ISSN 1392–1320 MATERIALS SCIENCE (MEDŽIAGOTYRA). Vol. 9, No. 1. 2003

Dependence of Air Permeability on Fabric Porosity and Integrated Fabric Firmness Factor φ

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Received 03 September 2002; accepted 20 October 2002

Synthetic filtering materials are quite widely used for the air filtering, and the filtering characteristics depend on the structure of fabrics. The air permeability of fabrics may be kept as one of characteristics of filtering parameters of the fabric. This property is also important for the fabrics used in aviation industry. In this article features of the technical fabrics, dependence of the air permeability from various parameters of the structure of fabrics are analysed. In the article the fabrics woven from various polyester multifilament yarns with different sets of yarns, dependencies of air yield permeating from the areas of fabric pores are presented. It has been found that yield of air permeating in fabrics also depends on the integrated fabric firmness factor φ. In the article dependencies of air permeability on the integrated fabric firmness factor φ is analysed.

Keywords: air permeability, porosity of fabric, fabric structure parameters.

1. INTRODUCTION

Technical fabrics widely are used in air filters. The filtration quality depends on the filtering characteristics of a fabric, which are determined by fabric's structure. In aviation industry polyester fabrics woven from multifilament polyester yarns are used also and the characteristics of air permeability are important, too [1]. The air permeability of a fabric could be discussed as one of the filtering characteristics.

The fabric porosity determines part of the air yield that gets through the pores of a fabric, and which part of it permeates through fabric yarns. It is self-evident that the air that permeates through yarns becomes cleaner than that getting through the pores [2]. On the fabric structure one can distinguish between places without yarns and places in which yarns block up the air. The latter ones could be further divided into areas covered by the warp, areas covered by the weft, and areas covered by both the warp and the weft, i.e. the places in which the warp and the weft interlace [3].

The investigations of determination of parts of yield permeated through yarns, yarn intersection points and pores are presented in [3]. A very strong relation between the relative areas of fabric pores S_p and fabric cross-section was stated also.

The shape and dimensions of the cross-section are determined by the peculiarities of the raw material of yarns, the fabric density, the parameters of the weaving technology, etc. That is why the form of the cross-section of a thread is usually approximated, i.e. expressed in a geometrical figure most exactly corresponding to the shape of the cross-section. At present various mathematical models are suggested. While exploring actual fabrics, particularly those made of multifilament yarns, it has been noticed that at the intersection points of threads their cross-section takes form of a lens [4].

In this article the yarn cross-section is considered as having the form of lens (this model of multifilament yarns is most often found in practice) and the influence of fabric porosity on air permeability is investigated.

2. EXPERIMENTAL RESULTS AND DISCUSSIONS

During the present experiment fabrics woven in plain weave from polyester multifilament yarns with different densities of the warp and the weft were checked.

Air yield permeating through fabric Q and the relative areas of fabric pores S_p have been measured.

The relative area of fabric pores S_p was calculated according to the equation:

$$S_p = l_1\, l_2\, P_1\, P_2, \tag{1}$$

here P_1 and P_2 is the set of the warp and the weft yarns, l_1 and l_2 are the distances between the projections of the warp and the weft cross-sections onto the fabric plane-surface.

Fifteen different fabrics have been investigated. There were checked fabrics woven in plain weave from polyester multifilament twisted 29.4 tex yarns (first group of fabrics) with various set of the warp and the weft (the set of this as well as for others groups was: $S_1 = 160 \div 310\ \mathrm{dm}^{-1}$, $S_2 = 110 \div 210\ \mathrm{dm}^{-1}$). The dependence of the air permeability Q on the relative area of fabric pores S_p is presented in Figure 1.

One can see from Figure 1, the dependence of the air permeability Q on relative area of fabric pores S_p is expressed by the equation of the second order with quite a high correlation ($R^2 = 0.9167$).

