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Geometrical and mechanical properties of jacquard and intarsia knitted fabrics

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Jacquard, intarsia and jacquard-intarsia fabrics can often be manufactured to a similar pattern design specification even though their properties may be quite different. This problem has been dealt with in the present work which defines CAD programmes for electronic knitting of groups of similar patterns by three different techniques. The geometrical and mechanical properties of these structures, as measured by KES instruments, are analyzed and the differences encountered are accounted for. It is possible to choose the required geometrical and mechanical properties for a particular design pattern by choosing the appropriate design techniques.

Keywords: CAD system, Fabric properties, Intarsia knitted fabric, Jacquard knitted fabric, Jacquard-intarsia knitted fabric

1 Introduction

Due to their elastic properties, the knitted fabrics are ideal for sportswear where performance is the most important factor. The applications of these fabrics are also extended to the areas where the aesthetic aspect takes prime importance associated with comfort and easy care. Jacquard, intarsia and intarsia-jacquard knitted fabrics are included in this group.

Nowadays, with the existing CAD systems, it is possible to prepare complex designs easily and produce the corresponding knits on an electronic flat bed knitting machine with high quality levels and production rates, since the CAD system and the knitting machine controller softwares are compatible[1]. It is possible to produce the kind of knits mentioned above on several flat bed knitting machines. Therefore, it is important to know the advantages and disadvantages of using a specific CAD system to program the designs and to knit on a specific flat bed knitting machine, according to the utilization of the final product[2].

The present work was divided in three parts:

- Preparation and programming on a CAD system (Micro SDS) nine different designs from a basic design with the purpose of producing jacquard knits with horizontal stripe backing and birdseye backing, and intarsia and intarsia-jacquard knits.
- Production of samples on an electronic flat bed knitting machine (SES 122 FF05), keeping constant the yarn feed tension, yarn characteristics, carriage speed, take down tension and stitch cam position.
- Comparison of the knits produced in terms of production time, loop length, piece length, width, mass per unit area, number of wales and courses per unit length, breaking strength, air permeability, stretch and recovery properties, and handle.

2 Designs Selection

Nine different designs were selected from which jacquard knits with horizontal stripe backing and birdseye backing, intarsia and intarsia-jacquard knits were produced. To make easier the identification, the designs and the knits have been classified according to the general form:

$$A\ X\ Y$$

where

A Two possibilities (J for jacquard and I for intarsia).

X Ranging from 1 to 9 in order to identify the design. Designs 1, 2 and 3 have two colours, designs 4, 5 and 6 have three colours and designs 7, 8 and 9 have four colours.

Y Two possibilities 1 and 2. For jacquard designs, 1 corresponds to the horizontally striped backing and 2 to the birdseye backing. For intarsia designs, 1 corresponds to simple intarsia and 2 to intarsia-jacquard.

3 Production Time

Keeping constant the speed carriage while knitting the various kinds of fabric with the same design, different times of production and, therefore, different rates of production were obtained (Fig.1). It is observed from Fig.1 that the jacquard knits with horizontal stripe backing and with birdseye backing show similar production times. Nevertheless, both show greater times for designs with a larger number of colours. Intarsia and intarsia-jacquard knits of the same design show similar production times. When the design motif leads to a significant reduction in the number of yarn carriers, knitting intarsia-jacquard instead of intarsia from the same design shows a lower production time. If, on the contrary, the design motif does not permit a reduction in the number of yarn carriers, intarsia knits show a lower production time since it is necessary to spend time knitting the ladder backing when the intarsia-jacquard knits of the same design are produced.

On comparing the production times of jacquard knits with those of intarsia and intarsia-jacquard knits, it is observed that:

- for designs with two colours, production times are lower for jacquard knits. The designs selected had a mean difference of 15%
- for three-colour designs, production times are reduced with intarsia and intarsia-jacquard knits by about 22%
- for four-colour designs, the production times are favourable to intarsia and intarsia-jacquard knits having, for the designs selected, a mean difference of 116%.

