Mansoura Engineering Journal

Volume 16 | Issue 1 Article 27

5-1-2021

# Factors Influencing the Air Resistance of Acrylic Single Jersey Fabrics.

Hemdan Abou-Taleb
*Associate Professor., Textile Engineering Department., Faculty of Engineering., El-Mansoura University., Mansoura., Egypt.*, haboutaleb@mans.edu.eg



Recommended Citation
Abou-Taleb, Hemdan (2021) "Factors Influencing the Air Resistance of Acrylic Single Jersey Fabrics.," *Mansoura Engineering Journal*: Vol. 16 : Iss. 1 , Article 27.
Available at: https://doi.org/10.21608/bfemu.2021.169874

# FACTORS INFLUENCING THE AIR RESISTANCE OF ACRYLIC SINGLE JERSEY FABRICS

العوامل المؤثرة على مقاومة الهواء لأقمشة الجيرسيه المفردة المصنوعة من الاكريليك

By HEMDAN A. ABOU-TALEB

Textile Engineering Dept., Faculty of Engineering, Mansoura University,
Mansoura, EGYPT

خلاصة — فى هذاالبحث مقاومة الهواء لأقمشة الجيرسيه المصنوعة من خيوط الاكريليك أمكن قياسها ودراستها. وقدأمكن التوصل الى معادلة رياضية لحساب المسامية وذلك بواسطة استخدام موديل هندسى لربط المسامية مع قطر الخيط وعدد الصفوف والاعمدة فى وحدة الطول . بواسطة تحليل الانحدار المتعدد أمكن التوصل الى معادلة معملية تربط مقاومة الهواء لأقمشة الجيرسيه مع معامل الضيق والمسامية وكثافة التضخم. باستخدام هذه المعادلة أمكن التنبوء بمقاومة الهواء لأقمشة الجيرسيه بدقة .

In this paper the measured air resistance of single jersey fabrics made from acrylic yarns is investigated. A mathematical approach on a geometrical model is attempted to relate the fabric porosity to yarn diameter and wale and course spacing. An empirical equation is fitted to the measured air resistance data using multiple regression analysis. The regression equation relates the air resistance to the fabric parameters of tightness factor, porosity and bulk density. This empirical relationship is shown to predict the air resistance accurately.

## 1. INTRODUCTION

The air resistance of a textile fabric whieh is the recriprocal of fabric air permeability is an interested property. The air resistance of a fabric is useful in evaluating air filtration fabrics, parachute fabrics and sound absorbing fabrics. In apparel fabrics, the air resistance is an important fabric comfort factor which air flow through the fabric is the principal source of body temperature regulation.

The main factors that would control the air resistance of nonwoven fabrics would be the amount of exposed fibre surface area and the size and shape of the shannels through which the fluid flows. As such, the air resistance is a complex function depending on a number of fabric characteristics sueh as weight per unit area, thickness, porosity and fibre fineness[1]. Gorbach[2] investigates the air permeability of fabrics in relation to structure. He derives the basic aerodynamic characteristics of filtration process and shows that, for constant aerodynamic resistance, the resistance of fabrics to air movement is governed by eover factor, which is in turn dependent only on the coefficient of friction. An obvious factor that must influence air permeability is the mean pore size of the woven structure and this parameter has received some attentior in recent years[3]. Perner and Raue[4] set up an equation to calculate the degree of cover of a Malimo fabric and then air permeability measurements is carried out in an attempt to demonstrate the accuracy of their equation. They deduced that the pore volume can characterize air permeability under certain defined conditions. Knitted fabrics are tested on Welfer's apparatus and it is shown that air permeability is linearly related to the theoretical cover factor[5]. In structural effects, pul-knitted, rib-knitted and plain-knitted structures are shown to decrease, in that order, in their air permeability, air pressure and fibre content also having some influence[6]. Subramaniam et al[7] pointed that the air permeability of multi-fibre systems of needle punched nonwovens is strongly dependent on the fibre volume fraction. Hence in predicting the air permeability of needle punched nonwovens, the fibre volume fraction should be taken into consideration. Also Dent[8] shows that, although the air permeability of nonwoven fabrics depends primarily on the web weight per unit area as pointed by Kothari and Newton[9], it depends secondly on the fabric density. The main factors that would control the air

In the last twenty years, several studies have correlated the air permeability with fabric geometry. Most of the work reported in the literature was concerned with woven and nonwoven fabrics, but with respect knitted fabrics very little work has been done on this topic.

