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Role and Application of Automation and Robotics in Spinning Section in Textile Industry

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ABSTRACT

Modern technology transformation and the introduction of automatic machinery have changed the textile industries in numerous ways. There is development of advanced equipment and systems and they are being used in various manufacturing processes by manufacturing industries. The arrival of computer-controlled machinery has made it possible to complete industrial tasks more quickly, improving product quality and efficiency and lowering energy and production costs. Numerous aspects of the textile manufacturing process make extensive use of automation. Robotic applications are hugely used in yarn manufacturing technology among different textile automation divisions. The paper discusses various textile yarn spinning techniques and how automation has revolutionized these procedures. It provides comprehensive information on automation and robotic applications, from fiber opening in the blow room to yarn packaging in the winding in the spinning section.

Keywords: Automation, spinning, robotics

I. INTRODUCTION

Automation has transformed the production of textile materials, resulting in a revolution in the textile industry. Automation has significantly changed this industry by incorporating cutting-edge technology like robotics, artificial intelligence, and data analytics. There are many benefits to automation in the textile sector, such as improved product quality, lower manufacturing costs, and increased productivity [1]. The textile manufacturing industry has always been a heart of innovation, and it's about to witness an even greater transformation with the integration of automation and robotics. By establishing the path for a new technology that is fast, accurate, and sustainable, those technological advancements are shaping the future of fabric production. From spinning yarn to cutting and stitching fabrics, automation, and robotics are transforming several production processes. Automation has been an engine of change in the textile industry [2].

Labor-intensive operations are being replaced by sophisticated technology that is outfitted with sensors and artificial intelligence, increasing production speed, precision, and consistency. Robotic systems are revolutionizing the fabrication and assembly stages of textile & garment manufacturing. Cobots, or collaborative robots, work alongside human operators to do repetitive tasks quickly and precisely. They excel in fabric cutting, stitching, and garment assembly. Robots provide increased manufacturing flexibility, productivity, and quality control due to their capacity to manage complicated structures and deviations from the norm [2].

II. AUTOMATION AND ROBOTICS IN SPINNING

Cotton ball collecting and ginning, which were previously done by hand, served as the starting point for automation in spinning. High Volume Instruments (HVI) have been introduced to test cotton fibers within less time which otherwise used to be done for a longer time. Many test results, like staple length, color grade, micronaire value, strength, elongation, and uniformity index by HVI. Automation is also used in yarn production to mix cotton to improve uniformity [3].The yarn manufacturing industry will likely continue to use automation to maintain its competitiveness in the global market, as seen by the trend towards intelligent factories[4].

The spinning mill uses automation at every stage from cotton ginning to yarn & cone forming. The process today is highly automated

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and includes automatic piecing (restarting of broken ends) and doffing (removal of full packages)[3].

2.1 Automation in Blow Room

Cotton fabrics start their life as giant bales. These are heavy and may be tough to transport across the workplace floor. To eliminate such issues automation mechanisms are used to handle bales in the blow room. Robots can move bales from the conveyor to storage and fetch them for processing on a first-in, first-out basis. This system ensures quick access to materials and minimizes human labor[5].

The evolution of cotton bale handling has significantly transformed the efficiency of textile manufacturing processes. In the past, workers manually opened and mixed cotton bales, a labor-intensive task that consumed considerable time and effort. This approach not only lowered productivity but also created problems with uniformity and quality, resulting in differences in the final product[6].Automatic bale openers provide several significant advantages in textile manufacturing. They enhance the processing speed and can handle large volumes of material efficiently, for example, the UNIflocA 12 by Rieter can achieve a production rate of up to 2,400 kg/h[7]. This high throughput is essential in meeting the demands of modern textile production. In spinning, management of linear density could be important, to ensure irregularity less operation of the process. Optical sensing devices discover beneficial programs in blow room lines. Photocells are set up at exceptional locations to manipulate the extent of cotton in the chambers. Similarly, photocells are used in blending chambers and filling trunks to ensure the correct level of material[8].

