Prediction of functional characteristics of interlock and rib knitted fabrics by the use of 3D computational modelling and analysis

Hassan Ali, Salma Farooq, Muhammad Owais Raza Siddiqui, Muhammad Dawood Husain and Saira Faisal

Department of Textile Engineering, NED University of Engineering and Technology, University Road, Karachi, Pakistan

Abstract

In this work, a computational model of interlock and rib knitted structures is developed to predict the air permeability and thermal properties of the fabric. Repeatable unit cells of interlock and rib structures are developed in COMSOL Multiphysics® software by using actual fabric parameters, extracted with the help of an image analysis technique. The obtained modeling results are then compared with the actual experimental values for the fabric. Furthermore, the validated computational model is utilized to analyze the effect of stitch length and fabric thickness on the thermal properties and air permeability of the fabric. It is found that stitch length has a direct relation with air permeability and an inverse relation with effective thermal conductivity. The fabric thickness influences directly the effective thermal conductivity and has an inverse relation with air permeability of the fabric.

Keywords: Air permeability; effective thermal conductivity; weft knitting; computational fluid dynamics; repeating unit cell.

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1. INTRODUCTION

Weft knitted fabrics are widely used in multiple application areas, and now with the help of knitted fabric simulation technology, manufacturers can easily distinguish the intuitive fabric simulation images that will shorten the trial-and-error process as well as improve the efficiency of work by shortening the development cycle of a product [1].

A loop is formed by bending the yarn from three points and these loops are entangled into one another and make the basic unit of the knitted fabric. The geometrical model of a single loop should be established, and the geometrical structure of the knitted fabric is obtained by the loop [2]. Numerous models have been developed for weft knitted fabrics starting from 2D (two-dimensional) to 3D (three-dimensional) loop models, which were used to investigate fabric properties, simulate geometric structures, and explore mechanical aspects, production, and design, while 3D simulation is more important than 2D loop models [1].

Analyses using geometrical models of knitted fabrics were performed in many studies (*e.g.* [3-9]). In the Kurbak's model, the loop was divided into 8 sections that described the orientation of yarn, and this model can establish tuck, purl, and rib stitches [9]. Demiroz *et al.* [10] have presented the mathematical approach to develop 3D models of plain weft-knitted structure. Choi and Lo [11] have also worked on a plain weft-knitted structure and analyzed the mechanical and dimensional properties of the structure. This approach was later extended by Kyosev *et al.* [12] who developed the models of the same structure and further considered the elliptical yarn cross-section. In the weft knitted fabric simulation, the piecewise function of the loop model was applied to enhance the 3D construction.

To determine the geometry of knitted spacer fabrics, a more accurate mathematical model was developed with the use of simulation in Abaqus software [13] and by numerical analysis mechanical properties of composite materials were predicted. The yarn path was also derived through equations and geometry of 1x1 rib knitted fabric was developed. The predicted geometry and compression modulus results showed the overall 4.0 and 4.2 % error, respectively [13].

Corresponding author: Muhammad Owais Raza Siddiqui, Department of Textile Engineering, NED University of Engineering and Technology, University Road, 75270, Karachi, Pakistan

E-mail: orazas@neduet.edu.pk

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Another study aimed to enhance the joint strength in composite pipes integrated with the plain weft knitted structure for which mathematical modelling and fabric simulations were performed. The curved shaped models were created for the joint composites with curved surfaces and the results revealed maximum of 10 % error in structural parameter predictions [14].

ABAQUS plugins were developed for the analysis of mechanical parameters of weft knitted composites including strength, stiffness and the mechanism of failure. It is reported that the maximum of 7 % error was observed in predicting the tensile modulus in both directions [15].

An algorithm was developed, which can forecast the pore size of weft knitted structures without the input parameters of machine and yarn combination. Although it has some inherent limitations, the model provides customization of the fabric as per the required end application, thus helping to manufacture customized structures more efficiently [16].

In a nutshell, the geometry of plain knitted structures is studied extensively, but interlock and rib structures have not yet been investigated much despite their importance. This research aims to build 3D computational models of interlock and rib knitted structures using the actual construction parameters of the fabric to predict the air permeability and thermal properties of the fabric. To validate the model, we kept the other fabric and knitting parameters constant and analyzed the effects of stitch length and fabric thickness on these properties.

2. MATERIALS AND METHOD

2. 1. Material

Samples were developed using 100 % polyester drawn textured (DTY) 75/72 multifilament semi-intermingle yarn from Suzhou Nextile fiber Technology, China. Table 1 shows experimentally determined specifications of the interlock and rib structure developed fabrics. The wales and course density were evaluated according to the BS EN 14971:2006 standard, the stitch length according to the EN 14970:2006 standard, thickness was measured according to the ISO 5084 standard, and the areal density of the fabric was calculated as per the standard EN 12127:1997. Thermal resistance was determined as per standard ISO 11092 and used for calculation of the thermal conductivity. Air permeability of the fabrics was tested according to the method specified by the ISO 9237 standard and the permeability value, *k*, was calculated by the Darcy's law, Equation (1) [23]:

$$V = -\frac{kA\Delta P}{\mu L} \tag{1}$$

where V is the total volumetric discharge per unit time, A is the cross-sectional area of wales a porous medium, $\Delta P/L$ ratio is the pressure gradient, μ is the fluid viscosity, and k represents the air permeability.

Table 1. Specifications of the weft knitted fabric samples, yarn 8.33 tex, yarn diameter 0.14 mm

Type of fabric	Wales per mm	Courses per mm	Stitch length, mm	Fabric thickness, mm	Areal density, g m^{-2}
Interlock Fabric	15.75[a]	18.11[b]	2.82	0.54	125
Rib fabric	10.24[c]	17.32[d]	2.70	0.36	65

[a]40 per inch; [b]46 per inch; [c]26 per inch, [d]44 per inch

Moreover, the interlock fabric was manufactured by using a Dragan double-bed circular knitting machine of 28-gauge, consisting of 2976 needles and 68 feeders (producer, country). The diameter of this circular knitting machine was 34 in. The needles used in the dial and cylinder of the machine have a length of 74 mm, thickness of 0.41 mm and latch size of 8 mm.

Similarly, the rib fabric was manufactured by using a Dragan double-bed circular knitting machine of 18-gauge, consisting of 1920 needles and 68 feeders (producer, country). The diameter of this circular knitting machine was 34 in. The needles used in the dial and cylinder have a length of 90 mm, thickness of 0.41 mm and latch size of 8 mm.

2. 2. Methodology

The methodology implemented to develop the 3D models of interlock and rib structures included: (i) development of parametric 3D unit cell of interlock and rib knitted structures; (ii) calculating the air permeability and effective thermal conductivity by using the developed unit cells; (iii) parametric analysis to predict and analyze the effect of stitch length and fabric thickness on air permeability and effective thermal conductivity to validate the models.