The aim of this work is to study the effect of geometrical properties on the air resistance of single jersey fabrics.

## 2. THEORETICAL PREDICTION OF FABRIC POROSITY

The porosity of single jersey fabrics could be calculated by considering the geometrieal model shown in Fig.1. In this model, it could be assumed that the projection of the central axis of the stitch yarn on the plane of the fabric is composed of straight portions and circular arcs of yarn diameter d. The structure repeat of jersey with height B and width A can be taken into consideration for calculating the porosity:

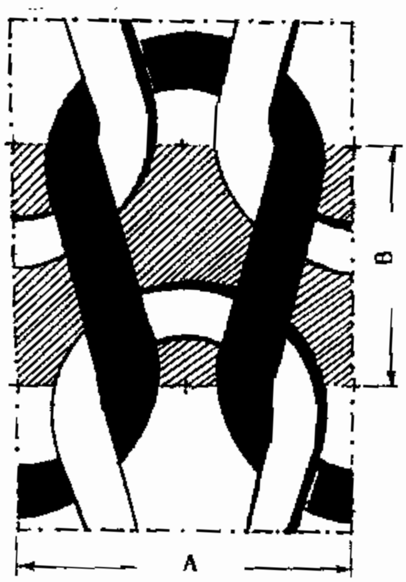


Fig. 1

Geometrical Model of Jersey Stiteh

The porosity (air volume fraction) P of a fabric defined as the ratio of open space to the total volume of the porous material was calculated as follows:

$$P = \frac{\text{air space volume}}{\text{fabric volume}} = 1 - \frac{S}{A.B} \qquad \ldots (1)$$

where S - projected area of stith parts

The area of the two straight portions of stitch =

$$= 2d\ (B^2 + d^2)^{1/2} \qquad \ldots (2)$$

and the area of total arc portions of stitch =

$$= \pi d\ (0.5\ A + d) \qquad \ldots (3)$$

The area covered by both the sets of straight and arc portions in each stitch is equal to $4d^2$.

Then, $$S = 2d\ (B^2 + d^2)^{1/2} + \pi d\ (0.5A + d) - 4d^2 \qquad \ldots (4)$$

Thus porosity or air volume fraction could be predicted.

## 3. EXPERIMENTAL

### 3.1 Fabrics Produced

Single jersey fabrics were prepared from 21x4, 21x6, 21x8 and 21x10 yarn tex with a twist multiplier of 2.7 for single acrylie yarns. Samples were prepared on a Passap duomatic 80 V-bed flat Knitting machinc with a length of 52 inches, 8 needles/inch gauge and 180 needles in both needle beds. By adjusting the cam, different stitch lengths were taken for each yarn count.

### 3.2 Tests

Stitch length was measured by unroving the fabric and measuring the length of yarn knitted into the course by appling a load (normally 10 grammes) sufficient to remove the knitting crimp without causing yarn extension [10]. Course and wale densities were measured using a thread counting glass. Thickness was measured with a Shirley thiekness meter with a pressure of 5 $gm/cm^2$. Mass per unit area was measured by weighing a known area of a fabric on a balance with a sensitivity of 0.001 g. Air resistance was measured using the Japanese Joyosaiki Tester. From the measured pressure difference (5 mm. of water) between the two sides of the fabric, the air permeability can be calculated using special tables. Consequently, air resistance can be determined.

## 4. RESULTS AND DISCUSSION

Figures 2, 3, 4 and 5 show the change of air resistance with stitch length, stitch density, mass per unit area and fabric thickness respectively. In general the air resistance increases with stitch density, mass per unit area and thickness, but decreases with stitch length. There is some of seatter, which may he due to the interaction effect of other fabrie parameters. Therefore, the air resistance is also affected by altering three other variables such as tightness factor, purosity and fabric hulk. Fabric tightness is defined as($K= \sqrt{tex} / L$), where L is the average stitch length (cm), fabric porosity or air volume fraction could be pedicted by the relationship deduced from the geometry of knitted stitch as presented in Equation 5 and fabric bulk is defined as the reciprocal of fabric density. The latter variables chosen here for analysis were related to the air resistance as shown in Figures 6,7 and 8.

The effect of fabric tightness on the air resistance is shown in Fig.6. The air resistance increases with the tightness factor of the fabric, but as stated previously, it also decreases the diameter of the channels in the fabric. Consequently, the air resistance will increase with the tightness factor as indicated in Fig.6.

As a consequence, the air resistance will decrease with the fabric porosity as shown in Fig.7. In agreement with the previous discussion, Figure 7 also indicates that a fabric manufactured with higher porosity will have lower air resistance.