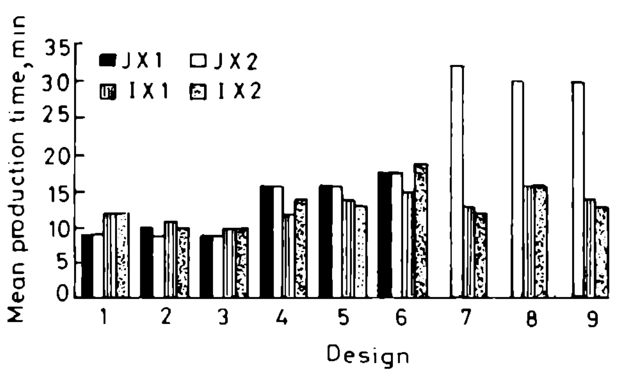

Fig. 1 —Relationship between mean sample production time and design

Taking into account that higher speed carriage can be established when producing jacquard knits than when producing intarsia and intarsia-jacquard knits, higher production rates would be obtained while producing jacquard fabrics in two-colour designs. For three-colour designs, similar production rates can be obtained for all the knits since it is possible to adjust the speed carriage 22% higher when knitting jacquard knits than when knitting intarsia and intarsia-jacquard knits. For four-colour designs, it is always advantageous to knit intarsia and intarsia-jacquard knits instead of jacquard knits.

4 Yarn Consumption

The digital stitch control system (DSCS) can only be used for producing jacquard, intarsia and intarsia-jacquard knits which don't need the yarn carriers placed at the knitting machine right extreme, or when producing samples with similar loop lengths. Samples where the loop length control is done in each course by comparing the actual loop length with a pre-established value, are not controlled by the DSCS system. Therefore, it was not possible to use the DSCS system for all the knitted samples. The yarn consumption analysis for the various kinds of knits with the same design was made using the experimental values obtained from the knitted fabric mass per unit area (Fig.2).

From above we conclude that we can predict, with great degree of accuracy, the yarn consumption and the mass of a jacquard knit with horizontal stripe backing, knowing the yarn consumption or the mass of the intarsia knit corresponding to the same design and vice versa, based on the number of knitted courses. For intarsia-jacquard knits, mass as well as the yarn consumption depend on the ladder backing extension. So, it is not possible to predict a value based on the value obtained from any other kind of knits.

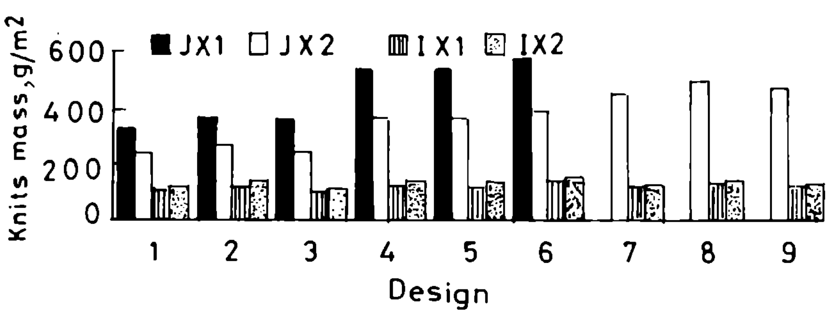

Fig. 2 Relationship between knits mass and design

The mass of the jacquard knits with birdseye backing shows deviation from the predicted value (based on the total number of knitted courses) when compared with intarsia knits of the same design, because there is a great number of loops that are not knitted on adjoining needles of the same bed or even on both beds.

5 Geometrical Properties

When we define the stitch cam position we obtain different loop lengths (Fig.3) for the jacquard knits (with horizontal stripe backing or birdseye backing), intarsia or intarsia-jacquard knits[3]. Intarsia and intarsia-jacquard knits show similar values of loop length (difference lower than 4%), and these lengths are similar to the theoretical loop lengths established by the stitch cam position for single jersey structure (difference lower than 6%). The other knits show higher values than intarsia knits corresponding to the same design, which is expected based on the fact that these knits are produced using the two beds of the knitting machine.

The differences obtained were:

14% for two-colour jacquard knits with horizontal stripe backing

— 16% for three-colour jacquard knits with horizontal stripe backing

— 23% for two-colour jacquard with birdseye backing

— 29% for three-colour jacquard with birdseye backing

35% for four-colour jacquard with birdseye backing.

