Computer-aided engineering of knitted fabrics

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THE development of a new knitted fabric involves more than merely aesthetical designing. To produce a knitted fabric with particular features that meet special physical requirements and thus has particular properties, requires that the technological parameters of that effort be precalculated or worked out experimentally as accurately as possible.

This is engineering work and researchers have dealt with that for decades. These methods have been written about extensively. They can generally be divided into two groups. Those which offer theoretical grounds and use pure mathematical deductions, and those which use empiric procedures which are based on experimental works.

In practice, the combination of these two methods prove good, when results of theoretical deductions are modified by practical values. The evident reason is that in case of both the pure theoretical deductions and the empiric methods, researchers must take special conditions into consideration and must simplify circumstances.

Results of experiments are valid only under specific experimental circumstances. Generalizing the results invariably results in errors. This is the reason why calculations give reliable results only under relatively limitated circumstances. Formulae have therefore to be based on such constants as "material constants" and "structural factors" and these can only be determined by experiments.

Fabric engineering methods are, therefore, rather complicated procedures. They involve many calculations and require knowledge and usage of charts or diagrams of practical data. Because they are complicated, they cannot come into general use in knitting mills to the degree which would be desirable and possible.

In addition their general use is hindered by the fact that the results sometimes prove to be inaccurate. Knitting mills prefer therefore production trials which demand, on the other hand, time and material. In many mills, this means that production machinery must be used for sampling and experimentation.

The expedient method is to calculate guiding values which approximate the final setting and are suitable for determining the parameters of the first production trial. Consequently, production trials have some basis on which to begin and are simply not based only on practical experience.

Surely, this will require a fewer number of experiments, less time and less material to achieve the final and perfect setting. This is especially important when new material, new machines and new fabric structures have to be introduced and if there is not yet practical experience at your disposal.

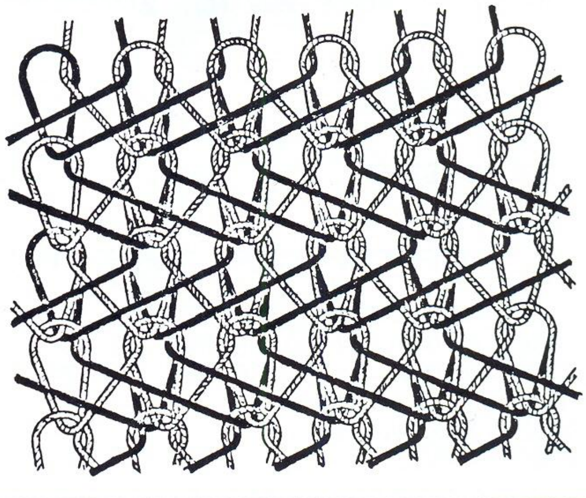
By spreading personal computers throughout the textile industry, it has become possible to carry out these calculations much quicker than before. Data from reports, material constants and structural factors can be stored in the memory of the computer, and complicated formulae can be computed in a moment. The longest time is required to type in the input data and to print out the result on paper. The calculation itself needs only a fraction of a second.

The technologist can obtain the starting machine setting parameters in minutes, while without a computer it would take hours. By means of the computer, the technologists can try more variations on the screen, can examine the effect of different input parameters, can determine how one or the other of possible variables modifies the result, which one can be neglected and which one has the strongest effect. This is a very important advantage.

Fabric engineering has a very rich, albeit scattered literature, which is an excellent source for every knitting mill to create its own computer programs for their special needs. Following are some of these programs.

For instance, a program was developed to help locknit fabric engineering.

FIGURE 1



Habselyem Knitting Mill is in Budapest, Hungary. This presentation was delivered at the XXXI IFKT Congress in Sofia, Bulgaria.

Locknit is a fairly special, although often used, structure (Figure 1). Many important fabrics are produced on this ground.

Often the aim is to produce a finished locknit fabric with a given area density and the technologist has to prescribe machine setting data according to these parameters. He must also consider the changes in the fabric's state during the dyeing and finishing process. The calculation method is known[1,2] but requires fairly complicated calculation.

The computer program begins with inputting of the following data: the required area density, the yarn material, the yarn count, the machine gauge and the number of needles. After a short time the computer prints our the parameters shown in Figure 2.

It can be seen that this detailed work provides all the important machine setting data which are necessary for the first trial and the grounds on which machine setting can be refined, if it is necessary at all. However, it is important to know that a part of the formulae used in the calculation are based on statistical laws. Their results are, therefore, valid only with a given statistical probability.

Another program can compute the loop length of a warp knitted fabric. There are many formulae known by different authors for such a calculation [3...8], but their results are different.

This program can be used in fabric engineering if the aim is to reproduce a fabric from its main parameters, such as, stitch density in both main directions, number of guide bars, fabric structure, yarn count, and yarn content. Only the loop length has to be determined.

After typing in the input data, the computer prints out loop lengths calculated by means of the formulae given. Further run-in ratios and area densities can be calculated from these loop lengths as well as Munden's k-values which are obtained by multiplying stitch densities and loop length[9].

Area density (given in ounces per square yard or in grams per square meter) is one of the most complex and most characteristic parameters of the fabric. By comparing area density values calculated from the different loop lengths from the different formulae with the real area density of original fabric, it can be determined which loop length formula gives the best approximation.

This program can also be used for determining the actual loop length and k-values from given area density and run-in ratios.