2. 2. 1. Development of 3D models of interlock and rib structures

The interlock and rib structures consist of the face of a plain loop on both sides of the fabric. In the case of interlock fabric, the wales are interlocked and opposite to each other while in the rib fabric single yarn is used to create the loops on technical front and the back. In the case of interlock, sinker loops of two 1×1 rib courses cross over each other alternately, to produce an interlock fabric. Majorly, the structure can be segmented into two including the arms and the needle loops, obtained by mathematical equations, while the second segment is the sinker loop or linking bottom part of the loop which connects the front and the back loop in case of interlock structure [18].

The 3D model of plain loop is also explained in literature [19] by using a second continuous cubic non-uniform rational B-splines (NURBs). Some key points include (i) the plain loop is the space curve, easily identified by using data points and weight factor, which bends in all 3 dimensions; (ii) assumption that the yarn is continuous during bending and its cross-section is uniform and circular; (iii) the structure of a single loop is determined by using the data points from $P_0 = (X_0+Y_0+Z_0)$ to $P_8 = (X_8+Y_8+Z_8)$. Practically, the NURBs curve must follow the path obtained from these data points. The parameters for calculating the points include the width of head and sinker loop, height of the loop, space between adjacent sinker loops, thickness of fabric, adjacent loop distance in wale direction and coefficient of inter-meshed points represented by γ, Equation (2):

$$\gamma = C / H, \quad 0 < \gamma < 1 \tag{2}$$

where C is the distance of two adjacent loops in the wale direction and H is the height of the loop.

The single loop consists of 9 interpolation points, as shown in Figure 1(a), which were then calculated. It is assumed that the points P_2 and P_6 are the mid points with respect to P_1 and P_3 and P_5 and P_7, respectively [19].

Figure 1 shows the development steps of 3D computational model of interlock structure while Figure 2 shows the development steps of 3D computational model of rib structure. Both structures are created by using similar methodology as discussed above.

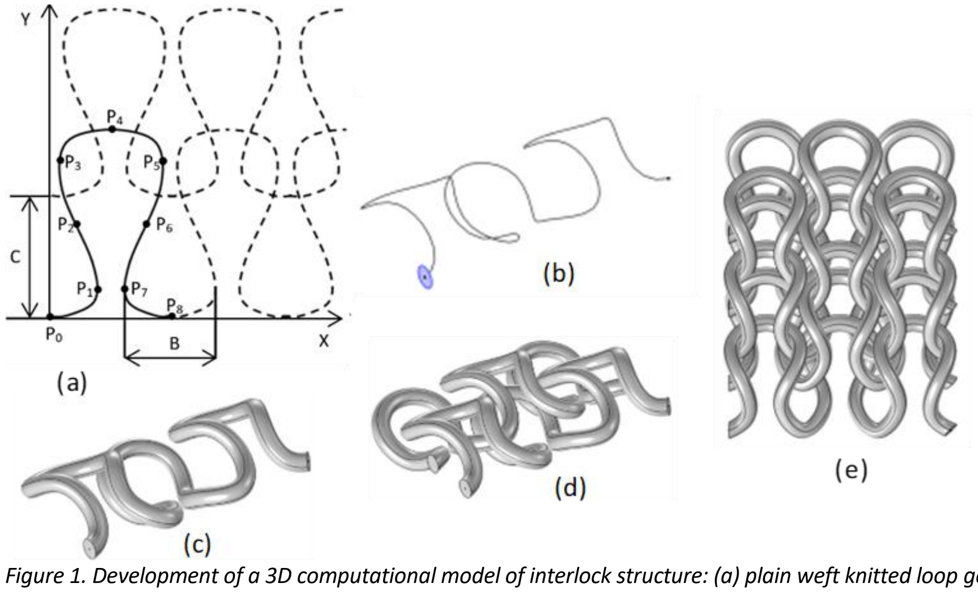

Figure 1. Development of a 3D computational model of interlock structure: (a) plain weft knitted loop geometry, (b) interpolation curve with yarn circular cross-section, (c) 3D loops of the 1st yarn, (d) interlocking of the 2nd yarn to complete the structure

Image analysis was performed by using the actual images of the fabric to extract the parameters of the unit cell described earlier. The 3D computational model of structures is developed by using similar assumption that the loops on technical back are the mirror image of technical front loops and are similar to the technical front of the plain weft knitted structure. The center line of the created interpolation curve lies in the three-dimensional space. By using the sweeping tool, circular cross-section of yarn is created and then the loops were mirrored.

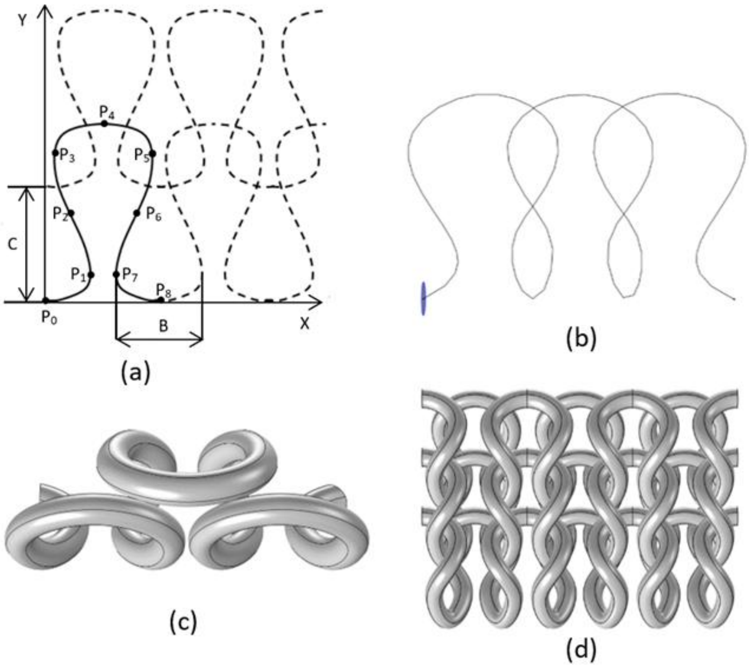

Figure 2. Development of the 3D computational model of rib structure: (a) plain weft knitted loop geometry, (b) interpolation curve with yarn circular cross-section, (c) top view of rib structure, (d) computational model of rib structure

The 3D loop geometrical models of weft knitted Interlock and rib structures were developed based on the improved model of plain loop and their central axes as some 3D space curves were achieved by using non-uniform rational B-splines (NURBS). Figure 3 shows the top view of the ideal and the developed interlock structure. Here, the central axis of yarn is determined by the data points of yarn path. The equations for calculating the points are obtained with the relation between the actual parameters of fabric, calculated by using image analysis techniques, and the data points.

