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Scope Of Knitted Fabric Design In Wearable Electronics And Smart Textiles

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Abstract: The fundamental and applied design in material science involves machine learning and big data tools, The statistical data generated by the sensors and components in smart wearable's response to activate the smart device based on our requirements. The flexibility and weight reduction concept applied for textiles sensors, due to the principle of fabric formation knitted technology plays important role in designing of wearable and smart textiles. The sensing elements in the fabric formed as loop in fabric design or embedded in smart device. This paper highlights the overview of various knitted fabric design and its techniques adopted to form a sensors for various applications.

Keywords: Knitted fabric design, strain sensor, wearable textile, conductive fabric

1. INTRODUCTION

The smart textile structures derived from intelligent or smart materials. Smart textiles that are able to sense based on stimuli from the environment and it reacts and/or adapt to them by integration functionalities in the textile structures [1]. A smart textile is not limited to specific one, which extend the functionality and usefulness of common fabrics. The application of smart textiles includes many fields such as medical, transportation, energy, protection, security communication and textile electronics [2]. The textile products fibers, filaments (yarn), fabrics such as woven, knitted and nonwoven structures etc., interact with the environment via smart textiles. Wearable textiles can be divided as following categories.

- Passive smart textiles: These can be only able to sense the environment/user, based on sensors.
- Active smart textiles: Based on the environment, signals from actuator by integration and as sensing device which reactive sensing to stimuli.
- Very smart textiles: These can be sense, reactive based on sensing information and adapt their reactive to the given condition.

The integration of wearable technology (e-textiles) in social welfare is increasing due to the implementation of smart textiles. The polymeric materials can be made as sensors, actuators etc., called as electomechanical systems. Flexible and nonflexible are the two type of wearable sensors. All components developed using textiles are increasing the potential applications of smart system.

The choice of fabric structure for the wearable elements is important; the development in flexible and smart devices for health, sports and allied application textile sensors plays important role. The weft knitting structures are excellent conductive and strain sensors, the structures of the loop architecture involve mainly knit, tuck and float stitches. Based on the combination of these basic stitches in knitted sensors the device efficiency varied. Due to flexibility in nature, the fabric knitted with larger dynamic range between tuck and miss stitched sensor is excellent for strain applications [11].

2. KNITTING TECHNOLOGY

Knitting defined as the interlacing of loops of yarn in a horizontal or vertical direction. Textile fabric manufacturing technologies were followed to develop the wearable components in the smart system. Various techniques involved in circular knitting and flat knitting fabric production adopted for the development of main components in the wearable system due to its flexibility and knitting principle. The conductive or sensitive raw material in the form of yarn individually or in combination with conventional yarn is knitted to make the whole fabric or certain loops of yarns in weft knit fabric structure.

The basic knitted fabrics plain jersey, rib, interlock and purl selected with the structure having the combination of knit stitch, tuck and float stitches. The derived fabrics from the basic fabrics produced with the combination of various basic stitches. The float stitch in the fabric consume less yarn by forming almost straight loop, and tuck stitch employed in the fabric consume more yarn compared to other stitches.

The knitted fabric used as a component in smart wearable produced as circular and open width knitted fabric, most versatile and efficient patterning in a fabric achieved in flat knitting techniques. The 2D and 3D shaping panels produced for smaller scale productivity. The vertical and horizontal stationary thread (inlay yarn) can be integrated in to the flat knitted fabric during manufacturing in knitting. The flat bed knitting machine divided in to following categorizes [12].

- Hand-propelled and hand-manipulated models
- Automated, electronically- controlled, power driven machines.

3. WEFT KNITTED FABRIC DESIGN IN SMART WEARABLES

The most of the knitted strain sensors developed in weft-knitting technology[4]. The figure 1 shows the basic knitted fabric designs involved in smart wearables. The knitting parameter affect the performance of the sensor. The higher thickness knitted fabric provides lower mean electrical resistance. The fabric extension, fabric thickness, fabric porosity influences the electrical property of the weft knit strain sensor [11]. The wireless strain sensor were developed with various knitted structures such as plain jersey, plated fabric (co-knit), plated structure with conductive thread as inlay(co-knit-conductive stitch), plain jersey with non-conductive stitch as inlay and half plating (co-knit-alternate). The knitted fabric analysed in terms of tensile (stress-strain), stretch relaxation, and utilized for monitoring the movements of body parts such as knee, elbow and finger [14]. The elastic sensor fabric produced with single jersey fabric and the contact resistance and contact force were analysed by the researcher and found that the contact resistance of the overlapped loop in a sensor is decreases with a proportional change in function of the contact force [13].