Figure1: Automatic bale opening and mixing

The automated contamination removal system is used in the blow room to detect and remove colored parts or plastic residuals that will cause contamination of the produced yarns. The CCD cameras detect the distorted colors or contrasts generated by the polarization in light polypropylene and transparent or semi-transparent PE foils. A pressurized air nozzle beam and speed sensor work together to selectively activate the detected contaminated portion of the fiber mass, which is then blown out of the fiber channel and into a waste suction unit. As a result, material impurities are removed from the fiber mass through screening[9].

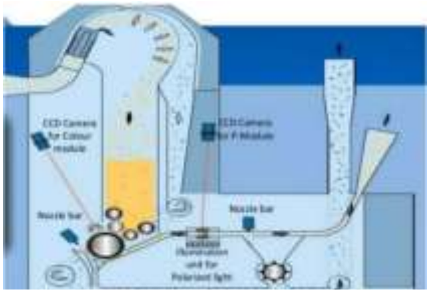

Figure 2: Automatic contamination removal system

Automated transfer of chute fiber from the blow room to the carding line is a system of feeding small tufts of fibers directly from the blow room to a sequence of cards, organized in a circuit using the pneumatic pipe. A condenser installed in the pneumatic pipeline sucks the fiber tufts from the blow room and gives it to the flock feeder by the pneumatic pipe[10].

2.2 Automation Carding Section

The carding machine uses an autoleveller and chute feed system, which has maintained the quality of the sliver and boosted the production rate [10] and [11]. There are also added features including an automatic dust collector, auto stop motion, etc. If there is any problem with the machine using the auto-stop device, the machine shuts down automatically. It is also helping to make uniform slivers by reducing handling [11].

There is also an automatic sliver container doff and change. The produced slivers on the carding and drawing machines are packaged inside cans. Traditionally, replacing full sliver cans required manual intervention, which can be time-consuming and labor-intensive[12].The automatic can-changing mechanism integrates seamlessly with the carding machine for the replacement of a full-sliver can with an empty one. This system typically includes components such as a pneumatic cylinder and a jacking bar that assists in lifting and positioning the new can[12].

2.3 Automation in draw-frame

Robots and transport devices with microprocessor-controlled non-contacting sensors and detecting systems are used in today's material handling machinery in the textile yarn spinning section. The flow of materials between two different machines is now entirely automated. A can-link or can-connect system connects the breaker and finisher draw frames in the drawing unit of the spinning department [13].A famous feature of modern draw frames is the incorporation of autoleveller technology. This system continuously monitors the sliver thickness and adjusts the sliver draft, which is the ratio of delivery speed to the feeding speed of the slivers in the draw frame [14]. The autoleveller greatly reduces differences brought on by changes in fiber components by regulating the speed of the drafting rollers, ensuring consistent and uniform quality in the manufacturing of the rovings and yarn subsequent processes[14].

Automatic can changers provide continuous operation and greater efficiency by lowering the manual workload and delay of the sliver production process. Overall operational efficiency can be greatly increased due to this automation, which optimizes machinery use[15]. These can be categorized into flying can change; and interrupted can change mechanisms.

2.4 Automation in combing section

The combing preparation section consists of a drawing machine, followed by a lap-forming machine. Lap formers are essential machines used in the textile industry to prepare lap, which is a key input for the combing process [16]. They play a significant role in converting the sliver into a compact lap that is suitable for further processing. Traditional lap formation methods often involve considerable manual intervention, which can be inefficient and lead to variations in product quality. Automation addresses these issues through streamlined operations and enhanced consistency [17].

Modern lap formers utilize servo drives that provide precise control over machine operations, leading to improved lap formation and reduced fiber waste[18].There are also automation harnesses sensors to monitor the quality of fibers and the lap's thickness in real-time. This feedback loop allows instant adjustments, ensuring that the lap meets the specified quality standards[18].

Many contemporary lap-forming machines integrate seamlessly with other automated systems within the combing section, enhancing workflow and data sharing across different stages of production. This integration allows for higher efficiency and better overall management of the combing process[19].

