Study on 3- Dimension Simulation for Loop Structure of Weft- Knitted Fabric Considering Mechanical Properties of Yarn

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ABSTRACT

The 3-dimension loop model for weft-knitted structure was constructed using mass points and springs. Firstly the yarn model was made by cross-section models along the yarn axis. In the yarn model, twist was expressed by setting all of the cross-section models by rotating with the angle along the yarn axis. In order to transfer the yarn model into loop model, Kurbak's model was applied to construct the loop model with the loop geometric structure. After getting the loop model, it was simulated in order to express the tensile properties. In this case, the construction of knitted loop structure was changed in order to determine the properties of the loop model under the tensile condition. The stress-strain result of the yarn was applied in the determination of the tensile properties of knitted loop model by simulation. Then, the simulation result of the loop model was examined by comparing with the result of the experimental one, the loop model can show its tensile properties for both loading and recovering processes agreement with the experimental result. In the simulation of the construction change of knitted structure, the friction at the contact point of the yarn was not taken into account in this case. The model may be more improved by accounting the friction at the constant point of yarn in the future.

1. Introduction

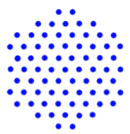
The knitted fabric shows different properties comparing with others due to mainly its interloped structure together to form the chain of loop. Actually knitted fabric is formed by yarn and so the properties of yarn is the first important factor determining in the properties of fabric and its behaviour. The second one is the geometrical structure of loop which causes different mechanical properties such as extension and bending properties of fabric. Therefore, the yarn model was firstly constructed by means of mass spring system and its mechanical properties were determined. After that, the loop model was constructed and its mechanical properties were also determined.

2. Construction of yarn model

The yarn model was constructed with the cross sections. Each cross section were made with the mass points which can represent the amount of fibres in the real yarn. Two kind of springs, tensile and bending springs were applied in the mass points to determine the properties of yarn. Figure 1 shows the components used in the simulated yarn model. The cross sections were allocated along the yarn by rotating with an angle. By this way, twist was expressed in the simulated yarn.

(a) Extension spring.

(b) Bending spring.



(c)Section with mass points.

(d) Simulated yarn.

Figure 1. Components used in simulated yarn model.

2. Making the three-dimensional model for knitted loop structure

In the processing of knitted loop structure, the parameters of knitted loop were based on wale spacing, course spacing, and yarn diameter. In this case, Kurbak's model was used to construct the geometric structure of loop model. The three-dimensional knitted loop structure was constructed using the simulated yarn which was made by mass spring system. The geometrical knitted loop structure was constructed by setting the sections with the angle θ varying from one section to another section. Figure 2 shows the loop structure with the sections and the angle of section with its coordinate system. The obtained loop model was repeated along the z-direction according to the wale spacing and along the y-direction according to the course spacing in order to make weft-knitted fabric structure model for plain stitch. Figure 3 shows simulated weft-knitted fabric structure model for plain stitch. Finally the simulated weft-knitted fabric was constructed by using C++ program with OPEN GL method.

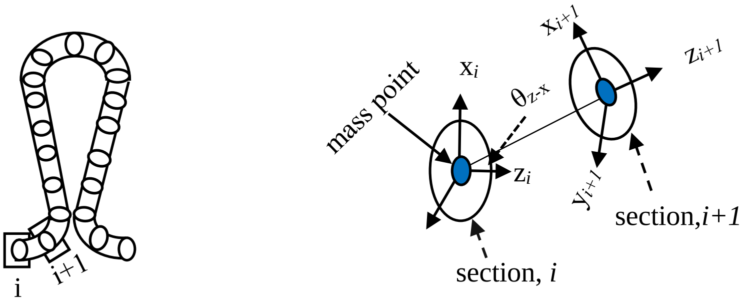


Figure. 2 Loop structure with *i* and *i+1* sections

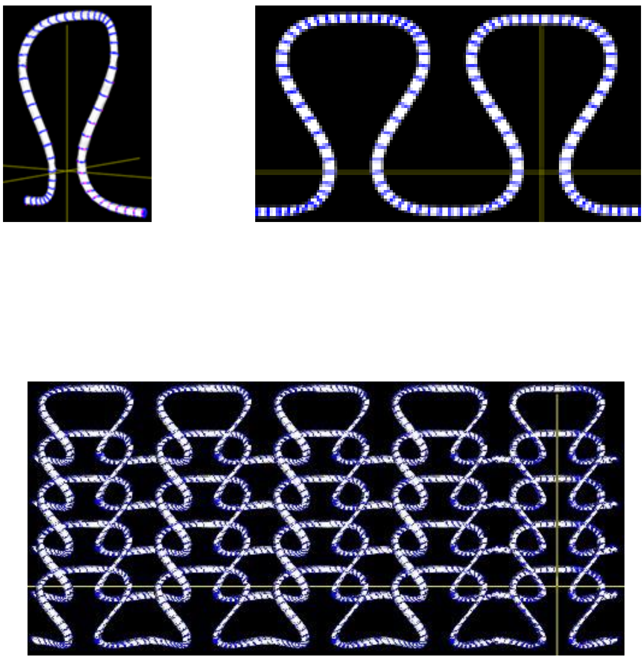


Figure 3. 3- dimension of simulated weft-knitted structure.