These values show that the bigger the yarn length between two contiguous loops, the more is the deviation between the experimental loop length and the theoretical one, either in the stitch cam position for single jersey or for intarsia knits.

The results obtained for piece length[4] (Fig.4), width[5] (Fig.5), number of wales per unit length (Fig.6), and number of courses per unit length[6] (Fig.7) reflect the effect of knits structure. The knits produced on two beds have bigger length and width and lower number of wales and courses per unit length than the knits

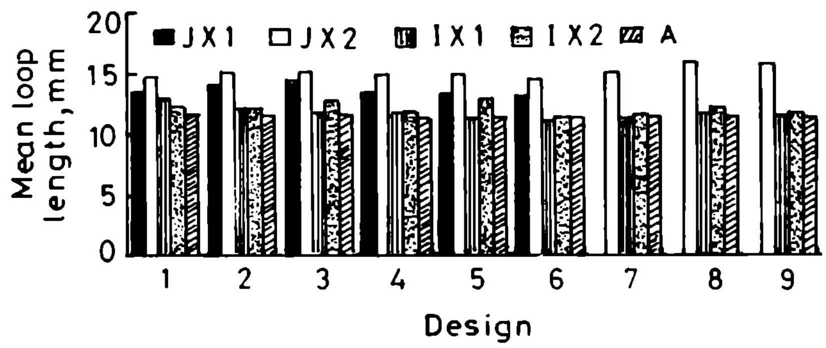

Fig. 3 Design's mean loop length [A — Loop length defined by the stitch one position for single jersy structure]

