COMPACT AND ROTOR YARNS – YARN QUALITY
AND ITS FURTHER PROCESSING

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Polish cotton industry alike the whole Polish economy has been politically transformed. In comparison to 1989, output of cotton products decreased by 30% - 50%, a number of state owned enterprises went into bankruptcy whereas numerous private companies replaced them. Remaining companies had to modernise themselves in order to retain their production capacities.

In several spinning mills there work newest machines, like in the Western countries. Preliminary cotton processing starts on bale pluckers, next the material is intensively opened and cleaned on the machines of world-known manufacturers: Rieter and Truetschler. The carding machines' efficiency is over 100 kgs/h and they are equipped with sophisticated sets of licker-ins, new-type card-clothing and drafting adjusters. Long staple cotton for fine yarns is processed in combed spinning systems with doubling-winding machines and highly efficient combing machines (60 kgs/h).

Serious changes took place in the proper-spinning phase. 40% – 50% of yarns spun in the card system in Poland employs rotor spinning machines. On the other hand, the machine producers for ring spinning, like Rieter, Suessen, Zinser make every effort to improve the yarn quality. These endeavours were crowned with success – a new kind of yarns was invented – compact yarns. It was at ITMA '99 when the compact spinning systems were presented for the first time.

Research on compact spinning has been conducted since 1991; the firs spinning machine for industry was built in 1995. In 2000, all over the world, there were 200,000 ring spindles with compact drafting apparatuses from Rieter, and 150,000 spindles with the drafting apparatuses from Suessen. Compact spinning systems aim at improving yarn quality through narrowing the sliver leaving the drafting apparatus, before its twisting into yarn and through liquidation of the twist triangle.

Suessen introduced the "Elite" compact system for ring spinning machine Fiomax 1000 with triple pair of drawing rollers. The "Elite" system for pneumatic condensation of the sliver is installed behind the delivering rollers of the apparatus. The delivering roller propels a perforated belt surrounding the mould in which there is underpressure. In the mould, there is an inclined slot in a perforated belt, in relation to the flow of fibre stream. It causes the fibre stream change its direction and the flat sliver becomes condensed into a compact stream. Inclined placement of the slot (Fig. 1) additionally eliminates the influence of the layer thickness on the condensation effects. The condensation zone ends in the line of seizure of fibres between the delivering roller and the perforated belt. This line overlaps the place of finishing the twist, at the same time liquidating the twist triangle.
It follows from the industrial experience and researches conducted in experimental stations [1 – 3, 6 – 13], that the main virtues of the compact spinning system are: smaller number of breaks during the spinning process (by 30% - 60%), further during the processing – lowering of the twist by about 20%, greater efficiency connected with greater yarn strength and the possibility of spinning when the twist is lowered. Further, there are: lower dust emission, (because of the compact structure of yarn), possibility of increasing winding and beaming speed. During twisting on the twisting frame, the twist can also be lowered by 20%. The structure of yarn with the lowered twist improves the dye-stuff sorption and lowers the dye-stuff consumption.

Advantages when weaving
Consumption of size is lowered by 25% - 50%, single and twisted yarns do not need gassing. Lower hairiness and greater yarn strength decreases yarn breaks number during warping by 30%. There are less splicing points and less jams of yarn when shedding. During weaving, a twisted yarn may be replaced with a cheaper, single compact yarn. During weaving, the number of breaks of warp lowers of ca. 50% and of weft – ca 30%. Number of warp breaks during shots on rapier looms decreases by 33% and on pneumatic looms – of about 45%. The speed of weft insertion may be increased from 500-600 m/min. up to 700-800 m/min.

Yarn produced in the compact system, when compared with the classic one (Fig. 2.), is characterised with: greater smoothness, greater shine, greater resistance to abrasion – 40% - 50%, lower hairiness (measured on Uster apparatus – ca. 20% - 30%), lower hairiness (measured on Zweigle apparatus – 60%), higher strength and elongation – by 8 – 15%, lower non-uniformity of linear density.
In relation to classical yarns manufactured from the raw materials of the same characteristics, **rotor yarns** are constructed in some other geometrical way. The fibres are less orderly situated along the yarn axis. However, this results in a lower yarn strength, with simultaneously lower non-uniformity of linear density.

