# A STUDY OF THE EFFECT OF YARN IMPERFECTION ON KNITTED FABRICS

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ABSTRACT

The main factors, which may be considered to affect a high quality knitted fabrics, besides knitting machine conditions and labour skill, are yarn regularity and percentage of yarns imperfection. Yarn quality has not only remarkable effect on fabric appearance but also an infleunces on machine performance and product cost. In this work different yarn sources, winding machine settings and knitted structure are studied. It was found that yarn quality may be considered as a major factor that cause loss in the profit of knitting mills. Fabric appearance and knitted fabric properties of the grey bleached and finished fabrics are affected by the yarn quality. Also yarn imperfection has a great effect on knitting machine performance and number of broken needles as well as wear of the knitting elements and its life time.

## INTRODUCTION

Knitted fabrics are mainly used in production of underwear and outerwear garments. The general requirements of these fabrics are not only the stability of the fabric but also the appearance and comfort to suit its end-use.

Machine setting and state as well as labour experience and skill beside the yarn quality affect to a great extent fabric appearance, physical and mechanical properties of the knitted fabrics.

With a perfect machine conditions as well as a relatively good operative skill a good knitted fabric can be produced, only if the yarn used has a minimum imperfection.

In the literature the yarn faults and its effect on machine productivity are discussed. Some workers [1] stated that yarn faults play an important role in affecting knitting production. Other workers, Schneider [2] studied the effect of added materials to the yarn and its degree of concentration on fabric appearance. He discussed also the extraction method to remove stains. Offermann [3] studied the dimension behaviour of plain knitted fabric in relation to variation in yarn feed length and machine diameter and found that with the same material and structure properties the dimension and shrinkage properties can be varied as a function of yarn feed length.

Buck [4] developed an idea, to oppose motion of needles and sinkers, which enabled to measure the effect of yarn quality on efficiency levels. Other researchers [1] studied the effect of thin and thick places of yarn on the knitted fabric quality. He related the loss in the efficiency was due to yarn breaks, on the other hand, yarn faults can seriously down grade the appearance of the knitted fabrics. Egbers [5] studied the effect of yarn type, yarn tension, yarn speed and sinker materials on yarn-induced material wear. He found that the usual needle life would be reduced by half when rotor yarns were used instead of ring yarns. He observed also that the increase of wear is connected with yarn structure and the content of fine dust on the yarn surface. The level of material wear is a function of yarn tension and the quality of processed yarns. Douglas [6] stated that the lower production rate is due to yarn quality and increase in feeders. Also, he found that the variation in yarn count gives down grading due to stripiness results and leads to higher production costs. Other workers in this field [7,8,9] had offered some methods for fault detections.

### *Scope of work*

Usually knitting mills refuse the produced yarn spun by spinning mills due to some problems enclosed with the appearance of the grey knitted fabrics. The causes of these problems are count variation, yarn appearance and yarn imperfection. These affect on knitted fabric

properties, machine performance and product cost. Therefore, in this work yarn sources and yarn preparation before knitting operation will be studied. The effect of knit structure and finishing process on the appearance of the produced fabric will be investigated. From the economical point of view production cost for all processed fabrics will be discussed.

*Experimental work*

Egyptian cotton Giza 80 and Giza 75 is used. Yarns of 30/1 and twist factor 3.4 were chosen. These are carded yarn which are mostly used in Egyptian knitting industry either for outwears and underwears. Five spinning mills are chosen. These mills feed these yarn to the knitting mills. Before knitting operation, yarn properties are tested. The results are tabulated in Table (1) and will be discussed later.

To study the effect of yarn preparation one yarn source is choosen and the spinning bobbins are wound through four different winding machine settings. The different four settings allow, 100%, 140%, 160% and 180% of the original yarn diameter and of a length 2 cm, to be wound separately in each experiment. Thin places, which are finer as 50% of yarn diameter may be removed. The yarns are wound on packages with the same yarn tension through all four settings (5-2-5), (7-2-5), (8-2-5) and (9-2-5).

To investigate the effect of knitting structure on the fabric appearance, three structures are chosen, single jersy, fine rib and derbby. These structures are the mostly used in manufacturing sport wear, hosiery goods, gloves, mittens wristlels, upper garments and other knit wear.

Mechanical and physical properties of the knitted produced fabric, which are measured, are bursting strength, fabric air permeability, fabric weight and fabric appearance. Tests are carried out according to ASTM.