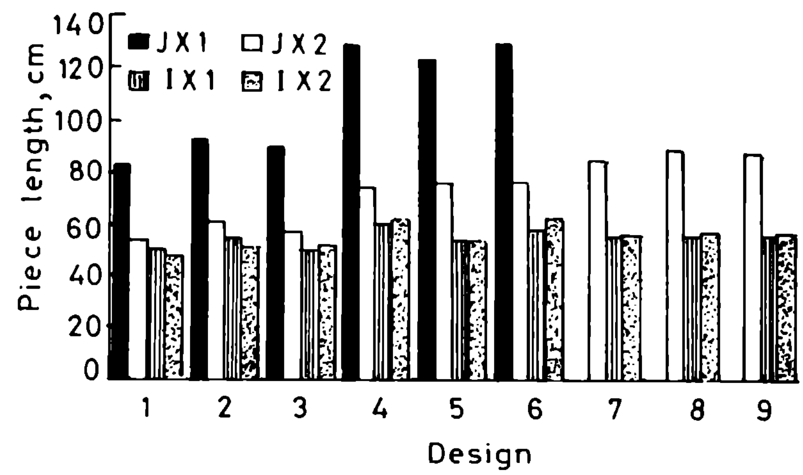

Fig. 4 Relationship between piece length and design

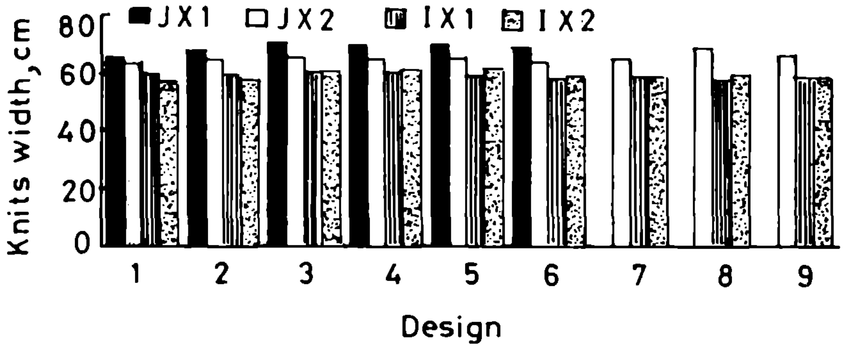

Fig. 5—Relationship between knits width and design

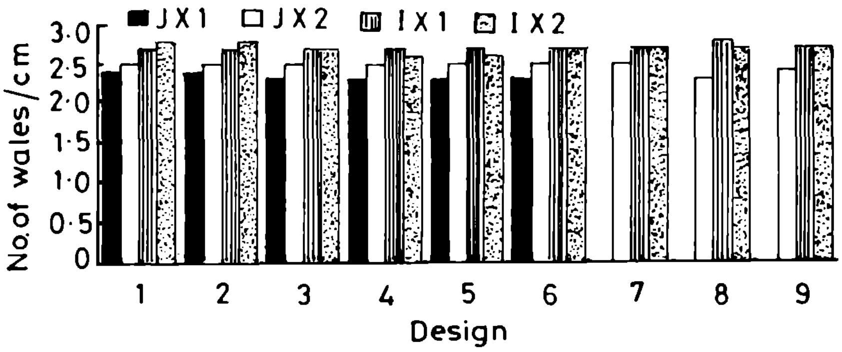

Fig. 6—Relationship between no. of wales/cm and design

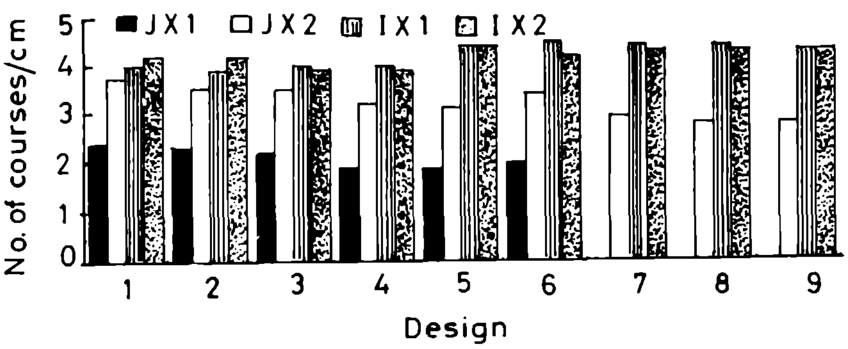

Fig. 7 Relationship between no. of courses/cm and design

produced on one bed. Moreover, the knits with a larger number of back-knitted courses per number of face-knitted courses are the ones that have bigger length and width and lower number of wales and courses per unit length. Among them, the first place is for the jacquard knits with horizontal stripe backing. It is important to note that in this kind of knits, there is a higher number of knitted loops at adjacent needles of the same bed or of different beds, indicating that the large amount of yarn is involved in the knitting process and, therefore, it is possible that a bigger extension of the front loops occurs. This effect is not so prominent in jacquard knits with birdseye backing since in this case the amount of yarn involved in the knitting process is lower due to a considerable number of loops knitting at alternate needles. The yarn fluctuation between those loops gives more cohesion to the structure and so a lower increase in the length and width of these knits occurs when compared with jacquard horizontal stripe backing knits. Intarsia and intarsia-jacquard knits show similar values for these properties because they have similar structure.

However, for some designs, we could have significant differences, mainly in the width and number of wales per unit length due to the effect of ladder backing of intarsia-jacquard knits.

Fig.8 shows the influence of the knits structure on mass per unit area[7]. It is observed that the knits produced on two beds have greater mass per unit area and among these the most cohesive structure i.e. the four-colour jacquard with birdseye backing has the maximum mass per unit area. Intarsia-jacquard knits always have greater mass per unit area than intarsia knits of the same design; this difference is the function of ladder backing extension of the intarsia-jacquard knits.

6 Mechanical Properties

Fig.9 shows that Intarsia-jacquard knits in single jersey structure with ladder backing have greater elasticity[8] in the wales direction; this elasticity being greater as the ladder backing extension is either in the width or in length direction. On the other hand, the intarsia-jacquard knits in single jersey structure show values close to the intarsia knits of same design. Regarding the extensibility of the other knits in the wales direction, we can conclude that the conditioning factor is the elongation in the length direction undertook by the yarn involved in the loops during the knitting process. So, the knits whose loops suffered greater elongation in the length direction during the knitting process are those that show less elasticity — the three-colour jacquard knits with horizontal stripes backing and the four-colour jacquard knits with birdseye backing.