Similarly, the curve in Fig.8 shows that air resistance decreases with increasing fabric bulk. This curve results because the heavier fabrics have greater air resistance. The increase in fabric weight, will also increase the desity of the fabric where the thickness of fabric samples is approximately held constant. The increase in density will decrease the size of the air passages in the fabric resulting in a higher resistance to the flow of air. The use of fabric bulk is to be preferred to mass per unit area and thickness since it is less affected by yarn tex.

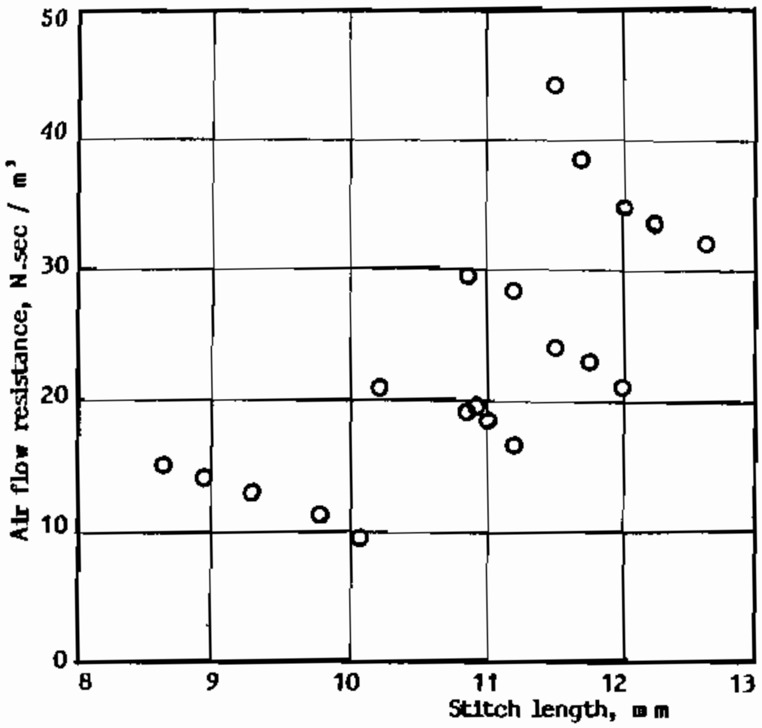


Fig.2
Influence of stitch length on the air resistance

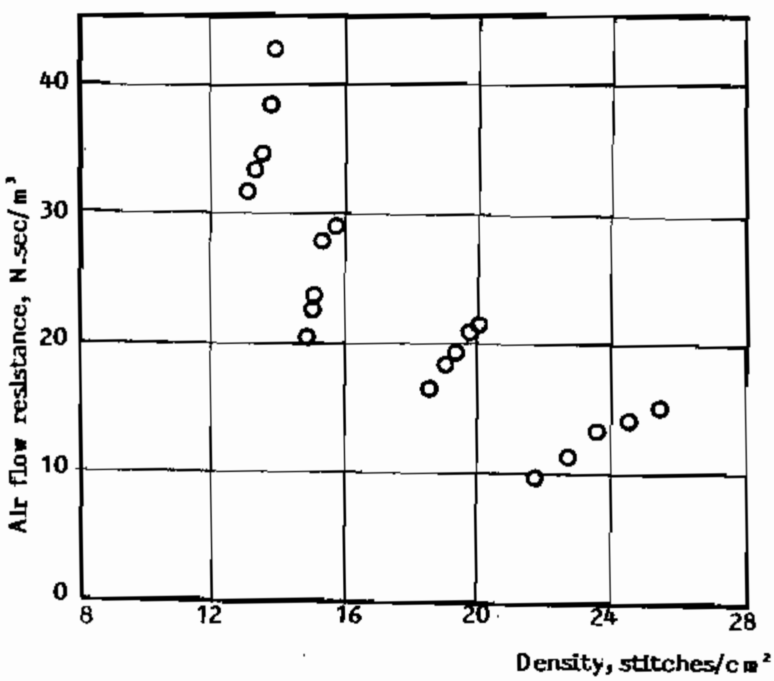


Fig.3
Influence of stitch density on the air resistance

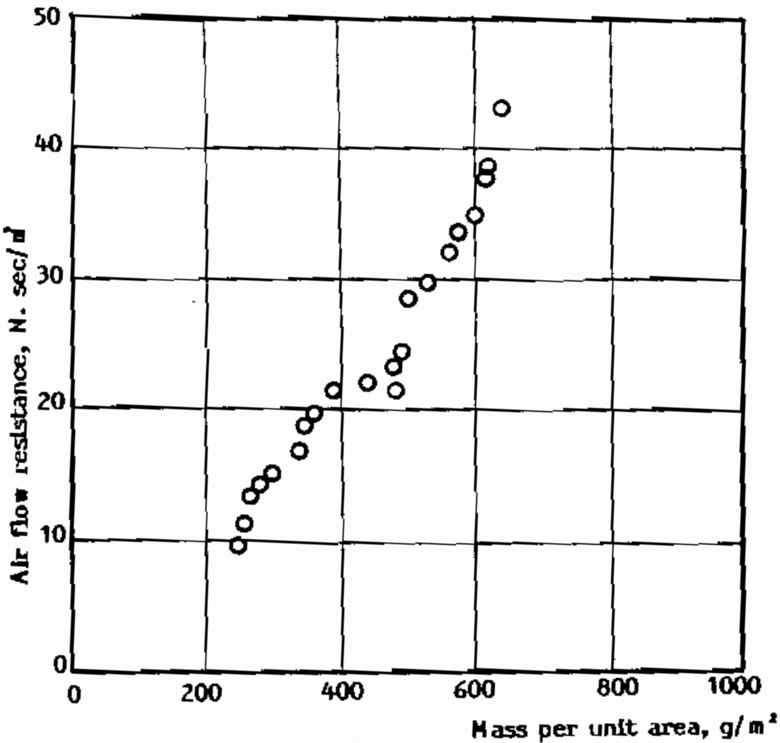


Fig.4
Influence of mass per unit area on the air resistance

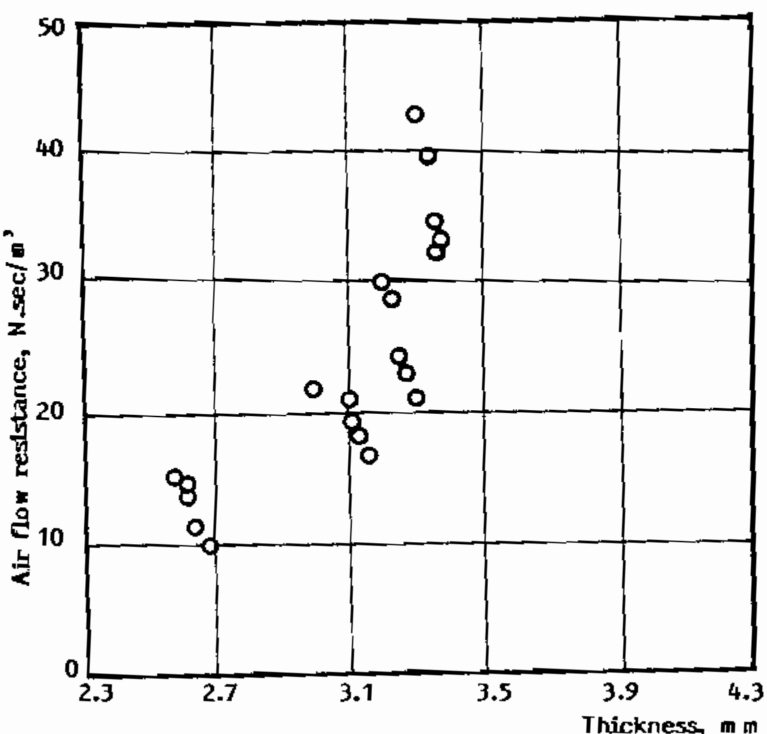


Fig.5
Influence of fabric thickness on the air resistance

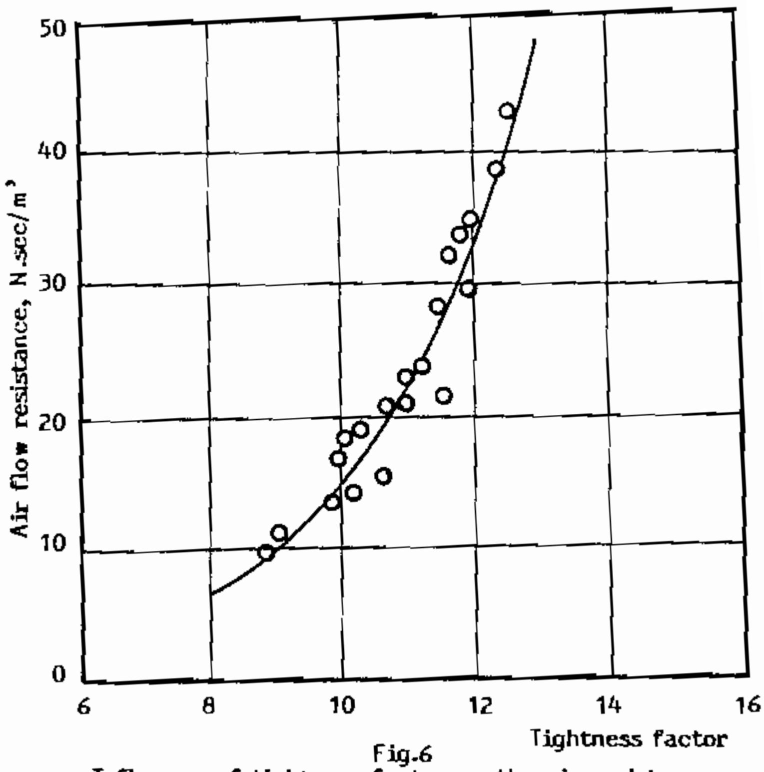


