

# Contribution for the Development of a Flexible Ring Spinning-frame

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## ABSTRACT

The wool and cotton spinning processes are quite different, regarding the opening, cleaning and blending operations. However, yarn formation with different parameters due to fiber characteristics (length and origin) could take place in the same machine. Factors involved are the drafting and twisting parameters. In this work, a preliminary study regarding the use of the ring spinning process to produce wool and cotton yarn is carried out concerning the drafting system, as this is one of the major differences between the processes for the two materials. During the drafting operation, fibers must be moved relatively to each others as uniformly as possible, by overcoming friction between them. As they show different average lengths, it is necessary to provide means for automatic adjustment of the roller distance according to the type and length of fiber being processed.

*Key Words: Spinning, Flexibility, Drafting-systems, Wool, Cotton, Mechatronic*

## 1. Introduction

Staple fibers have a wide range of physical properties, most of which have some effect on the methods used in processing them into yarn, such as fiber length, impurities and fiber cleanness. In spite of this differences in the operations used to transform the raw material into yarn, the last step, the yarn formation, uses the same principle, based on the use of a ring spinning frame.

Ring spinning using the traveller to guide the yarn onto the package was invented in USA by Addison and Stevens in 1829<sup>[1]</sup>. The ring method was developed into the most successful method of spinning and is widely used for processing cotton, woollen, flax, spun silk and man-made fibers.

In spite of the fact that the principles used in the yarn production of different fibers are the same, the machine design is different.

Due to this factors, a study was carried out in order to propose mechanical modifications in a cotton ring spinning frame allowing the use of the same machine to produce wool and cotton yarns. Figure 1<sup>[2]</sup> shows a schematic view of a conventional cotton ring spinning frame. The roving bobbins (1) are creeled in appropriate holders (3). Guide rails (4) lead the rovings (2) into the drafting arrangement (5) which attenuates them to the final count. Upon leaving the front rollers, the emerging fine fiber strand (6) receives the turns of twist needed to give it strength. In order to wind up the yarn on a bobbin

(8), a traveller (9) is required to cooperate with the spindle. The traveller moves on a guide rail - the ring (10) -, encircling the spindle. We also have a thread guide (7), which is used to direct the yarn into the bobbin.

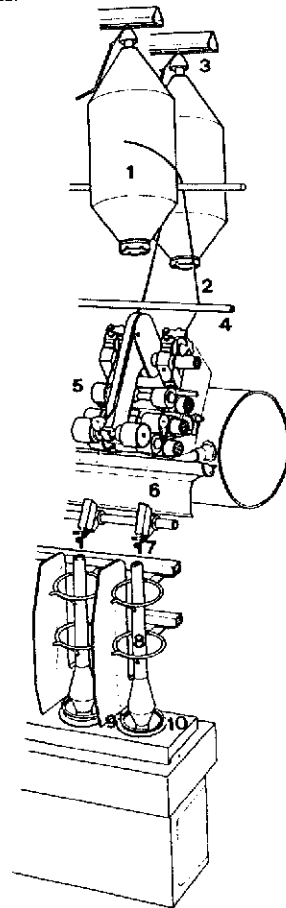


FIGURE 1. Ring spinning frame

The first step of this study was to analyse the mechanical parameters involved in the spinning system that were determined by the fiber established, namely the fiber length and origin.

After solving this problem, it was found that the operations that play the most important role were the drafting and twisting. Therefore, this work is concerned with the mechanical modifications to include in the drafting system so that two kinds of fibers (cotton and wool) can be processed. The advantages of this new type of machine would be:

- *Wool and Cotton yarns could be produced in the same machine (Spinning Flexibility );*
- *Possibility of producing small quantities of yarn;*
- *Quick mechanical adjustment ;*
- *Possible on-line response of the machine.*

## 2. Drafting Concepts

Drafting is the process where elongation of a strand of fibers takes place, with the objective of orienting them in the direction of the strand and reducing its linear density. It is important to realise that the drafting process does not cause any significant elongation of the individual fibers - it merely re-arranges their relative position as they pass through the drafting zone between the two sets of rollers. In a system such as this, various drafting zones can be defined. In practice, the last one through which passes the continue flow of fibers, shows the highest draft ratio and is called the main drafting zone.