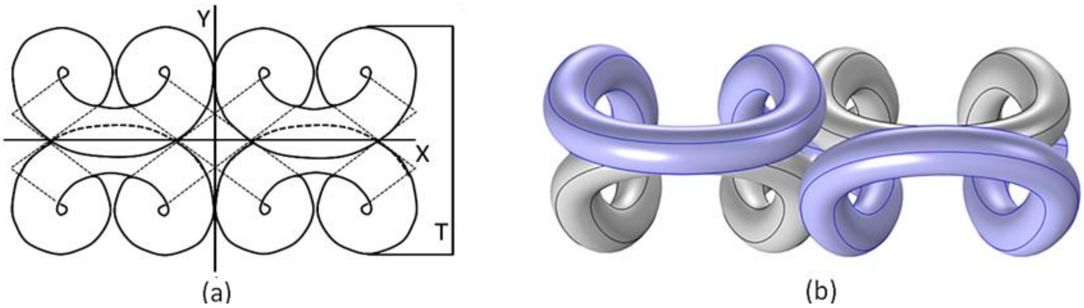

Figure 3: Top view of interlock structure: (a) ideal structure and (b) developed 3D model

2. 3. Analysis

2. 3. 1. Air permeability

Stitch length, also known as loop length, is one of the most critical parameters in the knitted fabric production process which influences dimensional and physical properties of the end product. These include air permeability and thickness of a fabric, which are mainly influenced by the loop length [20].

The air flow rate which passes perpendicularly through a unit area is defined as the air permeability. The air permeability of a fabric is directly proportional to the stitch length so that the increment in loop length will increase the air flow rate through the structure of the fabric [21].

Similarly, the stitch length has an inverse relation with the areal density and thickness of the fabric. As the loop length decreases, the fabric's stitch density increases, so the overall areal density and thickness of the fabric increase [22].

The air permeability (k) of the yarn used in the interlock and rib fabric in the traverse direction is calculated using the Gebart model [23], Equation (3):

$$k = \frac{16R_f^2}{9\pi\sqrt{6}}\left(\sqrt{\frac{V_{max}}{V_f}} - 1\right)^{\frac{5}{2}} \quad (3)$$

where V_{max} is the maximum fiber fraction volume which is $\pi/2\sqrt{3}$ of hexagonal fiber array, R_f is the fiber radius which is 0.01 µm and V_f is fiber volume fraction

Similarly, the fiber volume fraction, and porosity of the yarn ϵ_p, can be calculated by using the Equations (4) and (5):

$$V_f = \frac{4T_y}{d^2 10^3 P_f} \quad (4)$$

where T_y is the count of yarn, tex and P_f / g cm^{-3} is the fiber density.

$$\epsilon_p = 1 - V_f \quad (5)$$

Figure 4 shows the methodology to predict air permeability of interlock structure while Figure 5 shows the methodology to predict air permeability of rib structure. The unit cell of interlock and rib structure is placed inside the air domain which is then extruded to 2 mm at the inlet and 6 mm at the outlet. The pressure difference is then created at the front and back side of the structure by applying the inlet pressure of 300 Pa and outlet pressure of 0 Pa. The geometry is then discretized by using tetrahedral elements. The outward volume flow rate across the geometry is then calculated by the developed geometrical models.

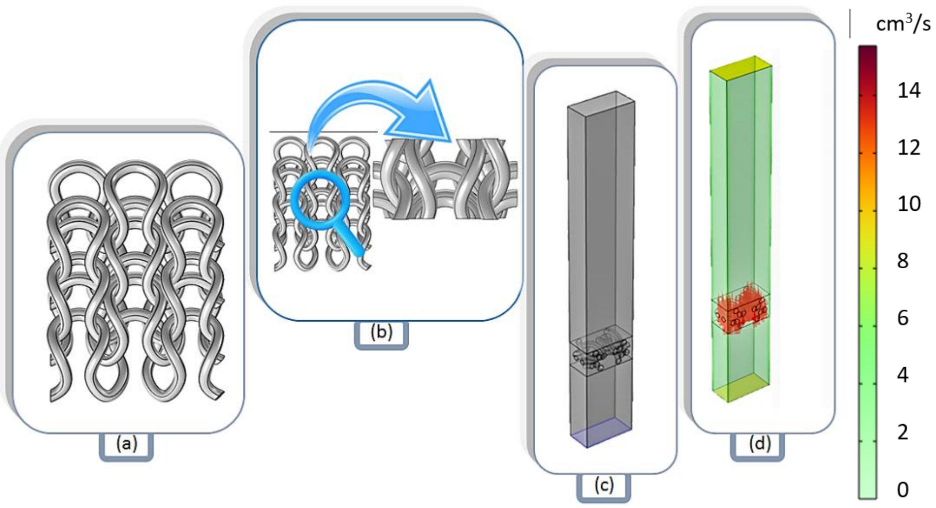

Figure 4. Methodology for prediction of the air permeability of interlock fabric: (a) interlock structure, (b) unit cell, (c) unit cell with extruded geometry, (d) predicted outward volume flow rate through the geometry

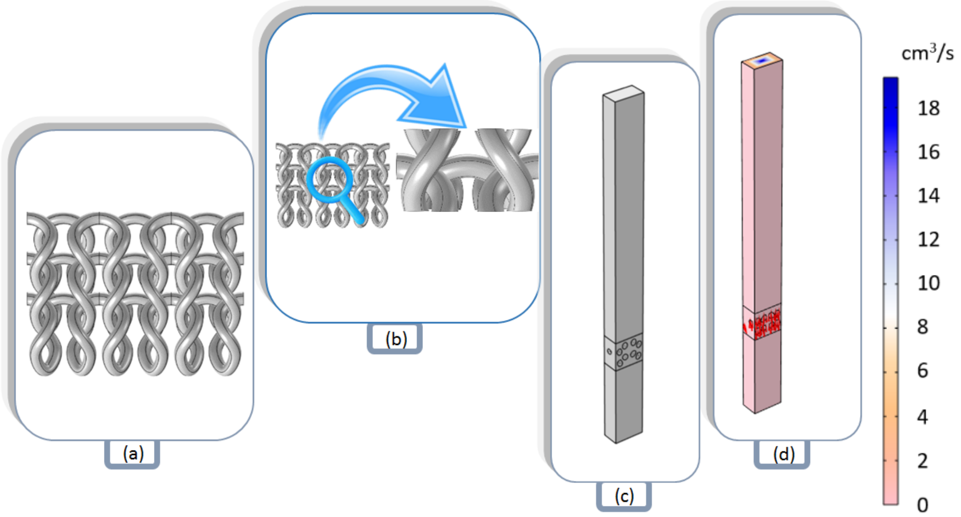

Figure 5: Methodology for prediction of the air permeability of rib fabric: (a) rib structure, (b) unit cell, (c) unit cell with extruded geometry, (d) predicted outward volume flow rate through the geometry

2. 3. 2. Thermal conductivity

Thermal resistance directly correlates with thermal insulation and is inversely proportional to the thermal transmittance. Thermal resistance is also directly related to the stitch length. As the stitch length is reduced, the thermal resistance decreases due to the increment in thickness of the fabric, and the thermal conductivity and absorptivity increase due to the increased stitch density of the fabric and the less porous structure. Also, the thermal conductivity is directly proportional to the areal density of fabric and thermal absorptivity is inversely proportional to the thermal resistance. The increase in the areal density of fabric results in the increment of contact points due to which the conductivity increases [24].