3. Construction change of the weft-knitted structure under tensile condition

The construction of the weft knitted structure was considered to be changed in order to show the tensile properties of the knitted loop model. In here some hypothesis were made to change the construction of the knitted structure as follows;

1. The loop structure was compressed up to the limit of half of its initial height of loop under the tensile condition in the course direction.

2. The loop structure was compressed up to the limit of half of wale spacing under the tensile condition in the wale direction.

By this way the weft-knitted loop model was simulated its change of knitted loop structure under the tensile condition by using C++ program with OPEN GL method.

4. Evaluation of the weft-knitted loop model

The weft-knitted fabric sample was examined its tensile properties in the course direction by Kawabata Evaluation System. And then the weft-knitted loop model was simulated by inputting the same parameters of loop parameters as in the weft-knitted sample. The weft-knitted loop model can show its tensile properties for both loading and recovering processes with well-agreement of the experimental result as shown in Figure 4.

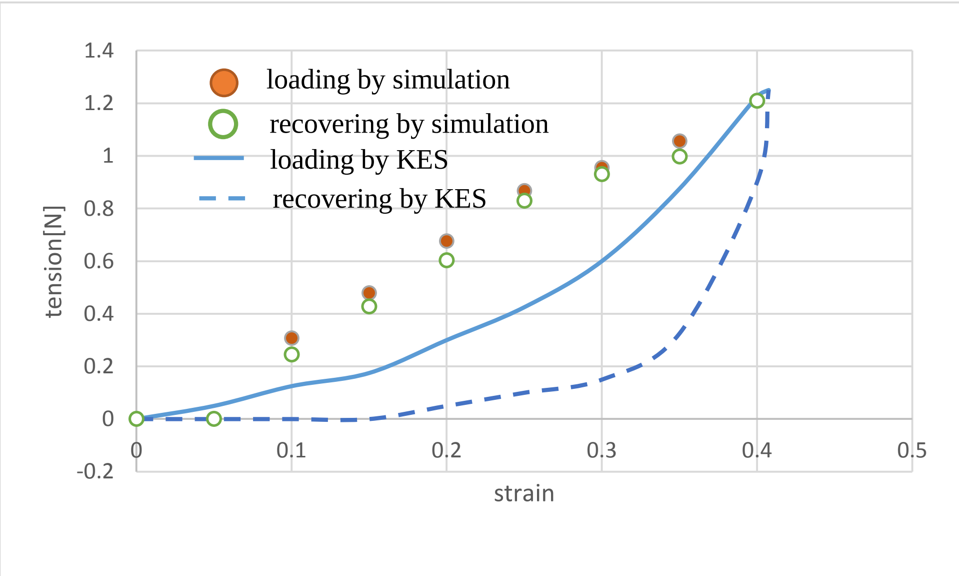


Figure 4. Result of tensile properties for loading and recovering processes.

平成２９年　２月　６日

学位論文審査報告書（甲）

1．学位論文題目（外国語の場合は和訳を付けること。）

Study on 3- Dimension Simulation for Loop Structure of Weft- Knitted Fabric Considering Mechanical Properties of Yarn

（糸の力学的特性を考慮した３次元よこ編布構造のシミュレーションに関する研究）

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3．審査結果の要旨（600～650字）

当該学位論文に関し，平成29年2月6日に第1回学位論文審査委員会を開催し，提出された学位論文及び関係資料について詳細に検討した．さらに，同日に行われた口頭発表後に，第2回学位論文審査委員会を開き，協議の結果，以下のように判定した．

よこ編布は衣服用途だけでなく，産業用途にも広く使われるようになってきた．比較的小さな力で大きな変形をするよこ編布は，その製品設計のために多くのシミュレーションシステムが開発されているが，いずれも衣服用途のための幾何学特性のみをシミュレーションするシステムに限られている．一方，産業用途においてはその機械的特性も重要になり，幾何学特性シミュレーションに力学特性を導入することが重要である．本論文ではまず，糸１本の力学特性をシミュレーションする手法を提案し，数種類の合繊フィラメント糸によって，その妥当性を検証した．続いてよこ編構造の力学特性を評価するため，糸のループ構造の３次元モデルを構築し，そこへ糸の応力ーひずみ関係を導入することに成功している．さらに数種類のよこ編布の引張り変形時の負荷ー除荷過程における荷重ー伸び特性を計測し，シミュレーション結果と比較することによって，提案した３次元モデルの有効性を実証している．

以上のように，本論文はよこ編布の幾何学特性および力学特性の評価・設計に関して有用な知見を得るなど，学術的な価値が高く，博士（学術）に値するものと判定した．

4．審査結果　(1) 判　　定（いずれかに○印）　合　格　・　不合格

(2) 授与学位　博　士（　学術　）