To study the effect of finishing process, all fabrics are scoured and treated by softeners to give an acceptable handle. For white clovers bleaching is carried out by adding giveal and $H_2$ $O_2$ as well as an optical brightener. Predyeing, a half bleaching is done and then the dyeing process is carried out with reactive dyestuffs on a Winch dyeing machine.

## RESULTS AND DISCUSSION

Following are the results of the studied parameters and the discussion of the effect of each on fabric appearance, machine performance and economic success in knitting mills.

*1. Effect of yarn sources*

In spite of the same cotton type, yarn count and ya twist factor, yarn irregularity and percentage imperfection vary from a spinning mill to another on This is obvious in Table (1) for yarn sources 2,3,4 a 5. Therefore, yarn quality differs in accordance to t spin plan of the spinning mill, i.e the number processes, type and state of the spinning machines a different machine settings. Also, the difference winding machine settings from one spinning mill another mill may be also one of the cause of varyi yarn quality. It is also shown in Table (1) yarn (mill which is processed from Giza 80, gives lower ya quality than those processed from Giza 75.

Table (2) shows the results of fabric appearanc which are carried out through expert inspecti method. This method is the only used for fab inspection in knitting Egyptian mills. From the resul it is clear that good fabric appearance is inversel proportional to the yarn imperfection. Yarn of high imperfection and consequently uneven gives a high percentage of Baree in grey fabrics. The yarn source shows the least fabric defects as a result of better ya quality. Because of higher thin places and neps of ya source 1, the variation in fabric weight is high. Due the stability of the knitted fabric after relaxation, t variation in fabric weight is dropped. Less percenta of yarn imperfection produces fabrics with high bursting strength, higher fabric cover and higher a permeability.

Figure (1) shows the no of machine stoppages and t no of broken needles per $10^5$ courses. It is clear th the increase in machine stoppages and also in brok needles may be due to the increase in stresses appli on the yarn during the knitting operation which are a result of yarn imperfection of the processed ya Yarn source 1 is the more tedious one in knitti production. So, it may be recommended that knitti operation needs yarn relatively free from ya imperfection to reduce machine stoppages and increase life time of the machine parts, mainly t needles. Therefore, yarn source 1, Giza 80, is n suitable for knitting machines. Controry is the ya sources 2...5. Yarn sources 4 and 5 show the le values of machine stoppages and broken needles, th values are almost near the standard of sufficient ya quality for knitting operation.

**Table 1.** Yarn Imperfection Different Spinning Mills.

| Spinning Source / measured Property | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Cotton type | Giza 80 | Giza 75 | G. 75 | G. 75 | G. 75 |
| Um% | 13.83 | 13.76 | 12.82 | 11.46 | 10.59 |
| Thin place/km [ - 50%] | 322 | 38 | 16 | 3 | 2 |
| Thick places/km [ + 50%] | 606 | 286 | 145 | 128 | 59 |
| Neps/km [ + 200%] | 1043 | 281 | 256 | 220 | 118 |

**Table 2.** Knitted fabric properties of different yarn sources

| Spinning Mill Source / Fabric Property | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Fabric weight [g/m$^2$] | after Knitting | 100.9 | 109.7 | 114.1 | 108.6 | 101.2 |
| | C.V.% | 11.6 | 3.7 | 1.6 | 6.4 | 9.7 |
| | after Relaxation | 116.2 | 111.7 | 118.6 | 114.9 | 115.3 |
| | C.V.% | 2.9 | 8.8 | 1.9 | 7.8 | 4.8 |
| Fabric bursting Strength [g/cm$^2$] | | 50.3 | 50.8 | 52.2 | 53.2 | 60.2 |
| Fabric density Wales/cm, Course/cm | | 33<br>46 | 31<br>44 | 33<br>43 | 31<br>45 | 30<br>45 |
| Cover factor | | 1.39 | 1.41 | 1.30 | 1.45 | 1.50 |
| Air permeability cm$^3$/min. cm$^2$ | | 812 | 921 | 902 | 925 | 981 |
| Fabric Appearance | Thick places % | 75 | 60 | 40 | 45 | 15 |
| | Thin places % | 60 | 50 | 30 | 35 | 10 |
| | Neps n | 45 | 45 | 40 | 30 | 15 |
| | Baree % | 80 | 15 | 35 | 25 | 10 |