Thermal resistance and thermal insulation are directly proportional to fabric thickness. As the loop length increases, the thickness of the fabric decreases, and the structure of fabric becomes more porous due to which the thermal absorptivity is decreased.

Effective thermal conductivity of the structures, K_{eff}, is predicted by using the Fourier's law of conduction, Equation (6):

$$K_{\text{eff}} = \frac{Qt}{S\Delta T} \tag{6}$$

where Q represents the heat flux, S is the surface area, t is the thickness of fabric and ΔT is the temperature difference.

By using effective thermal conductivity, thermal resistance of the structures (R), can also be calculated by using the thickness of the fabric, Equation (7).

$$R = \frac{t}{K_{\text{eff}}} \tag{7}$$

Similarly, the thermal conductivity of the yarn in axial direction, which is 0.50648 w $m^{-1}K^{-1}$, and in the traverse direction, which is 0.038696 W m^{-1} K^{-1}, can be calculated by using Equations (8) and (9) [25]:

$$K\text{ya} = K\text{fl}V\text{fy} + K\text{air}\ (1 - V\text{fy}) \tag{8}$$

$$K_{\text{yt}} = \frac{K_{\text{ft}}K_{\text{air}}}{V_{\text{fy}}K_{\text{air}} + \left(1\text{-}V_{\text{fy}}\right)K_{\text{ft}}} \tag{9}$$

where K_{ya} represents Yarn axial thermal conductivity, K_{yt} is yarn tranverse thermal conductivity, K_{fl} and K_{ft} are Fiber thermal conductivity in longitudinal and traverse direction, respectively, V_{fy} is fiber volume fraction of yarn and K_{air} is thermal conductivity of air.

The unit cell of the interlock structure is placed inside the box which acts as an air domain so that the temperature difference can be created at the front and back sides of the fabric to predict thermal conductivity, as shown in Figure 6.

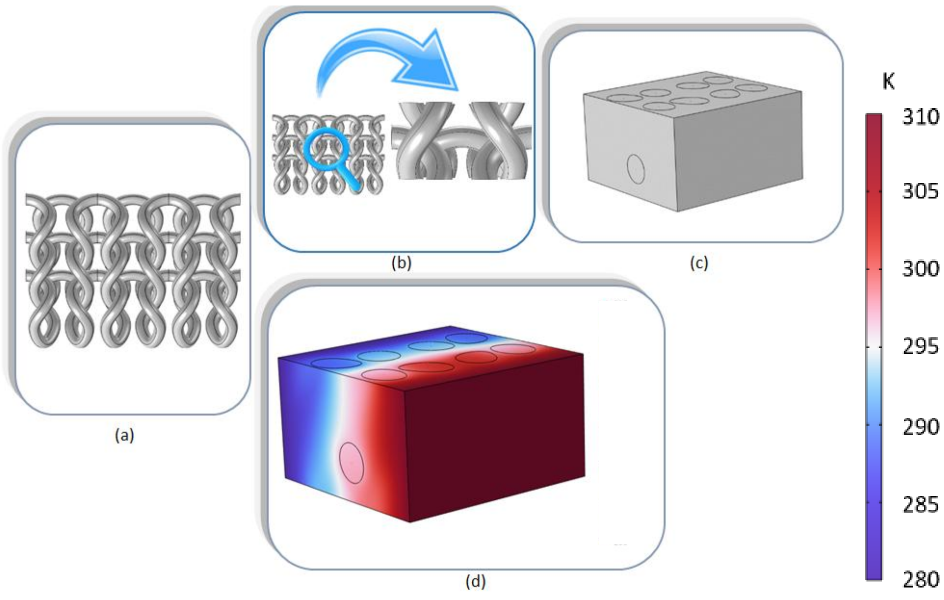

Figure 6. Methodology for prediction of the thermal conductivity of interlock fabric: (a) interlock structure, (b) unit cell, (c) unit cell with air domain, (d) predicted temperature profile

Similar methodology is opted for the Rib structure which is shown in Figure 7. Heat is transferred from the hot surface towards the cold surface. The hot surface temperature is 310 K while that of the cold surface is about 280 K. The whole geometry is then meshed by using the tetrahedral geometry, and the total net energy rate is calculated.

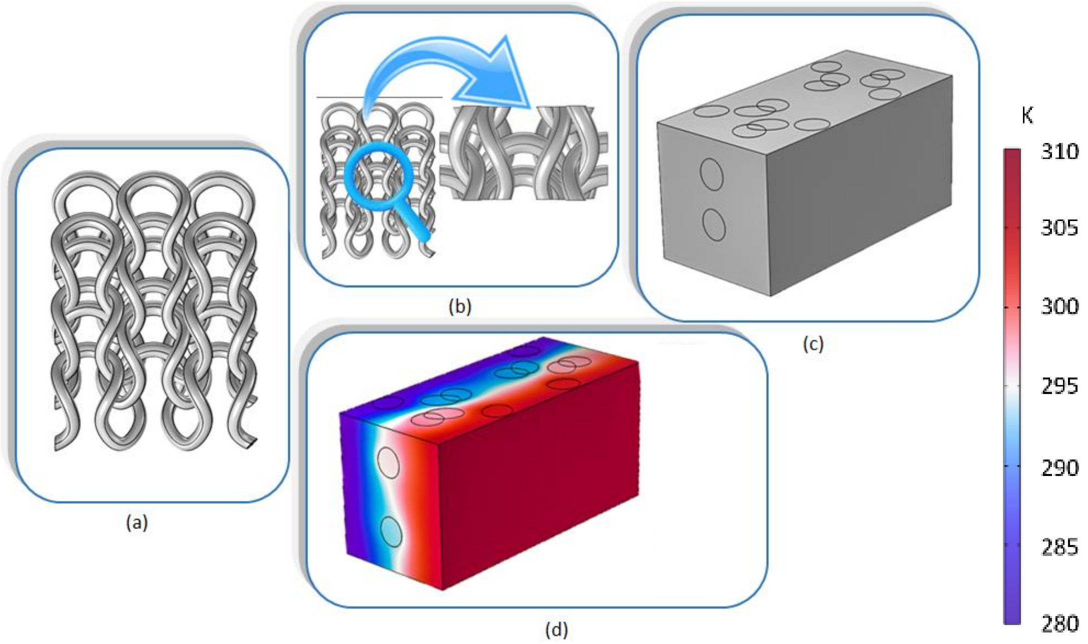

Figure 7: Methodology for prediction of the thermal conductivity of rib fabric: (a) rib structure, (b) unit cell, (c) unit cell with air domain, (d) predicted temperature profile

3. RESULTS AND DISCUSSION

3. 1. Model validation

Air permeability of the interlock and rib knitted fabrics is analyzed by using the unit cell, the image analysis and numerical modelling, as shown in Table 2.

Table 2: Air permeability of interlock and rib structures, yarn - 100 % polyester

Type of fabric	Fiber diameter, mm	Fiber volume fraction	Porosity	Air permeability, μm^2		Absolute error of model, %
				Actual	Predicted	
Interlock fabric	0.01	0.3893	0.6107	4.642	4.795	3.2
Rib Fabric	0.01	0.275	0.725	4.902	5.33	8

By using the unit cell, the thermal conductivity of the interlock and rib fabric are analyzed, and the obtained results are shown in Table 3.

