Consequence of Anxiety and Humidity on the Performance of Temperature Sensing Fabric

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ABSTRACT - *This article reports the outcome of strain and moisture on the presentation of newly developed Temperature Sensing Fabric (TSF) in the workshop environment. Temperature Sensing Fabric is a double layer crocheted structure; made of polyester as a basal yarn and surrounded with fine metallic wire as recognizing element. Fabricated on a manufacturing scale computerized knitting machine, the TSF samples made of nickel, tungsten and copper wires in the form of bare and isolated form were used in this study. In order to investigate the concert of TSF under variability of strain and humidity environment, tailor-made methods were devised, as significant standards were not available. In strain testing, the TSF trials made of insulated sensing wire completed better in comparison to the samples made with bare sensing wires. Outcomes of the humidity challenging revealed that all kinds of TSF samples could be used in a high humidity environment (up to 90% RH) without any negotiation in their identifying presentation.*

Keywords *-Temperature Sensing Fabric, Resistance Temperature Detector, Textile Sensors, Strain Sensing, Humidity Sensing.*

I. INTRODUCTION

This paper presents part of the exploration carried out for the progress of Temperature Sensing Fabric (TSF) for physiological observing of human body. The TSF was made by embedding a fine metallic wire as sensing portion into the double layer knitted structure of polyester on an industrial scale flatbed knitting machine. One of the research aims was to estimate the consequence of external parameters on the concert of TSF. For the said purpose, this study was carried out by endangering the TSF into various strain and humidity surroundings and by exploratory its performance.

1.1. Wearable Health Monitoring Systems (WHMS) The physiological observing of the human body contains the quantity of standard vital signs such as inhalation movement, cardiac activity and pulseoximetry and body temperature. The vital signs designate the status of the health of the human body. Individually vital sign has its corresponding role in diagnosis of the disease and management of the disease process. For instance the evidence of the abnormal body temperature can be an indicator of illness at an initial stage and can be a useful guide to take suitable action.Researchers all over the world are construction efforts to enhance the quality of patient’s life by cultivating their mobility and reducing the hospitalization costs. This resulted in the expansion of range of prototypes of monitoring systems for variability of end users which is generally known as Wearable Health Monitoring Systems (WHMS).

1.2. Temperature Sensing Fabric (TSF) TSF was established by protection in mind its integration with the WHMS so that it can be arrayed to measure the temperature of the human body on continuous basis for stretched periods deprived of any hassle to the wearer. Temperature sensing fabric was considered on the conceptual basis of Resistance Temperature Detector (RTD) and contrived on an industrial scale electronic flat-bed knitting machine. Few separable studies have also been informed towards the development of textile based temperature sensors. Though these studies are preliminary in nature that is sensor was made of guide procedure and was inadequate in characterization. Anintangible illustration of TSF showing surrounded sensing wire in a rib structure is shown in Figure 1, where L and W characterize the length and width of the TSF correspondingly. The working principle of the TSF is based on the essential tendency of the metal wire to contrast its electrical resistance due to the change in its temperature. The metal wire is entrenchedalmost in the middle of a double layer structure; consequently it is hardly perceptible and does not affect the aesthetics of the fabric.

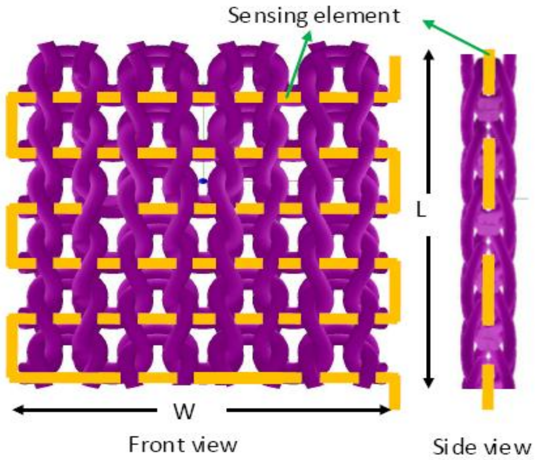

Fig 1. A conceptual illustration of TSF showing embedded sensing

II. EFFECT OF STRAIN

2.1. Methods and Materials:

Two kinds of stress test that is tensile and meandering were achieved on a purpose-designed test rig. Subsequently, there was no standard existing to be used as a benchmark to accomplish the strain test; a specifically-designed test rig was developed. The test rig was premeditated by considering the following requirements:

• It should deliver standard repeatable testing conditionssuch as dissimilar levels of extension and bending of TSF)

• It should not obstruct the strain and strugglemeasurement process.

