PRESENTATION

Session:
Spinning And Textile Processing

Title:
Ring yarn from 100% cotton materials on the superconducting turbo ring spinning up to a spindle speed of 50.000 rpm

Speaker:
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Conference Organization
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TECHNISCHE UNIVERSITÄT DRESDEN

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ITM LEADING IN FIBRE & TEXTILE TECHNOLOGY
The Research Institute of University of Excellence

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Institute of Textile Machinery and high performance material technology (ITM), TUD Dresden, Germany

RING YARN FROM 100% COTTON MATERIALS ON THE SUPERCONDUCTING TURBO RING SPINNING UP TO A SPINDLE SPEED OF 50.000 RPM

37th Bremen International Cotton Conference

Bremen // Date, 20. March 2024

Figures – TUD Dresden

- **190 years** of innovation and dynamic development
- **17 Faculties in 5 Schools**
- **600 full professors / 8,303 employees / 28,952 students**
- Since 2012, TUD has been one of Germany's 11 Universities of Excellence
- Ranked among the top 1% of the world's universities
- **Among the top 3 German universities** in terms of third-party funding

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ITM - Team

Professors	3
Full paid researchers	>100
Doctoral candidates	60
Technical employees	42
Student associates	160

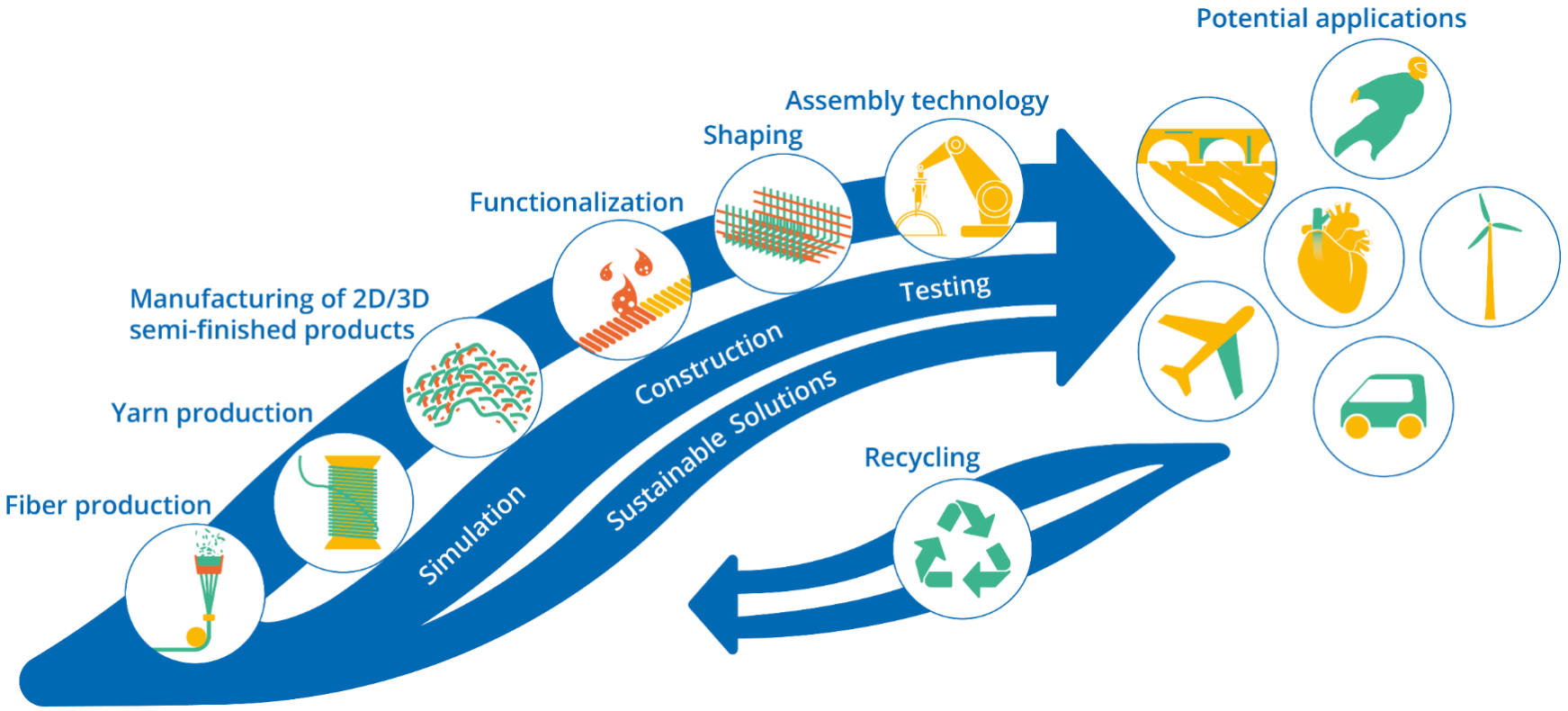
Faculty of Mechanical Science and Engineering

- 1 out of 17 faculties at TU Dresden
- 13 institutes and 51 chairs

ITM with 2 chairs:

- Textile Technology and
- Development and Assembly of Textile Products

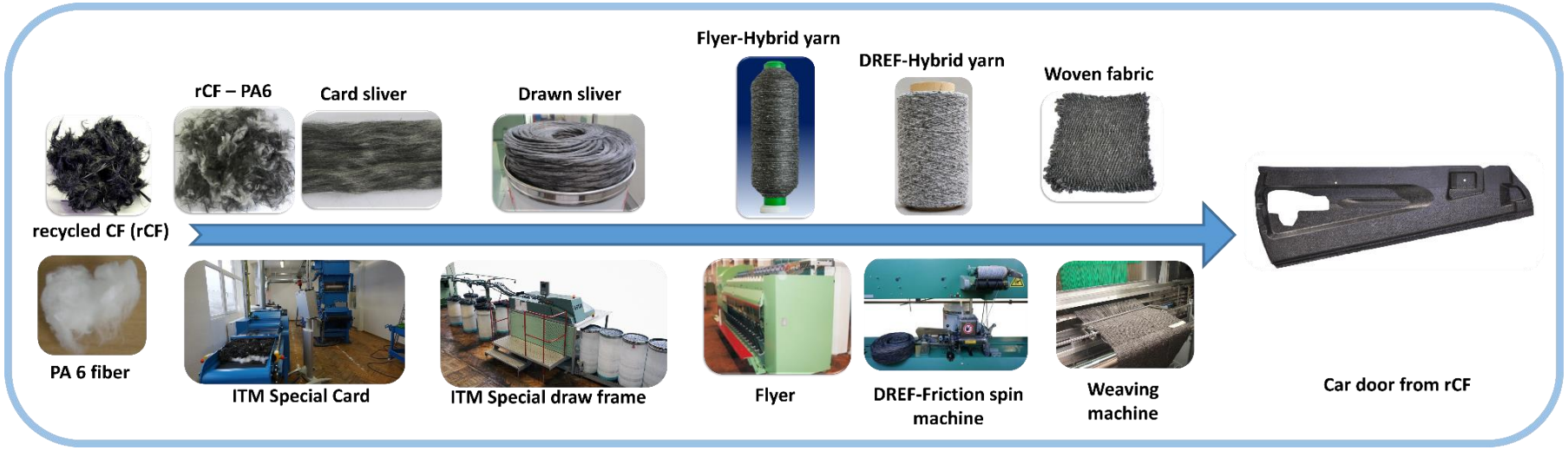
Research at ITM – From molecules to composites