Table 3: Thermal Conductivity of Interlock and rib structures, yarn – 100 % polyester

Type of fabric	Specific heat, J kg^{-1} K^{-1}		Thermal conductivity, W m^{-1} k^{-1}		Absolute error of model, %
	Yarn	Air	Actual	Predicted	
Interlock fabric	1030	1006.96	0.04112	0.0430	4.57
Rib Fabric	1030	1006.96	0.0395	0.0378	4.3

3. 2. Model utilization for parametric analysis

By using the developed validated models for interlock and rib knitted structures, the parametric analysis is then performed by gradually increasing the stitch length and decreasing the thickness of the structures to predict and analyze the effects on air permeability and effective thermal conductivity of the fabric. The results are shown in Tables 4 and 5.

Table 4: Impact of the stitch length and fabric thickness in the air permeability and thermal conductivity of the interlock structure

Fabric code	Stitch length, mm	Fabric thickness, mm	Air permeability, μm^2	Thermal conductivity, W m^{-1} K^{-1}
A1	2.76	0.60	4.770	0.04920
A2	2.82	0.54	4.795	0.04300
A3	2.86	0.48	4.850	0.04000
A4	2.90	0.44	4.863	0.03635
A5	2.95	0.40	4.891	0.03481

Table 5: Impact of the stitch length and fabric thickness on the air permeability and thermal conductivity of the rib structure

Fabric code	Stitch length, mm	Fabric thickness, mm	Air permeability μm^2	Thermal conductivity, W m^{-1} K^{-1}
B1	1.38	0.6	4.68	0.04
B2	1.43	0.58	4.752	0.0392
B3	1.68	0.54	4.955	0.03906
B4	1.89	0.5	5.33	0.0378
B5	2.3	0.46	5.45	0.037

Change in the stitch length results in the change in geometry of the overall structure and its properties which results in the change in air flow through the fabric. Air flow through the interlock and rib fabric structures are simulated in Figures 8 and 9, respectively. The velocity magnitude is shown by using the arrow lines, parallel to the air flow through the free and porous air domains. Hence, the variation in volumetric flow rate across the geometry is observed with the change of stitch length and fabric thickness.

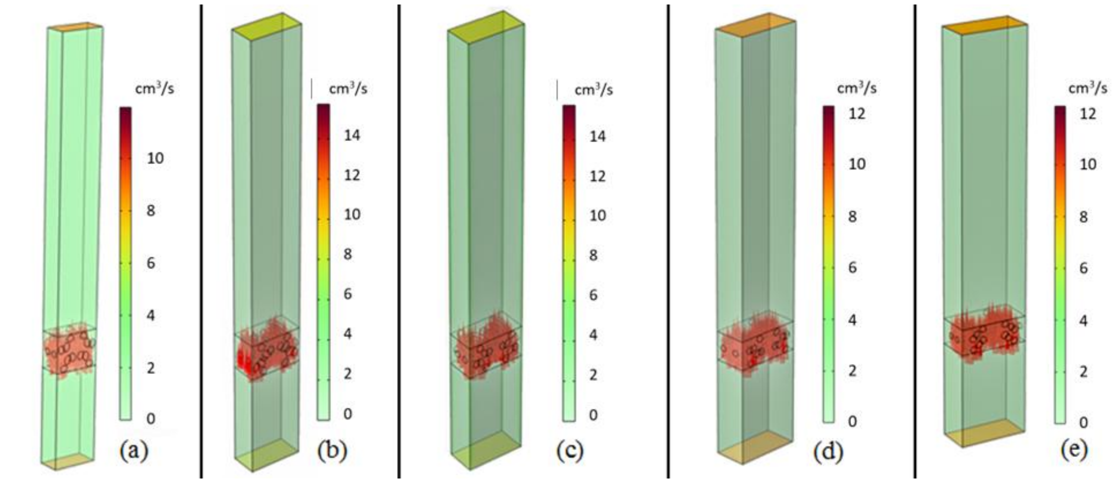

Figure 8: Simulation results of velocity magnitude in the interlock knitted structure in the free and porous air domains: (a) fabric A1, (b) fabric A2, (c) fabric A3, (d) fabric A4, (e) fabric A5

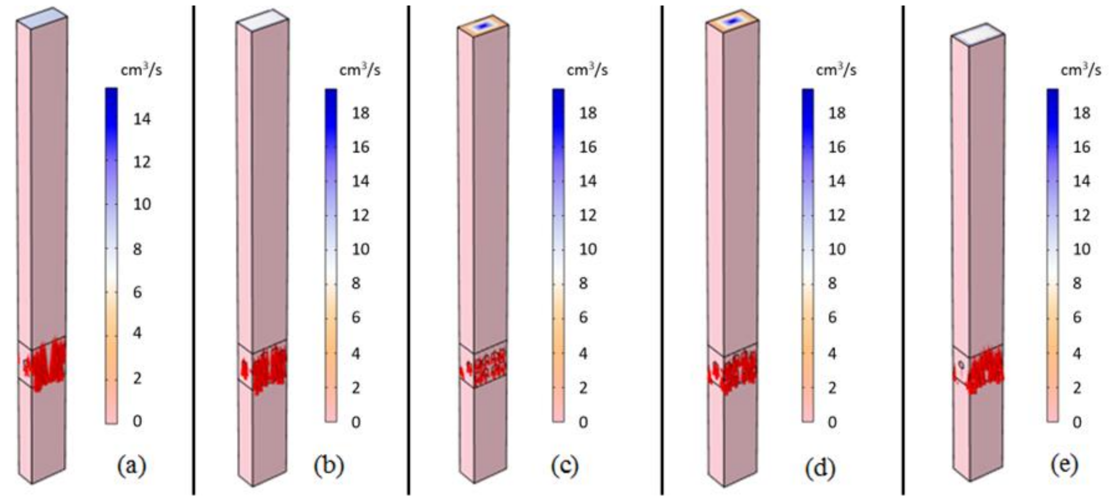

Figure 9. Simulation results of velocity magnitude in the rib knitted structures in the free and porous air domains: (a) fabric B1, (b) fabric B2, (c) fabric B3, (d) fabric B4, (e) fabric B5

Similarly, the change in the structure geometry by changing the stitch length and fabric thickness also results in the change in overall effective thermal conductivity of the fabric. The major reason behind is the change in the fiber volume fraction in the overall fabric by changing the fabric parameters. Due to the change in heat transfer the total net energy rate also varies, which results in the variation in thermal properties of the fabric. The simulation results of the heat transfer through Interlock fabric are shown in Figure 10, while the simulation results for the rib fabric are shown in Figure 11.