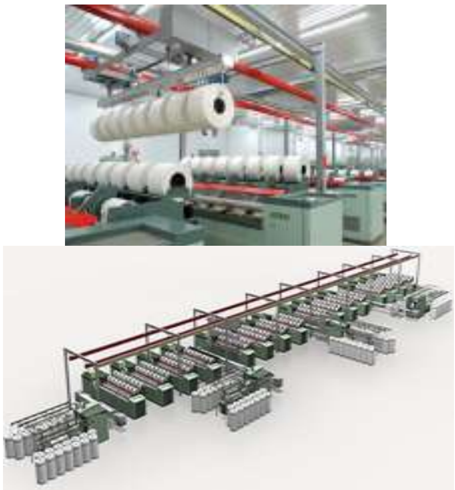

Figure3: RIETER fully automatic lap transportsystem

On the other hand, machine automation (Comber) includes automatic lap-changing and piecing mechanisms. The automatic system removes the empty tubes, positions the 8 full laps, and prepares the lap/batt ends for the subsequent pneumatic piecing. With the fully automated lap-changing system, the efficiency of the comber is increased by about two percent[20][21].

2.5 Automation in Roving Frame

Roving frames convert slivers into roving by combining drafting, twisting, and winding processes[22]. Few machines in a modern spinning mill are as critical as the roving frame. Automation and robotics in speed and roving frame machines are significantly enhancing productivity, efficiency, and quality in textile manufacturing. Automation assists with tasks such as piecing, bobbin doffing, and material transport, and helps minimize human handling in operations[23]. The electronic draft installed on roving frames, such as the Marzoli FTM320, facilitates straightforward machine setup without requiring mechanical modifications. This capability enhances the flexibility of operations, making it suitable for diverse production programs and requirements in spinning mills. Electronic drafting systems also play a crucial role in maintaining high-quality standards during yarn production. They allow for precise adjustments to the roving fineness through user-friendly interfaces, ensuring consistent quality of roving[23].

One of the most crucial aspects of modern roving frames is automation, especially on doffing since doff is costly, frequent, has a quite important negative influence on efficiency (especially on lengthy roving frames) and, if carried out manually, can harm the roving bobbins. Nowadays numerous

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alternatives for automated doffing are available. Advances in automatic doffing technology allow for quicker and more efficient bobbin changes. Machines like the Marzoli models can replace full bobbins with empty tubes in under three minutes, significantly reducing machine downtime[22]. During the new doffing cycle, the full bobbin packages are delivered to the transport mechanism which takes the full package to the ring-spinning machines. Also, a semi-automatic doffing option for the machine is available. The ergonomics of this version are far better than those of conventional manual-doffing machines. After the bobbin formation is completed, the bobbin rail lowers and tilts out for a smooth bobbin collection. Furthermore, there's a parking rail in the front of the bobbin rail with empty tubes so that the substitution of empty tubes after taking full is as smooth as possible[22].

Figure 4: Automatic roving frame

Automatic roving bobbin transport systems are integrated solutions that optimize the workflow within textile spinning mills.These systems can be fully automated, semi-automated, and manual setups depending on the availabilities of the facilities in the spinning section[24]. Automatic roving bobbin transport systems can be integrated with other automatic machines, such as roving frame machines and ring-spinning frames, allowing for a more interconnected production process. This integration supports efficient and smooth material flow, ensuring that the right materials are delivered to the right locations at the right time[25].

2.6 Automation in Ring Frame

Ring spinning is a system of spinning machines to transform roving into yarn. It is a long, rectangular, double-sided machine wherein the top component is designed to keep the bobbins, the center component for drafting, and the lower component offers the necessary twist and wind yarn on the cops[13]. Many innovations are carried out by spinning machine manufacturers across the globe.

Automatic roving transfer:This setup of installation enables economical usage of areas in the spinning department. Between the ring-spinning machines and the roving frame machines, the bobbin transport system transports empty tubes and full roving bobbins. A manual guided operation is feasible in addition to semi- or fully automatic movement of the roving package. The automatic tube cleaner and bobbin exchanger at the roving frame afford an intelligent overall package. This is also an automatic mechanism for exchanging roving bobbins in the creel of the ring-spinning machine[26].