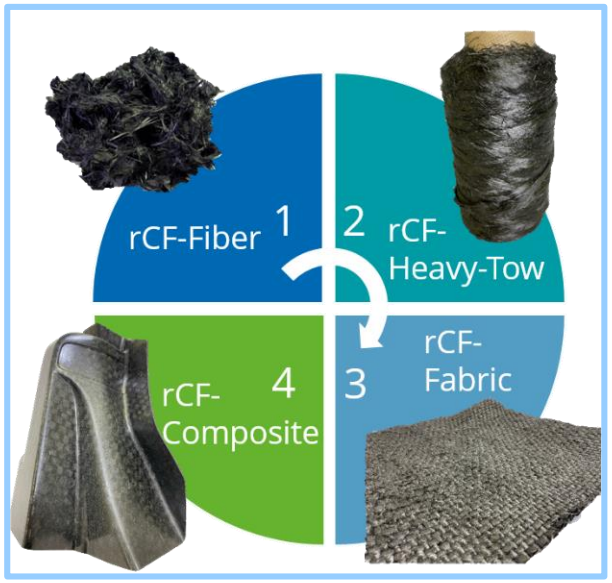


Textile technologies and assembly technologies for textile products, electrical engineering, civil engineering, lightweight engineering, construction, biology, chemistry, design, measuring and control technology...

Research Group „Multi-Material Yarn Structures for High-Tech Applications" of ITM – Fiber structures for technical applications

- Development, modeling, and simulation using spinning machines and processes
- Development of hybrid yarns for composites
- High performance staple fiber yarns of CF, GF, AR and basalt for technical applications
- Technological development for the gentle processing of recycled carbon fibers from fiber preparation to spinning in lab and industrial scale
- Development of bio-based thermoplastic wood structures made of wood wool for complex-shaped, bio-based composites
- Development of braiding yarn and braiding technologies for technical applications





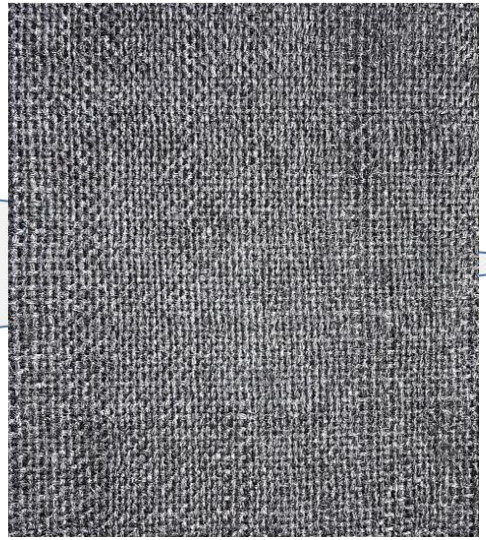
Research Group „Multi-Material Yarn Structures for High-Tech Applications" of ITM – Fiber structures for technical applications

- New metal staple fiber yarns from 100% cost-efficient metal staple fibers

Planed metal fiber

100% metal spun yarn

Fabric structure made of 100% metal spun yarn



Outline

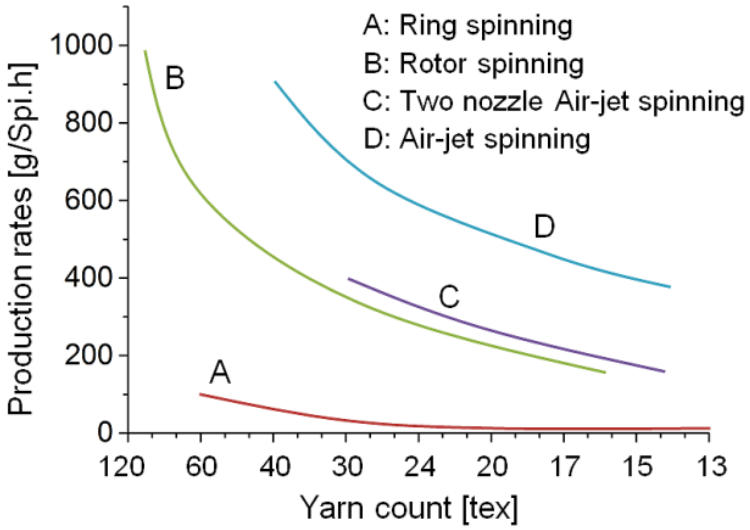
- Introduction and motivation
- State of the art and research
- Turbo ring spinning tester
- Textile technological investigation
- Conclusion and outlook