During experiment it was also established dependence of air permeability Q on relative area of pores of fabric S_p of the plain weave fabrics (sixteen different fabrics), woven from multifilament polyester yarns - the warp is 29.4 tex and the weft is 27.7 tex (second group of fabrics). It is important to stress that 27.7 tex yarns are twistless yarns, which projection onto fabric, having the same density, is bigger then yarns 29.4 tex (for example if set of

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weft is 150 dm^{-1}, projection of 29.4 tex yarns is 0.39 mm, then 27.7 tex yarns – 0.47 mm. If set is 125 dm^{-1}, projection of 29.4 tex yarns is 0.4 mm, then 27.7 tex yarns – 0.5 mm).

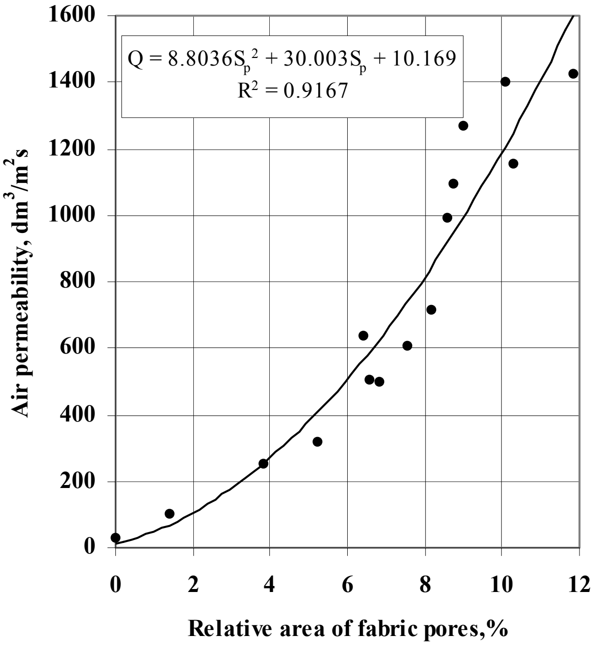

Fig. 1. Dependence of air permeability Q on relative area of fabric pores S_p of the fabrics of first group

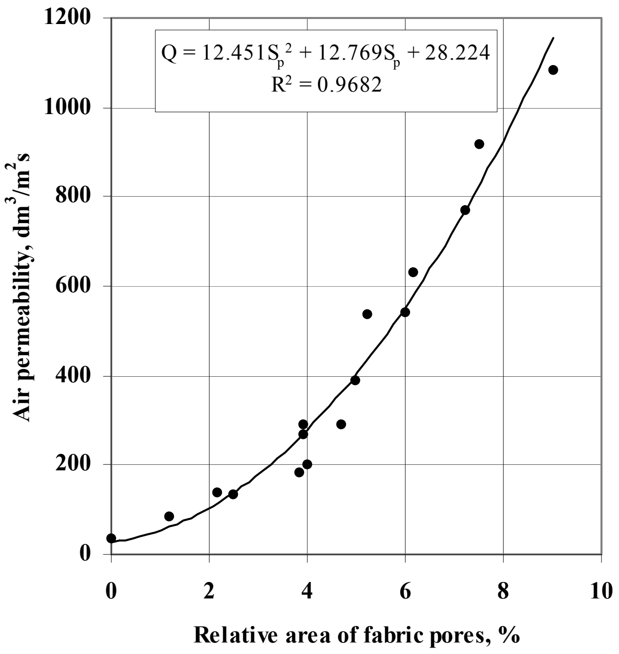

Fig. 2. Dependence of air permeability Q on relative area of fabric pores S_p of the fabrics of second group

Though the first group (warp and weft from 29.4 tex yarns) are filter and the second are aviation fabrics, but in this case also was received similar dependence like in the first case. The dependence of air permeability on relative area of pores of the fabric of the second group is presented in Figure 2.

The third group of fabrics checked in this investigation was woven also in plain weave from polyester multifilament yarns. In these two different fabrics were used folded 15.6 tex × 2 warp and 29.4 tex or 27.7 tex weft yarns.

The dependence of air permeability Q from relative area of fabric pores S_p of the all groups of fabrics (the total 33 different fabrics) is presented in Figure 3.

