

Automated Weaving Machines in Textile Industry-A Review

Tushar Mishra¹, Sumit Chaudhary²

Assistant Professor¹, Associate Professor²

Department of Mechanical Engineering

IIT Madras - Indian Institute of Technology - [IITM], Chennai

Corresponding Author's Email: -tusharmishra35@gmail.com¹

Abstract

The Process Automation System (PAS) often uses a network to interconnect sensors, controllers, operator terminals and actuators. In weaving technology, the loom, which is a mechanical device used to produce woven fabric by inserting warp and weft yarn, i.e., is principal mechanical device for weaving. The biggest benefit of automation in weaving mechatronics is to save labour. Today's weaver needs to ensure that he/she is able to manufacture and supply the finest quality of fabric. Automation is also used to save energy and material and to develop accuracy, quality and precision. The first significant move towards automated weaving occurred when John Kay invented the flying shuttle in 1733. The term Jacquard is not specific or limited to any particular loom, but rather referred to the added control mechanism that automated the patterning. The PICANOL brand is generally recognized as the world leader in the field of weaving machines. Loom Data Monitoring System is used to collect data from every loom and display at centralized computer. Automated weaving machines are one of the most important advancements to come from the industrial revolution. Many of the latest developments in weaving machines have focused on automation, digital upgrades and innovative end products that add value including technical textiles, e-textiles and 3-D structure.

Keywords:- air-jet loom, Yarn transport, weaving industry, Mechatronics solutions, electronic cam, Loom technology, Jacquard loom, Textile segment.

INTRODUCTION

Weaving technology has seen advancements, automatic shuttle looms and automatic shuttle-less looms with advantages of higher productivity, water-jet loom and air-jet loom that use water or pressurized air to transport the yarn with multiple colour weft insertion. Weaving and knitting machines builders have been leading the way in utilizing computer technology in textile manufacturing for years with their use of CAD, bi-directional communication and artificial intelligence. A cad system can be used to develop the fabric to be produced and the design can then be transmitted over the network to the production machines to produce the desired fabrics. The design instruction can be sent by modem from one country to a weaving machine located anywhere else in the world. Weaving is the process of interlacing two sets of threads together at right angles such that they form a unified fabric. The two sets are defined as the warp and weft threads and within each set the threads lie parallel to each other. During the weaving process, the warp is defined as the set being held stationary, while the weft is the set being introduced into the warp [1].

In weaving, the loom is a mechanical device used to produce woven fabric by inserting warp and weft yarn is the principal mechanical device for weaving. Today, automatic shuttle looms and automatic shuttle-less looms are used for weaving. Automatic looms include methods of holding the yarn such as rapier and gripper systems. They offer advantages such as higher productivity compared to water jet and jet looms that use water or pressurized air for yarn insertion especially in the cases involving multiple colour weft insertion. The automation technology used in the weaving also includes sizing machine control systems. These systems provide a mechanism for management to make sure that all warp threads are sized identically under standard operating conditions. These monitoring and control capabilities can be integrated in the weaving mills computer network. Implementation of electronic control such as computer control in automatic looms are simplified in operations as the only condition such as yarn type and weave, width needs to be input in order to optimize operations to be performed [2].

Weaving is the most popular and widely used process of fabric production for the clothing, home furnishing fabrics and decoration. In fact the word weaving means the process of fabric manufacturing, the process by which the fabric is made by interlacing warp and weft threads called weaving. Weaving machine are using computer controlling device for a long time.

Automation is used in weaving industry especially in weaving, warping, sizing used in loom. Some processes have been completely automated. The biggest advantage of automation in weaving machine is that it saves labour. However, it is also used save energy and materials and also to improve quality and accuracy. Only qualified and appropriate technology ensures survival in the global competition. In order to keep pace with the world today's weaving industry needs to ensure that it is able to produce and supply the best quality fabrics in a short time, and at low cost. Automation/robotics is the only options that can help the weaving sectors to achieve this goal [3].

Weaving is the most widely used method of fabric production for the decoration, clothing and home furnishing textile sectors. However, technical textiles, including wire cloth are also produced on modern weaving machines. Irrespective of weft insertion method used, very high cycle and acceleration rates are essential for weaving machines. Furthermore, weaving machines are characterized by a large number of nonlinear motion sequences and time-critical starting times. Mechatronic solutions devised from a combination of mechanical cams and servo drives for warp let off and fabric take up are the start-of-the-art. More recently, harness motion and weft insertion have also been implemented with individual electronic drives in some instances [4].

Automation or automatic control is the use of different control techniques to operate equipment, machinery, processing in manufacturing factories, boilers, and heating ovens, steering and stabilizing of ships, switching in telephone networks, aircraft and other applications with minimal or reduced human interaction. There are some processes which have been completely automated. The major advantage of automation in any department is that it saves labour. However, automation is also used to save energy and materials and to develop accuracy, quality and precision [5].