Piecing end breaks: Automatic piece refers to the process facilitated by specialized equipment in ring-spinning machines to reconnect broken yarn ends automatically. Automatic piecing systems mitigate the need for manual intervention by allowing quick repairs, which significantly reduces production downtime. Automatic piecing units typically employ gripping arms and fingers that engage with the spindle to stop its rotation during a piece operation. Once the spindle is secured, the unit facilitates the joining of broken yarn ends[27].

Roving stop motion: a spinning machine manufacturer called Marzoli has brought out a roving stop motion, in which the roving is locked at the back of the drafting system when a sensor detects a break in the yarn. The sensor placed below the lappet senses the presence of yarn at each spindle position. Additionally, the sensors at each position are used as data collection units of each spinning position. This has potential applications for machine monitoring and production data acquisition[28].

Automated doffing systems: Modern ring spinning machines have automatic doffing systems that allow rapid changeover of full bobbins with empty ones. For instance, Rieter's G 38 model features a doffing cycle time of 90 seconds, reducing machine downtime and maintaining high production efficiency[29][28]. This rapid doffing mechanism is crucial for optimizing productivity in spinning mills.

Automatic cop transport to winding: By limiting the need for personal intervention, this method eliminates the cost of labor and handling errors[30].

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The system can include various technologies, such as conveyor belts and automated guided vehicles, which transport the cops seamlessly between ring frames and winding machines[31].The transport systems are closely integrated with ring spinning machines and winding machines, which allows for real-time monitoring of production statuses and facilitates automated adjustments to optimize efficiency[31].

2.7 Automation in winding machine

The winding process is critical as it prepares larger cone yarn for weaving or knitting, removing defects and ensuring consistent quality. Automated cone winding machines utilize advanced technologies to streamline the winding process and minimize manual labor[32].

Automated systems in modern winding machines are:

Yarn Clearer: - at any winding movement the yarn quality is controlled and maintained by an electronic clearer mechanism. Released by a yarn fault signal, the yarn-cutting blade of the cutter executes cutting orders, preventing yarn containing thick or thin places or double ends from running onto the package[33].

Automatic Splicing: In modern winding machines winding head has a splicing unit that automatically joins the two yarn ends together after a yarn breaks or the bobbin changes itself. The benefits of automatic splicing are significantly increased productivity, greater quality control, and reduced waste. It consists of a tail grabber and an automatic diameter-calculated splice initiation technique. The precision shear wheel and anvil mechanism guarantee a clean cut and no overlap[8].

Controlling Yarn Tension and Winding Speed: Yarn tension during winding is a significant factor influencing the quality of the final product. Proper tension helps an even and consistent yarn diameter, which is crucial for high-quality fabric[34]. Advanced tension sensors can provide real-time feedback on the tension levels of the yarn during winding. This information is used to make immediate adjustments[34].Modern systems include programmable logic controllers (PLCs) or microcontrollers (such as Arduino) that automatically adjust tension based on preset parameters and real-time data[34].

Auto Doffing: These systems are designed to detect when a cone is full and perform the necessary actions to replace it with an empty cone without operator involvement. This functionality is particularly crucial in high-speed production environments where maintaining continuous operation is essential for profitability[35].

Once a full cone is detected, robotic arms or mechanical transfer devices remove the full package and replace it with an empty one quickly and efficiently[35]. Modern systems usually feature a user-friendly interface that allows operators to monitor the doffing process and make any necessary adjustments easily. This interface can include touchscreen displays and remote monitoring capabilities to improve operational oversight[35].

Automatic cone packing and palletizing: Automatic cone packing systems are designed to wrap and package yarn cones in a streamlined and efficient manner. AI-based inspection systems are utilized to detect defects in cones before packing, thus preventing defective products from reaching the customer. This includes ensuring that no mixed-up counts occur during packing[36].The machines use robotic arms equipped with specialized tools to pick and arrange boxes or cones onto pallets according to predetermined patterns. This process is highly efficient and reduces the need for manual labor[37].