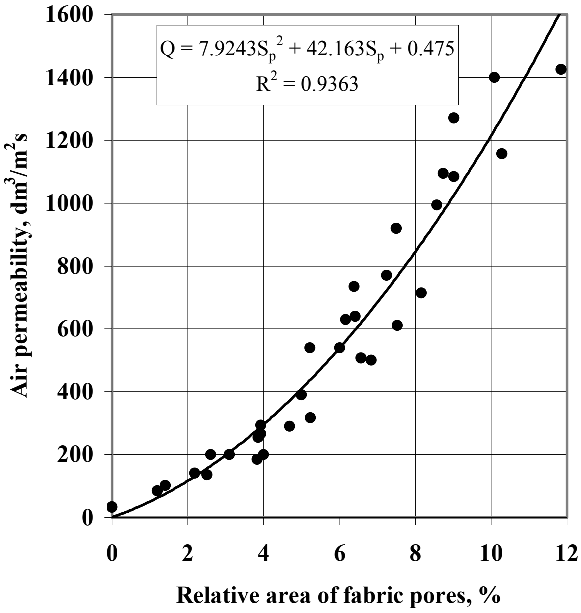

Fig. 3. Dependence of air permeability Q from relative area of fabric pores S_p of all groups of the fabrics

As it is observed though folded warp (15.6 tex × 2) were used in a fabric, but the yield of air permeability dependently from the relative area of pores of the fabric changes like in previous two cases, when were used not folded 29.4 tex warp. In this case (for all three groups of fabrics) is received the equation of the second order with quite a high correlation ($R^2 = 0.9363$) as well.

It means that dependence of air permeability on relative area of pores is similar to the all polyester fabrics that have similar linear densities yarns (not taking into account the structure of these yarns (twisted they are or not, folded or not)).

Air permeability Q also depends on the structure of a fabric. There are known various factors describing the structure of a fabric [5 – 14]. They are divided into two groups: factors based on the theory of Peirce [12], and factors based on the equation of Brierley [13, 14].

The integrated fabric firmness factor φ [5 – 7] includes not only parameters of structure of the fabric, but it can reveal characteristics of resistance too, it also may asses technological characteristics of looms and yarns. For these reasons we used this factor in our investigations.

The dependence of air permeability on integrated fabric firmness factor φ of the fabrics, woven in plain weave from polyester multifilament 29.4 tex yarns is presented in Figure 4.

It is seen that higher is integrated fabric firmness factor defines less yield of air that permeates through the experimental fabric.

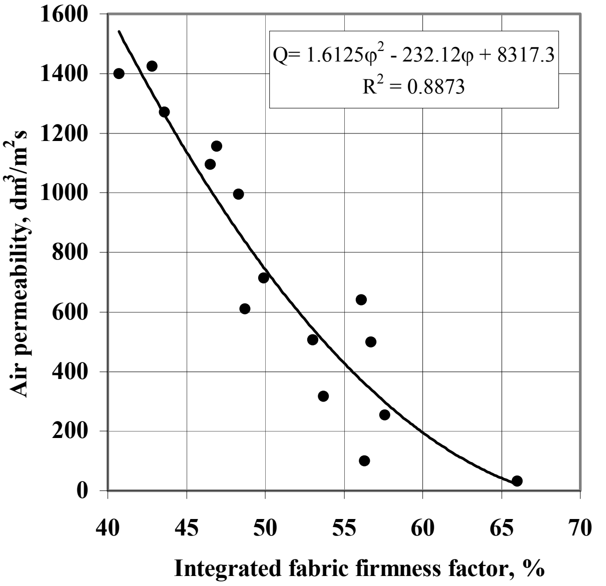

Fig. 4. Dependence of air permeability on integrated fabric firmness factor φ of the fabrics of first group

Very similar dependence is received for the second group of fabrics where linear density of warp is 29.4 tex, and weft – 27.7 tex (Figure 5). This dependence is expressed by the equation of the second order with high correlation ($R^2 = 0.8877$) as and in the first case when were checked filter fabrics ($R^2 = 0.8873$).