The perseverance of inventors is testimony to the importance of cloth in our culture and of the lucrative nature of the business. Mechanization of the weaving process began in the eighteenth century. Prior to development in automation, one weaver was needed to operate one loom and an assistant was necessary if a complex pattern was being woven. There were a few developments prior to 1700 century but none of them had any significance or permanent influence. Improvement in speed of weaving during 18th century were given impetus by the

invention of spinning machinery for the production of yarn necessary for weaving. Acceptance of advancement in loom technology was also aided by improvement in spinning and cloth finishing technologies [6].

Originally jacquard machines were mechanical and the fabric design was stored in a series of punched cards which were joined to form a continuous chain. The jacquards often were small and only independently controlled a relatively few warp ends. This required a number of repeats across the loom with. Larger capacity machines or the use of multiple machines, allowed greater designs could be woven across the loom width. The jacquard machines are very costly to maintain as they are complex and require higher skilled persons. An expensive design system is required to prepare the designs for the loom and possibly a card-cutting machine [7].

In 1936, the name Picanol featured for the first time on a weaving machine. After the release of more than 3 30 000 weaving machines since after 80 years of inception, Picanol brand was recognized as the world's leader in the field of weaving machines. Over 50 years ago, Picanol started offering its machines in the Indian market. In 2008, they decided to set up their own organization for sales and service in the Indian market, and the company came closer to the Indian customers day after day. The key factor that Picanol machines are so popular is that their variety and flexibility, combined with the highest quality and performance. Almost 99% of the fabrics can be woven on a Picanol machine. The present machines are used in different sectors by different clients from denim to technical textiles. The machines are known for their high performance and sturdy structure [8].

Loom Data Monitoring system is used to collect data from every loom and display at centralize computer. It displays fabric length of each loom, warp break counts, weft break counts, loom efficiency%, beam due length of beam, operator performance, down time or machine stop time due to various breaks, machine production speed in m/min, picks/min, date, shift, year, machine operator, style wise reports, etc. Advance microprocessor based unit is installed at each machine to collect production and stoppage signals and transfer to PC via peripherals and interfacing circuits. Various reports are generated to analyse performance of looms, production rate, operator performance, raw material quality, etc [9].

Automated weaving machines are one of the most important advancements to come from the industrial revolution. Prior to their invention, most people only owned few garments that were woven and maintained by the family. With the introduction of machines it was churn out textiles affordable clothing suddenly became available. As an expert in the industry, Roger Me ester was able to construct a fully automated weaving machine controlled by Adriano Boards. In Adriano a few patterns can be completely different from the preceding parallel and the machine can even adjust the pattern on the-fly during the weaving process, meaning it can create rich tapestries [10].

Many of the latest developments in weaving machines have focused on automation, digital upgrades and innovative end products that add value including technical textiles, e-textiles, and 3-D structures. With labour shortages impact every weaving mill in North America, they found increasing demand from the customers for automation technologies for weaving mills as told by Oliver Meier, textile director North America, Staubli. Item aS.p.A today combines the historic weaving brands from Somet, Sultex and Vamatex, which the company reports combines Swiss precision wit Italian creativity. The company established Itema Tech with the main of providing technical fabric producers a partner that offers a complete range of weaving solutions and skilled technical team to help fulfill specific customer requirements for technical fabrics [11].

AUTOMATION IN WEAVING DEPARTMENT OF TEXTILE MILLS

Weaving is the most widely used method of fabric production for the decoration, clothing and home furnishing textile sectors. However, technical textiles including wire cloth are also produced on modern weaving machines. Irrespective of weft insertion method used, very high cycle and acceleration rates are essential for weaving machines. Furthermore, weaving machines are characterized by a large number of non-linear motion sequence and time critical starting times. Mechatronics solutions devised from a combination of mechanical cams and servo drives for warp let-off and fabric take-up are the modern state-of-the-art. More recently, harness motion and weft insertion have also been implemented with individual electric drives in some instance. The demands on the automation are mentioned as follows: constant velocity relation between warp let-off and fabric take-up as a function of the main drive; constant thread tension during the process; weft insertion synchronized precisely with cycle time; fast position oriented supply of weft threads corresponding to the colour

selection; increase in machine time cycle; etc [1].

The automation technology used in weaving also includes sizing machine control systems. These systems provide a mechanism for management to make sure that all warps are sized identically under standard operating conditions. These monitoring and controlling capabilities can be integrated in the weaving mill's computer network. Implementation of electronic control like computer control in automatic looms has simplified operations only under the conditions such as yarn type and weave, width need to be input for the optimum operations to be performed. The automatic weaving machines required good standards of technical training and diligence to ensure satisfactory operation of the automatics. The machines by which automatic weft replenishment is achieved are complex. Also it is necessary to be more careful in the care and adjustment of the picking mechanism during shuttle in the machines when compared to the shuttle being removed and replaced manually [2].