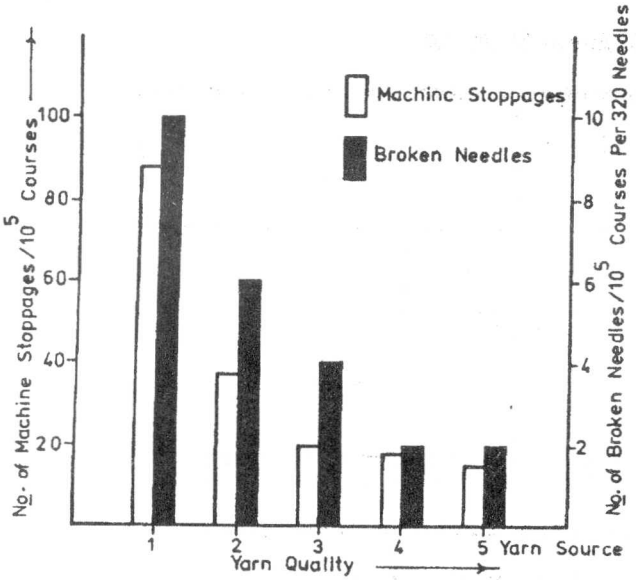


**Figure 1**. Machine stoppages and broken needles of different yarn sources.

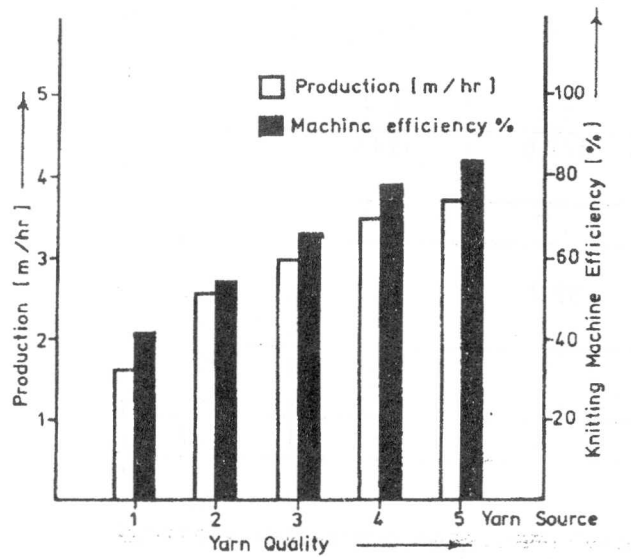


**Figure 2**. Machine production and efficiency of different yarn sources.

The knitting machine production and efficiency are shown in Figure (2). It is also remarkable that, the higher machine production and efficiency are for yarn from source 4 and 5. From the economical point of view and as plotted in Figure (3) yarn from sources 5 shows a decrease in knitting cost by 30% relative to yarn source 2. While the other yarn sources, i.e, 4 and 3 show a decrease of 22% and 10% respectively. T decrease in knitting cost is as a result of yarn quali The worst yarn quality, source 1, shows hig production costs which has not economical success knitting mills.

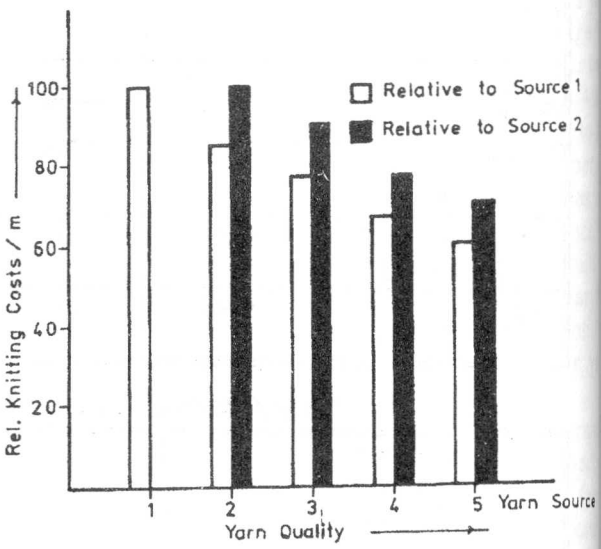


**Figure 3**. Relative cost of different yarn cource.

After half bleaching of the produced knitted fabri some fabric defects such as thick, thin places and ho are disappeared while the neps in knitted fabric, y source 1, is still high, Table (3). Generally, it remarkable that, finishing process improv significantly the fabric appearance, while the wo yarn with higher imperfection still has bad appearan in spite of the reduction of some fabric faults af finishing operation.