The strain-rig was made with couples of jaws, one of which was transportable, guided by parallel tracks secured on a wooden board as shown in Figure 2. The clips were straddling on both jaws to hold the TSF fabric by its non- sensing area. One of the jaws was fixed although the other jaw was allowed to move to produce the mandatory stretch or bend in the fabric. Tensile and bending tests were executed on the strain-rig by the relocating the movable jaw from its original position. Moving the moveable jaw away from the fixed jaw twisted extension in fabric, while bringing it towards the fixed jaw produced a bend in the fabric. In order to measure the length of a TSF fabric during a tensile test, a length measurement scale was also obvious beside the tracks.In order to see the effect of any independent variable on other dependent variables, it is imperative that outstanding independent variables should be uniform during the test. Correspondingly, in order to quantify the strain-dependent struggle, the TSF temperature should be constant throughout the test; otherwise it would add error to the measurement. Since the setting of the jaw position involved guide handling which may increase the TSF temperature because of transfer of heat from the human body to the TSF: consequently a five minute pause was permissibleamong each new setting of the jaw position so that the TSF could regain thermal equilibrium with the room An Agilent 34401A multimeter (Figure 3) along with a four-wire resistance dimension connector was working to measure the TSF resistance during the strain testing.

Tensile Test Procedure: The tensile test was accomplished by exercising the tensile forces on a non-sensing area of the TSF that is moving the modifiable jaw away from the fixed jaw as shown in Figure 4 and by physicallycomputingthe extension of the TSF fabric along with the conforming resistance. The extension of the TSF sample was calculated by considering the initial (Li) and final (Lf) lengths of the TSF (distance between the clamps).

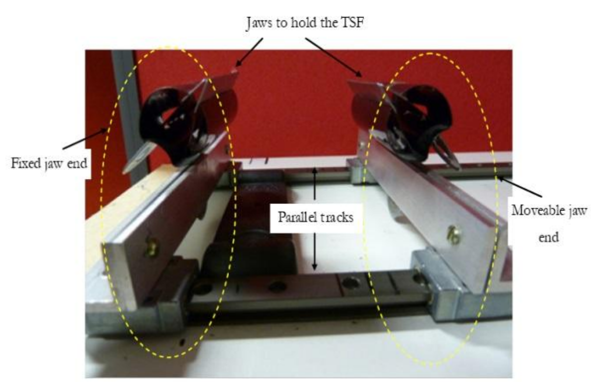

Fig 2. Test rig for the strain testing (Tensile and Bending)

Fig 3. An Agilent Bench-top multimeter

$$Extension\ \% = \left(\frac{L_f - L_i}{L_i}\right)100$$

Bending Test Procedure: The meandering test was accomplished by manufacturing a bend in the sensing area of the TSF by affecting the adjustable jaw towards the fixed jaw as shown in Figure 5 and by physicallycomputing the bending height of the TSF fabric along with the matching resistance. Image a of Figure 5 shows the various levels of bending test. The height of bending curving can be associated to the bending stresses practiced by the TSF. The height of bending curvature was designed from the neutral position when the TSF was in a comfortablecomplaint before the test.

