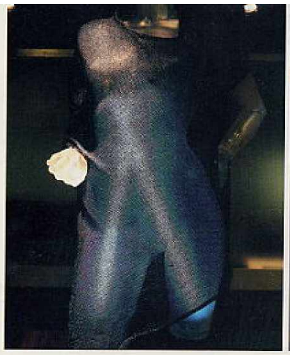


Influence of stitch length on knitting control parameters

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Knitters are often faced with the problem of what significance to attribute to the controllable parameters (stitch constructions, linear density of the yarn, texture, twist, stitch length, etc.) in order to obtain a knitted fabric meeting the quality requirements fixed in advance and expressed in the specifications. In this study, we propose to correlate the features of the yarn used with those of the knitted item produced in order to help the knitter to choose the suitable yarn on the one hand and to carry out the optimum adjustment of his machinery on the other hand.

The main object of this study is to find out how to obtain a lighter knitted fabric without loosing its thermal insulation properties and/or thickness, or how to raise these properties without increasing weight and/or thickness. In addition, we will try to analyse the impact of changes in stitch length, linear density, yarn twist and yarn texture on the knit properties, cost and time of knitting.

The parameters that we will try to optimise during this study are:

1. mass per area (M) of the knit in g/m^2 [1],
2. thickness (E) of the knit expressed in mm, a decisive factor for the comfort provided by a knit [2],
3. adiathermic power (AP), the property of a material to preserve the body heat that it surrounds, which permits to assess the protective calorific power of the knit and facilitates the choice of the raw material as well as the type of stitch constructions [3]. The French Norm NFG 07-108 makes use of the following formula for calculating this parameter:

$$AP = 17{,}4 x \mathrm{Log}\left(1000 \times \frac{E^2}{M}\right)$$

Material and methods

Different samples have been knitted using 100% cotton yarns on a Protti PV92SX flat knitting machine with the English gauge E7 [4], while one of the following parameters is being changed each time:

1. the yarn length absorbed by stitch (LAS): this is achieved by varying

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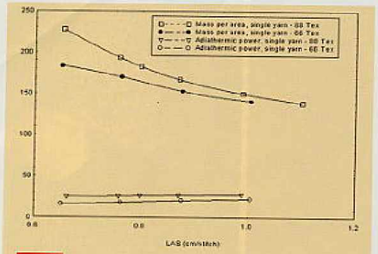

Fig. 1

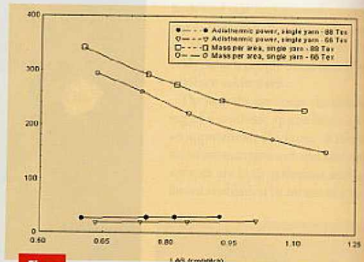

Fig. 2

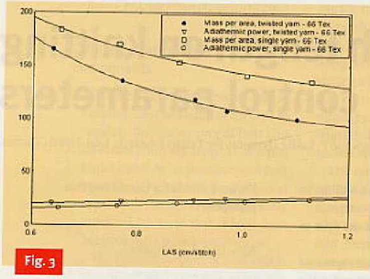

Fig. 3

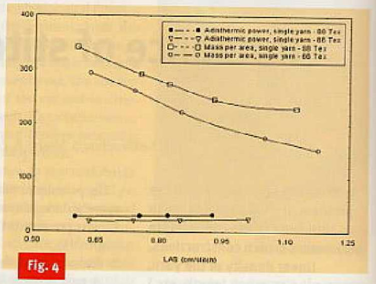

Fig. 4

the clow mechanically while regulating the position of the falsest cam,

2. the type of stitch constructions (jersey or rib 1×1),
3. the linear density of the yarn (66 or 88 tex),
4. the twist coefficient of the yarn ($\alpha m = 80$ or $\alpha m = 100$),
5. the texture of the yarn (single or twist).

Contrary to the arrangement of stitches that may vary according to the state of deformation of the knit, the LAS remains constant. That is why this parameter permits to characterise the tightening of the knit on the one hand and to adjust the knitting machine on the other hand.

Measures of the LAS have been carried out according to the French Norm NFG 07-101 with the help of an ITF maillemètre.

Results and discussion

LAS influence on the knit mass per area

The experimental results mirrored in figs 1 and 2 reveal that the mass per area decreases with the increase of the LAS for the two stitch constructions and for the two linear densities of yarn. Indeed, as the LAS value rises, the stitch becomes looser, which explains the decrease in the mass per area. Besides, the thinner the yarn, the more obvious is the reduction.