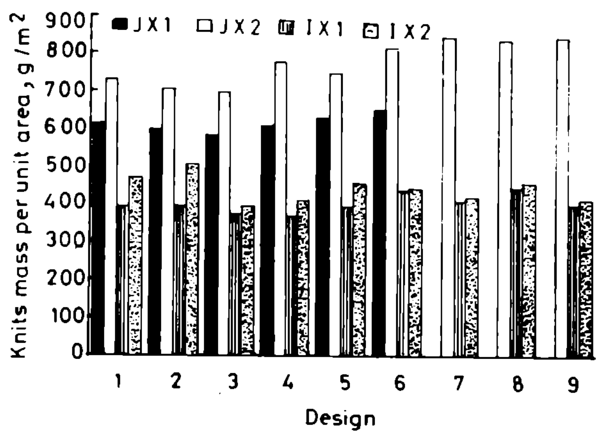

Fig. 8—Relationship between the sample mass per unit area and design

In the courses direction, the intarsia-jacquard knits in single jersey structure with ladder backing show less elasticity than intarsia knits, because the ladder backing tends to approximate the two areas of the knits face contiguous to the ladder, reducing the extensibility in this direction. Again, the intarsia and the single jersey structure of intarsia-jacquard knits show identical values for elasticity in the courses direction. The two-colour jacquard knits with horizontal stripe backing are the only ones which show higher elasticity than the intarsia knits of the same design. All the other jacquard knits show less elasticity than the intarsia knits of the same design. The jacquard knits with the same number of colours give less elasticity in the birdseye backing version because, in this structure, as mentioned earlier, there is a great number of loops knitted in alternate needles on the same bed, and the yarn length between the two loops is not enough to allow a significant elongation in the courses direction. As the number of colours of the design is increased the elongation is decreased due to the progressive structure cohesiveness.

When determining the properties like breaking strength[9] (Fig.10), breaking elongation[9] (Fig.11), air permeability[10] (Fig.12), compression and surface characteristics[11], the values obtained showed CV of 10% and, sometimes, greater. Because of this, a