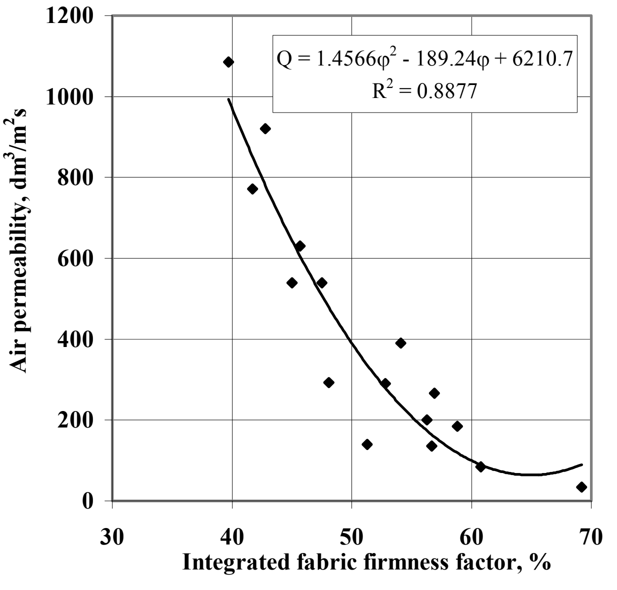

Fig. 5. Dependence of air permeability on integrated fabric firmness factor φ of the fabrics of second group

The dependence of air permeability on integrated fabric firmness factor φ of the all three groups of fabrics, assessing fabrics with folded warp, is presented in Figure 6.

One can see from Fig. 6, that also the second order equation is received, but in this case the coefficient of correlation is considerably lower than in other cases ($R^2 = 0.6264$).

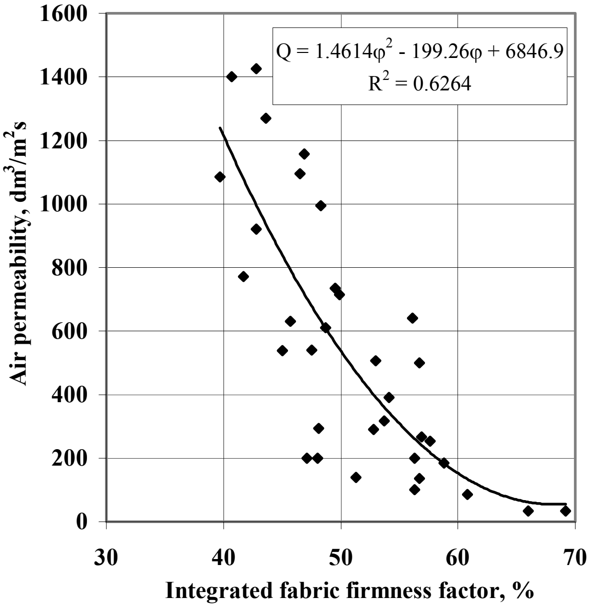

Fig. 6. Dependence of air permeability on integrated fabric firmness factor φ of the fabric of all three groups

Thus we cannot prove that dependence of air permeability on integrating fabric firmness factor φ is equal to all polyester-fibre fabrics, despite the structure of its yarns (twisted they are or not, doubled or not).

3. CONCLUSIONS

During the present investigation the fabrics woven in plain weave from polyester multifilament yarns with various set of the warp and the weft ($S_1 = 160 \div 310$ dm^{-1}, $S_2 = 110 \div 210$ dm^{-1}) were checked. Fabrics were woven from different linear densities (29.4 tex, 27.7 tex and 15.6 tex × 2) multifilament polyester yarns.

During the experiment the dependence of air permeability Q on relative area of fabric pores S_p was established. This dependence is expressed by the second order equation. This dependence is valid to all polyester fabrics of approximately equal linear density of yarns, despite to the structure of threads (twisted they are or not, folded or not).

Air permeability also depends on integrated fabric firmness factor φ. When the integrated fabric firmness factor increases the yield of air permeating through a fabric decreases. We cannot prove that dependence of air permeability on the integrated fabric firmness factor φ is equal to all polyester fabrics despite the structure of threads (twisted they are or not, folded or not) this dependence is different and depend on the structure of yarns.

The established dependencies of air permeability on fabric structure parameters allows to forecast yield of air permeating through a fabric and efficiency of its filtering.

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