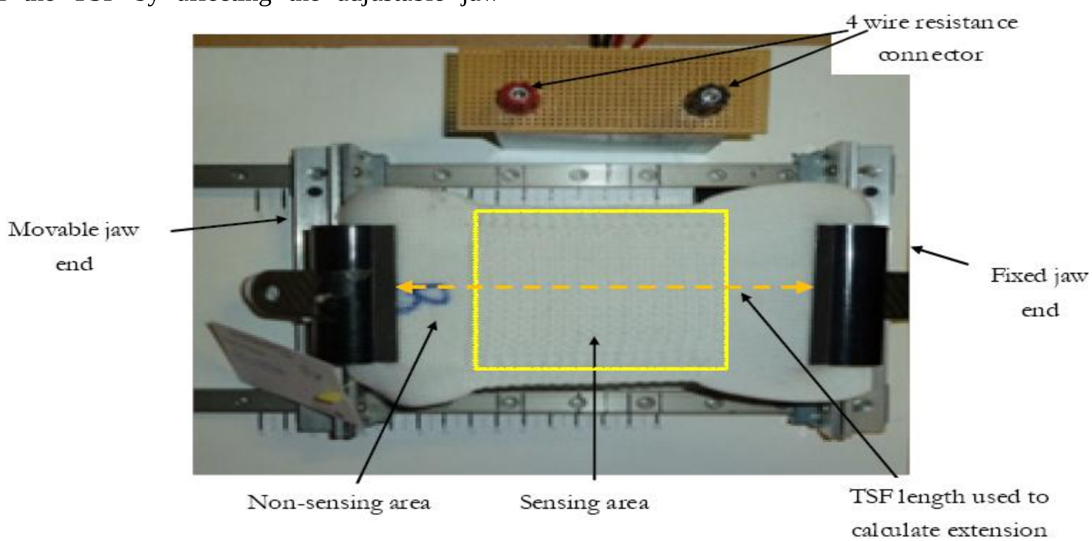

Fig 4. Tensile strain testing on strain-rig

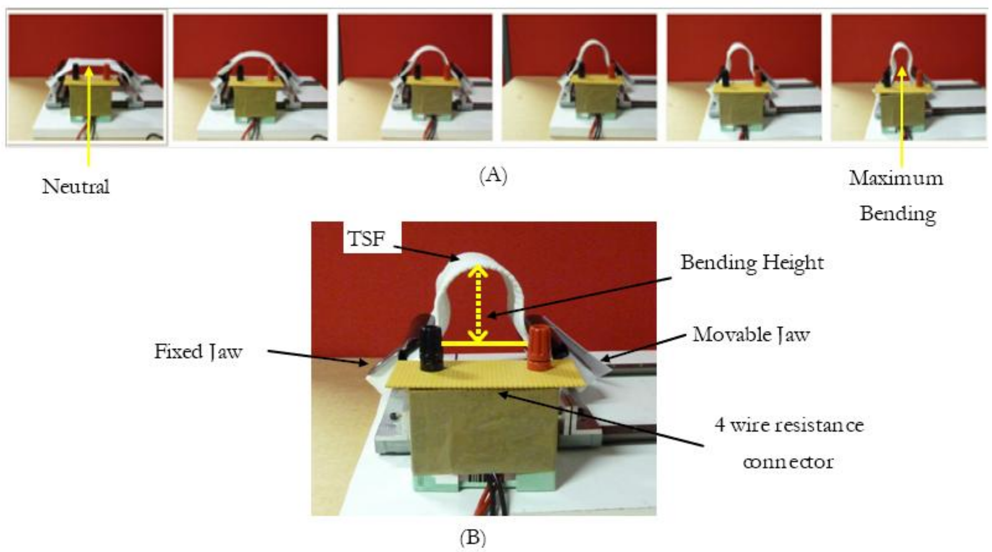

Fig 5. Bending strain testing on strain-rig

III. EFFECT OF HUMIDITY

3.1. Methods and Materials:

In order to revision the inspiration of high relative humidity on the sensing presentation of the TSF, following instruments were employed: a multimeterfor the quantity of TSF resistance an Oregon Scientific Weather Station for quantity of room temperature and humidity and a digital balancefor capacity of the TSF mass. All experimentations were accomplished in a conditioned laboratory equipped with Mitsubishi Mr. Slim air conditioner and Hygrometric hygrometer in which a thermal environment of 30 to 90% Relative Humidity (RH) was formed at a room temperature of 20°C. The primary laboratory RH level of 65% was raised to 90% by altering the Hygrometer settings. Afterwards the laboratory reached the 90% RH and preserved it for an hour, the environment temperature and the mass & resistance of the TSF were noted. Subsequently that Hygrometer was turned off, permitting the RH level of the laboratory to drop progressively to 30%. This whole process took more than 15 hours. The environment temperature and the mass &resistance of the TSF were distinguished at several humidity levels between 90% and 30% of RH. The temperature of the laboratory through the whole duration of the test was measured to be in between the range of 20 to 22°C.