Yarns from the latest models of rotor spinning machines are similar to a considerable degree, to ring spun ones. [5, 10].

Outer appearances of products received from rotor yarns spun on the most modern rotor spinning machines and from ring spun yarns are very close, while the efficiency of rotor spinning machines is much greater.

Fashion tendencies, as well as growing possibilities of application of rotor yarns in manufacture of various kinds of textiles broaden the range for their application and rise the demand. According to literature [15], nowadays, ca. 20% of all yarn in the world are produced on 7,5 mln spinning points of rotor spinning machines. High level of their automation and more and more higher yarn quality show that in future, rotor spinning will make a place for itself in the world yarn production.

**Compared to the ring spinning, rotor spinning is more advantageous.**

- More uniform yarn is formed during the spinning process with smaller number of stoppages. Greater uniformity of rotor than of classic yarn allows to improve weaving and knitting machines' efficiency.

- Forming of big cheese-cops eliminates the process of re-winding. These cops can be used directly on weaving and knitting machines.

- It is possible to use cheaper raw material, as well as recycled materials, including cleaned waste and still, to receive a good-quality yarn. There is no problem in simultaneous processing of several materials of varying colours.

- Minimal number of workers operating the spinning machines is needed. Taking into consideration the high efficiency of rotor spinning machines, automatic liquidation of breaks and cops' removing, the number of personnel needed, is smaller than in case of ring spinning machines, when converted into 1 kg of yarn produced. Fig. 3 [15] represents the
comparison of costs of manufacture of rotor (R) and ring (C) spun yarns (in EUR/kg of yarn), for yarns of the linear density of 20 and 30 tex.

![Comparison of manufacturing costs of rotor R and ring C spun yarns](image)

Fig. 3. Comparison of manufacturing costs of rotor R and ring C spun yarns
A-waste, B-energy, C-services, D-wages, E-means of production [15]

The main portion of the rotor yarn manufacturing costs is the price of raw material which constitutes 60%. Individual technological operations constitute respectively: opening and cleaning – 4%, carding – 6%, drawing – 3%, spinning – 27% [15].

- Rotor spinning machines are characterised with a high degree of automation. Automation was also used for cans' transportation, sliver splicing, cops' removing and their palette packing.

- A great spinning velocity is possible, while spinning a wide range of linear densities of yarns – from 10 to 200 tex. The speed over 200 m/min is reached when spinning low and medium linear density yarns. Rotary speed of the rotors above 140,000 r/min is technologically possible, only in exceptional circumstances. (Fig. 4). [15].

![Increase of the rotary velocity of rotors, during years](image)

Fig. 4. Increase of the rotary velocity of rotors, during years.

Quality of yarns manufactured on rotor spinning machines of the 3rd generation, including Rieter R1, R20 and nowadays, R40, as well as on Schlaflhorst spinning machine improved parallel to multiplication of production. Rotor yarns' quality is close to this of the ring spun ones, with a considerably higher efficiency of the rotor spinning machines.

Yarn quality depends on the following indices: linear density and deviation of the proper linear density from the nominal one, linear density variation coefficient, twist (twist coefficient), strength and braking strength indices, cleanness of yarn, linear density non-uniformity according to Uster (CV%), yarn hairiness.
Research object and discussion of results.

The analysis of cotton yarns formed on ring spinning machines Fiomax EliTe and PJ, as well as on 3rd generation rotor spinning machine R1 was conducted.

Combed and carded cotton yarns were made on Fiomax EliTe and PJ compact machines. their linear densities were: 15, 18 and 20 tex. Combed as well as carded yarns were made of the same raw material from which 24% of combers were removed.

Research was conducted under the special project No: 06 T08 157 2001 C/5683 in the WIMA Spinning Mill, as it is the only Polish mill operating EliTe compact spinning machine of Suessen.

R1 rotor spinning machine made yarns of the linear densities: 18, 20, 25, 30, 35, and 40 tex. Twist coefficient $\alpha_m$ of the yarns was 140, and the rotary speed of the beaters was 7.000 r/min., and the rotary speed of rotors 100.000 r/min. and their diameter was 30 mm.

The research took into consideration the following yarn parameters: yarn tenacity $T$, breaking elongation $E$, resiliency degree $R$, non-uniformity of linear density, faults and hairiness.