Introduction and motivation

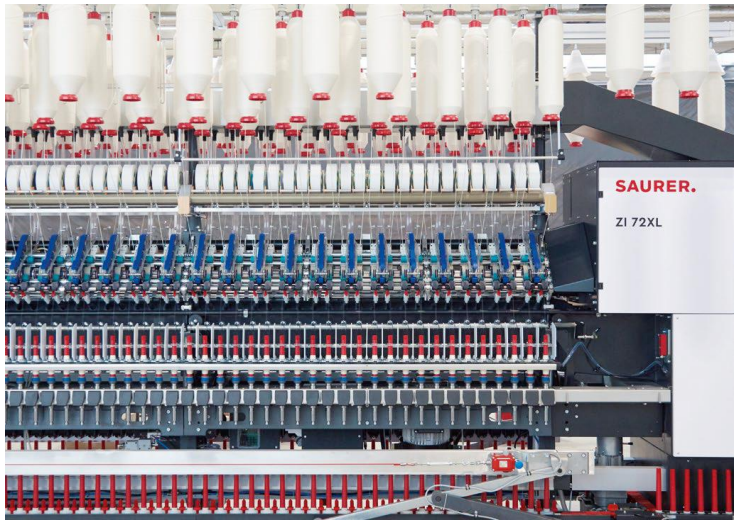
Ring spinning m/c | © Rieter

Ring spinning process - Advantages

- Universal spinning process for the production of any yarn count and textile material
- Best yarn quality regarding yarn structure and tenacity
- Uncomplicated and easy to operate
- approx. 80% market share of short staple yarn production [ITMF/Gherzi]



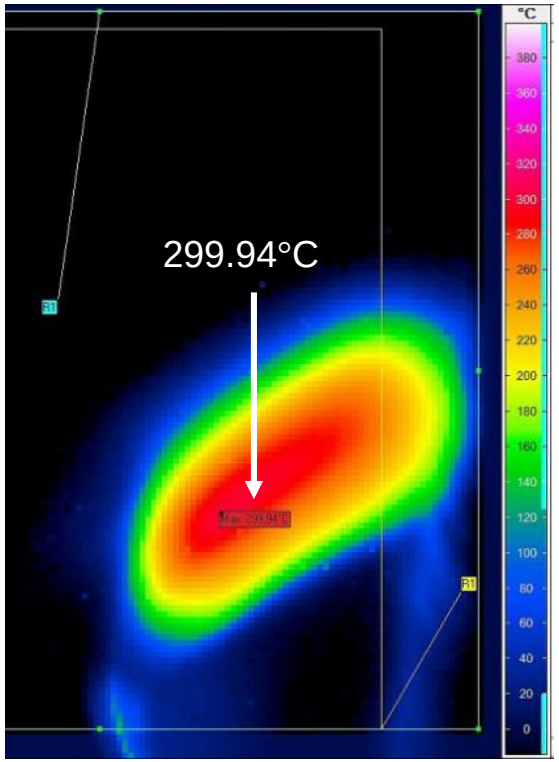
Production rate of different spinning processes | © Rikipedia



Ring spinning m/c | © Saurer

Introduction and motivation

Ring/traveler twisting system



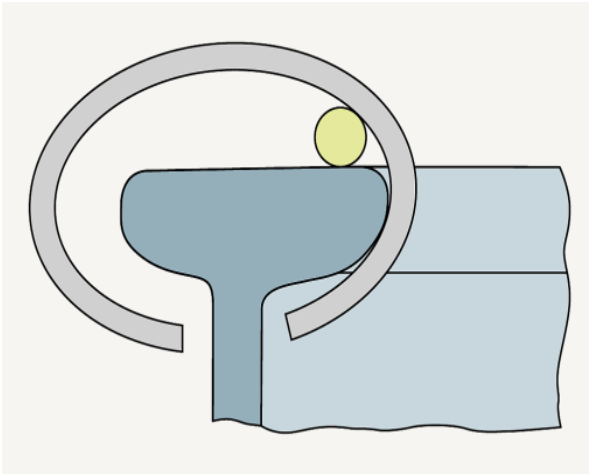
Temperature of traveler @ 20.000 rpm

Limitations of the ring spinning process

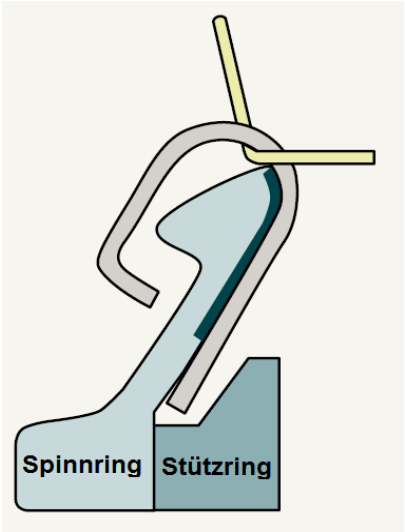
- The frictional heat between traveler and ring (melting point in man-made fibers)
- The wear of the ring/traveler system, especially in traveler
- The frictional heat between the balloon control ring and the yarn
- Increment of yarn tension at the higher spindle speed

State of the art and research

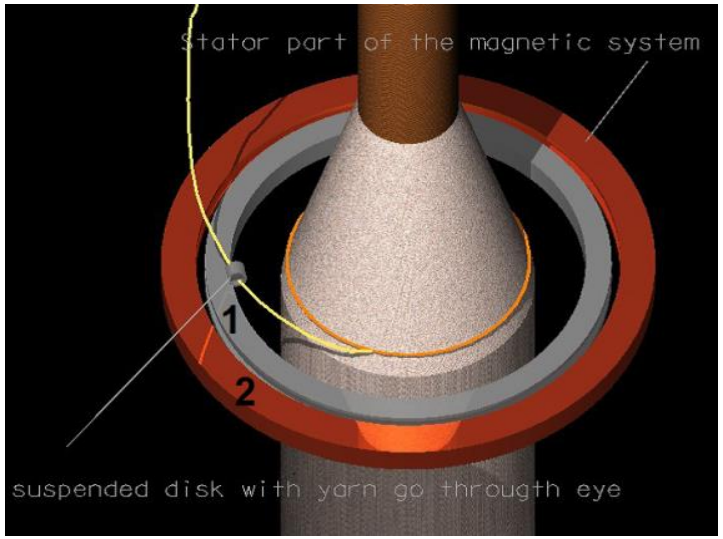
- Different topologies and material combinations of ring/traveler system
- Special surface modifications of ring and traveler
- Electromagnetically controlled ring
- Ring with air-bearing
- Different concept of reducing yarn tension