Electronic let-off and take-up mechanism machines where let-off motion weaver's beam is driven by a servo motion, as the diameter of the beam changes, the RPM of the beam is controlled by the load cell. Fabric on the other hand is synchronized with take-up and let-off speed. Due to the crimp in the warp, the speed of fabric take-up is less than the speed of the warp let-off. In electronic warp and weft stop motion, the edge of each warp is monitored by a single drop wire. When warp threads break or rupture, the corresponding wire falls on the contact bar and the machine shuts down immediately. Like the warp, when the weft thread is sent, the machine will shut down with torn or broken [3].

The six production steps winding, weaving, sizing, weaving inspection and packing include 16 points of automation. Of these, 12 deal with materials handling or transport. Only four applications deal with automating the machine operations themselves. This includes automated process control on the slashes and the weaving functions of the automatic pick repair, automatic warp breakage locator and computerized machine control. Manual assistance is still required for beam replacement repair of warp breaks. Implementation of electronic control such as computer control in automatic looms has simplified operations as only the conditions such as yarn type and weave, width need to be input in order to the optimum operations to be performed. Weaving machines are characterized by a large number of nonlinear motion sequence and time critical starting time. Mechatronic solutions devised

from combination of mechanical cams and servo drives for warp let-off and fabric take up are the modern state-of-the-art. More recently, harness motion and weft insertion have also been implemented with individual electric drives in some instances [4].

Execution of electronic control such as computer control in automatic weaving loom has simplified operations as only the condition such as a type of yarn and weaves. Objects of automation in weaving technology such as; it is applied to weave the perfect fabric; it is applied to weave a large quantity of the same fabric; it is applied to weave a fancy fabric better; it is applied to reduce the cost of fabric production and it is applied to improve the working conditions of the operatives [5].

BENEFITS OF AUTOMATION IN WEAVING

The automation of patterned fabric production began with the 1804 invention by Joseph Marie Jacquard. His s called invention in jacquard mechanism could be mounted on any loom and controlled the lifting of the warp yarns that create the fabric's pattern. In 1835, the first automatic shuttle change enabled weft yarns of different colours to be inserted automatically in the weaving. In 1895, the invention of automatic pirn change in shuttle introduced by H. Northrop. Not until the 1905 did automatic weft winding directly on the weaving machine became commercially viable. It was introduced by the Lesona Company and known as the Unifil system shuttle less looms appeared in the mid-twentieth century and employed various systems: grippers, rapier and jets of water or air. Gripper machines use a small projectile that picks up a weft yarn from a supply on the side and carries it to the other side; rapier machines use a long thin rod which travels from one side and grabs a weft which it pulls across as it returns; jet looms use a jet of air or water to propel the weft from side to side. Jet looms have the advantage of being particularly fast and can weave widths up to 85 inches. The modern rapier loom was launched in 1963 by Dornier of Germany. Thee projectile loom was invented in Switzerland by the Sulzer Brothers in 1924 did not come into commercial use until 1953. Fabrics from shuttle less looms do not have a selvedge as the weft is not a continuous yarn [6].

Originally the Jacquard machines were mechanical and the fabric designs were stored in a series of punched cards which were joined to form a continuous chain. The Jacquards often were small and only independently controlled a relatively few warp ends. A company must

choose looms and shedding mechanism to suit its commercial requirements. It is recorded that in 1855 a Frenchman adapted the jacquard mechanism to a system by which it could be worked out electro-magnets. Bonas Textile Machinery NV launched the first successful electronic Jacquard at ITMA in 1983 MILAN. Although the machines were initially small, modern technology has allowed Jacquard machine's capacity to increase significantly and single end warp control can extend to more than 10,000 warps. The jacquard head used replaceable punched cards to control a sequence of operations. It is considered an important step in the history of computing hardware and the ability to change the pattern of the development of computer programming and data entry. Some earlier computers such as 1944 IBM automatic sequence controlled calculator received program instructions from a paper tape punched with holes similar to Jacquard string of cards. Punched cards remained in use in computing until the mid 1980 [7].