Non-uniformity of linear density, faults and hairiness were measured on the Uster Tester 3, applying the passing speed of 400 m/min. and the measuring time 5 min. Received results were compared to Uster Statistics [14].

Comparison of the basic parameters of ring spun yarns were presented on graphs 5 – 8.

The analysis of combed and carded cotton yarns' parameters formed on classic spinning machine PJ and on the compact one Fiomax EliTe, showed that:

Combed and carded 15, 18, 20 tex yarns from the compact EliTe spinning machine are characterised with better parameters than those of the parallel yarns made on the PJ spinning machine.

Those from EliTe, when compared with yarns from PJ posses: greater tenacity, greater elongation, lower non-uniformity of mass measured on short sections, considerably less faults – thin and thick places, neps - higher resiliency, lower hairiness. When the linear densities of compact yarns are growing, non-uniformity of their density is lowering, number of faults becomes smaller and the hairiness becomes greater.
Fig. 6. Parameters of 18 tex yarns from: PJ and ET - Fiomax EliTe.
co – combed, ca – carded

Fig. 7. Parameters of 20 tex yarns from: PJ i ET - Fiomax EliTe.
co – combed, ca – carded

Fig. 8. Hairiness of ring-spun yarns 15, 18 i 20 tex according to Uster
Combed yarns, when compared to carded ones have higher breaking tenacity and lower mass non-uniformity, by ca, 4%, and lower hairiness.

After comparing the results received with the Uster Statistics [14], Fig. 9 and 10, it was stated that particular parameters belong to the following levels of the total world production:

- CVm mass non-uniformity:
  - combed yarns below 5%
  - carded yarns on the 25% line
- hairiness:
  - all yarns considerably below 5%.

20 tex yarns were subject to processing on knitting machines. Preliminary trials were made on a cylindrical rib knitting machine with Nn 18. For the trial purpose the rib stitch was selected. In all cases the knitting process progressed undisturbed. On the basis of manual evaluation, it must be stated that knitted fabrics manufactured from EliTe yarns, when compared to the remaining fabrics made from PJ yarns, were more uniform and smooth and they possessed soft and silky touch.

Selected quality parameters of analysed rotor yarns formed on R1 spinning machine were presented on the collective graph – Fig. 11.
From the dependencies presented on Fig. 11, it follows that when the linear density is growing, the breaking tenacity and hairiness are growing too, whereas the non-uniformity of mass and number of faults are lowering. The greatest values among faults appear in case of thick places.

Fig. 12. Uster Statistics 2001 100% CO, carded rotor - spun
Fig. 13. Uster Statistics 2001 100% CO, carded rotor - spun

After comparison of the received results with Uster statistics [14] Fig. 12, 13, it was stated that individual parameters remain at the following levels of the total world production:

- CVm mass non-uniformity:
  - yarn of 18 and 20 tex below 25%
  - yarns of 25 - 40 tex below 5%
- hairiness:
  - all yarns at the level of 25%

Conclusions:

- Yarns from the compact EliTe spinning machine, when compared with the PJ yarns are characterised with: greater breaking tenacity, greater elongation, lower mass non-uniformity measured on short sections, considerably lower number of faults, such as thin places, thick places and neps, greater resiliency, considerably lower hairiness.

- Combed compact yarns, when compared with carded ones have greater breaking tenacity and smaller non-uniformity of mass and lower hairiness.

- Comparing the received level of analysed parameters of compact yarns with Uster Statistics for ring spun yarns, it is possible to say that their majority is below 5 or 25% of the world production, what marks their high quality.

- Knitted fabrics made of EliTe, when compared to remaining knitted fabrics made from PJ yarns were more uniform and smooth and had soft and silky touch.

- Comparing the received level of analysed parameters of rotor yarns with Uster Statistics, it is possible to say that their majority is below 5 or 25% of the world production, what marks their high quality.

- Greater resiliency of rotor yarns justifies their use mainly in knitting. This feature makes up for their lower breaking tenacity.

- When the linear density of yarns is lowering, their linear density non-uniformity is lowering too.

- Low linear non-uniformity and small number of faults results from implementation of the Uster Polygard set in each spinning point of R1 spinning machine.
Bibliography

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