Anti-wedge ring|© Rikipedia



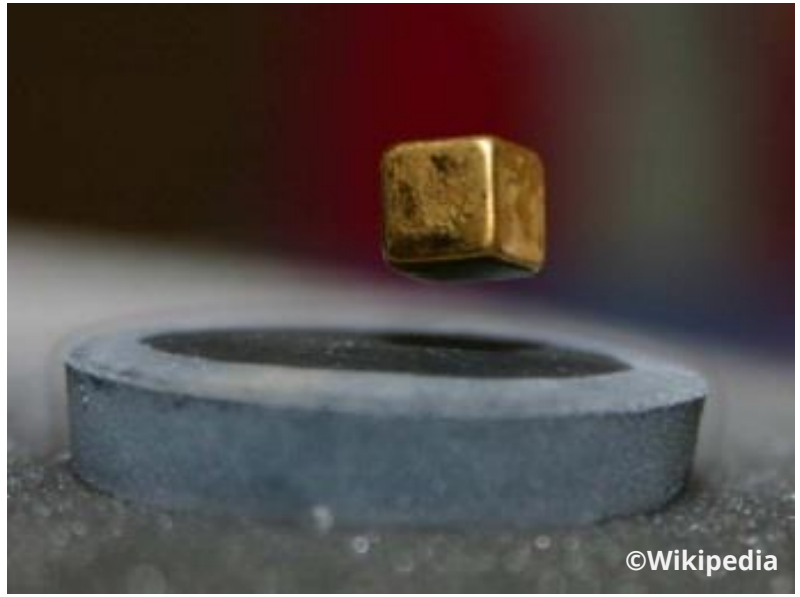
Inclined ”Orbit Ring“|© Rikipedia



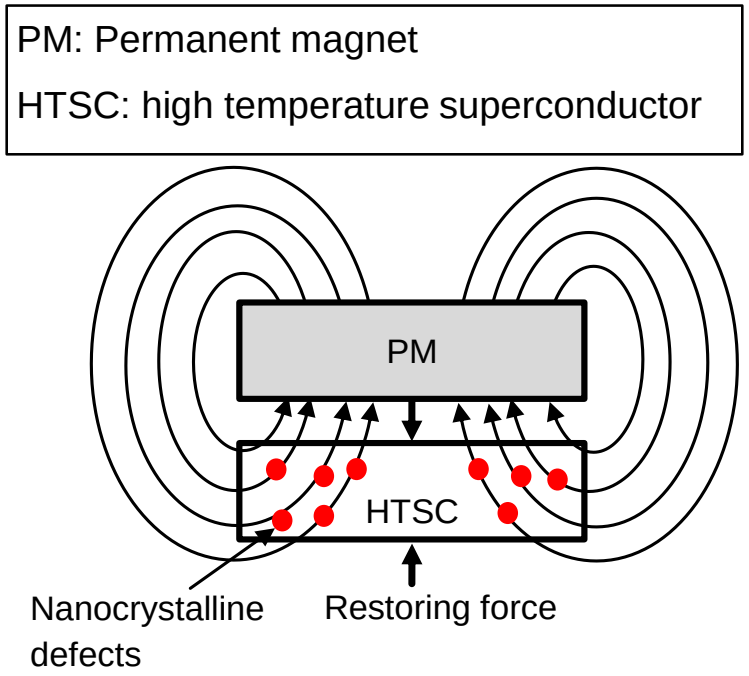
Electrically controlled ring with a levitated ring|© US Patent 7205692

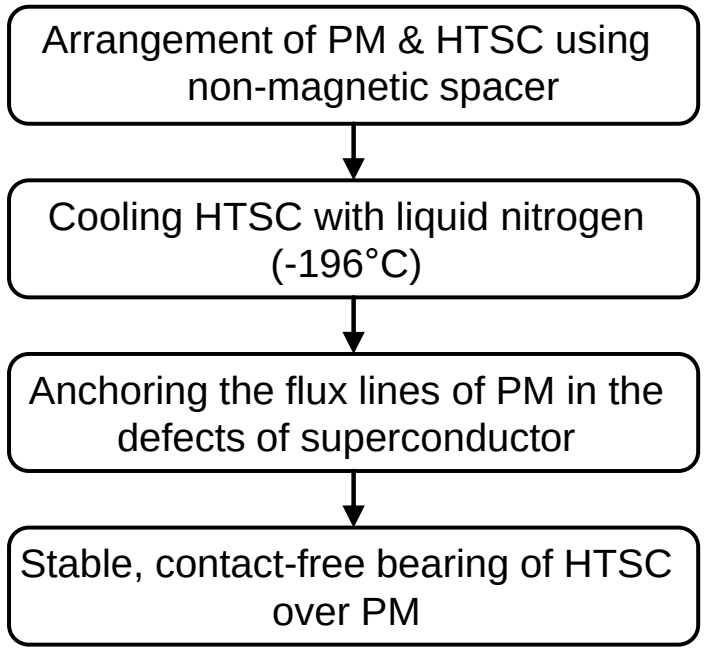
Rotating ring with air bearing|©ITV Denkendorf

State of the art and research



A magnet levitates above a high temperature superconductor cooled with liquid nitrogen (-196°C)