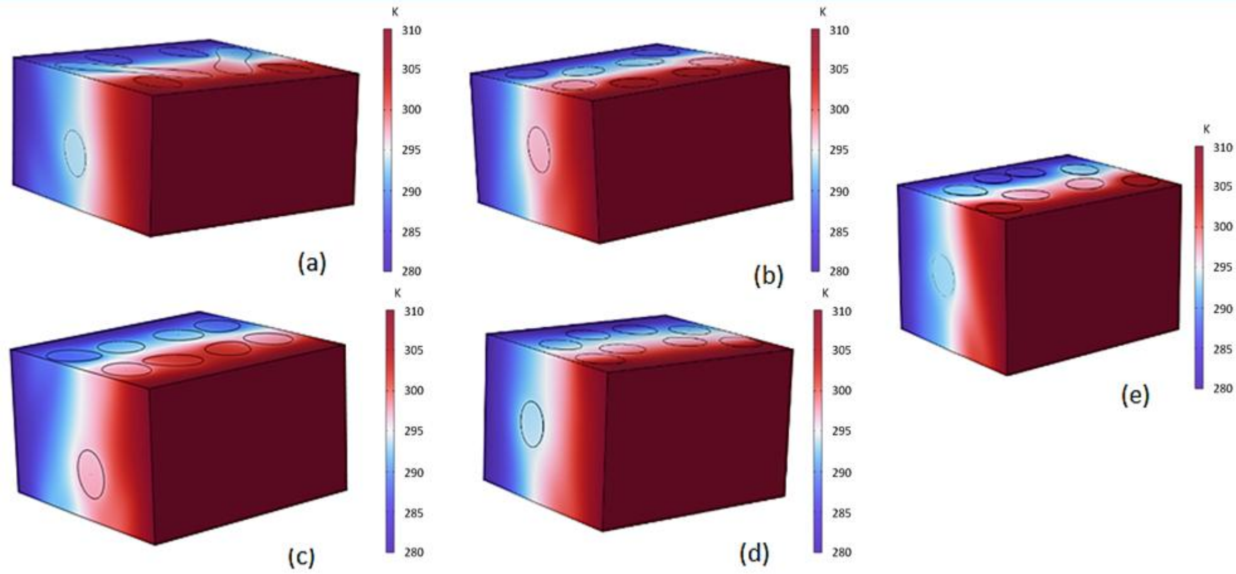

Figure 10. Simulation results of heat transfer through the unit cell of interlock fabric: (a) fabric A1, (b) fabric A2, (c) fabric A3, (d) fabric A4, (e) fabric A5

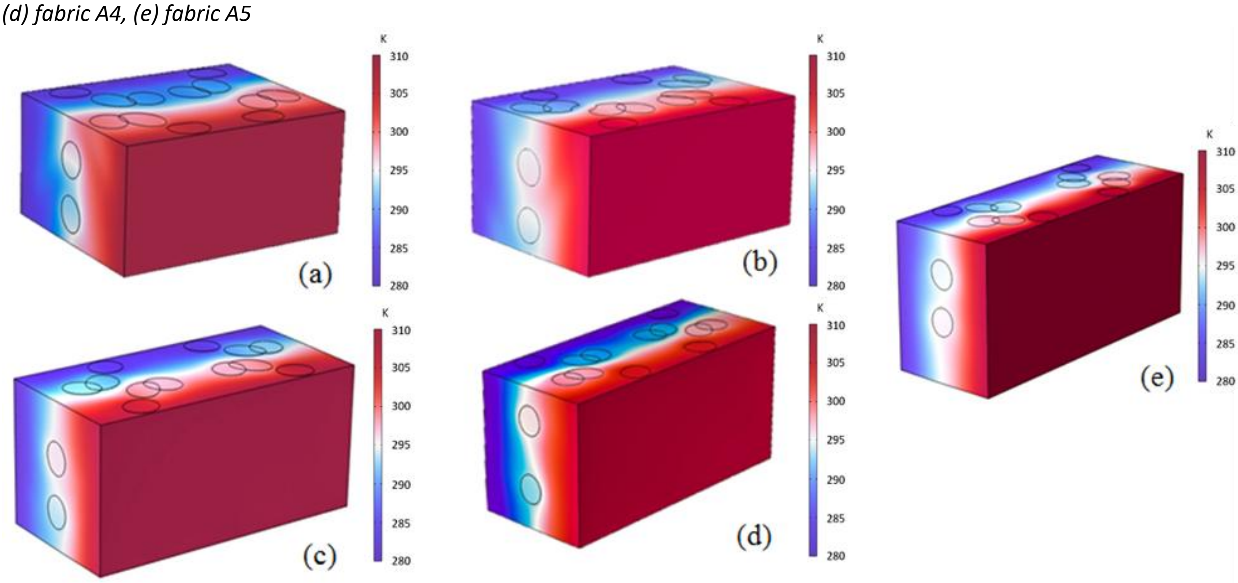

Figure 11: Simulation results of heat transfer through the unit cell of rib fabric: (a) fabric B1, (b) fabric B2, (c) fabric B3, (d) fabric B4, (e) fabric B5

Figures 12 and 13 directly show the general relationships of the air permeability and effective thermal conductivity with the fabric parameters, stitch length and fabric thickness. The following could be concluded:

a) By increasing the stitch length, the air permeability of the knitted fabrics also increases due to the decrement in stitch density and the increment in porosity.
b) Increasing the fabric thickness by keeping the yarn count and yarn diameter constant, the fabric's air permeability decreases. Hence, air permeability is directly related to the stitch length whereas inversely proportional to the fabric thickness.
c) Similarly, if the stitch length of the fabric increases, it will reduce the effective thermal conductivity of the fabric.
d) By increasing the fabric thickness, the effective thermal conductivity of the fabric also increases. Hence, the thermal conductivity is directly proportional to the fabric thickness and inversely proportional to the stitch length of the fabric.