According to the general Munden laws relative to the knit geometry [5], mass per area can be calculated using the following formula which goes with experimental results.

$$M = \frac{T}{10} x\, l\, x\, N = \frac{T}{10}\left\{\frac{a}{l} + b\, x\, l + c\right\}$$

Where: T is the linear yarn density in tx,

l is the LAS in cm / stitch,

N is the stitch density per cm^2

a, b and c are constants depending on the stitch constructions and the material used.

From the results featured in figs 3 and 4 above, we can note that for the same LAS, the mass per area is more important for a single yarn than for a twist one. In the same way, the more important the twist coefficient, the more the mass per area is raised. This is due to the fact that the stitch density is bigger for a single yarn (more flexible) and/or more twisted.

LAS influence on the adiathermic power of the knit

The first requirement a material must satisfy is thermal insulation expressed by its faculty to preserve the body heat in existing atmospheric conditions.

Several methods can be used to measure this thermal insulation property such as the technique of «heat body». Also, it can be calculated from the measurements of thickness and mass per area, two parameters that are directly related with the quantity of air retained inside the textile structure and forming a thermal insulation barrier.

In figs 1 and 2, linear relationships between the adiathermic power and the LAS have been established for two stitch constructions and two yarns of different linear densities showing an increase in this property along with the LAS. In fact, the number of air «micro-pockets» inside the knit increases, which reduces the thermal exchange with the outside and thus improves the calorific retention capacity.

LAS influence on the thickness of the knit

The relation between the knit thickness and the stitch dimension expressed by the LAS was the object of several researches [6]. In this study, a linear relation between these two parameters has been established, as shown in fig. 5.

Measurements reveal that thickness slightly increases with the LAS as, when the LAS increases, the stitch becomes higher and hence the knit becomes slightly thicker.

Even though there is only a slight increase in thickness, it involves an improvement in the knit's calorific retention power. In fact, the material's thermal resistance is proportional to its thickness

$$r_{th} = \frac{E}{\lambda},$$

where E is the knit thickness and λ is its thermal conductivity.

Relation between knit mass per area, adiathermic power and thickness

According to figs 1 to 5, we note that:

- when the LAS increases, the mass per area increases, too, whereas the adiathermic power decreases for the two stitch constructions;
- for an identical LAS, when the yarn count increases, both mass per area and adiathermic power increase;
- for the same LAS, using a twist yarn instead of a single one, the adiathermic power increases and the mass per area decreases and vice-versa;
- for the same LAS, using a yarn with a higher twist coefficient both mass per area and adiathermic power improve;
- thickness remains approximately constant when the LAS changes.

Thus, increasing the length of stitch and/or using a twist yarn allows to obtain a lightweight knit with an important thermal insulation without varying significantly the thickness. However, while increasing the LAS, two considerations must be born in mind: the practical feasibility of the knit and its aesthetic aspect.

Impact of LAS changes on the cost and time of knitting

The cost of a linear knit meter depends on the knitting time and the quantity of yarn consumed. On the other hand, increasing the LAS of the knit reduces the number of rows required per linear meter because the height of the stitch increases.

Thus, an increase in the LAS decreases the knitting time according to the following formula:

$$T_2 = T_1 \times \frac{l_1}{l_2}$$

where T_2 is the time required for knitting one linear meter with LAS = l_2;
T_1 is the time required for knitting one linear meter with LAS = $l_1 < l_2$.
The following curve, obtained from the formula above, represents the ratio of time required for knitting one linear meter with LAS = 0.5cm/stitch and time required for different LAS.

Besides, a decrease in the mass per area resulting from an increase in the LAS reduces the quantity of yarn consumed by a linear meter and consequently the cost of the knit.

Conclusion

In the hosiery field, several parameters can be examined and simple yet practical relations can be established, but what is most important is that the best ones are selected. That is, those that the knitter can most easily control and which may have a real impact on the knit's quality and cost.

On the other hand, it is important to raise the number of measurements for each parameter controlled in order to improve the reliability of the results while remaining useful in industry. ■

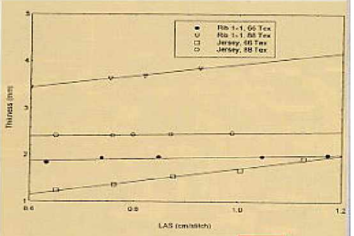

Fig. 5

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