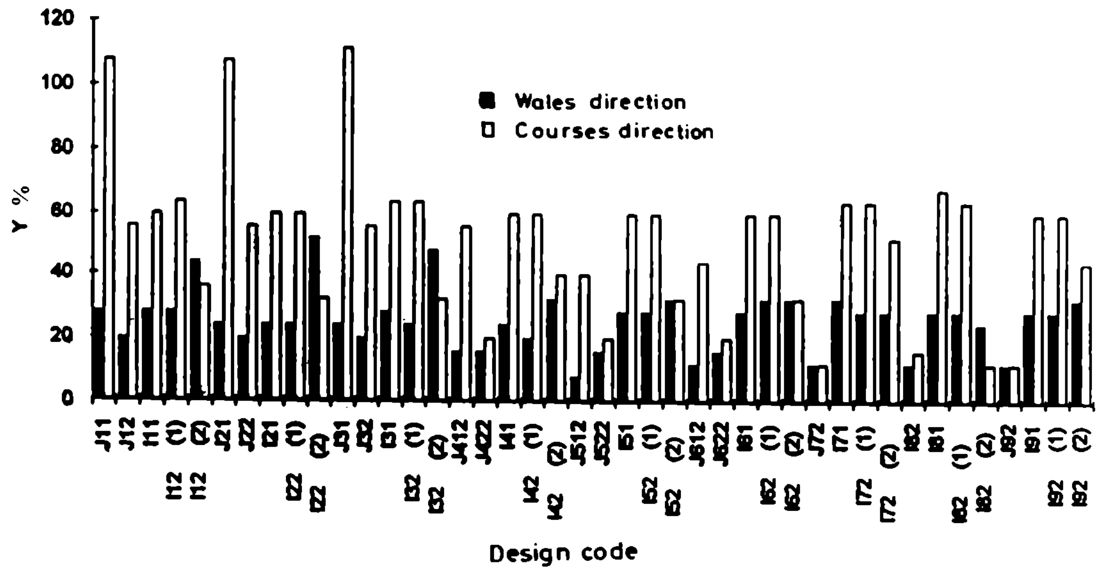

Fig. 9—Mean extension along wales and course direction

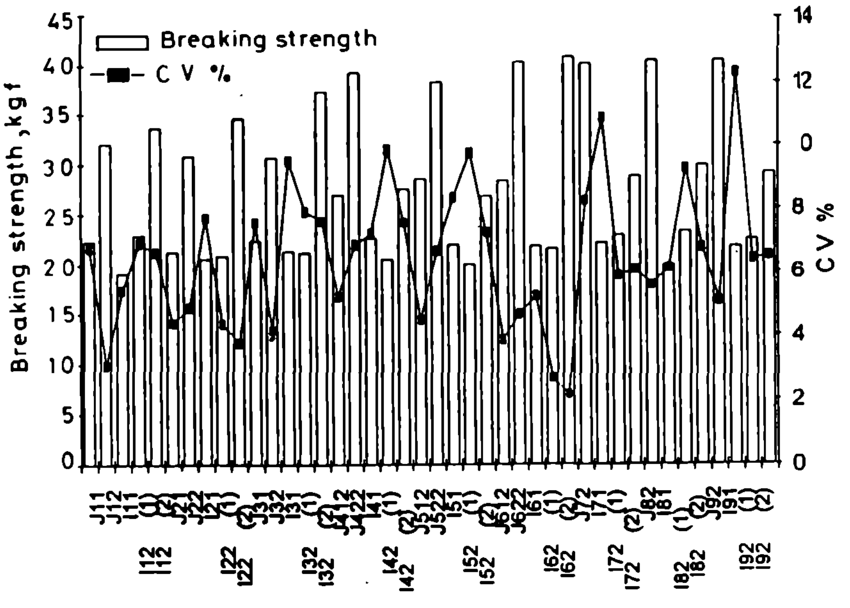

Fig. 10 Relationship between breaking strength and design

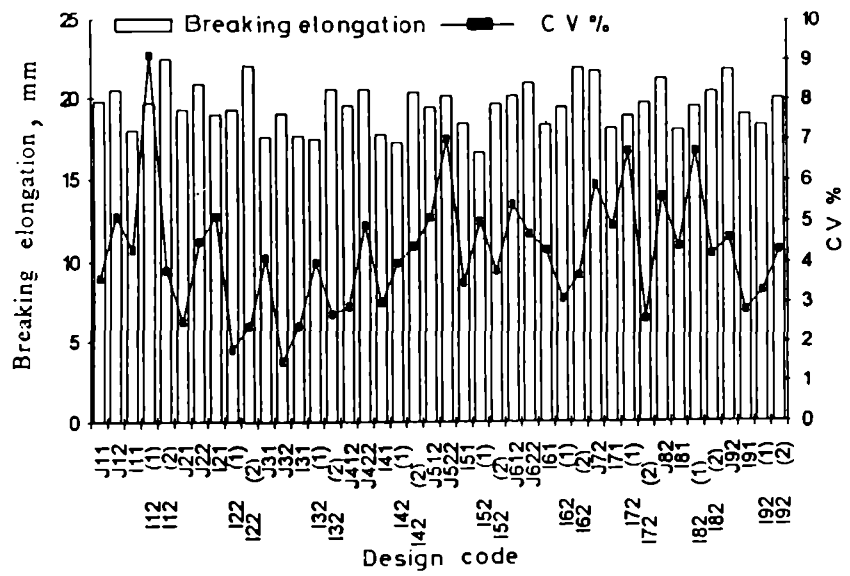

Fig. 11 Relationship between breaking elongation and design

statistical analysis of the results was made using the Snedecor "F" test to verify the variance equality and, afterwards, using the Student's 't' test to verify the mean equality. Finally, a variance analysis[12] was made to verify the influence of the structure factor on the results.

The properties which allowed the comparison between different kinds of knits were the breaking strength, breaking elongation, thickness (at 0.5 gf/cm^2 and 50 gf/cm^2 foot pressure) and friction coefficient in the wales direction. It was not possible to make comparisons of all properties for the knits studied.

Table 1 shows the values of different properties for the knits where the structure factor had no influence on the results.