III. CONCLUSION

Manufacturing processes in a variety of industries have been completely transformed by the introduction of industrial automation and robotics. Automated machines and systems can perform tasks such as spinning, weaving, dyeing, and printing with greater speed and precision than manual labor in the textile industry. The textile industry has benefited greatly from automation, which is transforming the production of textiles. By imposing automatic tactics and intelligent technologies, textile yarn manufacturers can maximize productivity, enhance best control, lessen costs, and adapt to dynamic market needs. Specifically, automation in fiber and yarn manufacturing brings numerous benefits, including increased productivity, improved product quality, enhanced worker safety, cost savings, increased efficiency, data-driven decision-making, and sustainable manufacturing practices. The evolution of different automated technologies and robotics continues to support the efficiency and effectiveness of spinning operations in textile manufacturing.

REFERENCES

[1]. QODENEXT, "Automation in Textile Industry.," 2023. [Online]. Available: https://qodenext.com/blog/automation-in-textile-industry/.

[2]. Aladdin365, "Textile Automation & Robotics: Transforming Manufacturing

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Processes.," 2023. [Online]. Available: https://blogs.aladdin365.com/blogs/unleashing-the-power-of-automation-and-robotics-the-next-chapter-in-textile-manufacturing/.

[3]. N. Tarafder, "Spinning Processing with Automation," Journal of Management and Applied Sciences, vol. 1, no. 1, pp. 30-34, 2024.

[4]. R. Davis, "SPINNING FOCUS: Spinning Automation − Development And Progress," 2021. [Online]. Available: textileworld.com. https://www.textileworld.com/textile-world/2021/04/spinning-focus-executive-forum-spinning-automation-development-and-progress/.

[5]. admin, "Application of robotics in textile industry: A review of recent advances," 2023. [Online]. Available: https://indiantextilejournal.com/application-of-robotics-in-textile-industry-a-review-of-recent-advances/.

[6]. U. ARS, "Processing Cotton," 2023. [Online]. Available: https://www.ars.usda.gov/oc/timeline/cotton.

[7]. Rieter, "UNIfloc A 12 – The Automatic Bale Opener," 2024. [Online]. Available: https://www.rieter.com/products/systems/fiber-preparation/bale-opener-unifloc-a-12.

[8]. A. S. JOSHI, "Automation In Textile Spinning," 2021 . [Online]. Available: https://textilevaluechain.in/in-depth-analysis/articles/automation-in-textile-spinning.

[9]. M. S. Mia, "Details study of the Blow-room line," 2022. [Online]. Available: https://www.slideshare.net/slideshow/10-details-study-of-the-blowroom-line-pdf/252305920.

[10]. B. Paldiya, "Aero Feed or Chute Feed System in Carding," 2021. [Online]. Available: https://textilelearner.net/chute-feed-system-in-carding/.

[11]. Textileblog, "Applications and Impacts of Automation in Fiber and Yarn Manufacturing," 2021. [Online]. Available: https://www.textileblog.com/automation-in-fiber-and-yarn-manufacturing/.

[12]. CN201420120Y, "Automatic sliver-can changing system of carding machine," 2013. [Online]. Available: google.com. https://patents.google.com/patent/CN201420120Y/en.

[13]. N. A. Raaz, "Automation in Yarn Manufacturing Process," 2021. [Online]. Available: https://textilelearner.net/automation-in-yarn-manufacturing/.

[14]. Textiletriangle, "Drawframe," 2023. [Online]. Available: https://www.textiletriangle.com/sm/spinning/drawframe/.

[15]. P. R. Lord, "Sliver preparation," in Handbook of Yarn Production, Woodhead Publishing Series in Textiles, 2003, pp. 155-167.

[16]. Y. Trivedi, "Lap Preparation in Combing | Sliver Lap Machine," 2021. [Online]. Available: https://www.textilesphere.com/2021/11/lap-preparation-in-combing-sliver-lap-machine.html.

[17]. Combing_Ch_6.pptx., "Automation in Combing Section," 2024. [Online]. Available: https://www.uptti.ac.in/classroom-content/data/Combing_Ch_6.pptx.