**Table 3.** Fabric Appearance after Bleaching For different Yarn Sources

| Measured Fabric appearance | Yarn Source | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Thick places % | 60 | 40 | 35 | 35 | 10 |
| Thin places % | 40 | 30 | 25 | 25 | 10 |
| No of holes | 8 | 3 | 2 | 3 | 0 |
| Neps n | 84 | 23 | 14 | 18 | 11 |

*2. Effect of Winding machine settings*

Winding is the only process for carded ya preparation before the knitting takes place. Therefo

four settings on winding machine are chosen with the aim to produce yarns with different imperfection. These yarns are taken from one spinning source and are tested after the winding process. The results are tabulated in Table (4). It is clear that the thin places are almost constant between all four yarns and its value is within the standard. Setting 1 (5-2-5) shows fewer imperfection than the other three settings. It has less thick places and neps. After processing these yarns into knitted fabrics, the properties of the knitted fabric are measured and recorded in Table (5). It is clear that, if the yarn is cleared as required, knitted fabric properties improved. Area covered by the fabric has no significant effect as a result of lower percentage of thin places in all yarns. Fabric strength and air permeability are improved as the thick places are removed. Also the variation in fabric weight depends on the thick places in the processed yarn. The variation in fabric weight at setting 4 (9-2-5) is higher than setting 1 (5-2-5), which has less thick places of the processed yarns.

**Table 4.** Different Winding Machine Settings.

| Winding Machine Setting / measured Property | 5-2-5 100% | 7-2-5 140% | 8-2-5 160% | 9-2-5 180% |
|---|---|---|---|---|
| Um % | 10.76 | 10.62 | 10.59 | 10.63 |
| Thin places/km [-50 %] | 2 | 0 | 2 | 2 |
| Thick places/km [+ 50%] | 43 | 53 | 59 | 72 |
| Neps/km [+200%] | 98 | 120 | 118 | 112 |

The higher knitting machine efficiency, which is the result of less no. of machine stoppages and broken needles was recorded by yarn setting 1 (5-2-5), Figure (4), while yarn setting 4 (9-2-5) gave lower machine efficiency and more broken needles. So, the production in [m/hr] by yarn setting 1 (5-2-5) is higher by 35% than the production through processing yarn setting 4 (9-2-5), as shown in Figure (5). The reduction in production rate of the knitting machine due to processing yarn with higher thick places and neps, which was followed by an increase of 25% in knitting cost than that by yarn setting 1 (5-2-5), Figure (6).

**Table 5.** Knitted Fabric properties of different winding machine Settings

| Fabric Property / Machine Settings | | 5-2-5 | 7-2-5 | 8-2-5 | 8-2-5 |
|---|---|---|---|---|---|
| Fabric weight [g/m$^2$] | after Knitting | 99.6 | 103.3 | 101.2 | 101.0 |
| | C.V.% | 2.7 | 3.7 | 9.8 | 8.4 |
| | after Relaxation | 113.3 | 116.8 | 115.3 | 112.6 |
| | C.V.% | 1.4 | 3.3 | 4.5 | 7.2 |
| Fabric bursting Strength [g/cm$^2$] | | 55.5 | 50.3 | 47.9 | 46.6 |
| Fabric density Wales/cm, Coorses/cm | | 31<br>47 | 30<br>47 | 30<br>45 | 31<br>47 |
| Cover factor | | 1.52 | 1.56 | 1.50 | 1.52 |
| Air permeability cm$^3$/min. cm$^2$ | | 1038 | 1011 | 981 | 977 |
| Fabric Appearance | Thick places % | 10 | 25 | 15 | 20 |
| | Thin places % | 5 | 15 | 10 | 15 |
| | Neps n | 5 | 15 | 15 | 20 |
| | Baree % | 20 | 10 | 10 | 15 |