Properties like air permeability, compressional energy, compressional resilience, compression-thickness curve linearity, compression rate, mean deviation of frictional coefficient (in the wales and courses direction), surface roughness (in both directions) and frictional coefficient in the courses direction were studied to verify the general tendency of the results, because the values obtained for these properties for each kind of knits could not be

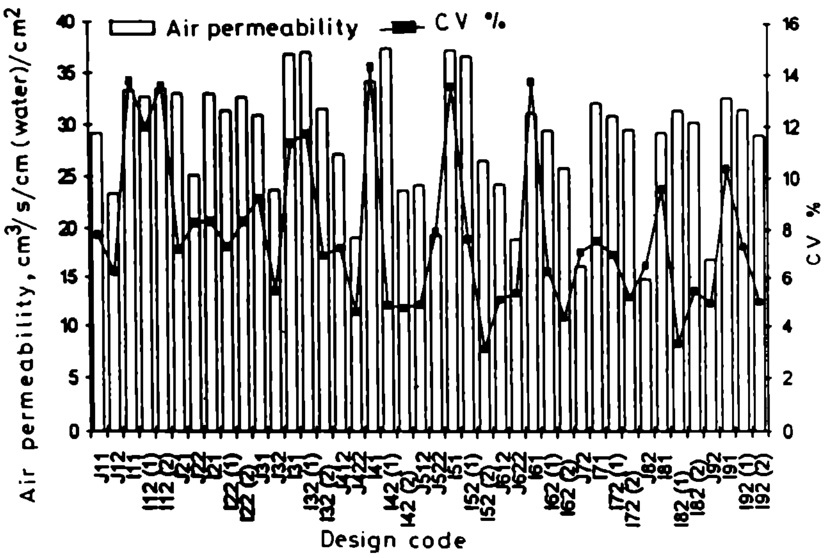

Fig. 12—Relationship between air permeability and design

Table 1—Knit fabric properties

Type of knit	Breaking strength kgf	Breaking elongation mm	Thickness (mm) at 0.5 gf/cm²	Thickness (mm) at 50 gf/cm²	Friction coefficient along wales direction
Two-colour jacquard knits with horizontal stripe backing	22.02	—	5.39	—	0.337
Two-colour jacquard knits with birdseye backing	31.22		6.01	4.74	0.324
Three-colour jacquard knits with horizontal stripe backing	28.01	19.77	5.34	3.92	0.323
Three-colour jacquard knits with birdseye backing	39.41	20.60	—		0.309
Four-colour jacquard knits with birdseye backing	40.54	21.67		—	0.298

considered as belonging to the same mother population.

The reason why we obtained variation coefficients so high for some properties among the same kind of knits is related with the characteristics of the yarn used on the knitting process. This yarn, a high bulk acrylic, has large variation in thickness. Nevertheless, it was not possible to classify the yarn regularity because tables for this yarn linear density (270 tex) do not exist. This becomes clear looking at the fact that intarsia knits have higher variation coefficients and a structure that diminishes the yarn irregularities less. For the designs that need yarn carriers to knit small areas, besides the yarn irregularity, the more open structure in these areas leads to variation in properties.

7 Conclusions

The present CAD systems for electronic flat bed knitting machines are much more advanced than the Micro SDS and have appropriate functions that permit a quicker programming of the design. These include even those used for the production of intarsia jacquard knits. Much more powerful in terms of automatic processing speed of designs (about 60 times quicker), these systems turn meaningless the differences between the programming time and the automatic processing time of the different types of knitted fabric. The new systems make possible the connection of various image acquisition peripherals and simulate on the screen or in printed form the knit corresponding to a programmed design before it is knitted.

It is possible to predict for a given design with 2, 3 or 4 colours, several properties of the knits produced from it in a jacquard with horizontal stripe backing and with birdseye backing, intarsia and intarsia-jacquard versions using a high bulk acrylic yarn. The properties which could be predicted are the mean production time per sample, mean yarn consumption, experimental loop length for the same stitch cam position, length, width, mass per unit area, number of wales and courses per unit length and elasticity. It is also possible to predict breaking strength, breaking elongation, thickness (at 0.5 gf/cm^2 and50 gf/cm^2foot pressure) and frictional coefficient in the wales direction for some kinds of knits. For all other properties, it is not possible to make any prediction.

It would be of interest to verify these conclusions with higher number of designs, which would permit analyse the influence of design parameters on each of the properties studied among each kind of knits.

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