AND EXPERIMENTAL STATIC AND DYNAMIC TENSION OF ELASTOMERIC YARN IN WEFT INSERTION ON RAPIER LOOM

Elastomeric yarn count	**Average experimental Dynamic tension (cN)**	**Theoretical dynamic tension (cN)**	**Average experimental static tension (cN)**	**Theoretical static tension (cN)**
220 DTex	23.75	21.23	9.0	14.25
340 DTex (Spandex 40%)	27.25	25.12	18.5	17.41
340 DTex (Spandex 35%)	25.5	25.52	17.5	18.12

The error between the theoretical and experimental results are less than 10% except for one reading. So, a high degree of consistency exists between the theoretical and experimental values of the static and dynamic tension values and thereby the model could be validated with promising results.

V. CONCLUSIONS

A rapid growth in the usage of stretchable fabrics could be noticed with the popularization of stretchable denim trousers. Accordingly, volume in stretchable fabrics manufacturing was greatly improved. Due to versatile properties of the rapier loom, rapier looms were utilized in the fabrication of woven stretchable fabrics with elastomeric weft usage. In elastomeric weft insertion, controlling tension is much important and a considerable amount of yarns get wasted in setting the correct weft tension through the trial and error method. A mathematical model was developed to bridge the long-standing technological gap in related to elastomeric weft insertion on a rapier loom.

The tension devices along the entire yarn path across the tension head were used in the derivation of mathematical model for static tension variation at the weft insertion on a rapier loom. The dynamic tension added to the static tension was also modeled for elastomeric weft insertion. Further, the model was validated with practical results within 10% accuracy level. However, during the experimentation, rapier loom was run at a constant speed of 250 picks/min and the variation of dynamic tension of elastomeric weft with loom speed is yet open for research. In addition, how the elastomeric weft yarn tension affects the fabric properties is a niche area for research.

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