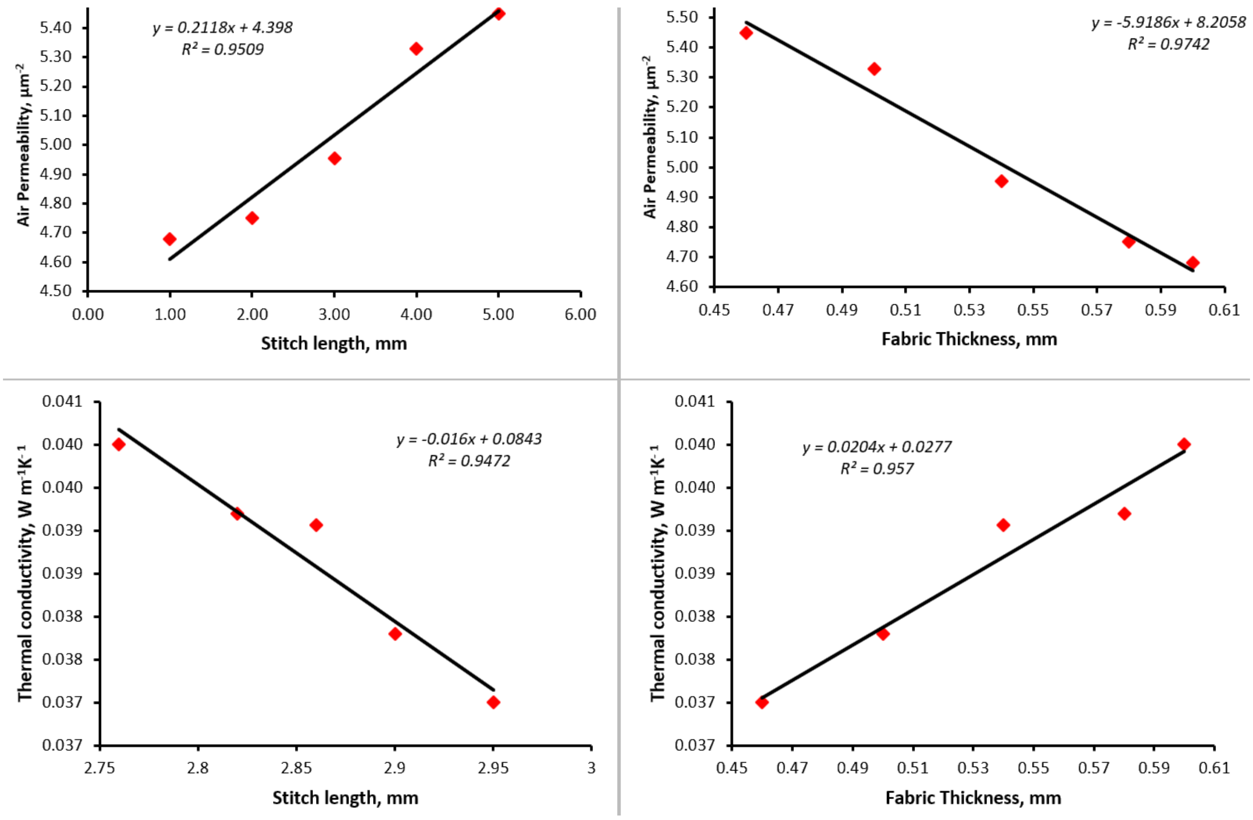

Figure 12. Relation between the air permeability and thermal conductivity predicted through interlock model with the stitch length and fabric thickness

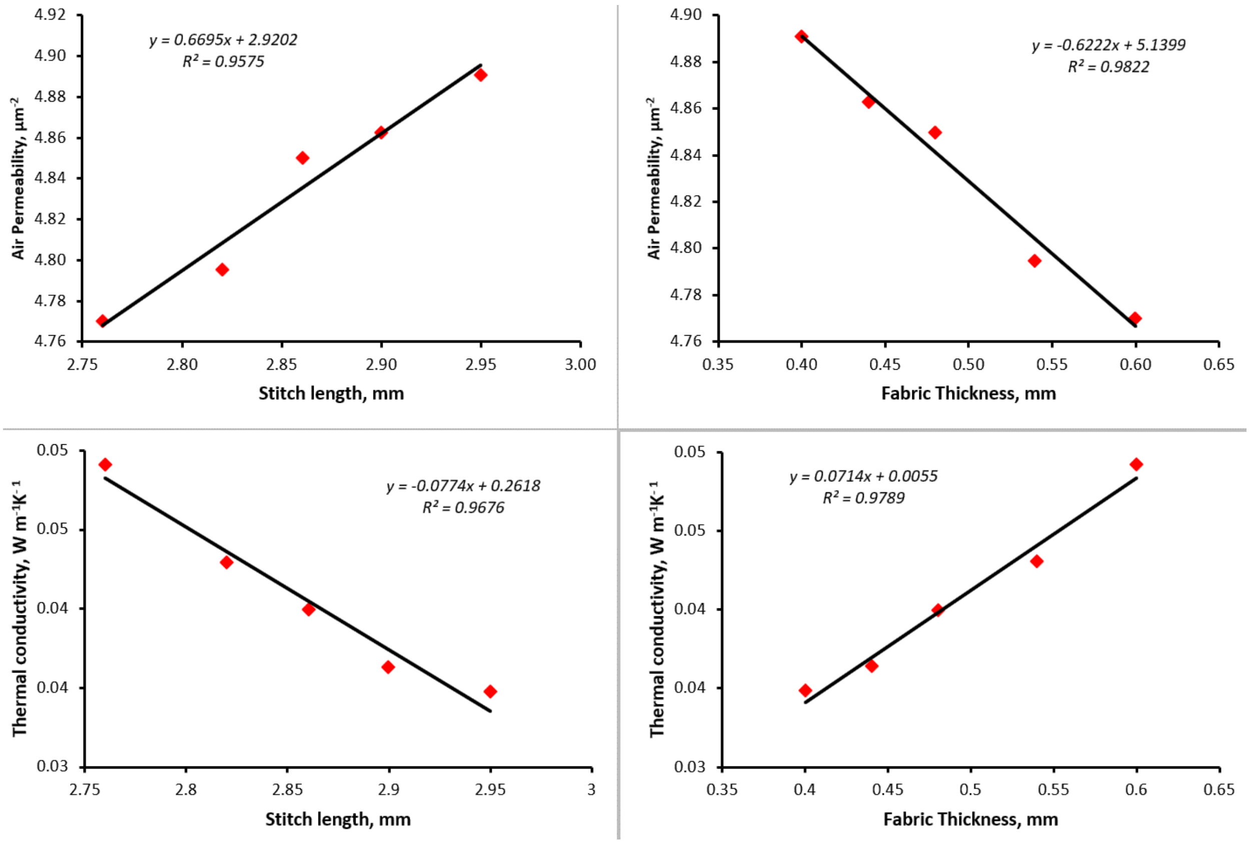

Figure 13. Relation between the air permeability and thermal conductivity predicted through rib model with the stitch length and fabric thickness

4. CONCLUSION

Functional and computational 3D models of interlock and rib knitted structures are developed by extracting the actual constructional parameters of the fabric, by using the image analysis technique, to develop a parametric 3D unit cell of the structures. The air permeability and effective thermal conductivity of the fabrics are then predicted and compared with the actual values to validate a model. The absolute error is less than 8 % between the predicted and actual value of both air permeability and effective thermal conductivity for both the structures. The parametric analysis is then conducted by changing the stitch length and thickness of the fabrics to analyze the trend and its effect on the air permeability and effective thermal conductivity. It is found that as the stitch length increases, the air permeability also increases while the effective thermal conductivity is reduced. Similarly, as the thickness of the fabric increases, by keeping the yarn diameter and yarn count constant, the air permeability is reduced, while the effective thermal conductivity is increased.

This approach and the developed models offer a powerful tool for accurately predicting and analyzing the performance of knitted fabrics, enabling more efficient and informed design processes in the textile industry, particularly for applications requiring specific thermal and comfort properties.