The third program computes machine setting data for cotton interlock fabrics. This is based upon the work of a British researcher[10]. Input data can be varied and according to them, the program provides different answers:

- It gives stitch densities and area density of the fabric in a fully relaxed state from the yarn count and loop length;
- It computes from which yarn count and loop length the fabric with its prescribed stitch densities can be reproduced and how much area density will develop;
- It tells what loop length, fabric width, area density and wale density will develop in a fully relaxed state of the fabric from a given yarn count, course density and number of needles;
- What loop length and stitch densities give a certain area density; and finally,
- How much shrinkage will ensue up to the fully relaxed state of the fabric if it had been knitted with a certain loop length and stitch densities.

Another program, which is based upon the work of a Soviet researcher[3], calculates the presumable optimal area density of different weft knitted fabrics when made from a certain yarn and with a certain structure. Hitherto the following structures have been analyzed: Plain single jersey structure, plain rib structure, single jersey structure with 1 x 1

FIGURE 2

MACHINE SETTING DATA:

YARN COUNT:	33 DTEX
MACHINE GAUGE:	32
NUMBER OF NEEDLES:	2650
COURSES PER INCH:	69.6
LOOP LENGTH IN GUIDE BAR NO. 1:	0.085 IN
LOOP LENGTH IN GUIDE BAR NO. 2:	0.114 IN
RUN-IN IN GUIDE BAR NO. 1:	40.992 IN/RACK
RUN-IN IN GUIDE BAR NO. 2:	54.657 IN/RACK

DATA OF THE GREIGE FABRIC:

AREA DENSITY:	1.75 OZ/SQ YD

DATA OF THE FINISHED FABRIC:

LOOP LENGTH IN GUIDE BAR NO. 1:	0.091 IN
LOOP LENGTH IN GUIDE BAR NO. 2:	0.114 IN
COURSES PER INCH:	62.5
WALES PER INCH:	49.8
AREA DENSITY:	2.27 OZ/SQ YD

floatings ("cross miss"), fancy rib structures, interlock structure, plush structure, fleecy structures (two and three thread), full cardigan structure, half-cardigan structure.

After feeding into the computer the data on yarn content, yarn count and fabric structure, the following data of an average machine setting will appear on the screen: Wale density, course density, average loop length for each yarn component, and area density.

The recounted examples well illustrate how a personal computer can be an aid to fabric engineering which is not simple at all. But a computer is available for other technological operations, too.

A program has been developed, for instance, which computes the yarn tension after a tension device on a creel of a warping machine (Figure 3). First, the coordinates of the pegs have to be input (Figure 4), as well as the masses of the yarn braking discs, the friction co-efficients between yarn and peg and yarn and braking disc, respectively.

The computer calculates the yarn tension and makes a diagram of the device showing the pegs and the yarn passing through the tension device to the right scale. This diagram helps the foreman to control the setting of the device. Using this program, it is relatively simple to determine what arrangements of the pegs, how heavy the discs and with what kind of threading it can produce at a certain yarn tension.

Another program helps the control of area density values in development work. Having fed each area density value of a trial lot into the computer, what appears on the screen is the mean, the confidence limits for different statistical probabilities and a statement about whether or not the trial lot is statistically different from the usual mass production.

We wanted to show by the above examples how a personal computer can help the technological or the product development work in the knitting industry. Using a computer it is easier to make calculations which are often neglected when a computer is not available because of their complexity and circuitousness.

Making these calculations by using a computer makes the work of product developers, technologists and quality controllers easier, faster and more accurate, which lifts the level of product development and increases the reliability of production.

FIGURE 3

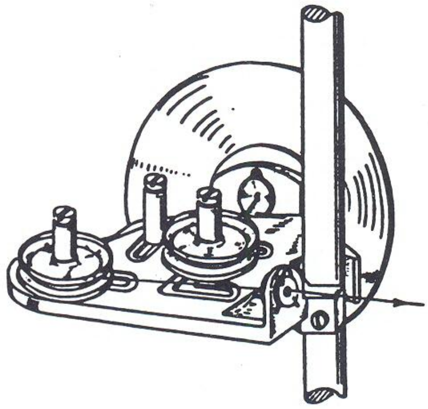
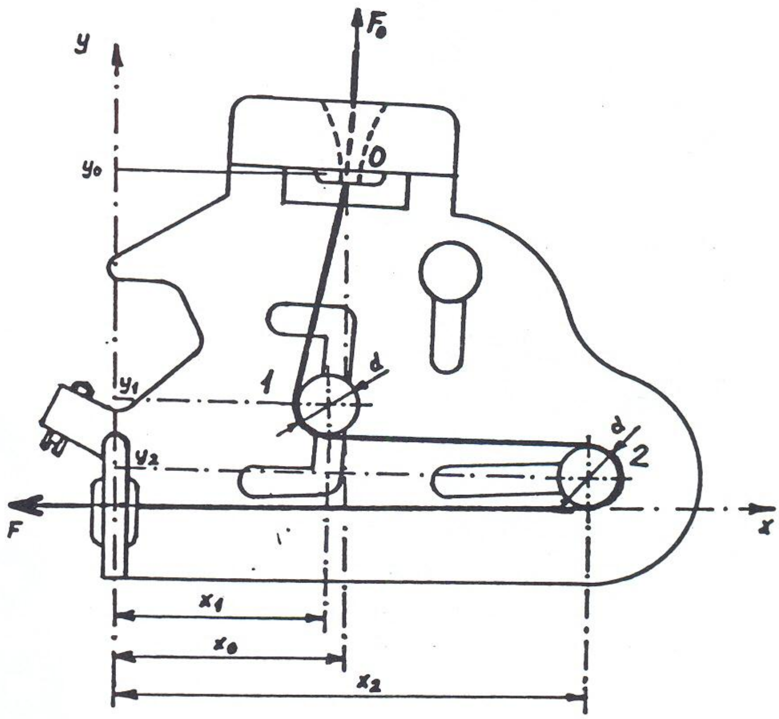


FIGURE 4



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