3.2. Result and Discussion:

Figure 9 grants the effect of comparative humidity on the relative increment of the TSF mass due to the increase in moisture. The relative mass of the TSF was planned with 32% RH as the base value. It can be seen from Figure 9 that the relative mass of the TSF is directly related to the relative humidity in an exponential manner. This association was more prominent at high humidity levels. At 65% RH, the average qualified increment of mass of all TSF samples was found to be anywhere between 0.2 and 0.3% which is low in evaluation to the documented moisture regaining of polyester i.e. 0.4% at 20°C and 65% RH. This error canbe associated to the initial RH value (32%) used to calculate the relative increment of the TSF mass. Once the entirely dry weight of the TSF is known, the above-mentioned error may be condensed further.

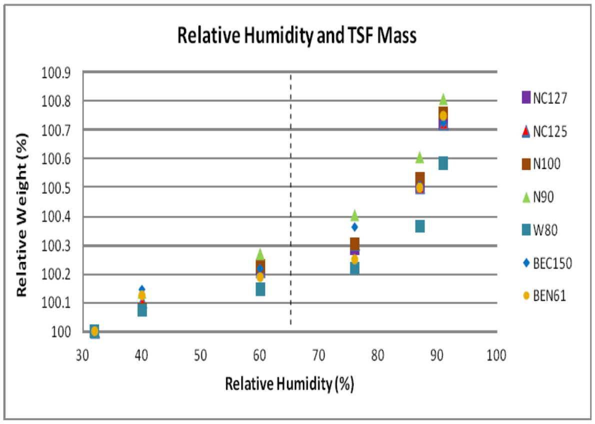

Fig 9. Moisture Regain of TSF at various humidity levels

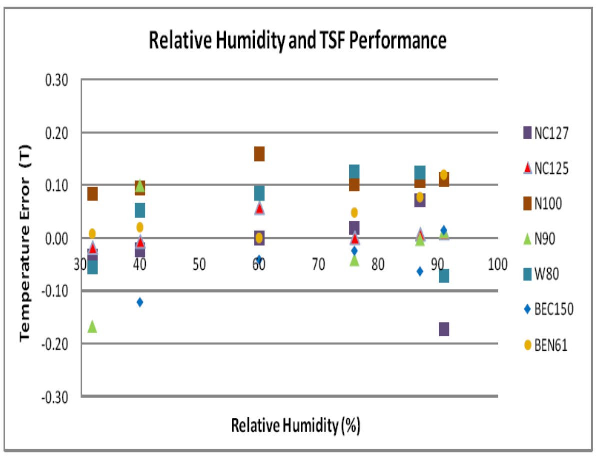

Fig 10. Effect of Relative Humidity on TSF Performance

IV. CONCLUSIONS

This article reports the outcomes of the consequence of strain and humidity on the enactment of Temperature Sensing Fabric (TSF) in the laboratory environment. The TSF is a double layer crocheted structure with embedded fine metallic wire as detecting element. The working principle of the TSF is based on the essential tendency of the metallic wire to diverge its electrical resistance due to the change in its temperature. The TSF illustrations made of nickel, tungsten and copper wires in the form of bare and isolated form were established in diversity of strain and humidity environment. The TSF samples made of separated sensing wire were found to be unpretentious by strain-dependent resistance errors; it may thus be animproved option to integrate them in the practical environment, in predilection to the TSF sample made with bare identifying wires. The moistness content of the TSF increased exponentially, with an increase of environmental humidity. The consequence of relative humidity on TSF performance was found to be irrelevant. The temperature error was random in nature and was well within the range of ±0.15°C. The TSF made with sequestered wire as well as bare wire distinguishing elements could be used in a high humidity environment deprived of any compromise in their sensing presentation.

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