The conductivity of the knitted sensor based on the conductive material in the system. The Cu wire integrated in a knitted coil in the body of the baby romper garment, and found that 1X1 rib stitch provides highest self-inductance compared to other yarns [9]. Without affecting the comfort and aesthetic property of the clothing textile based triboelectric nanogenerator (TENG) is integrated in seamless knitwear using advanced knitting technology. A knitted 3D shaping and seamless technology with plaiting and intarsia stitch enables the scope for wearable electronics [6].

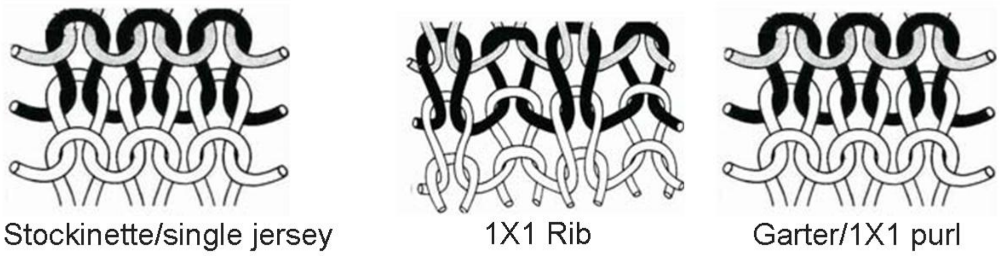

Figure 1: Basic knitted fabric designs for sensor application

The derivative of the knitted fabric is varied based on the composition of knit, tuck and float stitches. The figure 2 shows the basic stitches involved in weft knitted fabric design. The knitted fabric made with 50%knit stitch, 10% miss stitch and 40% tuck stitch sensor chosen for optimal sensor relative to the input weight of subject. The sensor produced with high tuck stitches sensor provides inverse linear relationship between resistance and load and also the fabric sensor is suitable for better linear fit with change in atmospheric temperature. If the fabric production with higher variation of miss and tuck stitched sensor produces no change in resistance under applied pressure in course direction. But in the walse direction there is a change in resistance under pressure was observed. The weft knit strain sensor resistance reduced with increases in miss stitch contribution in the fabric [11].

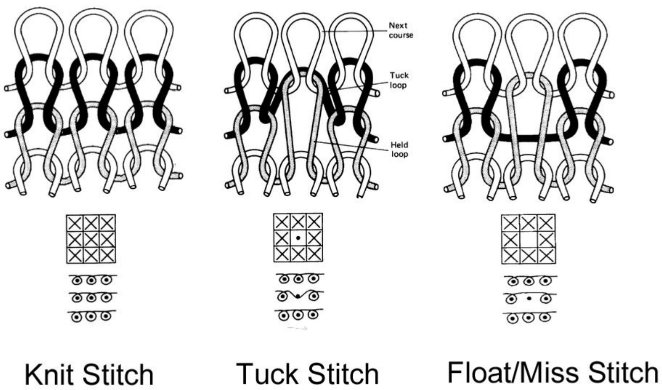

Figure 2: Weft knitted basic stitches for fabric design

4.KNITTED SMART COMPONENTS

The knitted flexible electro-active strain sensors are worked based on their resistance variation; it can be used for measuring the deformation in human body parts [8]. The stockinette stitch with elastic yarn used in romper shows higher sensitivity even changes in stitch numbers. The value of the self-inductance of the knitting coil in various styles has impact with the diameter of the yarn and the number of helical turns [9]. Silver-coated polymeric yarn is used to form a knitted course in single jersey fabric along with elastic yarn. The respiration belt developed for human respiratory monitoring. The knitted sensor works based on the electrical resistance under dynamic condition, the separation of the conductive loop contact point in a course with respect to applied strain [10]. The contact point in the loop configuration is affected by tuck and float stitched combination in fabric. The higher tuck stitched fabric sensor has increased the contact area, it regulates the contact resistance. If the knitted sensor made with increases in tuck stitches or float stitches, the initial or average resistance of the sensor decreased. And also increases in percentage of tuck stitch or miss stitch in the sensor, the sensor's piezoresistivity also linearly increased [11].