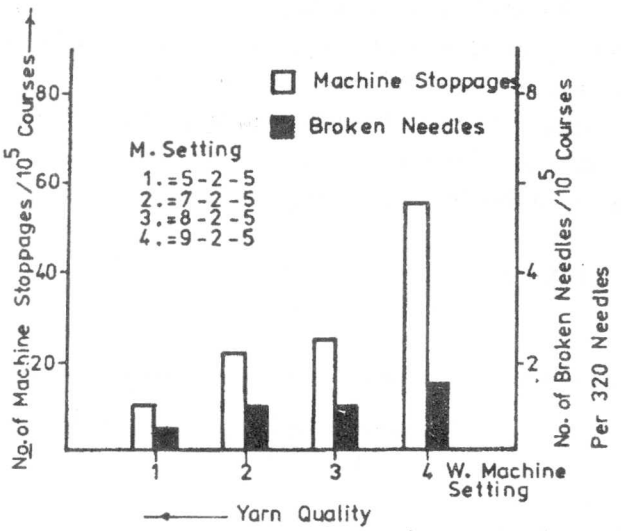


**Figure 4.** Machine stoppages and broken needles for different winding machine settings.

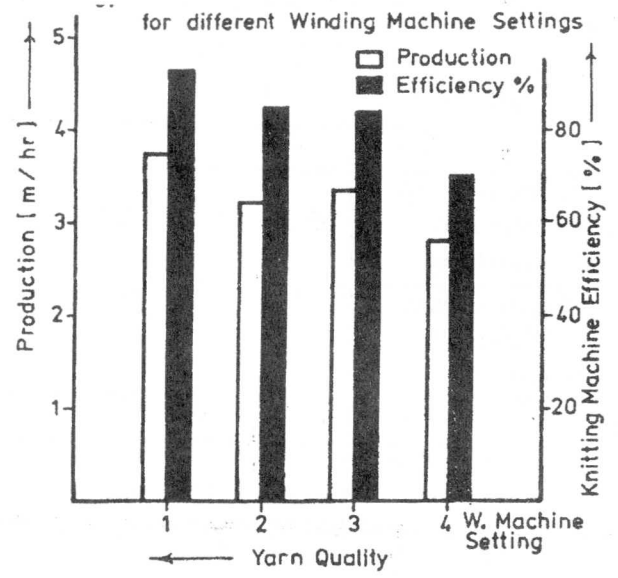


**Figure 5.** Machine production and efficiency for different machine settings.

From the economical point of view, it is remarkable that better yarn quality help to increase life time of the machine parts, to increase productivity and to decrease knitting costs. These can be only gained, when the winding machine settings are 7-2-5 or 8-2-5.

After half bleaching, the knitted fabric appearance is significantly improved. Table (6) shows that the knitted fabric, yarn setting 4 (9-2-5), still has higher percentage of thick places and thin places.

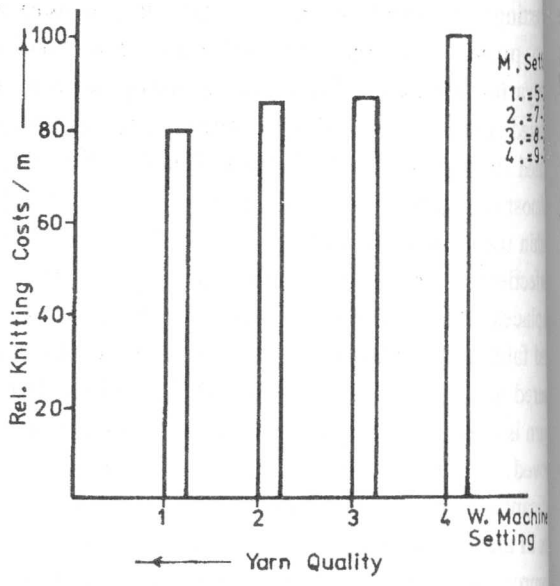


**Figure 6.** Rel. knitting cost/m for different wi machine setting.

**Table 6.** Fabric Appearance after Bleaching f different winding machine settings

| Measured | Winding Machine setting | | | |
|---|---|---|---|---|
| Fabric appearance | 5-2-5<br>1 | 7-2-5<br>2 | 8-2-5<br>3 | 9-2-5<br>4 |
| Thick places % | 10 | 10 | 10 | 25 |
| Thin places % | 10 | 10 | 10 | 15 |
| No of holes | 1 | 2 | - | 2 |
| Neps (no.) | 8 | 7 | 10 | 9 |

## 3. EFFECT OF KNITTING STRUCTURE

To study the effect of different knitting struct three knitting machines are used. Because the num of feeders and machine speed of the three knit machines are not the same, as shown in Table (7), theortical production may not be equal.