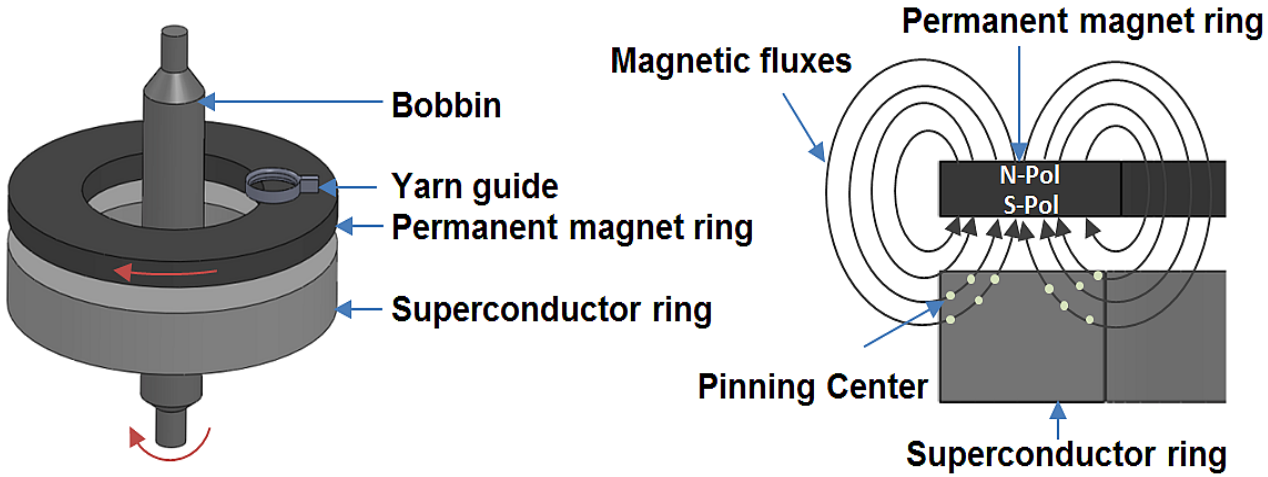




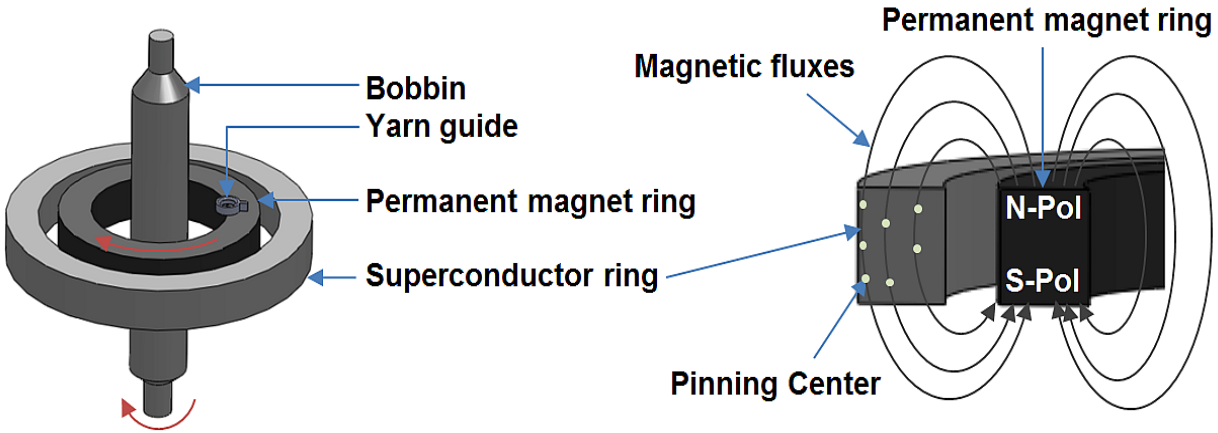
Functional principle of superconducting magnetic bearing (SMB)

- Frictionless and stable levitation and thus wear-free spinning operation
- No expensive control and sensor unit is required.
- Highly reliable in case of higher angular spindle speed

Turbo ring spinning tester – concepts of twisting element

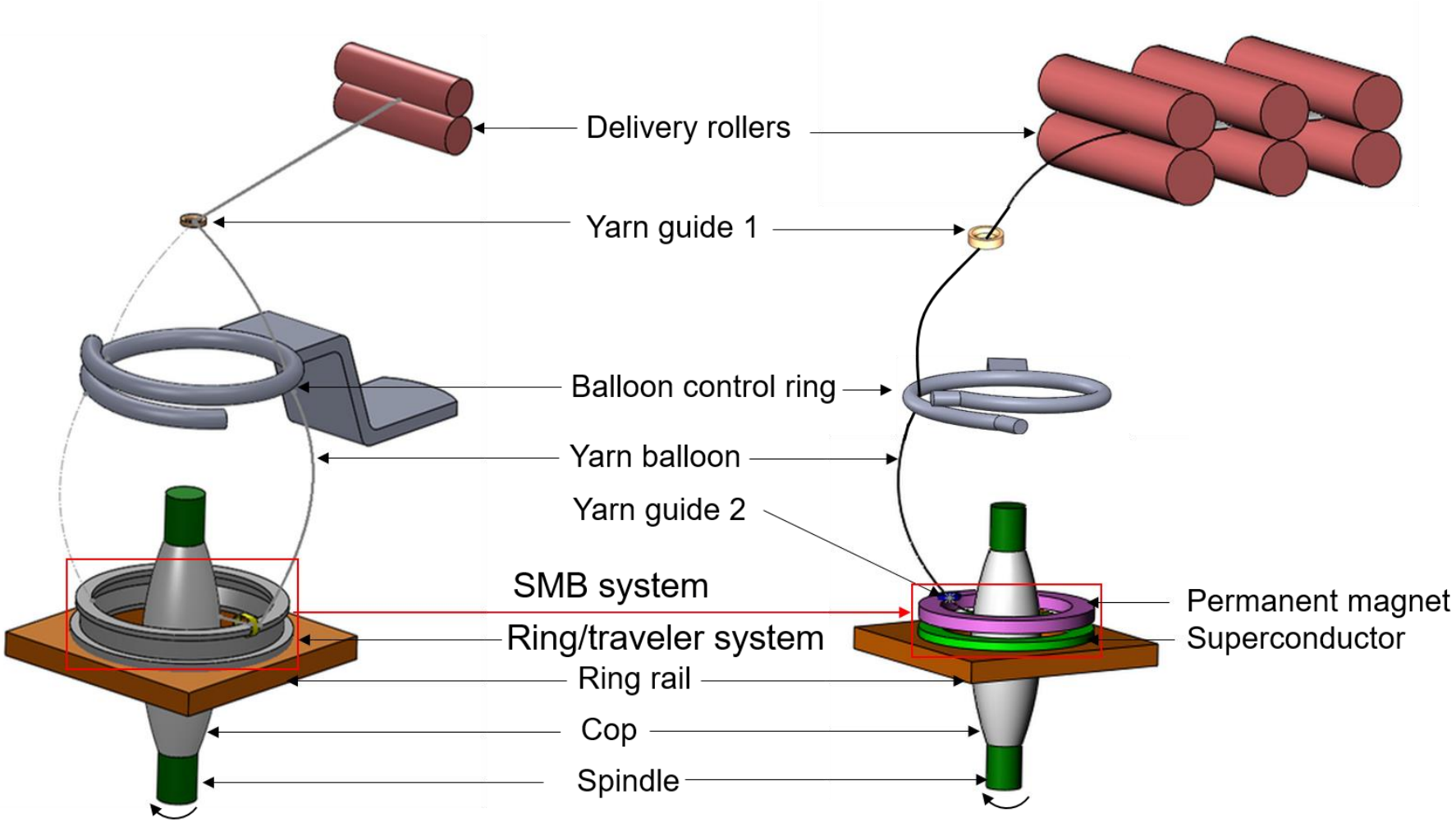


Concept 1: Topology and cross-sectional view, where magnetic fluxes are trapped in pinning center