MODERN MACHINERY DEVELOPED FOR WEAVING

For last 50 years, Picanol started offering its machines in the Indian market. The key factor that makes Picanol machines so popular due their versatility and flexibility, combined with the highest quality and performance. Almost 99% of the fabrics can be woven on a Picanol machine. The present machines are employed in different sectors by different clients. From denim to technical textiles, the machines are known for their high performance and sturdy structures. The Armaanya textile Plant currently has 40 Picanol OMNIplus Summun Dobby looms used to manufacture denim or supply solely to Arvind. The plant mostly works with cotton and Lycra and produces 10,000 metres of fabrics per day. The machines performed tremendously well and considered that these machines are the best machines in the world. Picanol was one of the finest manufacturers in the world but at that time it was best known for its air jet looms. Naptune Furnishing started its journey three decades ago with furnishing fabrics showroom in Ahmedabad. Currently, the furnishing market in India is expanding at a reasonably good rate with emerging opportunities for the existing and potential players. Naptune Furnishing's association with Picanol began about four years back when the company was looking for expansion in its weaving capacity. After collecting market data and conducting a thorough research the managing team at Neptune decided to go with Picanol which had proved itself time and again and was said to offer the best in technology [8].

Loom data monitoring system is used to collect data from every loom and display at

centralize computer. It displays fabric length of each loom, warp breakage counts, weft breakage counts, loom efficiency, beam forecasting and tentative time to reach set length of beam, operator's performance, down time or machine stop time due to various breaks, machine production speed in metres per minute and picks per minute, etc. Advance micro-processor based unit is installed at each machine to collect production and stoppage signals and transfer to PC via peripheral and interfacing circuits. Various reports are generated to analyse performance, operator's performance, raw material quality, etc [9].

Fully automated desk top weaving machine controlled by Arduino is incredibly complex, as it does not rely on any mechanical coupling. It means that every facet of the machine operation is adjustable via a stepper motor, Dc motor or servo motor. There are lot of motors to drive so that De Me ester needed multiple Arduino boards: an Arduino Mega 2560 and two Arduino Nanos. The mechanical components Are 3D-printed or made from aluminium extrusion and wood [10].

PicConnects a new platform that makes it possible for weavers to quickly react to changes in the weave room and that will have an immediate impact on the performance of the machine in various aspects, said by Erwin Devloo, Picanol's marketing communication manager. This new story with new applications in the future that Picanol is continuously working on SMIT most recently introduced the 2FAST rapier weaving machine. According to SMIT the 2FAST shows starting acceleration and 100% beat up efficiency right from the first weft insertion [11].

CONCLUSION

Weaving technology has seen advancements, automatic shuttle looms and automatic shuttle-less looms with advantages of higher productivity to water jet and air-jet loom that use water or pressurized air to transport the yarn with multiple colour weft insertion. In weaving technology the loom, which is a mechanical device used to produce woven fabric by inserting warp and weft yarn is the principal mechanical device for weaving. The importance of automation in weaving requires only qualified and appropriated technology to ensure survival in global competition. Weaving machines are characterized by a large number of non-linear sequences and time-critical starting time. Execution of electronic control such as computer control is automatic weaving loom has simplified operations as only conditions such as a type

of yarn and weaves. Acceptance of advances in loom technology was also aided by continuing improvements in spinning and cloth finishing technologies. A factory must choose looms and shedding mechanism to suit the commercial requirements. The key factor that makes Picanol machines so popular is that their versatility and flexibility combined with the highest quality and performance.

REFERENCES

1. "Automation in Weaving Machines: process, Benefits and Requirements", Hafiz Abdul Mannan, National Textile University, Pakistan, Last Updated on 25.06.2022.
2. "Automation Conferring Power to Weaving", [https://www.fibre2fashion.com/industry-article/7141/automation-conferring-power-to-weaving3:-:text=Automatic looms include methods of innovation.....](https://www.fibre2fashion.com/industry-article/7141/automation-conferring-power-to-weaving3:-:text=Automatic%20looms%20include%20methods%20of%20innovation.....)
3. "Application of Automation in Weaving Industry", Textile Blog 17.01.2021
4. "Automation in Weaving", <https://www.scribd.com/document/455189465/Automationin-weaving>.
5. "Automation in Weaving Technology", <https://textiletutorials.com/automation-in-textile-weaving-technology/>
6. "ENCYCLOPEDIA.COM", <https://www.encyclopedia.com/fashion/encyclopedias-almanacs-transcripts-and-maps/weaving-machinery>.
7. "Jacquard machine-WIKIPEDIA", https://en.wikipedia.org/wiki/jacquard_machine
8. "Picanol-weaving the future of Indian textile industry", The Textile Magazine, magazine.textile@gmail.com, October 1. 2018/Ganesh Kalidashan.
9. "LOOM AUTOMATION LOOM DATA MONITORING SYSTEM", <https://www.electrocom.in/LOOM-AUTOMATION-WEAVING.htm>.
10. "Fully automated desktop weaving machine controlled by Arduino", <https://blog.arduino.cc/2022/11/29/fully-automated-desktop-weaving-machine-controlled-by-arduino/>
11. "Weaving Machine Developments", <https://www.textileworld.com/textile-world/features/2021/10/weaving-machine-developments/>