Fig.6
Influence of tightness factor on the air resistance

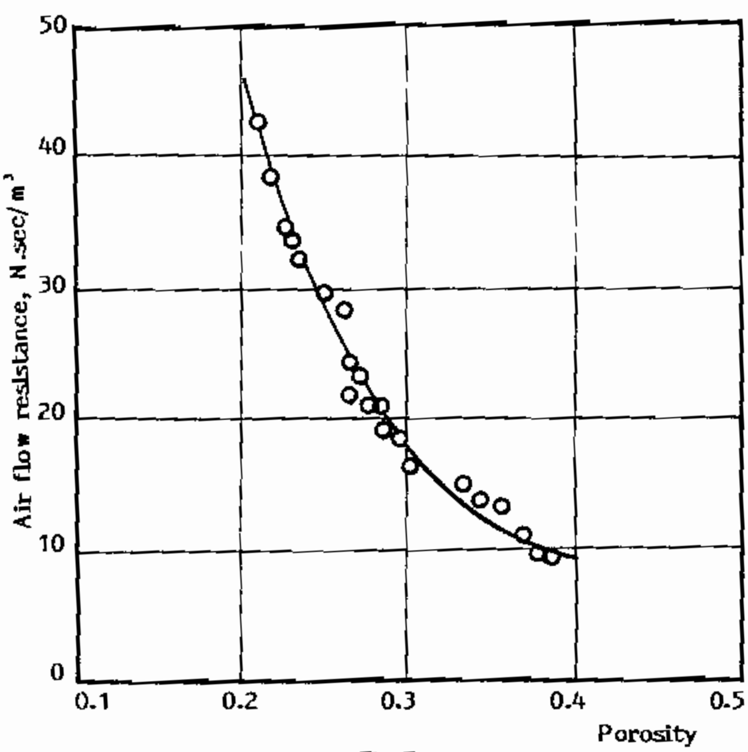


Fig.7
Influence of fabric porosity on the air resistance

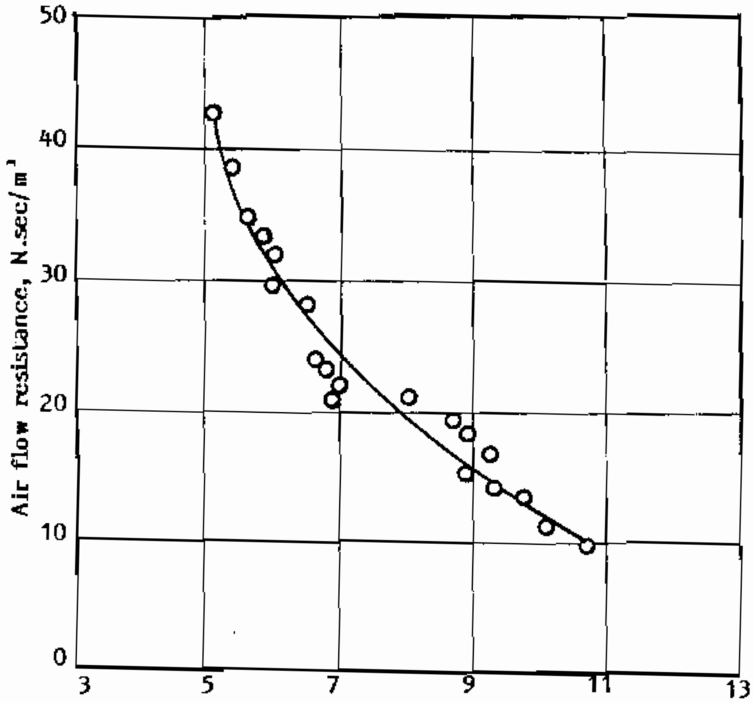


Fig.8

Influence of fabric bulk on the air resistance

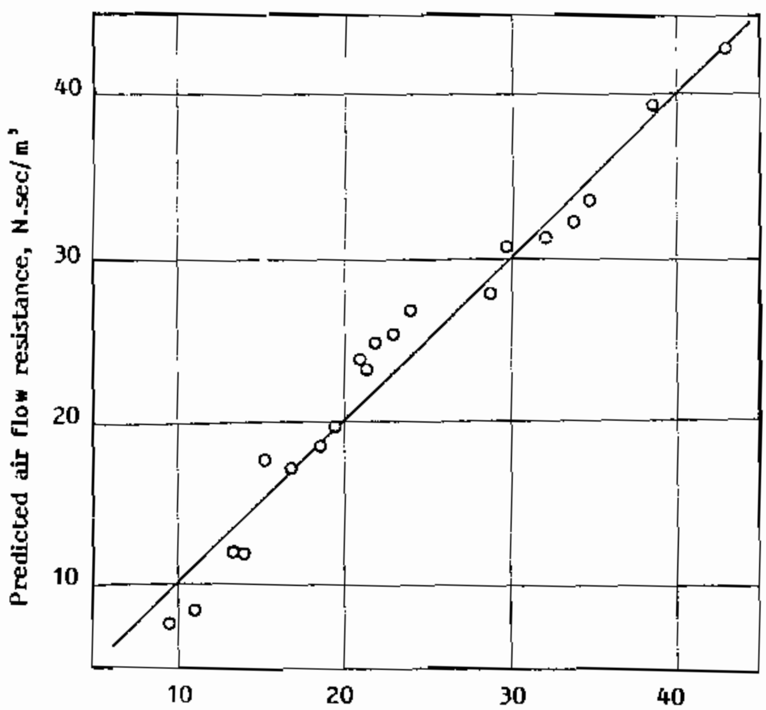


Fig.9

Comparison of measured and predicted air resistance

To investigate the interaction of fabric geometric properties, an equation relating the fabric air resistance to the variables of tightness factor, porosity and fabric bulk was fitted to the experimental results using multiple regression analysis[11,12]. The results of the multiple regression analysis are

$$R = 19.458 + 3.13\ K - 75.27\ P - 1.145\ B \qquad \ldots (6)$$

Where K = tightness factor of fabric, P=porosity of fabric and B=fabric bulk ($cm^3/g$), R=air resistance ($N.S.M^{-3}$). The correlation coefficient = 0.96. The fitted regression equation was used to predict the air resistance for each fabric. Fig.9 shows the