For wearable power sources in smart electronic textiles-TENG is fabricated and knitted tubular fabric. Furthermore, the integration of TENG in knitted pant also done using intarsia knitting technique [3]. These flexible fabric sensors involved directly for measuring the body parts. The knitted fabric having the thin conductive copper wire along with classic yarn is used to develop sensor integrating in a knitted garment to sense breathing of patients in daily basis. The conductive yarn combined with elastic yarn provides better results than PES base yarn [5]. The figure 3 shows the knitted sensor used for measurement or monitoring the deformation in various applications. The google's -Project jacquard touch responsive textiles in the form of fabric, clothing and any other textile products forms [7]. Based on the distribution of the conductive threads in a knitted pattern, these knitted fabric acts as a sensor or switches. The knitted pressure sensor also developed in 3D knitting techniques in two bed knitting machine [15].

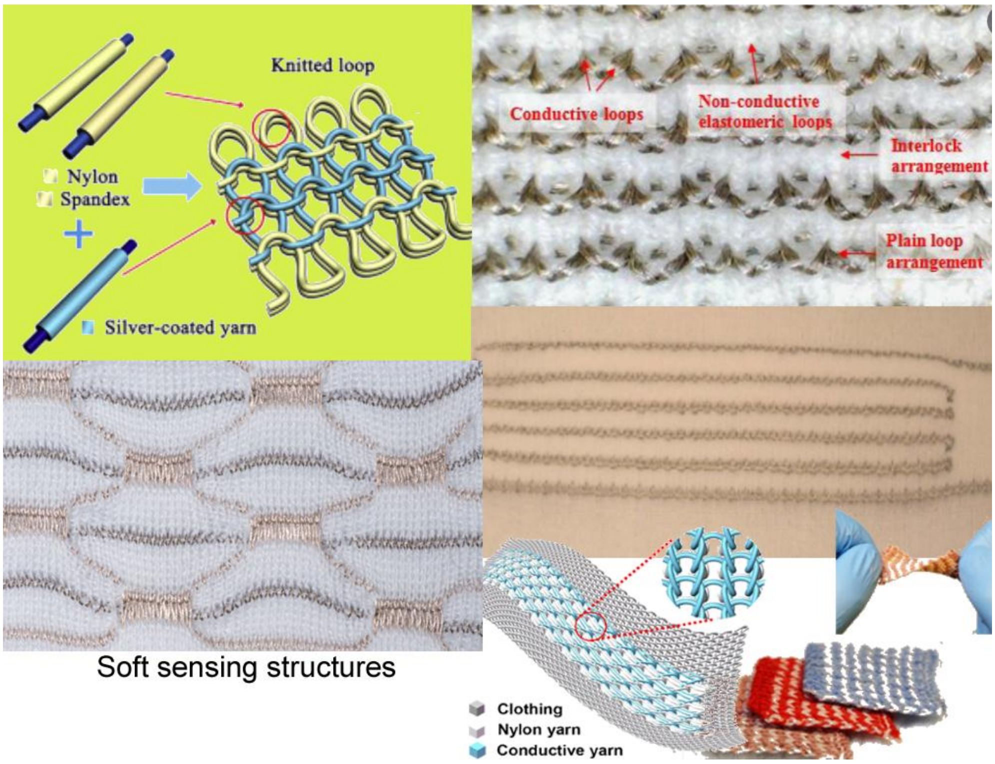

Figure 3: Knitted sensors

5.CONCLUSION

The knitted technology attracts the wearable component designers in the area of responding the devices using dynamic data and machine learning. The advances in textile technologies are the future scope to make the fabrics for future electronic textiles in all the fields. The knitted fabric contributes as electric path, sensing and interactive tool for smart wearable. Finally, the selection of fabric design for flexible knitted wearable and impulsive components in smart textiles is important.

6. REFERENCES

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