If we have the drafting process perfectly under control, the distance between any two leading ends after drafting would be equal to the distance before drafting. Figure 2<sup>[3]</sup> represents the ideal drafting procedure.

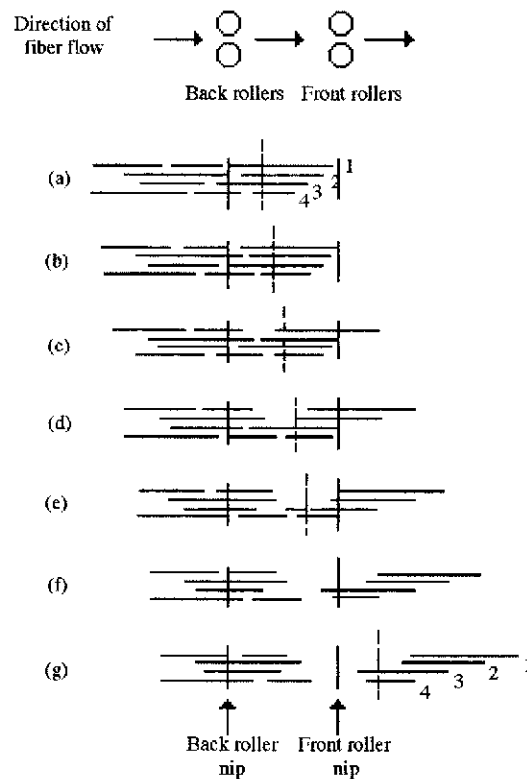


FIGURE 2. Ideal fiber movement during drafting

One of the most important parameters in the drafting system is the distance between roller nips, that should be equal to, at least, the maximum fiber length.

Lord<sup>[4]</sup> proves that both the theory and the statistical analysis of the literature emphasise the importance of fiber length vis-à-vis rollers setting. Under normal conditions, any fiber extending longer than this distance will be held by both rollers at the same time, which can cause breaking fibers.

Other studies<sup>[5]</sup> have shown that fiber length is an important parameter in setting up the distance between rollers, but also the fiber fineness and faultless such as nep and trash, are important.

### 3. Raw Material

This study is concerned with the production of yarn using different raw materials. One of the factors involved in the project, the drafting system, is related to the length of fibers used in the process, namely wool and cotton. Ring spinning machines are designed to operate efficiently only on a comparatively narrow range of staple fibers. Furthermore, within that range, careful adjustments have to be made to suit the processed material if the best results are to be obtained.

The lengths of wool and cotton are usually referred to in terms of staple lengths. In cotton fibers, the staple length is somewhere between the mean and maximum lengths; in wool fibers this parameter is the average overall length of the natural locks in their normal crimped condition.

The range of staple lengths of wool and cotton are shown in table I [6].

Table I. Range of staple lengths of textile raw materials (in.)

<b>Cotton</b>	
Bengals	$\frac{1}{2} - \frac{5}{8}$
Surat	$\frac{3}{4} - 1\frac{1}{16}$
American Upland	$\frac{3}{4} - 1\frac{3}{16}$
Egyptian Upper	$1\frac{1}{16} - 1\frac{1}{4}$
Egyptian KarnaK	$1\frac{1}{4} - 1\frac{3}{8}$
Sea Island	$1\frac{1}{2} - 1\frac{3}{4}$
<b>Wool</b>	
80s Australian Merino	$2\frac{1}{2} - 3$
56 s Southdown	$3 - 3\frac{1}{2}$
48 s Romney Mars	5 - 6
36 s Lincoln	10-12

### 4. Approach to the Problem

The problem is, therefore, to be able of yarn formation in the same machine, regardless of different parameters due to differences in fiber length and origin. During the drafting operation, fibers must be moved relatively to each other as uniformly as possible by overcoming the friction between them. As they show different average lengths, it is

necessary to provide means of automatically adjusting the distance between the drafting rollers according to the type and length of fiber being processed.

In order to achieve this objective, we started by analysing the present drafting system used for cotton, as shown in figure 3[2].