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REFERENCES

[1] Li YL, Chen SY, Yang LH, Cao LH. Study on three-dimension computer simulation of plain knitted fabrics. *Adv Mat Res.* 2011; 213: 595–599 https://doi.org/10.4028/www.scientific.net/AMR.213.595

[2] Sha S, Geng A, Gao Y, Li B, Jiang X, Tao H, Luo L, Yuan X, Ke H, Hu X. Review on the 3D simulation for weft knitted fabric. *J Eng Fiber Fabr.* 2021; 16: 1-10 https://doi.org/10.1177/15589250211012527

[3] Peirce FT. Geometrical principles applicable to the design of functional fabrics. *Text Res J*. 1947; 17(3): 123-147. https://doi.org/10.1177/004051754701700301

[4] Hurd JCH, Doyle, PJ. Fundamental aspects of the design of knitted fabrics. *J Text Inst* Proc. 1953; 44(8): 561-578. https://doi.org/10.1080/19447015308687861

[5] Shinn WE. An engineering approach to jersey fabric construction. *Text Res J.* 1953; 25(3): 270-277. https://doi.org/10.1177/004051755502500314

[6] Leaf GAV, Glaskin A. 43—The geometry of a plain knitted loop. *J Text Inst Trans.* 1955; 46(9): T587-T605. https://doi.org/10.1080/19447027.1955.10750345

[7] Munden D L. 26—The geometry and dimensional properties of plain-knit fabrics. *J Text Inst Trans.* 1959; 50(7): T448-T471. https://doi.org/10.1080/19447025908659923

[8] Postle R. 6—Dimensional stability of plain-knitted fabrics. *J Text Inst.* 1968; 59(2): 65-77. https://doi.org/10.1080/00405006808659967

[9] Kurbak A. Plain knitted fabric dimensions (Part II). *Text A.* 1998; 78: 36-44.

[10] Demiroz A, Dias T. A study of the graphical representation of plain-knitted structures part I: Stitch model for the graphical representation of plain-knitted structures. *J Text Inst.* 2000; 91(4): 463-480. https://doi.org/10.1080/00405000008659121

[11] Choi KF, Lo TY, An energy model of plain knitted fabric. *Text Res J.* 2003; 73(8): 739-748. https://doi.org/10.1177/004051750307300813

[12] Kyosev Y, Angelova Y and Kovar R. 3D modeling of plain weft knitted structures of compressible yarn. *Res J Text Appar.* 2005; 9(1): 88-97. https://doi.org/10.1108/RJTA-09-01-2005-B009

[13] Delavari K, Dabiryan H. Mathematical and numerical simulation of geometry and mechanical behavior of sandwich composites reinforced with 1× 1-Rib-Gaiting weft-knitted spacer fabric; compressional behavior. Compos Struct. 2021; 268: 113952. https://doi.org/10.1016/j.compstruct.2021.113952

[14] Ghatrenabi MH, Dabiryan H, Nosraty H. Modeling the Geometry of Weft-knitted Integrated Preforms as Reinforcement of Composite Joints. *Fibers Polym.* 2021; 22(9): 2572-2580. https://doi.org/10.1007/s12221-021-1180-x

[15] Omrani E, Dibajian SH, Hasani H. Development of ABAQUS Plugin Predicting the Mechanical Behavior and Failure Modes of Weft knitted-Reinforced Composites. *Fibers Polym*. 2025; 26: 883-907. http://dx.doi.org/10.1007/s12221-025-00850-2

[16] Huang R. Characterization and Modeling of Pores in Weft-Knitted Fabrics. PhD Dissertation, North Carolina State University; 2023. https://www.lib.ncsu.edu/resolver/1840.20/40816

[17] Ogulata RT. Air permeability of woven fabrics. *J Text Appar Tech and Manag.* 2006; 5(2): 1–10. https://www.researchgate.net/publication/283451342_Air_Permeability_of_Woven_Fabrics

[18] Jeddi AAA, Dabiryan H. Ideal stitch model for interlock-knitted fabric. *J Text Inst.* 2008; 99(4): 369–374. https://doi.org/10.1080/00405000701584444

[19] Li Y L, Yang L H, Chen S Y, Yuan J, Li N-N. 3D modeling and simulation of fancy fabrics in weft knitting. *J DongHua Uni*. 2012; 29(4): 351-358. https://doi.org/10.19884/j.1672-5220.2012.04.013

[20] Kejkar VKV, Tjprc. An Effect of Stitch Length. Lycra Percentage on Comfort Properties of Knitted Sport Wear. *Int J Text Fash Tech.* 2019; 9(3): 1-10. https://paper.researchbib.com/view/paper/225864

[21] Chakroun M G, Benltoufa S, Fayala F. The effect of fabric's structure on the breathability and the drying rate properties. *Comm Develop Assem Text Prod.* 2021; 2(1): 61–69. https://doi.org/10.25367/cdatp.2021.2.p61-69

[22] Megeid ZMA, Al-Bakry M, Ezzat M. The influence of stitch length of weft knitted fabrics on the sewability. *J Amer Sci.* 2011; 7(8): 610–617. https://www.jofamericanscience.org/journals/am-sci/am0708/068_6200am0708_610_617.pdf

[23] Gebart BR. Permeability of unidirectional reinforcements for RTM. *J Compos Mater* 1992; 26(8): 1100–1133. https://doi.org/10.1177/002199839202600802

[24] Afzal A, Ahmad S, Rasheed A, Ahmad F, Iftikhar F, Nawab Y. Influence of fabric parameters on thermal comfort performance of double layer knitted interlock fabrics. *Autex Res J.* 2017; 17(1): 20–26. https://doi.org/10.1515/aut-2015-0037

[25] Kaviany M. *Principles of Heat Transfer in Porous Media.* 2nd ed., Springer, New York, USA; 1995. https://doi.org/10.1016/S0017-9310(05)80083-3

Predviđanje funkcionalnih karakteristika interlok i rebrastih pletiva korišćenjem 3D računarskog modelovanja i analize

Hassan Ali, Salma Farooq, Muhammad Owais Raza Siddiqui, Muhammad Dawood Husain i Saira Faisal

Department of Textile Engineering, NED University of Engineering and Technology, University Road, Karachi, Pakistan

(Naučni rad)

Izvod

U ovom radu je razvijen računarski model interlok i rebrastih pletiva kako bi se predvideli propustljivost vazduha i termička svojstva tkanine. Ponavljajuće jedinične ćelije interlok i rebrastih pletenih struktura razvijene su u COMSOL Multiphysics® softveru, korišćenjem stvarnih parametara tkanine ekstrahovanih uz pomoć tehnike analize slike. Dobijeni rezultati modelovanja s zatim upoređena sa stvarnim eksperimentalnim vrednostima za tkaninu. Pored toga, validirani računarski model je korišćen za analizu uticaja dužine boda i debljine tkanine na termička svojstva i vazdušnu propustljivost tkanine. Utvrđeno je da dužina boda direktno proporcionalna vazdušnoj propustljivosti i obrnuto proporcionalna efektivnoj toplotnoj provodljivosti tkanine. Debljina tkanine direktno utiče na efektivnu toplotnu provodljivost, a obrnuto proporcionalno na vazdušnu propustljivost tkanine.

Ključne reči: Propustljivost vazduha; efektivna toplotna provodljivost; pletenje potke; računarska dinamika fluida; ponavljajuća jedinična ćelija