After carrying out the experiments, it was recor that the number of yarn breaks by single jersy w two breaks and the number of broken needles was o one, while each the derbby and rib structure has got either broken yarns or broken needles. This m that the processed yarn was suitable.

Table (7) shows that the knitting cost per meter derbby lower than the rib and single jersy. It

found to be 50% for derby structure and 12.5% for rib relative to single jersy. This reduction in costs may be due to machine type and its capital cost.

**Table 7.** Machine performance and Knitted fabric properties of different knitting structures.

| Knitted Structure / Machine | Derby | Rib | Single Jersy |
|---|---|---|---|
| no of feeder | 12 | 24 | 30 |
| Speed (r.p.m) | 30 | 30 | 24 |
| Courses/in | 28 | 30 | 50 |
| m/hr | 19.60 | 36.60 | 52.70 |
| efficiency% | 94 | 94 | 93 |
| Costs/m (P.T) | 20 50% | 35 87.5% | 40 100% |

Table (8) shows the air permeability for the three knitting structure and three different yarn quality. It is obvious from the results that air permeability decreases from yarn setting 1 (5-2-5) to setting 3 (8-2-5). This is due to increase in thick places by setting 3. Inspection of the knitted fabric samples show no difference at the same yarn quality, very clear unevenness as well as some holes were distributed on all samples.

**Table 8.** Fabric properties of different Yarn quality and Knitted fabric Structure.

| Knitted fabric Structure | Single Jersy | | | Rib | | | Derby | | |
|---|---|---|---|---|---|---|---|---|---|
| Fabric property | Yarn quality 1 | 2 | 3 | Yarn quality 1 | 2 | 3 | Yarn quality 1 | 2 | 3 |
| air permeability $Cm^3/min.\ cm^2$ | 1038 | 1019 | 981 | 1040 | 1013 | 964 | 1043 | 1009 | 953 |
| Coefficient of drapeability % | 5.81 | | | 6.38 | | | 6.61 | | |
| Cover factor | 1.5 | | | 0.57 | | | 0.90 | | |
| Fabric weight $gm/m^2$ | 130 | | | 140 | | | 300 | | |

For fabric defect illustration, the fabric were dyed into three colours, these colours are of most advisable one for declearing defects.

In the three fabric structures, a clear yarn unevenness appeared in the three different yarn quality. The derby structure showed lower defects specially in the best yarn quality, the corded form of the derby structure hid the other yarn defects, whatever is the yarn setting.

Due to thin places, fine rib and single jersy showed more defects which appeared in a form of a hole of 5 mm diameter.

Other fabric defects are shown in Table (9), where x is the unevenness-Baree due to count variation and its value is in all three structures and yarn quality the same. The defect y is a hole due to very thin and weak place, its value is in single jersy more than rib and derby. W is the obvious thin places in the fabric and it appears in low yarn quality 3 than best 1. The defect J is a thick place and $\phi$ is unclamped thread.

**Table 9.** Fabric defects of different structure after dyeing.

| Knitted Structure / yarn quality | Single Jersy | Rib | Derby |
|---|---|---|---|
| 1 | x, 9y | x, 1y | x |
| 2 | $x_1$ 1y, W | x, W | x |
| 3 | x,3y, $\phi$,j | x, $w_1$, 1z | x, 3j, 4w |

## CONCLUSION

From the results and discussion, it can be conclude that:

1. Cotton type affects yarn quality and consequently the properties and appearance of knitted fabrics.
2. Yarn sources, i.e spinning mill, affects the properties of the spun yarn. Different yarn sources of the same cotton type and yarn count give different yarn properties and, consequently different knitted fabric properties and appearance.
3. Setting of the winding machine affects the yarn properties and fabric appearance. As the yarn is

cleared as required, knitted fabric properties are improved.

4. As the percentage of yarn imperfection decreases, the fabric bursting strength, cover factor and fabric air permeability increase. This type of knitted fabrics is suitable for summer and sport garments.
5. The success of a knitting mill depends on cotton type and the source of the processed yarn, i.e the percentage of imperfection removed during winding the yarn after the spinning process. The best setting on winding machine 7-2-5.
6. Poor yarn quality has not economical success in knitting industry due to increase in production cost, decrease in machine performance and reduction in life time of the needles as well as bad fabric appearance.
7. Finishing process can improve the appearance of the grey knitted fabric.
8. Knitted structure has relative effect on fabric appearance. Derby knitted structure hides yarn defects through its corded form

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