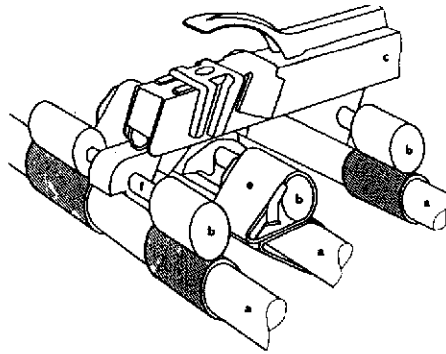


FIGURE 3. Drafting system for cotton

The drafting current systems use 3-line double apron drafting arrangements. They comprise three lower fluted steel rollers (a), to which the drive is applied. Top rollers (b), carried in a pivoted weighting arm (c), are arranged above the fluted rollers and are pressed against them.

The solution to the problem stated above is quite simple: To arrange the drafting rollers in a way so that the distance between them can be easily and quickly modified, manually or automatically, according to the requirements of the type of fibers being processed at the moment. This must be valid not only for processing different fibers but also for coping with differences within the same rover. However, the complete solution to the problem has to incorporate the ability for the last pressure roller to be moved accordingly with the respective drafting roller, otherwise the friction with the fibers is lost and the operation fails.

## 5. Conceptualisation of the New Drafting System

Once we have defined the problem and established its solution, a conceptualisation of possible mechanical alternatives was drawn out and evaluated according to the basic rules of the design process. Different ideas and concepts were put forward and evaluated for feasibility.

In the selected concept, schematically shown in figure 4, each of the drafting roller shafts is supported in bearings (1) that are housed in two moving blocks (2). The linear phased movement of these two blocks makes the drafting roller to move sideways. This effect is achieved by transforming the movement of a rotary actuator (6) into linear movement by

means of a screw and nut type mechanism (3). To make sure that both bearing supports of the same shaft move in phase, the movement of the rotary actuator is split by two screws, one for each bearing, by means of a chain and sprocket mechanisms with a 1:1 ratio (4,5). A technical drawing of the new arrangement is shown in Appendix.

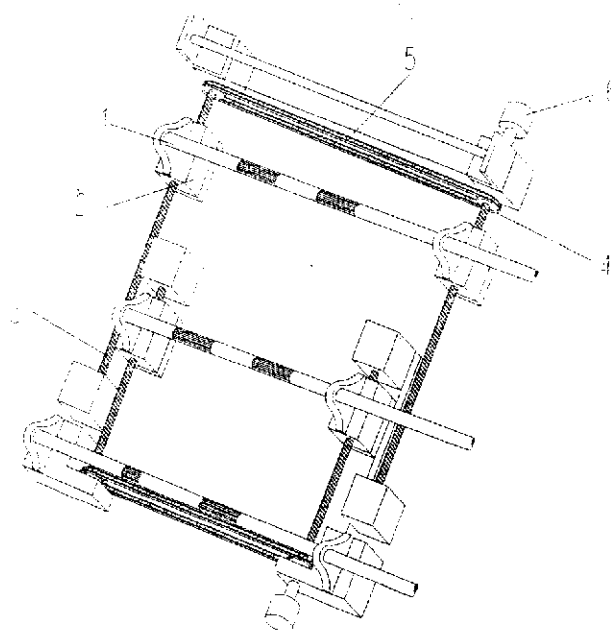


FIGURE 4. Schematic of the selected concept

The same solution can be applied to the second drafting roller.

This concept is both simple, effective and precise. Using stepping motors as rotary actuators, a convenient combination of the screw pitch with the minimum step angle of the motor can result in very small linear pitch; as an example, with a 5 mm pitch screw and 180 steps per revolution motor, the linear resolution is 0.03 mm. The solution also has the advantage of an easy on-line computer control, important if we decide to progress towards a mechatronic solution.

## 6. Conclusion

The project is still in the design phase, but the results of the preliminary studies gave indications of a successful outcome. Next, the same approach will be applied to the upper rollers (pressure rollers), with a similar mechanical and control technique.

The following step will be to develop a prototype experimental rig in order to test the ideas with different fibers and characteristics and the quality obtained, namely, yarn irregularity and strength .

If this study is successful, other machine parameters will be evaluated, namely the twist insertion system .

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