[18]. R. rieter.com, "Easy and Efficient Lap Transport," 2024. [Online]. Available: https://www.rieter.com/products/systems/automation/servolap-e-26.

[19]. N. Hasan, "Study of Lap Former Machine. | PDF |," 2024. [Online]. Available: https://www.scribd.com/document/557225910/Study-of-Lap-Former-Machine.

[20]. Y. Schwartz, "Rieter's new combing set for optimum output, economy," 2016. [Online]. Available: https://www.indiantextilemagazine.in/rieters-new-combing-set-for-optimum-output-economy/.

[21]. F. U. Baig, "Combing," 2018. [Online]. Available: https://www.slideshare.net/slideshow/combing-86779686/86779686#103.

[22]. Marzoli, "FT6E and FT7E: leading-edge roving frame technology - Fibre2Fashion," 2017. [Online]. Available: https://www.fibre2fashion.com/industry-article/7882/ft6e-and-ft7e-leading-edge-roving-frame-technology.

[23]. Y. M. Şimşek, "New FTM320 Roving Frame: Marzoli brings innovation in spinning," 2023. [Online]. Available: https://www.textilegence.com/en/new-ftm320-roving-frame-marzoli-brings-innovation-in-spinning/.

[24]. Sieger, "oving Transportation System|Roving Bobbins," 2024. [Online].

Available: https://www.siegerglobal.net/roving-transport-system.php.

[25]. G. TEXTEC, "Roving Bobbin Transport System," 2024. [Online]. Available: https://gsbtextec.com/index.php/roving-bobbin-transport-system/.

[26]. Saurer, " Bobbin transport system," 2024. [Online]. Available: https://saurer.com/en/products/automation/staple-fiber-spinning/bobbintransportsystem.

[27]. Rietergroup, "Competitive Advantage with Automated Piecing ROBOspin," 2024. [Online]. Available: https://www.rieter.com/company/news-and-success-stories/details/competitive-advantage-with-automated-piecing-robospin.

[28]. peacesoul123, "RECENT DEVELOPMENTS IN RING SPINNING.pptx," 2024. [Online]. Available: https://www.slideshare.net/slideshow/recent-developments-in-ring-spinning-pptx/270114362#104.

[29]. Q. Guoao, "About ring spinning machine with auto doffer," 2024. [Online]. Available: https://getliner.com/search/s/21014814/t/75195749?msg-entry-type=main.

[30]. US5924273A, "Textile yarn cop changing and transport system - Google Patents.," 2024. [Online]. Available: https://patents.google.com/patent/US5924273A/en.

[31]. TextileFocus, "The Role of AI and Automation in Textile Manufacturing," 2024. [Online]. Available: https://textilefocus.com/the-role-of-ai-and-automation-in-textile-manufacturing/.

[32]. LEBONINDUSTRY, "Automatic Cone Winder|Yarn winding machine," 2024. [Online]. Available: https://www.china-lebon.com/lblt-01-automatic-cone-winder.html.

[33]. M. F. M. Chowdhury, "Study on the Performance of Electronic Yarn," American Journal of Engineering Research (AJER) 6.8, pp. 157-162, 2017.

[34]. R. A. &. M. A. Mohamed Ali, "Yarn tension control technique for improving polyester soft winding process," 2021. [Online]. Available: https://doi.org/10.1038/s41598-020-79928-1.

[35]. R. Menor, "What is an Auto Doffer Winding Machine? - Motocono Blog.," 2024. [Online]. Available: https://motocono.com/en/what-is-an-auto-doffer-winding-machine/.

[36]. Textilemagazine, "Indo Texnology ' s automatic cone packing system; a game-changer for Birin Spinning Mills - The Textile Magazine.," 2024. [Online]. Available: https://www.indiantextilemagazine.in/indo-texnologys-automatic-cone-packing-system-a-game-changer-for-birin-spinning-mills/.

[37]. P. Hegarty, "Automated Palletizing: How It Works and How To Do It," 2023. [Online]. Available: https://www.formic.co/resources/articles/automated-palletizing.