comparison between the measured and predicted air resistance. As can be seen, the points fall on a stright line normally distributed with no bias, indicating that the empirical Equation 6 gives a good fit to the experimental data.

The correlation coefficient between the fitted equation and the experimental results as indicated in Equation 6 is 0.96. The correlation coefficient is the ratio of the total variation in the predicted air resistance, which can be explained by the relationship existing between the air resistance and tightness factor, porosity and fabric bulk. A correlation coefficient of 0.96 shows that 96% of the variation in the air resistance is due to the relationship between the air resistance and the variables as presented in Equation 6.

The empirical equation discussed above predicts the air resistance for twenty random samples well. As such, the empirical equation can be useful to a manufacturer who can relate tightness factor, porosity and fabric bulk to his knitting machine parameters. By changing the machine parameters, the manufacturer can produce a fabric of required air resistance. For example, in the case of single jersey fabrics, the tightness factor, porosity and fabric bulk will be related to yarn linear density and stitch length version. Using the empirical equation, the manufacturer can estimate the yarn linear density and stitch length version required to produce a jersey fabric of required air resistance.

## 5. CONCLUSIONS

The resistance to the airflow of a single jersey fabric is dependent on tightness factor, porosity and fabric bulk. At the same time the porosity was calculated from a geometrical model of a fabric by means of knowing the yarn diameter, the wale and course spacing. On the basis of the discussion and the empirical equation fitted to the data, it could be deduced that air resistance of single jersey can be affected by changing yarn linear density and stitch length version.

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