Concept 2: Topology and cross-sectional view, where magnetic fluxes are trapped in pinning center

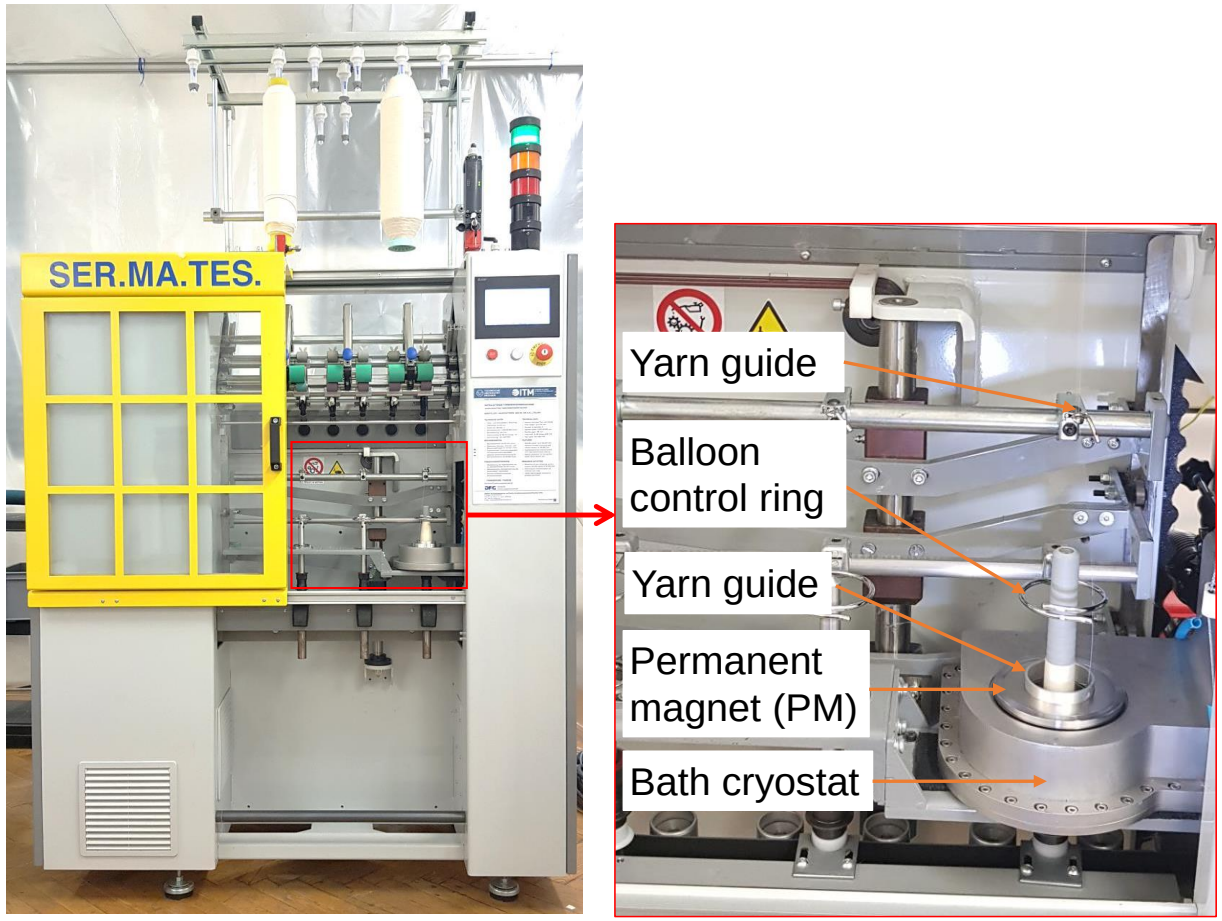
Turbo ring spinning tester – Integration of the designed twisting element



Ringspinning process with ring/traveler system

Ring spinning process with SMB| © DE 112012000596A5

Turbo ring spinning tester – Integration of the designed twisting element



(a) (b)

(a) Superconducting high performance ring spinning tester and
(b) superconducting magnetic bearing (SMB) twisting system with bath cryostat

Main features:

Twisting system:

SMB twisting system

Permanent magnet- NdFeB, Superconductor- $YBa_2Cu_3O_{7-x}$ (YBCO)

Cryogenic system with liquid nitrogen (LN_2)

Spindle speed: 5.400 - 50.000 rpm

Materials: Natural, chemical and blends

Fibre length: up to 45 mm

Number of spindle: 3

Special features:

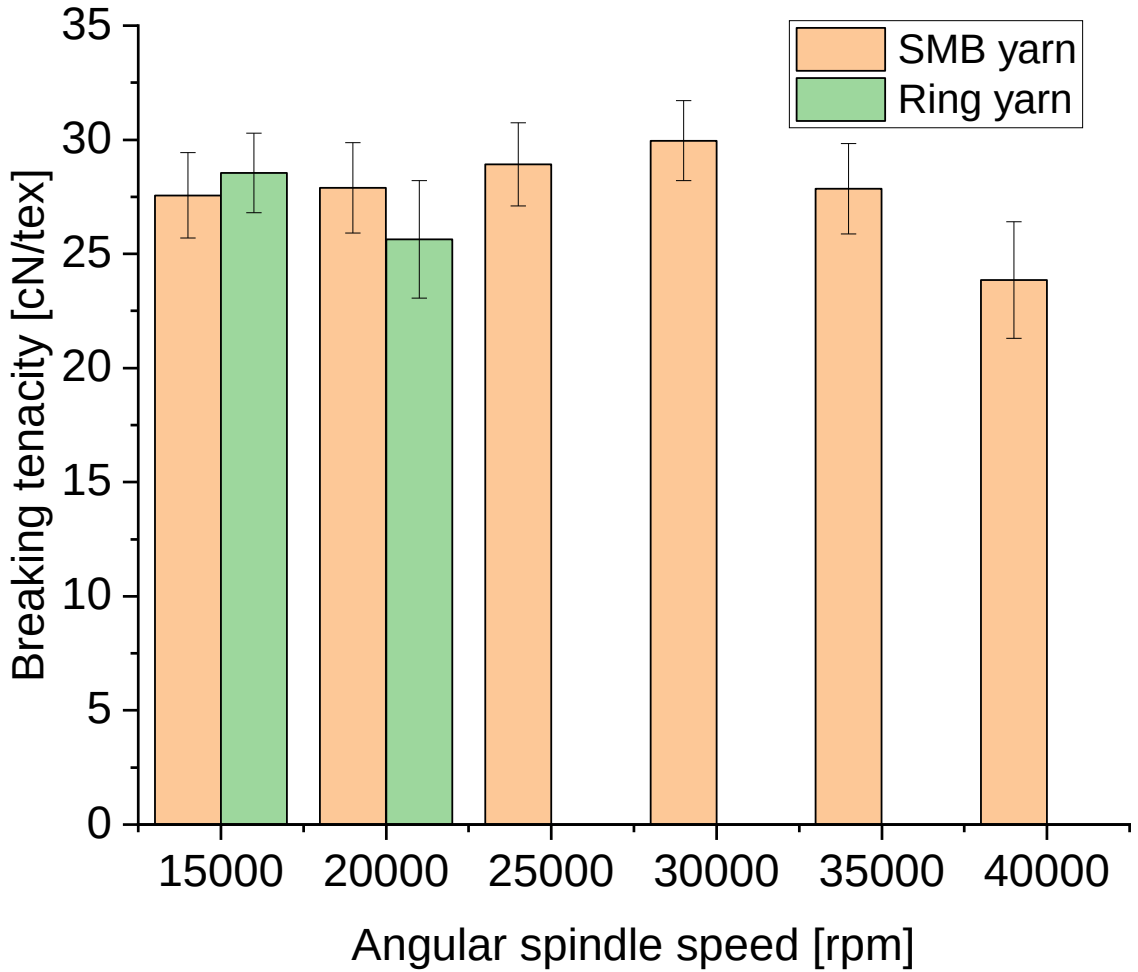
Security for operation of spindle

Programmable ramp settings

Textile technological investigation – process parameter

Process parameters	Material
	100% Cotton (CO)
Staple length (UHML)	36 mm
Micronaire range	3.6-4.3
Fiber strength	43.75
Roving count	492 tex
Yarn count	15, 20 and 30 tex
Main draft distance	46.5
Break draft distance	61.5
Break draft	1.2
Spindle speed	15,000-40,000 rpm
Delivery speed	7-50 m/min
Yarn twist	800 (20 tex) and 900 (15 tex) TPM
Ring diameter	40 mm

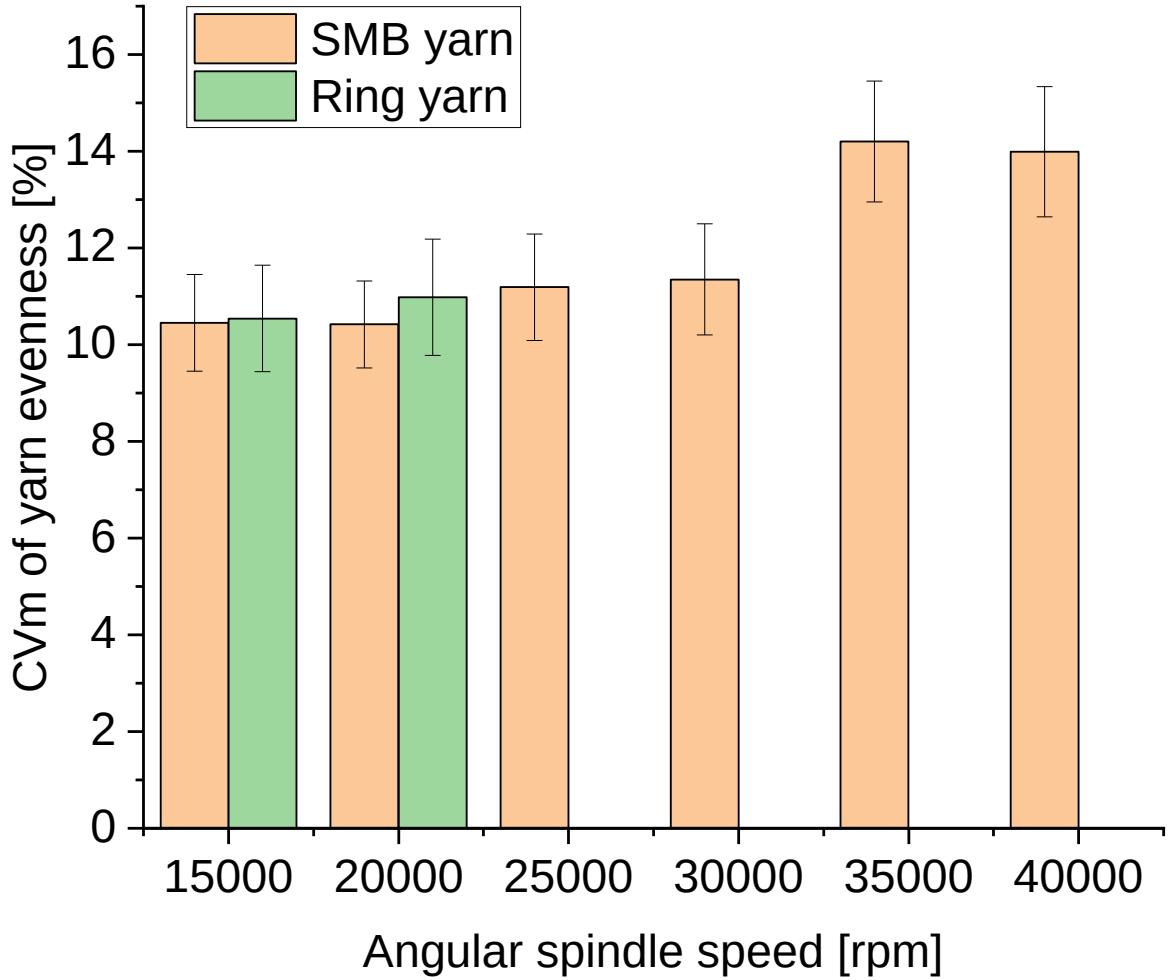
Textile technological investigation – Yarn strength of 100% cotton



Comparison of yarn strength of conventional and SMB ring yarn from 100% cotton material for different angular spindle speeds (yarn count 20 tex)

- The yarn tenacity was measured with the Uster Tensorapid 3+ yarn strength tester according to the standard norm DIN EN ISO 2062
- The strength of SMB yarn remains within a tolerance range even at an angular speed of 40.000 rpm.
- As there is no friction or frictional heat in the SMB system, the resulting yarn is characterized by enhanced quality with a minimum tolerance range.
- Therefore, the SMB system offers the potential to produce high quality SMB yarn at much higher angular spindle speeds, i.e. above 40.000 rpm.

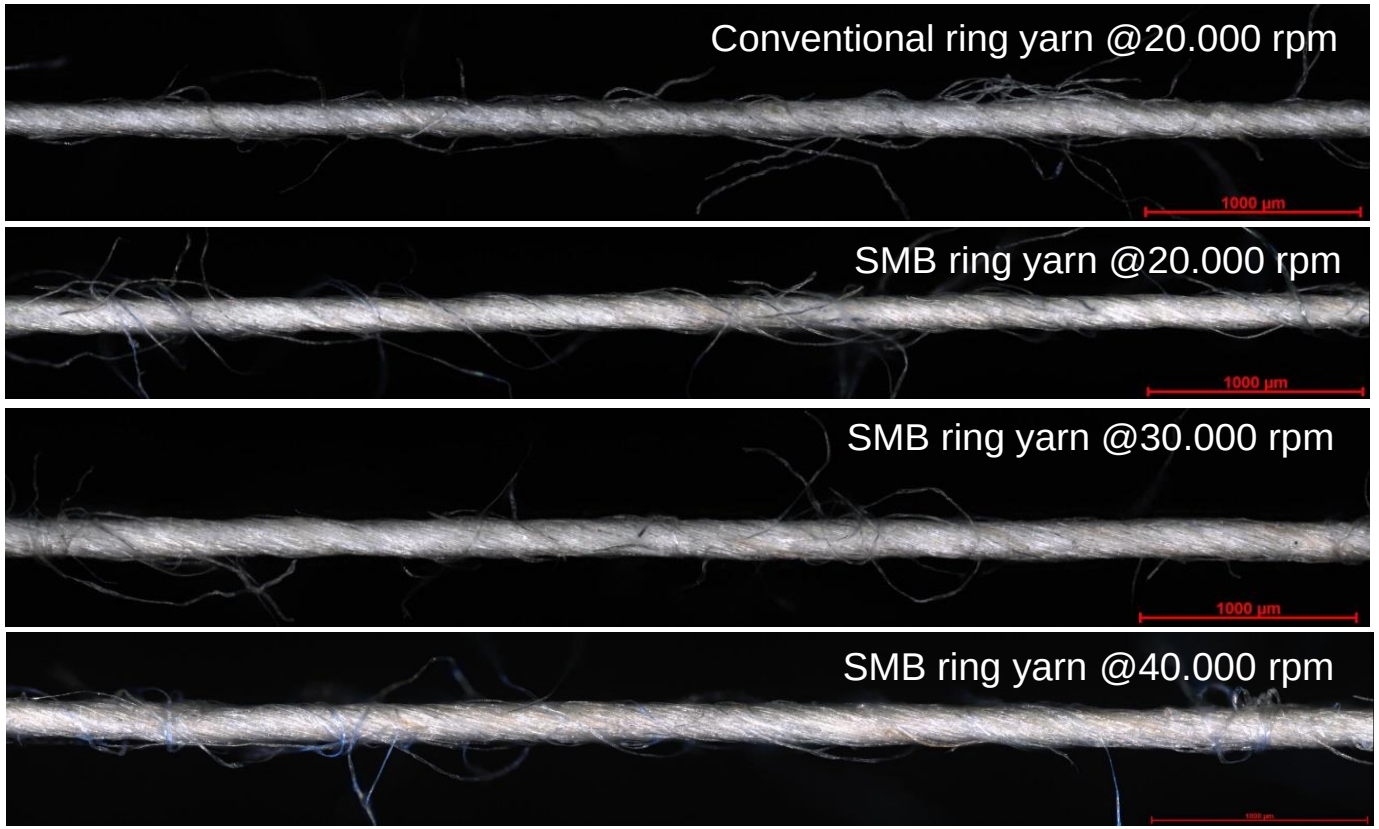
Textile technological investigation – Yarn evenness of 100% cotton



Comparison of yarn evenness of conventional and SMB ring yarn from 100% cotton material for different angular spindle speeds (yarn count 20 tex)

- The yarn evenness was measured with evenness tester Uster 3.
- The yarn evenness of ring and SMB yarn made from 100% cotton materials is comparable up to an angular spindle speed of 40.000 rpm.
- Once angular spindle speed increases, acting forces, such yarn tension and air-resistance, influence yarn quality.

Textile technological investigation – Yarn structure of 100% cotton



Comparison of yarn structure of conventional and SMB ring yarn from 100% cotton material for different angular spindle speeds (yarn count 20 tex)

The SMB ring yarn seems to be more voluminous and less hairy as a result of less process yarn tension occurring in the SMB system compared to the ring/traveler system.

Conclusion and outlook

- A special turbo ring spinning tester was developed to run the machine up to the angular spindle speed of 50.000 rpm.
- The strength of SMB yarn remains within a tolerance range even at an angular speed of 35.000 rpm.
- The yarn evenness of ring and SMB yarn made from 100% cotton materials is comparable up to an angular spindle speed of 30.000 rpm.
- The SMB yarn seems to be more voluminous and less hairy as a result of less process yarn tension occurring in the SMB system compared to the ring/traveler system.
- As there is no friction or frictional heat in the SMB system, the resulting yarn is characterized by enhanced quality with a minimum tolerance range.
- Therefore, the implementation of friction free SMB twisting system offers the potential to produce high quality SMB yarn at much higher angular spindle speeds, i.e. above 40.000 rpm.

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Thank you for your interest.

Your questions are welcome.

We would like to thank the German Research Foundation (DFG) for the financial funding of the research project (Project Numbers 459466327; Reference No. DFG CH 174/61-1, DFG BE 4791/5-1 and DFG HU 1726/9-1).

DFG Deutsche Forschungsgemeinschaft

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